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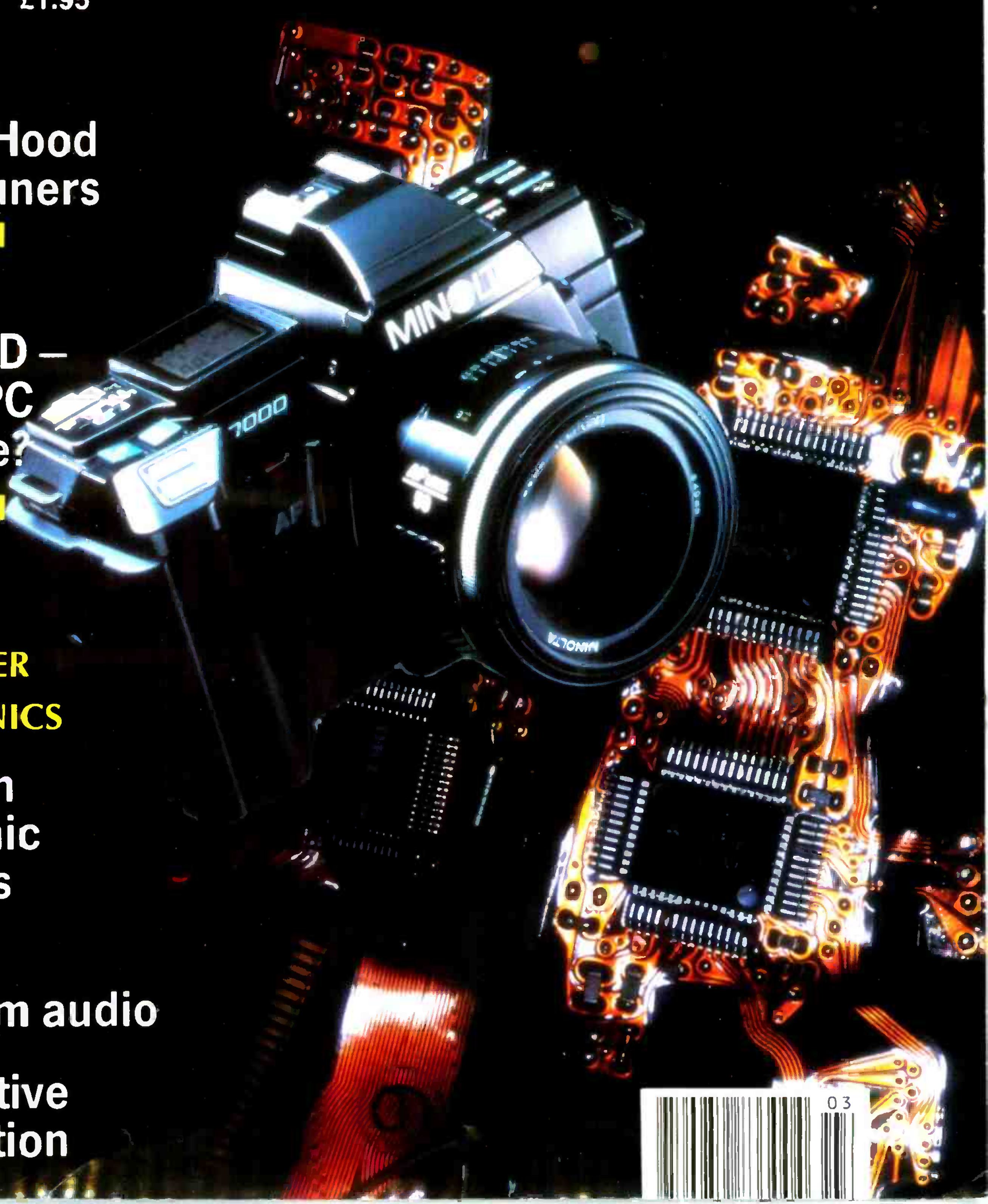

CONSUMER ELECTRONICS

Focus on electronic cameras

Behind bitstream audio

Automotive automation

03

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REGULARS

In next month's issue. Inside a professional mixing desk.. Studio mixing consoles represent the ultimate in audio electronics design. Doug Self, chief engineer for Soundcraft, reveals the secrets of packing in the headroom while keeping out the noise.

Also in the same issue: Engineering design with the PC

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Flights of conscience

One can't help but be impressed by the role of electronics in the Gulf war. The accuracy of Tomahawk missiles flying for hundreds of miles across sea and desert to strike within a few metres of the target is awesome; the technology which gives perfect sight to night-fighting aircraft is equally impressive.

The application of murderous technology must leave a deep sense of unease among those whose job it is to create these weapons. Can it be right to apply the ingenuity of man to the task of killing?

It is not acceptable at a personal level to say "I am simply doing my job... If I don't do it, someone else will." There has to be a better reason and it is this: the application of electronics, like that of nuclear physics, may be a power for good or evil. Once invented, it is there for ever. We have to find a way of living with it, hopefully to man's advantage. Inevitably the development will mirror both sides of human nature. To expect anything else is unrealistic. The good side must work to protect us from the bad. If this requires the development of effective weapons systems for use in our defence, then so be it.

There is a further requirement for all those who wish to remain on the side of the Angels. We have an absolute responsibility to do all that we can to prevent potentially offensive technologies falling into the hands of those who would use them for aggressive purposes. Western politicians have failed miserably in this. They traded with the Devil through pragmatism and greed, never at any time seeking to apply a higher conscience. They now ask others to pay the price.

The same people who speak so easily about "restoring the rights of the Kuwaiti people" and "the halting of aggression" must bear the entire responsibility for the young lives which have come to their end in the desert.

Frank Ogden

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Ground based telescopes may bring Hubble down to earth

Jokes about poor performance of the Hubble space telescope are already an established part of science history. What is less well known is that even when the HST is fitted with the planned correcting "spectacles" it could still, for the most part, be obsolete.

A Leader in *Proc. IEEE* (Vol 78 no 11) colourfully sums up the situation: "As Nasa's myopic cyclops staggers through space for the next few years ... the brightest prospects are on the ground."

Professor Laird Thompson of the University of Illinois and two colleagues writing in the same issue of the journal explain how in theory, and almost certainly in practice, it will be possible to build active ground-based telescopes that cancel out atmospheric turbulence (the effect that makes stars twinkle and which was the whole argument for spending over a billion dollars putting a telescope in space).

In concept, he told *EW + WW*, the idea has been around for over 30 years, but only recently has it become technically feasible.

Thompson explains that plane waves of light from a star become distorted so that the wave-front, far from remaining plane, resembles a crinkled surface. If a telescope were to be fitted with an auxiliary mirror crinkled in the opposite sense, the star should lose its twinkle and become a perfect point source once more.

Problems have been how to create a crinkly mirror that responds dynamically up to 100 times a second and how to derive a control signal inverse to the distortion of the atmosphere.

The crinkly mirror problem has in fact already been solved; there is an example of such an "adaptive optic" installed at the European Southern Observatory in Chile.

As for the control signal, what has been done up till now is to observe a bright star near the one under study and assume that both stars will twinkle to the same extent. A detector array monitors the guide star and, using that information, deforms the mirror so as to produce a clear image of the wanted star.

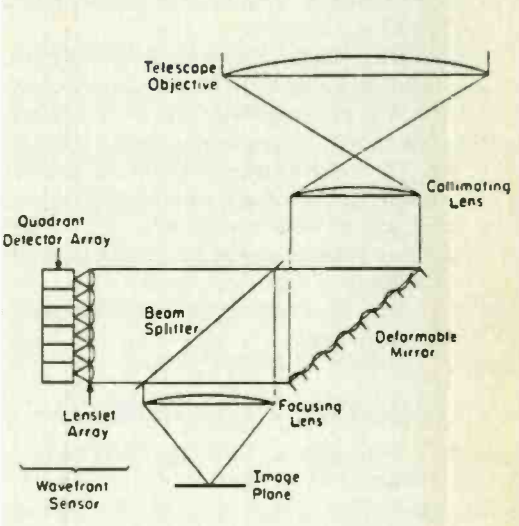
The system shown works well, except that there are surprisingly few guide stars suitably close to the fainter ones that astronomers actually want to observe.

Laird Thompson's solution is deceptively simple: If you take a laser beam and focus it like a beacon high up in the stratosphere, some light will be reflected back. And if that light can be imaged in the telescope then it should in principle look and behave exactly like a natural star in guiding the telescope.

In their latest paper, Thompson and colleagues calculate how such a system would work, fitted to a standard 2m telescope and using readily available lasers of around 15-85W.

They believe that, using existing components, the system should work at least as well as the Hubble does today, producing an image with a sharp central core surrounded by a fuzzy halo.

But as technology improves, Thompson is convinced the system will work — in the visible part of the spectrum — as effectively as a perfect space telescope. The difference is that the adaptive earth-bound system need cost no more than $8million - roughly 200 times less than the troubled Hubble.



Large-diameter adaptive telescope technology which could leave Hubble out in the cold.

Baseball players must learn to let go

Remember those "O"-level physics lessons spent wrestling with acoustic resonance in pipes and steel bars and wondering why it had to be learnt at all if you were never going to play the organ or xylophone. Now the *Am. Journal of Physics* (58, 8) has shown why those early studies were so important; they form the basis for research into truly vital subjects... like baseball.

Howard Brody of the University of Pennsylvania was intrigued by frequent but unverified conjectures that a baseball bat behaves as a free body at the moment it strikes the ball. On that basis all the stuff about holding the bat firmly to add momentum to the stroke is a load of nonsense.

Taking on the (American) sporting fraternity is clearly serious business so Brody planned his experiments carefully.

His object was to discover whether a hand-held bat vibrates in a similar way to a free one or more like a bat held in a firm vice at the handle. Fortunately the answer could easily be ascertained by analysing vibrations that actually occur when a bat is hit by a ball.

Fundamental resonance of a free bat is roughly twice that of a bat firmly clamped in a vice, and is also quite different from the second harmonic of the clamped bat (see figure).

Howard Brody, having measured all these frequencies in the laboratory, fitted his bat with a piezoelectric vibration sensor and went off to play baseball. The sensor was connected to a recording oscilloscope designed to display the vibrations that occurred when the bat was struck by the ball.

Measurements were taken using a variety of grips from light to firm.

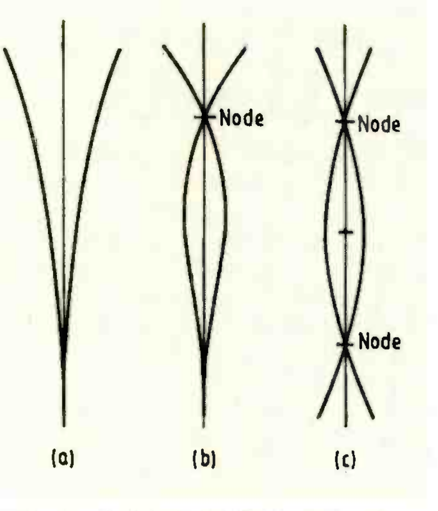
What the experiments showed conclusively was that the hand-held bat does behave as a free object, regardless of how firmly it is gripped. Complete absence of the low frequency clamped fundamental made this quite clear.

Brody therefore concludes that grip firmness at the point of impact should not influence the post-impact velocity of the ball.

Even more provocatively he suggests that, were the hitter to release grip completely at the moment of impact, effect in terms of ball trajectory would be nil.

Obviously firmness of grip has an influence on bat velocity up to the point of impact; it also affects the rate at which vibrations in the bat are subsequently damped.

But in terms of adding that extra oomph, forget it.



Vibrating baseball bat that could make the sporting world shudder.

Journey to Earth's core ends at laboratory

Static pressures greater than those at the centre of the Earth have been achieved for the first time in the laboratory. Researchers at Cornell University, led by Professor Arthur Ruoff, have used a diamond anvil cell to reach pressures of more than 4000 times that of the deepest oceans.

Actual pressure recorded reliably was 4.16Mbar, which compares with about 3.6Mbar at the Earth's core.

Other research groups have achieved higher instantaneous pressures, up to 100Mbar, in shock experiments using gas cannons or nuclear explosions, but by their nature, such experiments do not allow the study of compressed materials using lasers or X-ray diffraction.

The diamond anvil cell is widely used to achieve high pressures for long periods with samples of a size that can readily be analysed. The device consists of a pair of brilliant-cut diamonds, chosen for their crystal perfection, each with a tiny area polished off its tip.

Diamonds are mounted tip-to-tip and a tiny steel gasket with a hole drilled in the middle is placed between them. The substance to be tested is added to the hole and the diamonds are then clamped together in a powerful vice.

Cornell scientists used tungsten and molybdenum as test substances because their physical properties at high pressure are experimentally and theoretically well-known. The metals could therefore be used as a means of measuring pressures achieved in the equipment.

When the diamond anvil cell had been brought to maximum pressure, the tiny samples, no bigger than droplets of mist, were subjected to X-rays from a high-energy synchrotron source fitted with a collimator to narrow the beam down to 4μm in width.

By analysing diffraction of the X-rays, the scientists were able to calculate the pressures with great accuracy. X-ray diffraction is considered by far the most accurate and dependable way to measure the very large pressures achieved in anvil cells.

The team now plan to use their improved cell to conduct experiments into changes of state believed to take place at ultra-pressures.

For example, they hope to find evidence for a phase transformation predicted to occur in molybdenum where cubic crystals rearrange into a more closely packed hexagonal structure.

Intriguingly, there will be attempts to squeeze hydrogen and nitrogen into forms where they begin to show metallic properties. Earlier experiments using lasers showed that squeezed oxygen acquires a silvery reflectivity. What will be particularly interesting is to discover whether these "pseudo metals" also conduct electricity.

Ultimately the Cornell scientists plan to experiment with materials that are of direct significance to electronics engineers. These will include germanium, silicon, gallium arsenide and gallium antimonide.

"Alien" scientists find life on Earth

Life exists on Earth and it may be intelligent. This dramatic revelation by Nasa scientists, pretending to be aliens, is based on data collected by the Galileo space probe as it made its first Earth fly-by, coming within 950km of our planet.

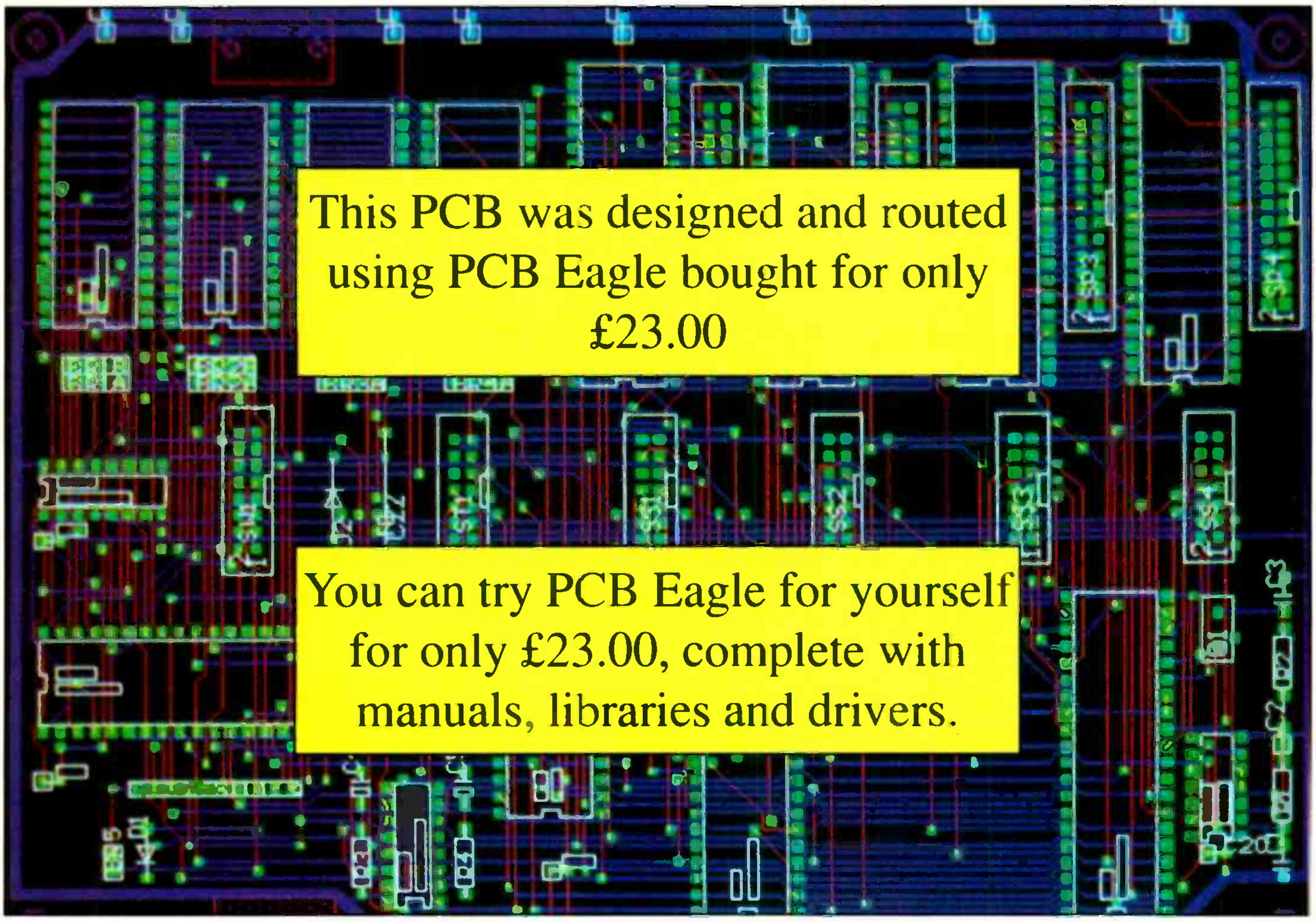
This fly-by was not deliberately intended to study the Earth, rather to gain momentum for Galileo's journey to Jupiter. But it did nevertheless provide a golden opportunity to test and calibrate instruments that might one day provide evidence of life elsewhere in the cosmos.

Infra-red measurements revealed nitrous oxide, methane and oxygen in the atmosphere, all indicative of the presence of life. The space probe also detected non-natural radio transmissions that grew in strength as it neared the Earth.

We are not told whether Galileo tuned into Neighbours or Wogan, but Nasa says the impressions would have led any alien operator strongly to suspect that Earth has intelligent life.

One technology, however, that didn't reveal the presence of life on Earth was photography. Although the Nasa scientists ordered Galileo to take a few thousand colour snaps of Earth, none of them revealed anything at all un-natural. From 950km out in space, it seems, nothing mankind has ever built is big enough to be seen on even the most detailed picture.

Galileo will perform another Earth sling-shot in December 1992 before heading off to reach Jupiter in 1995.



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CIRCLE NO. 130 ON REPLY CARD

Too much Sun gives Ulysses the wobbles

Ulysses, the joint ESA/Nasa spacecraft destined to become the first probe to circumnavigate the poles of the Sun is in excellent health at well over 200 million kilometres from the Sun; apart that is from a case of the wobbles.

Ulysses was launched by shuttle Discovery on October 6 last year and is now heading towards Jupiter which it will reach in February 1992. It will use Jupiter's gravitational influence to head out of the ecliptic—the plane in which planets orbit the Sun—to make a southward pass of the Sun.

All the scientific instruments on board Ulysses have now been switched on and scientists and ESA spacecraft controllers have confirmed that all are functioning normally.

To stabilise itself in space, Ulysses is spinning at 5rpm with its high gain antenna pointing towards the Earth so that telecommunications can be maintained. During the mission, Ulysses is in contact with the Earth for eight hours each day, while during the remaining sixteen hours, data is tape-recorded aboard the spacecraft.

Ulysses has one rigid and two flexible booms attached to the main body of the spacecraft. The radial boom was deployed on the first day of the mission and, at the start of November, the flexible booms were successfully deployed.

The delicate wire boom stretches 72m from tip-to-tip either side of the spacecraft while the other, axial, boom is 7.5m long and extends from the spacecraft body on the opposite side to the high-gain antenna.

Both booms act as antennae for the Ulysses unified radio and plasma wave experiment.

The Sun gives off bursts of radiation, observed as radio signals, as well as a highly magnetised plasma known as the solar wind. Waves within this plasma are generated in space and are being monitored by Ulysses.

Early in November Ulysses was faced with a wobble motion which has been attributed to one of its booms, with a larger amplitude than expected. Within two hours of the axial boom being deployed on November 4 controllers noted that the spacecraft had started to wobble about on its axis of rotation in the same sort of way as a spinning top moves.

Solar heating of such booms can throw a spin-stabilised spacecraft slightly off balance. As Ulysses rotates in space, the Sun heats up on side of the axial boom causing it to expand; by the time it has spun 180°, the other side of the boom is being heated. This sets up a wobble which is magnified by the spacecraft's rotation. Technically known as a precessional nutation the maximum misalignment reached 3°.

As the spacecraft heads away from the Sun, Ulysses will switch to higher frequency radio transmissions in the X-band to transmit greater rates of data; this requires greater accuracy of pointing towards the Earth. A nutation of less than 0.75° radius angle is required.

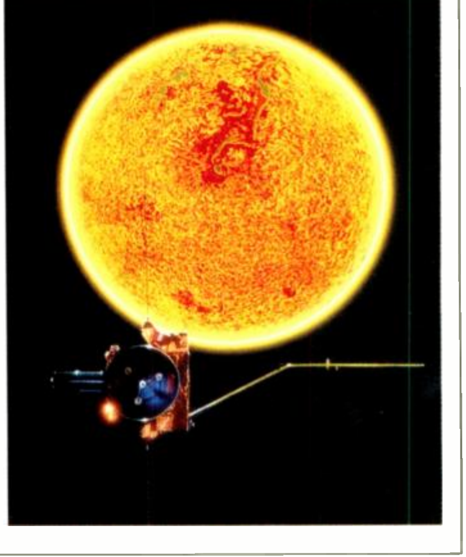
The effect of the nutation, if unchecked, would be to make X-band communications with the Earth more difficult.

A team of engineers from ESA and Nasa investigated the problem and correctly predicted that the nutation would decrease of its own accord because the spacecraft is heading further away from the Sun and the angle between the spin axis of the spacecraft and the Sun angle is decreasing.

Ulysses, like many other spin stabilised spacecraft which need to keep the high gain antenna earth pointing for communication purposes, has an automatic system to perform this task. This is a conical scanning system which also incorporates a nutation-damping effect.

In tests on the space-craft the system has been very effective in reducing residual nutation to less than 0.5°. ■

Ulysses Sun orbiter launched by shuttle, with boost motors still in place. (Right) Ulysses near the sun with both booms deployed. *Courtesy ESA/NASA*



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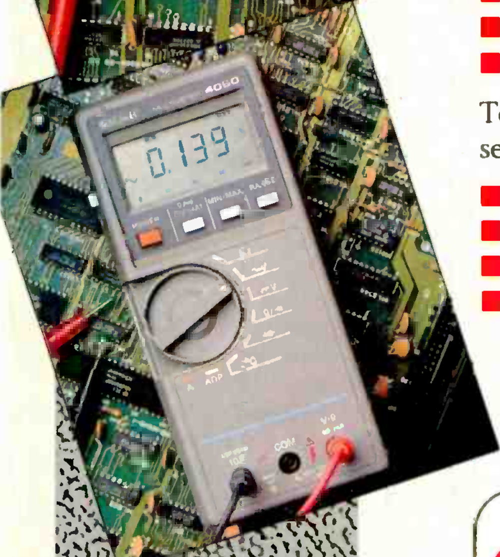

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CIRCLE NO. 138 ON REPLY CARD

EMR report delay inflames fears over cancer link

A row has blown up in the US over unexpected delays to publication of an Environmental Protection Agency (EPA) report linking electromagnetic fields to brain cancer and leukaemia in children. The White House has been being accused of stalling the report because of fears that it might alarm the public.

The report concerns the conclusions of EPA scientists who studied the effects on humans of all types of electromagnetic fields — from those produced by home appliances to those generated by high-power electrical transmission lines.

All previous studies on electromagnetic fields and cancer were reviewed, with the conclusion that there was a suggestion of a "causal link" between household power distribution systems and certain cancers in children including brain cancer, leukaemia and lymphoma.

White House science advisor D Allan Bromley and Assistant Secretary of Health James Mason are said to have told the EPA they were concerned that the report could alarm the public and this is believed to have caused the delay.

Their fear was that people would take too seriously the suggestion that there may be some connection with cancer.

Originally, it is thought that the EPA proposed classifying the electromagnetic fields as a class B1 carcinogen indicating they are a probable source of human cancer. But this conclusion was dropped when the report was reviewed internally.

Fibre to the PC

AMD says that its Supernet 2 chip-set brings the idea of "fibre to the desk" one step closer by allowing the construction of a complete FDDI (fibre distributed data interface) station on an AT-sized half-card.

This low-power chipset can support the FDDI 400Mbit/s memory bandwidth and drive either copper cable or fibre without modification. The chip which manages the physical layer of the connection was developed in collaboration with DEC, and uses cmos technology to monitor the integrity of the link and interface with two bipolar phase-locked loop chips, which allow the choice between copper and fibre and are on separate chips to eliminate possible instabilities in the 125MHz signals output to the network.

Media access control is contained in the Formac plus chip, which includes arbitration, address generation and buffering.

This is also implemented in cmos, and includes a "tag" mode, which the company says makes better use of the available buffer memory.

Silicon number

One supposes that it had to arrive sometime... the chip which does nothing more than produce its serial number in digital code.

The silicon serial number contains 64 factory-written bits which can be got at through what the manufacturer Dallas Circuit calls "a highly creative multiplexing system". There are just two pins, one of which is ground. The device is intended to provide access codes and network addresses. *Dialogue Distribution 0276-682001.*

GSM Euro-boost

The latest study on the prospects of GSM in Europe says that the new mobile phone system will have attracted 59 units per 1000 population by the year 2000. This is a 40 per cent increase on earlier forecasts. *PA Consulting Group.*

Spy glass

Glass manufacturer Pilkington has developed an RF absorbing glass which attenuates incident RF by up to 60dB at 1000MHz. The new material allows the construction of Faraday cages which look like normal office environments. Pilkington says that the resulting enclosures are bug proof but can also protect sensitive electronic equipment within the room from external e-m fields such as radar, etc.

PLANES RELY ON PCs

Air passengers landing in what was formerly East Germany may quite possibly find themselves guided down by an air traffic controller sitting in front of a PC. This low-cost approach is a result of a $5.75 million contract with Hughes Aircraft Company to supply 36 TracView air traffic control systems to the area. Hughes' system takes input from existing radars and with high resolution graphics shows controllers a plan view of traffic. Information includes aircraft call sign, position, direction, speed and altitude of each flight The system has already been used by controllers at Vancouver Airport (picture left).

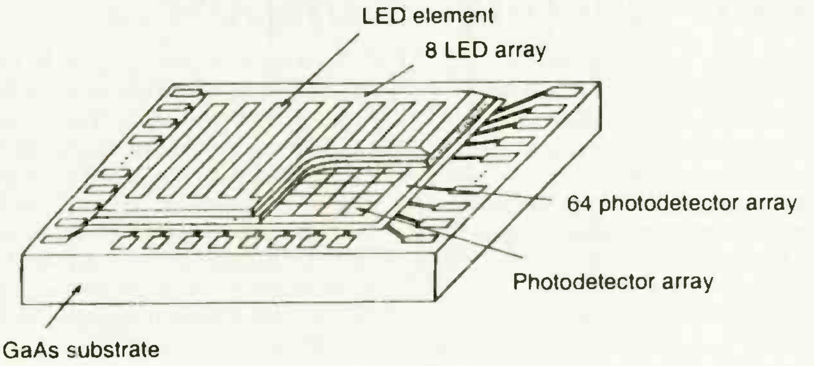
More DSP from TI

Texas Instruments has continued the expansion of its range of digital signal processing chips with the launch of two fixed-point units, the TMS320C51 and TMS320C16.

C51 is object and source-code compatible with the C50 variant launched late last year, but will be a lower cost chip intended for volume products. The company says it will run at up to 29Mips, with zero-overhead looping and context switching and on-chip serial ports.

Priced at under $10 in high volumes, the C16 fixed-point unit provides an upgrade path for users of TI's C10 and C15 chips, with which it is object-code compatible. The company hopes that it will find its way into modems, answering machines, and drive and motor controllers. Existing assembler/linker tools can be used to support the chip.

Both devices will be available this year, the C16 in the first half, the C51 in the second.



Learning chip that can teach you a thing or two

A prototype optical neural computing chip, which can "learn" on its own without an external computer, has been made by Mitsubishi Electric in Japan.

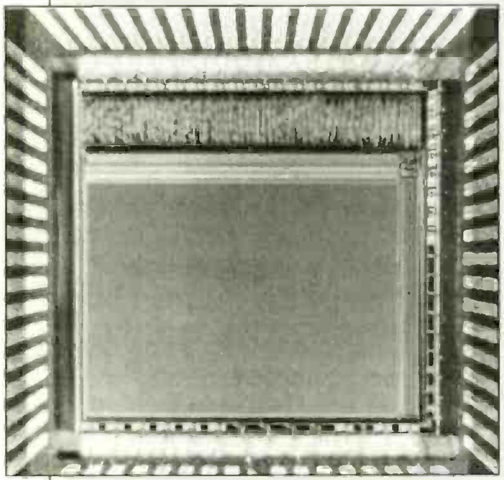
The ability to modify operation based on assimilation of data in a learning manner is a characteristic of neural computers which are modelled on the human brain.

In a neural device the output of each neuron in the chip depends on the sum of its inputs, with each input weighted according to its importance. But this weighting can be updated during operation — so the neuron can learn.

In Mitsubishi's chip the weighting function is part of the neuron design and the company says the device could be used in a fully-fledged optical neurocomputer.

Design is based on eight long narrow leds laid over an 8 x 8 array of photodetectors. The detectors have adjustable sensitivity, and it is this that is used as the weighting.

The neurochip fits onto a gallium arsenide substrate measuring 6mm square. It learns at 600MCups or 600 million connection updates per second. This is over 2000 times faster than a conventional neurocomputer and workstation.



VVL's cmos camera chip, with 84,000 photodiodes, and (right) the resulting black and white picture

Camera-on-a-chip moves to production?

First product to make use of the complete video-camera-on-a-chip, invented at Edinburgh University, is to be launched in the next two months.

The chip — which is to be licensed to OEMs for development by VLSI Vision Ltd (VVL) — is fabricated with ordinary cmos technology, and comprises a photodiode array (PDA) to detect light and charge sense amplifiers to produce an electric signal. Fabrication into a camera is achieved simply by gluing a lens on top of the PDA.

Neither the PDA nor the amplifiers are new technology, but putting them together is, and chip applications range from cheap security cameras, to robot vision, to videophones.

The whole chip fits on a thumbnail. When exposed to light about 84,000 photodiodes send packets of charge to amplifiers measuring 20µm across.

Only black and white pictures can be handled at present, but the team is working on a colour version.

Trans-Channel transputers

Despite being invented in the UK, Inmos's transputer has gained wider acceptance on the European mainland than at home. German systems house Parsytec is now indulging in its own version of "coals to Newcastle" by setting up a parallel processing centre in partnership with Glasgow University and a UK limited company to sell its products.

The research centre will have a 100-transputer Parsytec machine, and will be headed by the University's Dr Mustapha Al-Mudares, the 1000Mips, 150Mflop/s transputer cluster being networked to a VMEbus-based image-processing subsystem, Vax, Sun, Apple Mac and IBM PC computers. Dr Al-Mudares says that it will be used for a variety of tasks, including chip simulation, schematic capture, and fluid analysis. Also on the agenda will be solving the complex computations required to analyse the behaviour of very small electronic devices, including opto-electronics. The University has strong links with industry already, and Dr Al-Mudares says that the centre will help to expand them; interested companies will be offered free computing time to assess the centre's abilities to solve their computational problems.

Parsytec's UK company will be set up in conjunction with its present UK distributor, Dean Microsystems. The company will concentrate on computationally intensive applications, leaving Dean to run the real-time and industrial sides of the business. Richard Horton, formerly advanced systems manager at Dean, will head the new company, which should have a team of 6 to 10 applications engineers by the end of this year.

Scotland will also be the chosen site for Sunnyside systems, a company set up by ex-Burr Brown director Mike Eccles to produce very small transputer modules for real-time data acquisition. The first in the range, the spt156, uses a Motorola 56001 digital signal processor, along with a transputer, in a module 9 x 11cm. MS-DOS and OS-9 development tools are available to back up the hardware, which will interface with the VME and PC buses, as well as Parsytec's UniLink. The aim is to perform much of the signal processing at the point of capture, rather than at a central point. According to Eccles, this will lead to faster system development, because systems will be less complex and more easily expandable.

Inmos is building up to the launch of the next generation of transputers, code-named H1, with a spate of agreements to port standard operating systems to its hardware. The latest of these involves French software house Chorus, and will provide Unix capabilities on future H1 systems. The Chorus operating system is a distributed multiprocessing package based on a small basic kernal. Communications, memory management and real-time event processing are provided as bolt-on software modules.

Amazing density

Standard 3.5in floppy disks can be pushed reliably to 4MB of data storage with an increase to 20MB on the horizon. Peripheral maker Citizen says that its new 4MB drives fit existing computer slots and the interface complies with Ansi recommendations. The company expects the 20MB unit to be in production later this year.

Real-time OS with dos

Intel has produced a version of its 32-bit iRMX III real-time operating system which will allow users to run dos as a task, while iRMX III is running. This allows users to run dos applications programs and graphics user interfaces on the same processor which is running real-time applications.

The two operating systems can pass data via files, and iRMX can write direct into a Windows screen, allowing graphical or spreadsheet information to be updated on the fly. The port also allows dos applications to be ported to 32-bit processors and gain access to up to 4Gbyte of memory. Processing involves booting dos, then loading iRMX using a terminate-and-stay-resident routine. The real-time OS then encapsulates dos and makes it into the lowest priority task available.

Novice training

The Radio Society of Great Britain expects that the first UK novice licences will be issued during July 1991.

There will be two classes of licence: novice A permits operation on all novice bands while novice B restricts operation to bands above 30MHz. Aspiring operators need to complete the RSGB training course under the supervision of an approved instructor. Training requires some 30 hours of study over a 12 week period. This is followed by a simple examination. The novice A licence also requires the passing of a 5wpm morse test.

Further details are available from the RSGB Headquarters, Potters Bar.

An easy route to Electronic Control System Design

TDS9092 and the new 16-bit TDS2020 Forth Control Computers provide a flexible and easy to use route into electronic design. This is an especially useful approach for those in the field of mechanical engineering and system control where modern designs need the benefit of microprocessor based electronics, keyboards, displays, non-volatile memory and analogue input/output, but where software development is not the prime discipline.

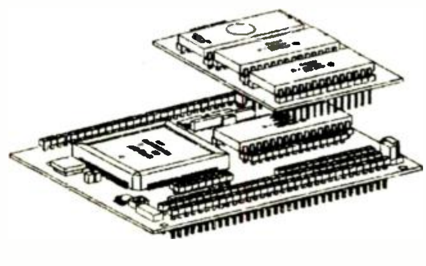
Software Controlled Products

When software is involved in product development the step of integrating hardware and software is fraught with difficulty.

Sophisticated tools in the form of development systems, emulators and logic analysers exist to help the debugging process. However once any software defects have been detected, the debug sequence of loops that involve Load Editor, Edit, Load Compiler, Recompile, Load Linker, Link return program to target system and Test, is entered. This sequence will be enacted for one error in one line of code or many. The agony really begins if the errors are interactive with respect to the hardware - the correction of one exposes another. This is why project managers tend to age prematurely.

But there is a solution to that which does not call for expensive support tooling or personnel but still allows a systematic and orderly approach to design using modern processors and manufacturing techniques.

The solution is Forth. It was invented (or discovered say some) to improve productivity. TDS2020 and TDS9092 users like the ability to deal with code on a word by word, or line by line basis interactively with the target system. It offers the designer the opportunity to write, test and run software in real time and avoid the time consuming steps of the Edit Compile Test Debug Loop for each single modification. On-board Forth offers in one entity a real time programming language, an operating system and a development environment.



The new TDS2020 Computer and TDS2020DV development module

A unique advantage

When you have developed your product using TDS2020 or TDS9092 and are now manufacturing, that is not the end of the story of the use of Forth. Use it for repair and maintenance because the language is *on-board*.

Build in a connector which gives serial access to the Forth computer in your instrument. Now with a PC or hand held terminal gain access to the internal language system. By pressing Control/C you can individually use all the procedures which make up the application.

For example in a temperature measurement device the Analog to Digital routine can be separately exercised to see if the fault is with the input transducer or amplifier. If not examine the other procedures individually. Test the Liquid Crystal Display by writing a few characters to it using the LCD routine, or try the keyboard subsystem by pressing a key to see if the keyboard subroutine returns the correct number.

On-board Forth is very useful during design and debugging but the ability to access individual software procedures in a finished product is invaluable.

Simple language

The simplicity of the language is another attraction. Forth is based on a memory resident dictionary of software procedures called words. These words can be interlinked and executed directly. New words for the dictionary are constructed from existing words, held in the dictionary and then linked in any order with other words to build programs.

It is a stack orientated language in which all functions communicate with stacks for most operations. Two stacks are involved; one is called the parameter stack and the other the return stack. The parameter stack is used to pass values to and from procedures. The return stack tells the program where to return to after a procedure has been completed.

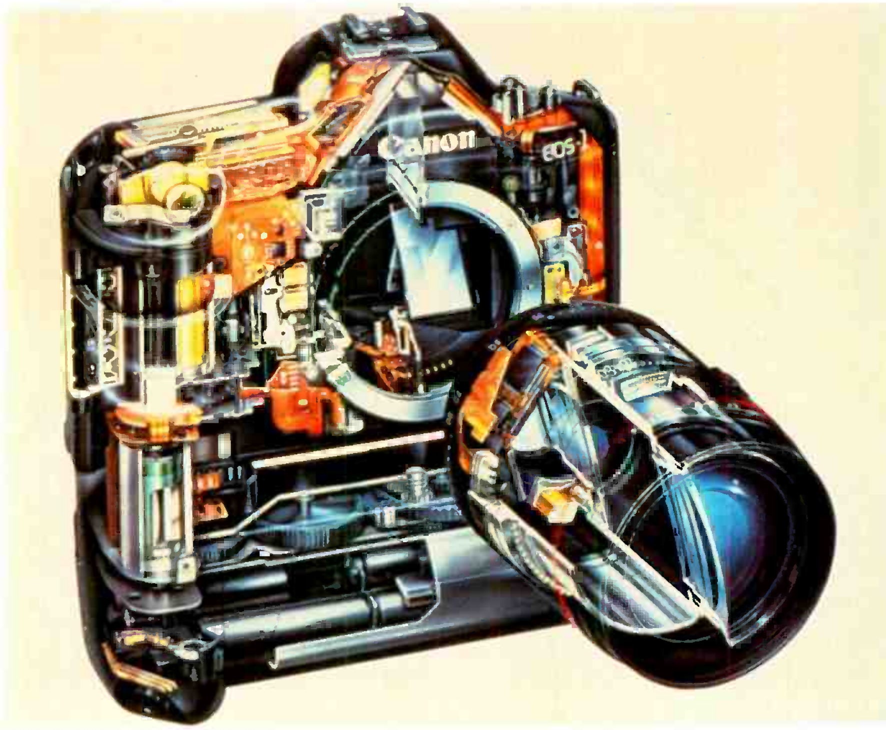
The essence of Forth is that it works its way through a hierarchy of the routines of words until it reaches the fundamental definitions that can be executed. The beauty of this inner interpreter is that it consists of only a couple of fast machine code indirect fetches, so Forth executes quickly.

TDS2020 and TDS9092 also have internal assemblers so that Forth and code can be mixed. Ideally an application program would be written 90% Forth, 10% assembler to get development done as quickly as possible. But by making sure the program spends 90% of its time in the assembler routine the overall effect is that of software running at machine code speeds.

Triangle Digital Services Ltd

223 Lea Bridge Road, London E10 7NE

Tel 081-539 0285 Fax 081-558 8110



ELECTRONIC CAMERAS EXPOSED

Point-and shoot still cameras now owe more to electronics than to optics. George Cole looks through the viewfinder at the high technology which fits in your pocket.

It is only relatively recently that electronic components have found their way into cameras, mainly because of the difficulties in putting components into such a small space. Many cameras now use LSI circuitry and flexible printed circuits to cram a host of features into a standard-size case.

Electronics was first used in photography many years ago, with the appearance of hand-held light meters. These early meters used selenium crystals, which produce a current when exposed to light, later models using cadmium sulphate, which worked better in low light conditions. Nowadays, most cameras have silicon or gallium arsenide photocells built into their bodies, with a Bi-cmos device to convert the light reading into an exposure value.

Electronic exposure meters also offer a variety of modes, from average metering which gives an overall image brightness level, to spot metering which only takes readings from a small part of the picture. A recent innovation is multi-pattern metering, in which the frame is split into a series of zones (typically six or eight); the camera's CPU analyses the brightness level in each of them to calculate the correct exposure.

Many single-lens reflex cameras offer program systems which use prepared software for greater flexibility. An aperture-priority mode lets the user select the aperture size and leaves the camera to set the correct shutter speed, while shutter priority works in the opposite way. With programmed exposure, the camera sets both aperture and shutter, while the photographer concentrates on framing the shot. In this system, the camera analyses the light level and uses algorithms held in the camera's CPU to determine the correct aperture and shutter speed settings; **Figure 1** shows how the system works. Here, an exposure value of 10 results in the camera selecting an aperture size of f4 and 1/60s shutter speed.

Some cameras also offer automatic flash metering, which uses a built-in photocell to measure the background bright-

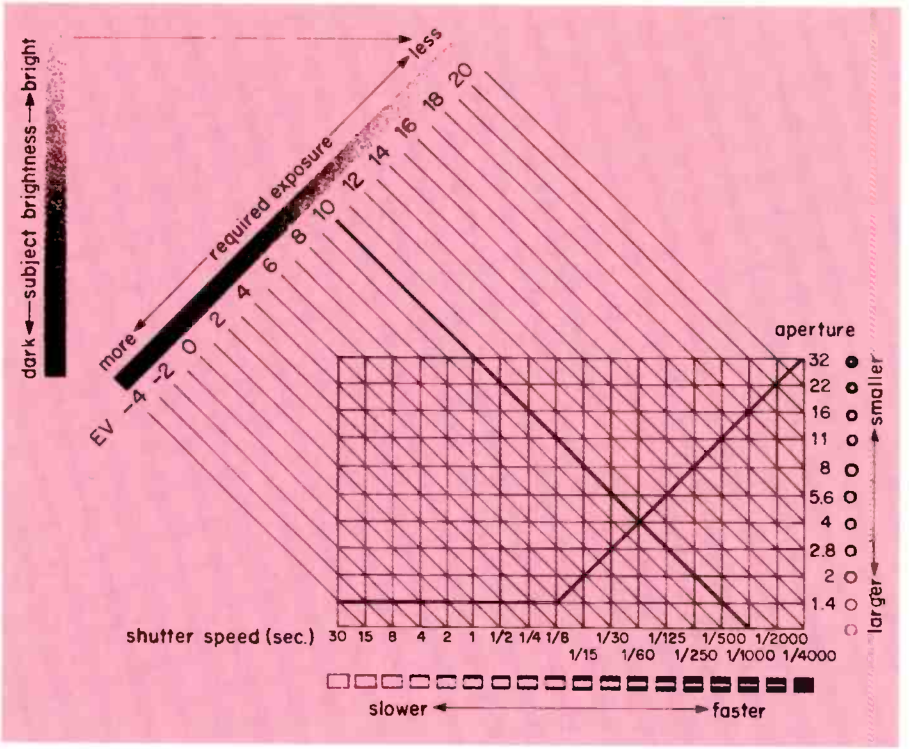


Fig 1, Operation of programmed exposure, in this case giving 1/60th at f4. The table and the associated algorithms are held in memory under CPU control within the camera.

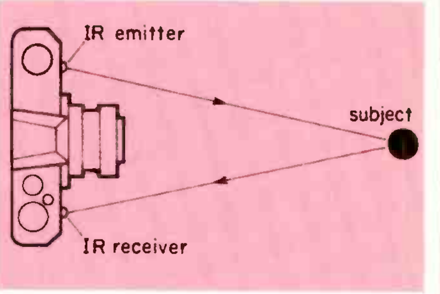


Fig. 2. Active infra-red autofocus transducer layout.

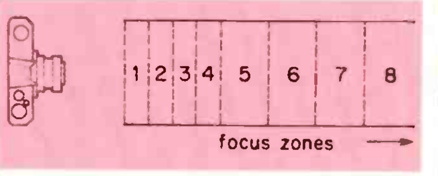


Fig. 3. Auto-focus recognises zones rather than precise placement.

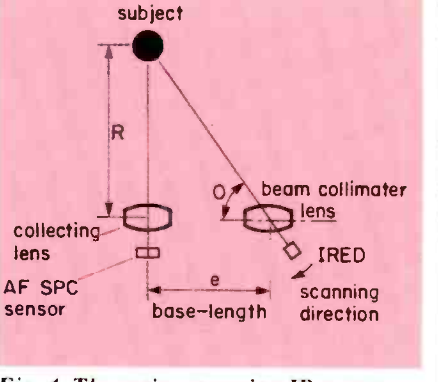


Fig. 4. The active scanning IR system used by Canon

ness and adjust the length of the flash burst to suit the exposure.

In 1983, Kodak announced DX coding, which automatically provides the camera with the film speed, number of exposures and type of film (slide or print). DX (Data exchange) works from a pattern of 12 silver (conducting) and black (non-conducting) squares on the side of the film cassette. When the film is placed inside the camera, the squares come into contact with a series of bridging pins which convey the data to the camera's interface IC. There is also a machine-readable bar code on the cassette and provision for two further codes on the film itself.

Several cameras have optional program or data backs which can be used in place of the normal camera back. Program backs are powered by small lithium batteries and many have a built-in timer which allows the camera to be programmed for unattended shooting. Most backs also offer a facility for recording the time and date on each frame. Canon markets a program back which can interface with a PC or cassette recorder for storage applications. Some backs even allow users to adjust the camera's program exposure system.

Minolta has developed a Creative Card Expansion system for its range of Dynax cameras. These are miniature rom cards which are slipped into a side compartment and allow the user to upgrade the camera's software menu. For example, there are cards for specialised photography (such as sports or portrait) and data cards for storing photographic information which can be displayed on the camera's LCD screen. The top of the range camera takes customised function cards which can be used to change some of the camera's basic operations, such as frame numbering and the exposure modes.

Automatic focus systems

In the absence of auto-focus (AF) systems, the user's eyes determine the subject sharpness and if the user has defective vision, the subject is moving quickly or light is dim, manual focussing can be difficult. Some of the cheaper compact cameras use a fixed-focus lens which is set to give an average focus throughout the picture, while other models offer preset focussing, which lets the user select several focussing distances. But these systems are inevitably a compromise and, for better results, AF systems are utilised. The challenge the camera companies faced was to develop systems which could detect when a subject was out of focus, calculate the focal error and then move the lens into the correct focal position.

There are two types of automatic focus: active and passive. Active systems are so-called because the camera uses a separate system for focussing, while the passive type makes use of the light received through the camera lens.

Polaroid developed one of the earliest active systems, in which a piezoelectric ceramic vibrator transmitted an ultrasonic beam which bounced off the subject. During transmission, the lens was moved slowly and then stopped when the camera sensed the reflected beam.

Modern cameras use infrared beams for improved accuracy. **Figure 2** shows the principles of a modern active focussing system; on one side of the camera viewfinder is an infrared transmitter and on the other an IR receiver. When the shutter is pressed, a beam is sent from the camera and reflected from the subject into the receiver, the time taken for the camera to detect the beam indicating the subject distance. However, IR systems do not focus on the subject specifically, but break the shooting distances up into focus zones, as in **Fig. 3**. The camera calculates which zone the subject is in and adjusts the lens accordingly. Some budget cameras offer only two focal zones, while other models may have up to 256. IR systems are accurate up to distances of around 12 metres and, if a subject is too far away for the beam to be reflected, the

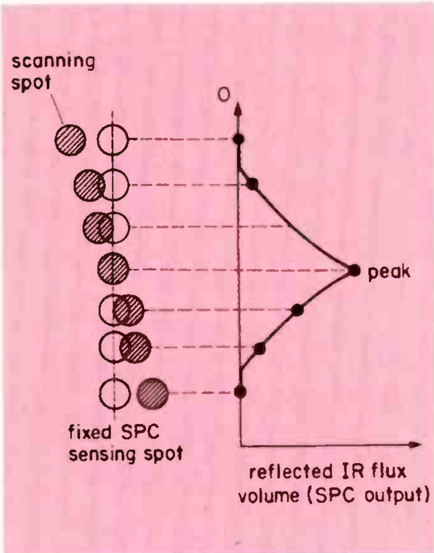


Fig. 5. When fixed and scanning spots coincide, focus is correct.

camera simply selects the last zone.

Figure 4 shows an active system by Canon, which uses a near IR beam at a wavelength of around 900nm. To reduce the effect of sunlight and fluorescent lights, the beam is pulsed at 10kHz and a visible light filter is used, the IR beam being detected by a silicon photocell (SPC). Transmitter and collimator lenses are movable and when the shutter is pressed lightly, both move to the near-distance position. When the shutter is fully activated the IR transmitter and lens begin to scan towards the infinity position. The beam hits the subject and is reflected back towards the SPC directly facing it, the SPC's output reaching a maximum when the reflected beam and sensor are exactly aligned as in **Fig.5**. When the subject is close, the IR energy is high and the timing of the peak is short, the opposite occurring when the subject is further away (see **Figs 6a** and **6b**).

Peak detection is made possible by a holding system which waits for 10ms to determine whether the peak is a true peak. If the SPC output begins to rise again during this period, then it is considered a false peak and the system continues to search for the true one. This reduces the possibility of false-peak errors which can be caused by electrical noise or subjects with a high reflectance; see **Figs 7a** and **b**. When the peak is detected, the camera and IR beam are stopped and the subject's distance is calculated from R = l tanq, where l is the viewfinder base length.

IR systems have the advantages of being fast acting and work in low light, but the beam covers a very narrow area and it is easy to mis-focus; for this reason, some cameras use a multi-beam system which transmits five IR beams. IR systems can also be fooled by objects with a low reflectance such as very dark objects and vapours and subjects behind glass.

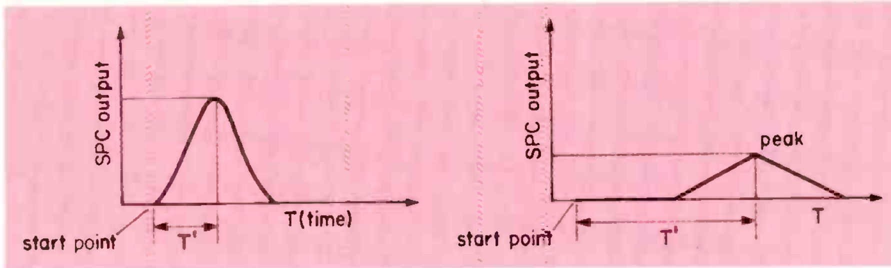


Fig. 6. Varying camera/subject distances produce different peaks in system of Fig. 5.

Phase detection system

For some time, camera companies tried producing accurate and fast-acting passive AF systems, but met with little success. A major problem was that 35mm cameras can use a variety of lenses of different focal lengths and manufacturers attempted to incorporate the AF ranging system and lens motor into the lens body. This made the lenses bulky and these early AF systems were slow and unreliable.

The breakthrough for 35mm SLR AF systems came in January, 1985, with the launch of the Minolta 7000. This incorporated nine ICs, including two 8-bit microcomputers — a control CPU and an AF CPU (see **Fig. 8**). The clock frequency was 4.19MHz.

The launch of AF SLRs meant that manufacturers had to market custom-made lenses in order for the camera's AF system to operate properly. These lenses incorporate a rom which holds details of the lens focal length and maximum aperture, electrical contacts linking the lens to the camera and passing the data on to the camera's main CPU.

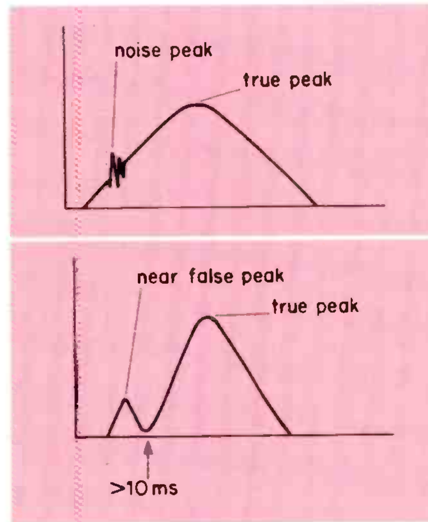
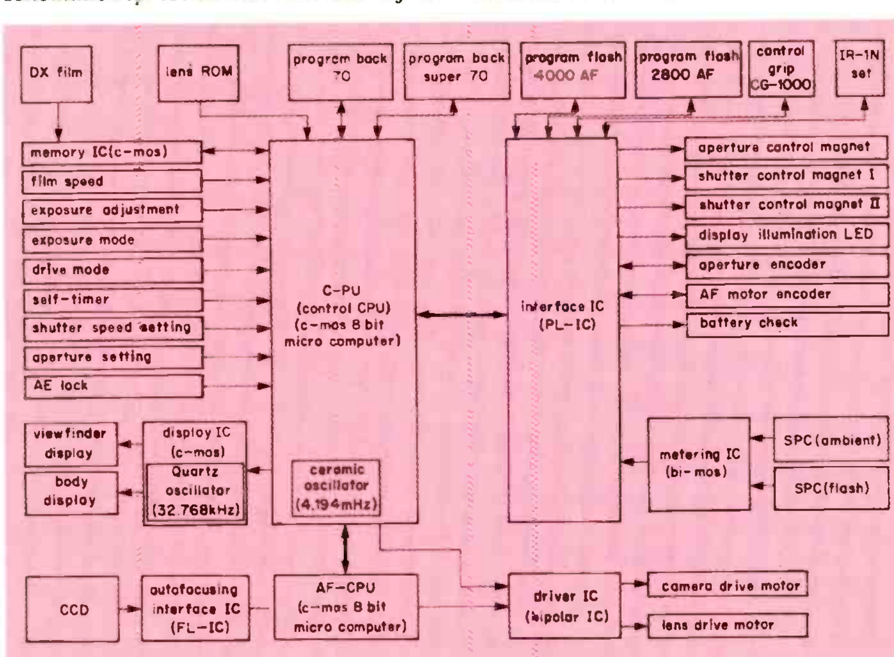


Fig. 7. A holding arrangement assesses whether peak is true or false.

Figure 9 shows the basic layout of the 7000's AF system: (1) is a rom IC which stores the lens information; (2) is the AF module which houses a 128-element CCD array; (3) is the AF CPU which uses data

Fig. 8. Exposure and autofocus functions often use independent processors. This schematic represents the electronics of the Minolta 7000 model.



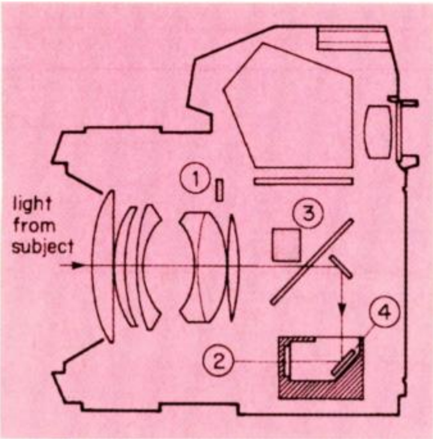


Fig. 9. Layout of Minolta 7000 AF system for different lenses.

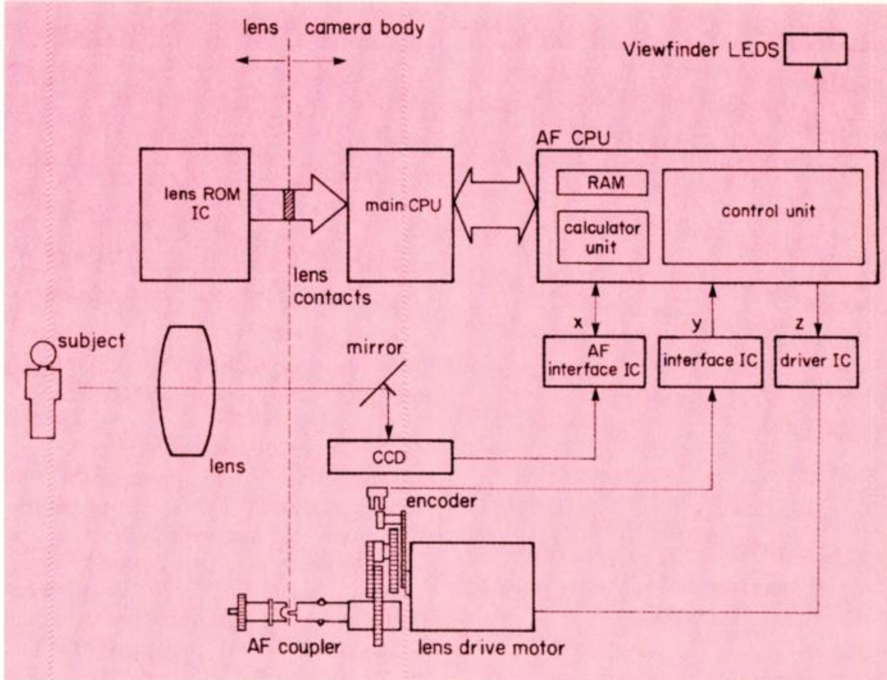


Fig. 10. Sophistication: operation of the Minolta 7000 uses a shaft encoder on the focus motor system.

from the CCD array and rom IC; and (4) is the focussing micromotor which moves the lens.

Figure 10 shows the 7000's system in more detail. Three ICs are involved: an AF sensor, AF interface IC and AF CPU. When the shutter is depressed, light from the subject passes through the semi-silvered central part of the main mirror, 60% passing to the viewfinder and the remaining 40% going to the AF sensor. **Figures 11** and **12** show that light entering the AF sensor is filtered and then split into two identical images which fall on to a horizontal CCD array to detect vertical contrast. The distance between the two images will depend on the subject's focus condition.

The camera uses a phase-detection system, shown in **Fig. 13**, to compare the CCD's output signal with a stored reference signal; if the subject is in focus, the two signals will be in phase. The AF CPU analyses the signals, looks for any phase differences and then calculates the focussing error. The AF CPU receives information about the lens from the main CPU and uses it calculate the lens adjustment, determining both the speed and number of rotations of a four-speed lens motor. For example, if the lens is set to near distance and the subject is at infinity, then the motor initially moves very quickly and then slows down as it approaches the correct focussing distance (see **Fig. 14**). Before the motor is activated, the AF CPU breaks each motor rotation down into a set of 18 pulses. The required number of pulses is then stored as a reference.

As the motor rotates, the second gear moves an encoder which passes through a photo interruptor to produce a series of pulses. When the number of motor pulses equals the number of stored reference pulses, the subject is in focus and the motor is stopped.

Passive systems generally work well and, in low light, many cameras can use leds to illuminate the subject and thus allow focussing in total darkness. But some conditions can cause problems. Because the system relies on vertical contrast, subjects with little or no contrast (such as a white wall) can confuse the AF system and cause the lens to hunt back and forth. Other difficult areas include very dark subjects, objects with many horizontal lines (such as window blinds) and subjects with complex patterns.

AF systems have been refined since the launch of the Minolta 7000. For example, cameras now have improved CCD arrays with more elements (typically 200) and larger focus areas. Some have several arrays which are aligned horizontally and vertically to detect either type of contrast. Minolta's latest AF system takes 60 readings per second to determine the subject's speed and direction and is thus able to cope with fast-moving objects.

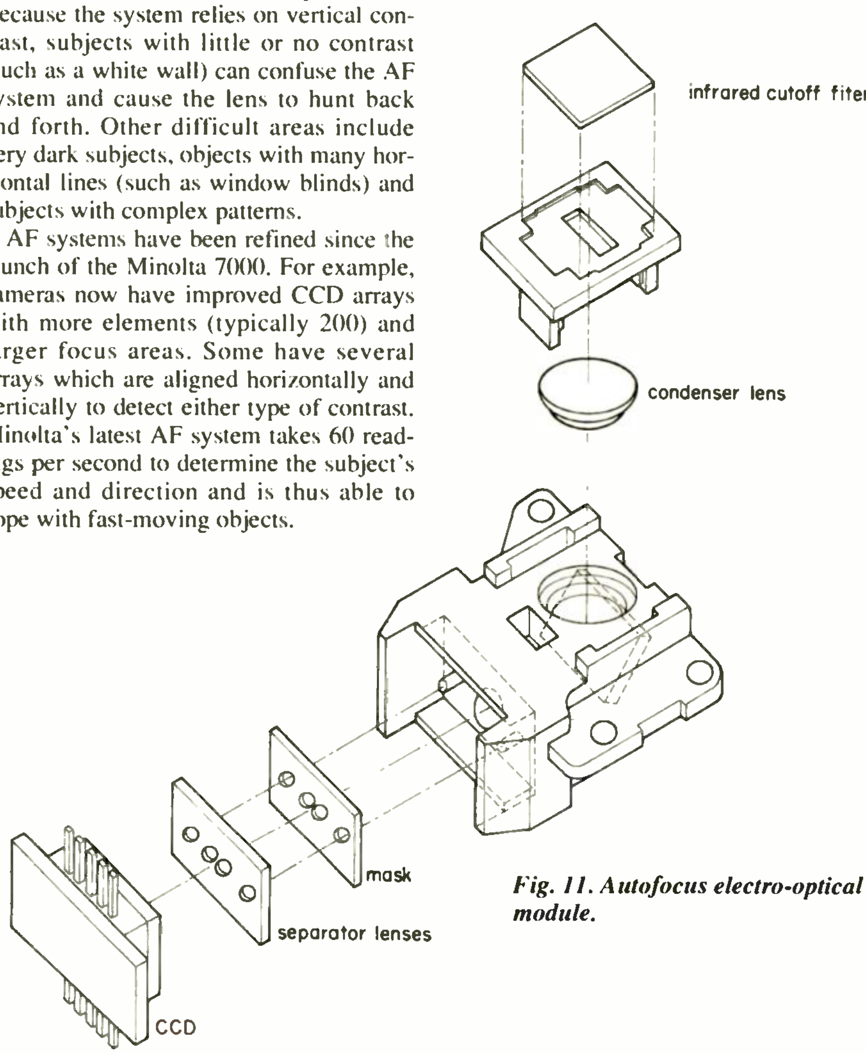


Fig. 11. Autofocus electro-optical module.

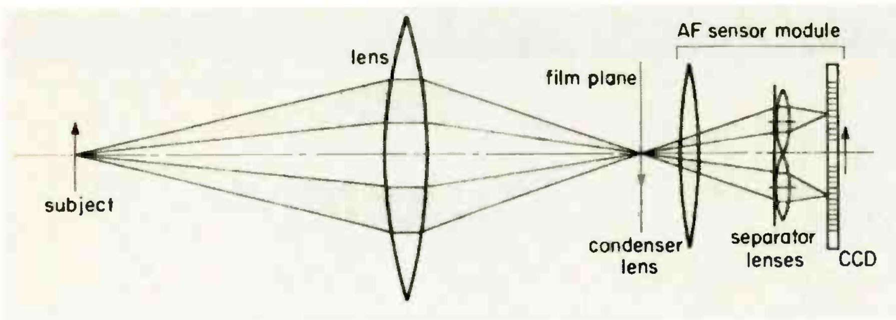


Fig. 12. Out-of-focus displacement is detected by a split beam falling on a CCD pair.

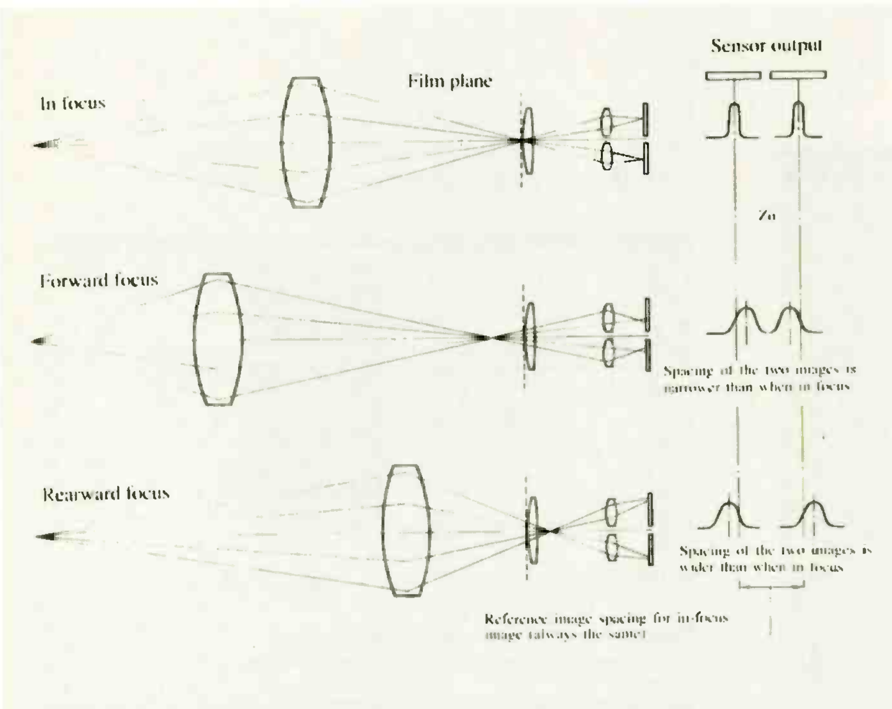


Fig. 13. Phase detection autofocus system. The focus plane appears as a phase displacement between the output from a pair of CCDs. Measurement of relative phase equates directly to focal position.

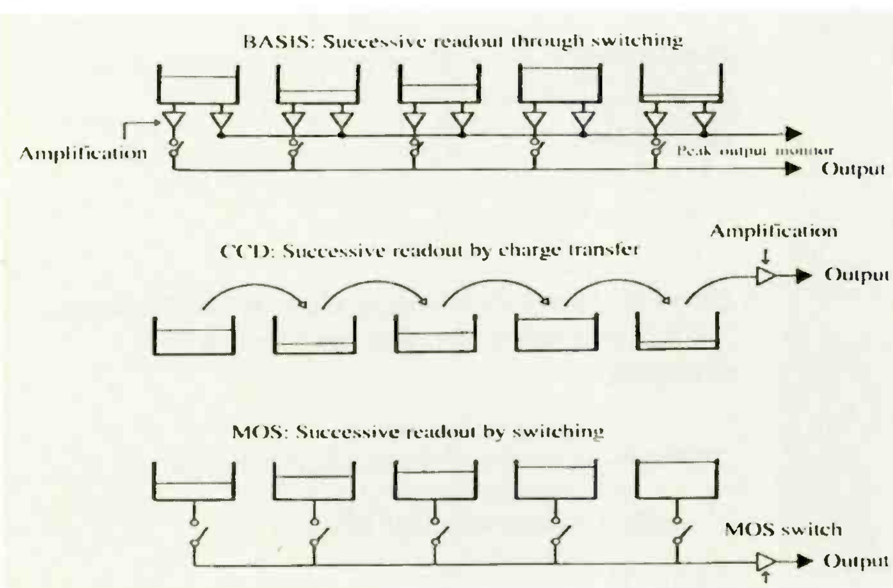


Fig. 14. Canon's Basis, which uses one amplifier per element to produce less noise and greater amplification.

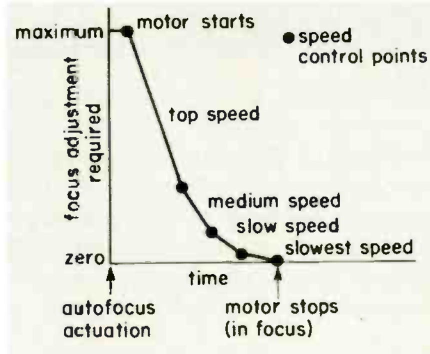


Fig. 14. Focus motor slows as the focal point approaches.

Canon has produced a new type of AF lens which incorporates a lightweight, ultrasonic motor and has also developed Basis (base-stored image sensor) which is claimed to offer improvements over conventional CCD arrays; **Fig.14** shows the differences between the two sensors. In a CCD array, the charge is transferred along each element and then to an amplifier, which also amplifies any noise that may have been produced during the transfer stage. But in a Basis array, each element has its own output amplifier to reduce noise and increase focussing accuracy at low light levels. There is also cross-ranging Basis, which uses both vertical and horizontal sensors, and Multi-Basis with a total of eight vertical and horizontal sensors.

The pace of development in electronic camera systems shows no sign of slackening. Some companies are developing "fuzzy logic" focus systems which are claimed to work more like the human eye and brain and work is progressing in the field of electronic shutters and apertures, which will result in cameras with virtually no moving parts. ■

Reference

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Acknowledgements

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TAPE LEADER?

Philips's digital compact cassette uses stationary heads, is backward-compatible with the analogue cassette and has backing from the music industry. Report from George Cole

At the end of December, 1990, Philips gave European journalists the first demonstrations of their new audio tape format, Digital Compact Cassette. DCC is the digital version of the familiar compact cassette and both formats have the same size cassettes, same recording times, same tape speed (4.75 cm/s) and same tape width (3.81mm).

News of DCC has started a format war with the Japanese-backed Digital Audio Tape (dat) system, launched in Europe last autumn, which uses a rotary head to record a series of diagonal tracks across slow-moving tape; DCC is a stationary-head system which records 16 parallel audio tracks along the tape.

Stationary-head digital tape recording is not a new idea: ten years ago, JVC demonstrated a system which put PCM digital sound on a conventional cassette. The JVC format used metal tape which ran at 1.5 times normal tape speed and a multi-track head recorded eight audio tracks along the tape. But the faster tape speed meant a shorter playing time and the frequency response was limited to around 15kHz. JVC never launched the system.

In 1983, the dat conference was set up to develop a world standard consumer digital tape system. Two working groups were given the brief to devise specifications for a stationary-head (S-dat) and rotary-head (R-dat) system. S-dat used a multi-track head to record 22 tracks across the tape (20 audio, plus auxiliary and sub-code tracks). Each audio track was 70µm wide, tape speed was 4.75cm/s and the bit rate was 2.4Mbit/s. Normal playing time was 90 minutes, although there was an optional half-speed mode which doubled this at the expense of lower sound quality.

When the S-dat group reported back in July 1985, it noted that there were problems with the format: the multi-track heads were made by expensive thin-film technology and the narrow tracks were sensitive to azimuth error. S-dat was abandoned in favour of R-dat. With R-dat already on the market and with the past problems of stationary-head digital formats, it seems odd that Philips should introduce DCC, but the company makes a

Table 1. Format Comparison

Format	Compact cassette	S-dat	R-dat	DCC
Minimum λ (µm)	2.5	0.65	0.65	1
Track width (µm)	600	070	13.6	180
Audio heads	2	2 x 20	2	2 x 8
Data rate	-	1.54 Mbit/s	1.54 Mbit/s	384 kbit/s

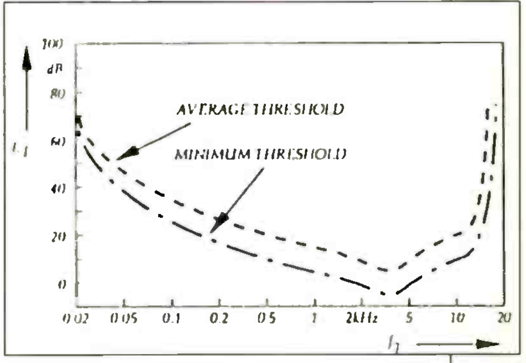


Fig. 1. Threshold of hearing, which varies from person to person.

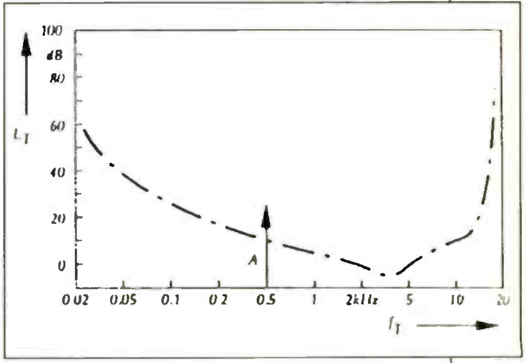


Fig. 2. Sound A exceeds the threshold and is therefore audible.

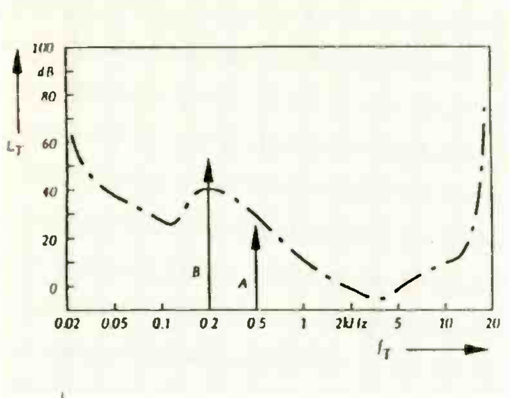


Fig. 3. Introducing sound B distorts the threshold and masks the previously audible A.

strong case for the new format. Philips says that dat is an expensive format, which uses a complex tape-drive mechanism and metal tape. What is more, dat is incompatible with existing compact cassettes and has little software support. But DCC uses a simpler tape mechanism, is backward-compatible with analogue audio tapes and has good support from the music industry.

Philips stresses that the only similarity between S-dat and DCC is that both formats use a fixed, multi-track head. Whereas dat uses high-density recording, DCC is a low-density recording format. S-dat's audio data rate was 1.54Mbit/s, whereas DCC's is 384kbit/s (see **Table 1**). This is made possible by a coding system known as precision adaptive sub-band coding (pasc) which is four times more efficient than the PCM coding used by the compact disc.

DCC coding system

Figures 1 to 3 show the principle behind pasc. The human ear has a threshold of hearing; only sounds above the threshold can be heard. **Figure 1** shows that the threshold level L_T varies amongst people and that the ear is most sensitive to frequencies of around 3kHz.

Audible sounds can be pushed below the threshold by louder sounds. In **Fig. 2**, soft sound A is audible, but when the loud sound B is introduced **(Fig. 3)**, A is no longer audible; it has been masked by B. Philips likes to use the analogy that a whisper can be heard in a quiet room, but not in a noisy high street.

At Eindhoven, journalists were given a practical demonstration of this: twelve test tones were generated and the journalists were asked to count them. The tones were generated again, but this time accompanied by broad-band noise. Now, only 5 or 6 tones could be heard. The test was repeated with noise bandwidths of 1000Hz, 250Hz and 10Hz and in all cases some masking occurred.

A pasc processor uses algorithms based on the ear's aural characteristics to code only those sounds which are above the hearing threshold; sounds that cannot be heard are not coded and so less bits are needed for recording. The system works by splitting the audio band up into 32 sub-bands and using real-time processing to calculate each sub-band's threshold level. Pasc is dynamic, which means that the number of bits allocated to each sub-band is constantly changing as its sound threshold level shifts. The system uses an average four bits per sample and DCC's bit rate is 768kbit/s.

Figure 4 is a basic diagram of the DCC system. The sound is first filtered into the 32 bands and then undergoes sub-band encoding. Sub-bands are then multiplexed into eight data channels and error-correction bits added. DCC uses a Reed-Solomon error-correction system which can correct burst errors of up to 2cm in diameter and repair damage that extends to 1.5 tracks. An auxiliary track containing sub-code and control bits makes up the ninth channel. After undergoing 8-10 modulation, the data is ready for recording on tape.

DCC recording head

DCC uses a multi-track head which is made by thin-film technology. The solid-state head is combined with a ferrite head, used for analogue playback. Although all DCC decks can play analogue tapes, most machines will not offer analogue recording; Philips has made this an optional feature because of the difficulties involved. Analogue recording requires a specially made recording head, an additional erase head and other circuitry and Philips thinks it would probably be easier to market a double tape deck: one for digital recording and playback and the other for analogue.

Figure 5 shows the DCC track layout, in which the tape is divided into two sectors, each having nine tracks (eight audio plus auxiliary track). Track width is 185µm and there is a 10µm gap between each track; the width needed for playback is only 70µm and, while this decreases the signal-to-noise ratio, it makes the system tolerant to mis-tracking or azimuth error.

DCC is an auto-reverse system and at the end of a sector, the tape head swivels around to read the second sector. Some decks may use two heads fused together to eliminate the short gap that occurs as the head switches sectors.

The auxiliary track has a data rate of 12kbit/s and carries control bits and subcodes which can be used for track location. All decks will record an inaudible start flag to allow for track search programming. There is an optional append function which puts a flag at the end of the last recording so that users can find spare recording space quickly. DCC has a large amount of extra subcode capacity and some of this may be used for a text display system that shows details of the recording on a deck display panel or TV set.

DCC tape and cassette

DCC's shortest recording wavelength is around 0.99µm, which means that it is possible to use low-coercivity tape. The format uses chrome tape, similar to that

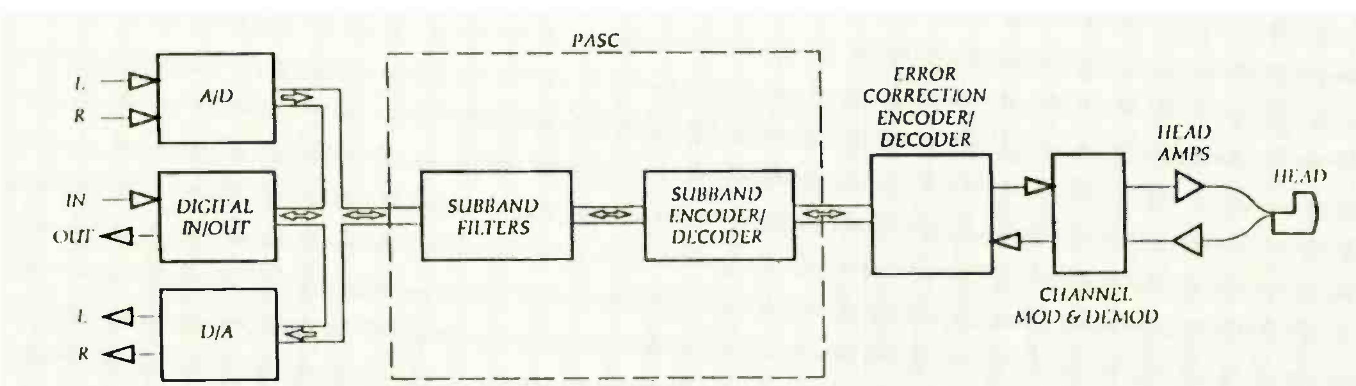
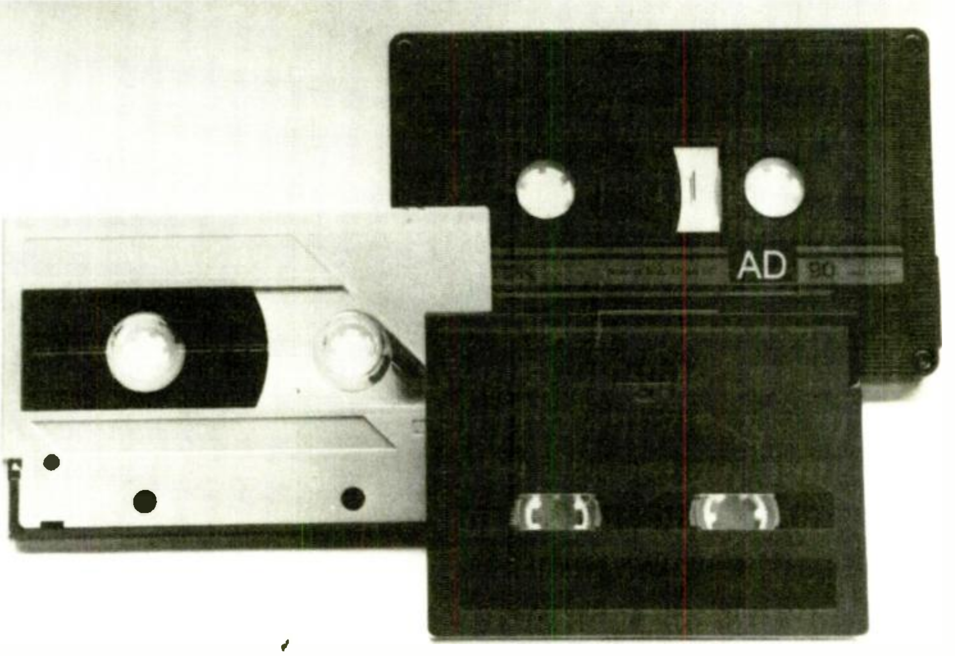


Fig. 4. Block diagram of precision adaptive sub-band coding (pasc).

used by the video industry, with a coercivity of around 700oersted. The tape leader must be at least 36cm long so that it can be used on future machines which will have more powerful motors to give faster tape search times. Philips claims that using chrome tape overcomes the problems faced by dat which uses metal powder tape. Philips claims that MP tape is sensitive to temperatures above 45°C, which limits dat's usefulness in car equipment — the inside of a car can reach over 100°C on a hot, sunny day. Also, metal tape is difficult to duplicate, which makes dat software expensive to produce.

A DCC cassette has the same external dimensions as a conventional compact cassette but is styled differently. The DCC type is flatter and has a metal slider to protect the tape and holes for the tape drive spindles and head. The front is entirely closed. Blank cassettes will have a record-protect slider and a tape length identification hole.



Cassette comparison. At the front is an R-dat cassette; left is an S-dat type and at the rear is the ordinary analogue cassette, which is same size as DCC type.

DCC format

All DCC decks will be able to handle three digital sampling rates: 32kHz (as used in digital broadcasts), 44.1kHz (compact disc) and 48 kHz (dat). DCC software and recordings made from analogue sources such as LP records will use a 44.1kHz sampling rate. DCC tapes (known as D30, D60, and so on) will have a maximum playback time of 90 minutes for both sectors, although provision is made for two-hour tapes. There is no long-play facility. Philips argues that this ensures that all DCC decks will play any DCC recording. The format also uses the Serial Copy Management System (SCMS) which prevents users from making digital copies of DCC recordings.

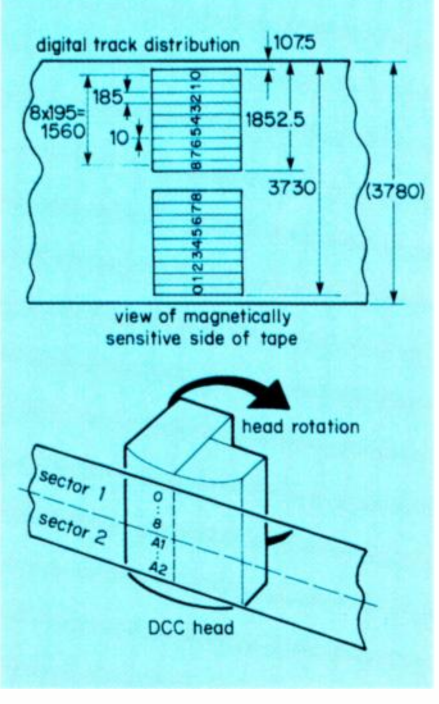


Fig. 5. Digital compact cassette track layout; each half has eight audio tracks and a control track. Auto-reverse is obtained by swivelling the head assembly to read the other half.

Although DCC decks can play analogue cassettes, ordinary tape decks will not be able to play DCC recordings, nor use DCC blank tapes.

DCC sound quality

Philips says that, when it conducted hearing tests on the first pasc-encoded material, it was shocked by the high sound quality. Tests conducted with members of the public showed that people could not tell the difference between the pasc material and CD sound.

It was only specialists at Polygram's sound laboratories who could detect any subtle differences.

In further tests, members of the public were trained to spot these differences but, even after training, 60% of them could still not differentiate between the two sources. Since then, the system has been refined even further and Philips confidently states that it is almost impossible to hear any differences. I certainly couldn't detect any, when I tried the tests at Eindhoven.

DCC marketing

At the Las Vegas CES show in January, Philips gave the first public DCC demonstration and plans to launch DCC in Europe and Japan early next year. The format is already backed by Polygram, WEA, BMG, EMI and RCA. Hardware supporters include Tandy and the Japanese company Matsushita (Panasonic/Technics) and more Japanese companies are expected to follow suit. DCC decks will cost around £350-400, with blank tapes around £5. ■

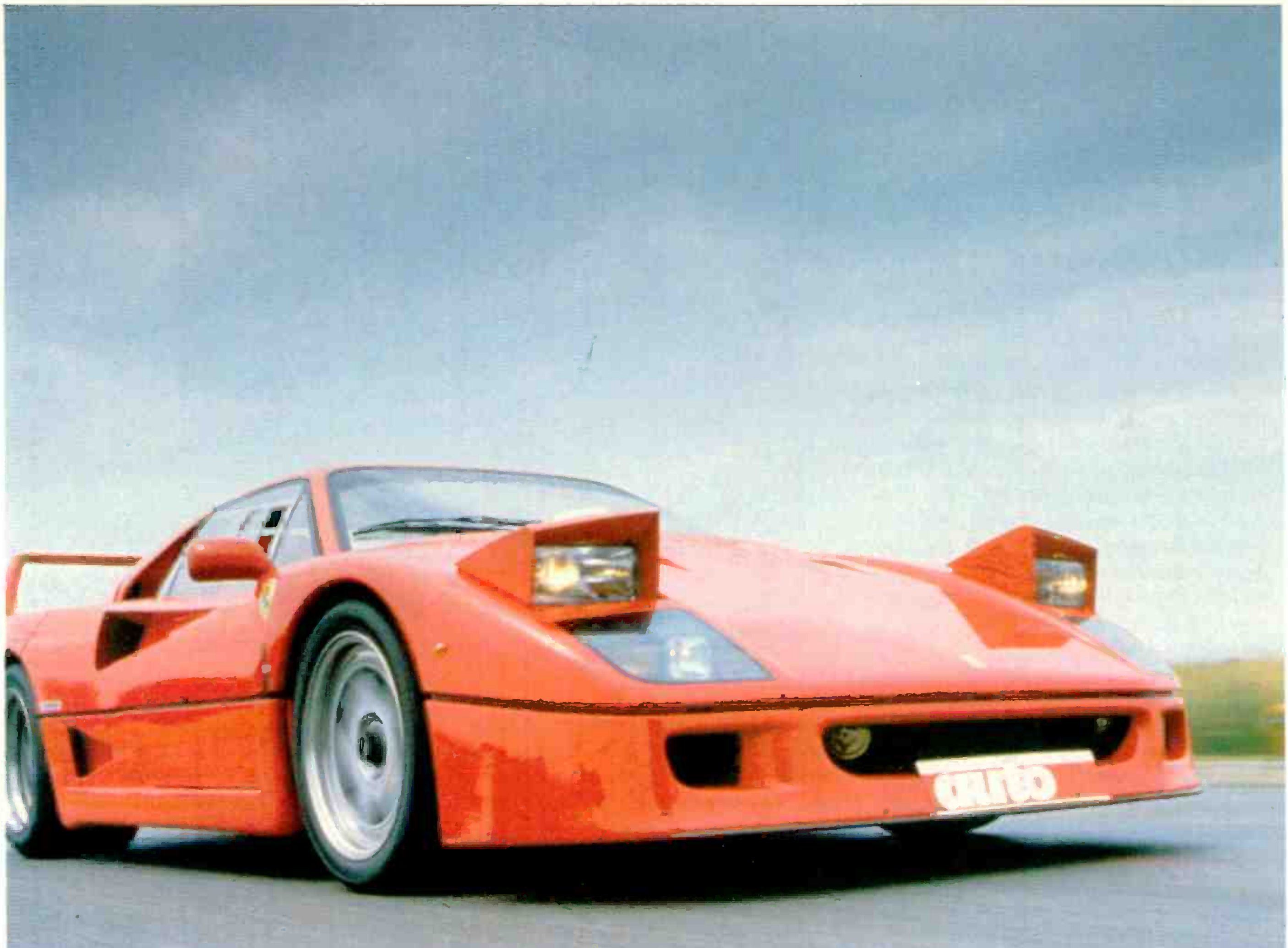
BOOK REVIEW

Foundations of Mathematics and Physics. Eds U. Bartocci and J.P. Wesley. This interesting collection of twenty-six papers, the proceedings of a conference held in Perugia in 1989, reveals that there is now in science a scale of difference of viewpoint that ranges from the downright orthodox to that which the conventionalist would consider heresy.

It is not a book for the faint-hearted, because it is left to the reader to formulate an answer to fundamental questions and, in consequence, decide for himself whether science is on the right track. Do the theorists in their desire for consequential consistency invent concepts to that end and expect Nature to conform to their ideas? Do the experimentalists chase ephemera in an attempt to confirm the notions of the theorists? Alternatively, is there some undiscovered facet of Nature which transcends the laws of thermodynamics?

These papers deal with theory, experiment and philosophy and the collection contains a wealth of references.

Benjamin Wesley (Blumberg, Germany). 383 pages. $(US)42.



AUTOMOTIVE AUTOMATION

Can car makers successfully adopt "useful" electronic systems (as opposed to gimmickry) in an integrated way? Tom Woodford checks out the technology nestling under the bonnet

Modern cars still contain a surprisingly low amount of useful electronics. With few exceptions, recent technology has been forced upon the car manufacturers, either by legislators or by market pressure from competitors. Most recently, the environmentalist lobby has added further input and confusion.

In a conventional car, electronic applications fall into several broad categories, to do with engine and fuel management, vehicle management and "driveablility", safety, servicing and reliability, entertainment, information and navigation and convenience; then there are the gimmicks and toys. There is substantial common ground between all of these groups, but current vehicles show very little integration between systems. To date, only one car (BMW 7 series) makes any attempt to treat the vehicle as a whole.

Cost and the hostile environment are two of the major reasons for the slow adoption of electronics in cars. A thermal indicator flasher costs a few pence, the electronic equivalent using a timing circuit and relay being significantly more. Unless some legislator imposes stringent frequency and mark/space ratio requirements which cannot be achieved by a bimetallic strip, why change?

A car is a most unfriendly place for electronic systems: apart from problems caused by vibration and the presence of moisture, oils and fuel, the available supply is not entirely up to laboratory standard. The nominal 13.8V "rail" will fall to 3V while starting a cold engine with thick oil in winter and many of the loads such as motors and solenoids cause load dump surges of ±250V for several microseconds; 100V for milliseconds is commonplace. Under-bonnet temperatures can rise above 160°C and fall as low as outside ambient which, in some places, could be -50°C. In winter, everything is sprayed with salt solution; in summer with dust. The worst problem is that the extremes all have a tendency to happen together and usually when you want to start the engine.

An obvious solution, for the control systems, is to mount the "black box" in the passenger compartment, where the environment will not be much worse than a human can tolerate. Even so, a pretty sophisticated housing is required to isolate vibration and moisture.

The key to any sophisticated control system is sensors and, for an engine management system, one or two of those need to be located near or on the engine. Cheaper, simpler and more reliable sensors are in continuous demand.

Connecting a bulky multicore cable to a control unit outside the engine bay necessitates a hole through the fireproof and soundproof intervening bulkhead. The problems of sealing and protecting the cable are therefore not trivial.

Until recently, most car manufacturers relied on their component suppliers for electronic sub-systems like electronic ignition and fuel injection. Bosch and Lucas were the dominant European independents, with appearances from Japanese suppliers, like Mikuni, with simpler offerings. These suppliers prefer to offer "turnkey" systems — an approach in which the expert component supplier can keep his knowledge to himself. For this reason, several car manufacturers have now started their own in-house development and production facilities for electronic systems. Ford were the first, with Rover, SAAB and VAG (Volkswagen/Audi) following on more recently.

Ignition control. The IC engine relies on a discontinuous process with practically everything in the system stopping and starting. So control requires a system capable of understanding discontinuities.

After ignition, the explosion in the chamber takes some finite time to get going. As the engine goes faster, the spark should strike sooner—before the piston reaches the top of the compression stroke —so that the bonfire is well and truly lit before the piston starts going down again.

In a conventional Kettering ignition system, the spark is produced by a contact-breaker and coil. A centrifugal weight rotates the contact-breaker within its housing to achieve speed-related ignition advance. With quite simple convolute pivot arrangements, relatively complicated speed/advance relationships can be generated. Unfortunately, the contact-breaker wears out and, as engines have developed, the need to use bigger sparks has necessitated a higher primary-coil current with increased pitting on breaker contacts. The contacts also have to remain closed for long enough to establish this current in the coil (the dwell angle) and the mechanical constraints of the system place an upper limit on possible spark energy. Most significantly, the mechanical system is limited in accuracy and wear is not predictable.

Optimum timing requirements for various spot-measured speeds and loads are plotted as a "map" or three-dimensional surface, which is then loaded into a prom used by the system as a look-up table against measured inputs to provide timing output

Initial electronic systems were developed to "help" the contacts, using them to switch the base current of a power transistor handling the coil current. Next was the replacement of the contacts completely and numerous systems appeared, although many suffered from practical problems. Only when fully integrated EM systems were developed did any further changes of significance occur on the ignition front. Then digital systems appeared.

BMW was the pioneer, with the "ETA" advanced-technology engine fitted to the 525e. Optimum timing requirements for various spot-measured speeds and loads are plotted as a "map" or as a three-dimensional surface, which is then loaded into a prom used by the system as a look-up table against measured inputs to provide the timing output. The processor interpolates for operating conditions between the stored points.

The disadvantage of this approach is that it can only be based on an empirical evaluation of one sample engine (or, at most a handful). Production differences will ensure that no engine will be controlled perfectly. Without prohibitive cost penalties, the number of stored points must be limited, since the time for access and that for subsequent calculations are limited by the processor.

What is needed is closed-loop control, but that is a long, long way away yet.

Fuel control and injection. Early fuel-injection systems were purely mechanical. Mercedes made a marketing point of its Kugelfischer system, which offered some 20% power output improvement. Similarly, the Triumph 2.5PI (for petrol injection) used Lucas/Tecalemit mechanical equipment to great advantage. These simple systems were surprisingly effective and it took a lot of electronic control to emulate them.

The advantage of fuel injection (in a petrol engine) is two-fold. A carburettor, however complex, has a very narrow operating dynamic range as an efficient device to vapourise petrol and mix it thoroughly with incoming air. To operate at all, the carburettor must introduce a restriction to the engine's airflow. Being a continuous-flow device, it also cannot adjust immediately to transient demand changes. Fuel injected directly into the turbulent airflow at the entry to each cylinder is more thoroughly mixed and each "dose" of fuel accurately metered to give a precise fuel/air ratio. Electronic control can, in theory, monitor the operating conditions of the engine and change the fuelling on a shot-by-shot, cylinder-by-cylinder basis.

It used to be believed that the moment of injection had to be timed accurately, like ignition. But to a degree, fuel can be injected any time, and will hang around the inlet manifold until needed. This has

The key to any sophisticated control system is sensors and, for an engine management system, one or two of those need to be located near or on the engine. Cheaper, simpler and more reliable sensors are in continuous demand

led to simpler and cheaper single-point injection or "throttle-body" systems, which are little different from an electronically-controlled carburettor. But resulting loop-delays in the overall system do not allow sufficiently accurate control, and new EC regulations make multi-point injection mandatory.

Fuel metering. The problem of fuel metering is measuring the *mass* of incoming air, since it is a mass ratio, not volume, that needs to be controlled. For liquid fuel, mass is directly related to volume, so metering by a timed "squirt" from each injector is adequate. Fuel temperature could be measured to determine specific gravity, but in practice it is easier to rely on the high-pressure pump and ambient engine temperature to deliver the petrol within a narrow temperature range.

Determining the incoming air mass is not so simple. Direct measurement of air-mass flow is possible using a hot-wire sensor, since the rate of heat loss is directly proportional to the number of air molecules passing in a given time. Corona-discharge displacement techniques could also be used, but these do not work well in fog. Alternatively the system can measure the volumetric flow rate, using a sprung flap and potentiometer, and simultaneously measure the air's temperature and absolute pressure.

Typically, IC silicon strain-gauge pressure sensors are mounted on the "black box" PCB and fed via a small flexible pipe. A processor furnished with Boyle's law and Avogadro's number can work out the mass all by itself. Fuelling requirements are obviously also load, demand and speed dependent, and thus a mapped look-up control is a sensible approach.

Closed-loop control can be added. Using an oxygen sensor in the exhaust pipe allows the system to tune the fuel/air mix to operate the engine at its optimum (stoichiometric) point. ...Reaction to sudden driver demand has to over-ride longer term optimisation routines

Engine behaviour during warm-up from cold requires extra fuel—a richer mixture—and this is usually handled by an additional injector to deliver extra fuel for cold starting. Under tighter future emission regulations, this will not be adequate and a separate sub-program is needed to manage the warm-up phase. Closed-loop control can be added. Using an oxygen sensor in the exhaust pipe allows the system to tune the fuel/air mix to operate the engine at its optimum (stoichiometric) point. Such control is limited, since the sensor response and its distance from the controlled system impose large loop delays. Reaction to sudden driver demand (foot to the floor) has to over-ride longer-term optimisation routines.

Later systems allow better control by eliminating the driver's direct input. The throttle pedal operates only a potentiometer or other position sensor and the management system controls the throttles via a servomotor. This sounds like introducing a "big brother" element, but allows greater pollution control while not limiting apparent performance.

The system has to be much smarter to include some discontinuities. For example, with a cold engine which "fluffs" or slows under increased load the correct response is to close the throttle slightly so that the bonfire doesn't blow out, the opposite of warm-engine behaviour. Allowing the control system to operate the throttle allows accurate control of idling speed; a petrol engine produces its most noxious pollution when at idle, so this allows a significant improvement in overall emission control.

Mixture control. The resistance of European manufacturers to the panic introduction of catalysts for emission control was based on the continuing development of the "lean-burn" engine. This technology uses highly efficient engine breathing design to achieve more complete fuel combustion which, in turn, permits the use of much leaner fuel/air ratios, reducing overall pollution and improving economy.

With excessively weak mixtures, "knock" becomes a significant hazard. Knock is actually detonation of the fuel instead of a controlled, steady burn. For a given set of conditions, it can be stopped by retarding the ignition timing. Closed-loop systems use a knock sensor in the cylinder-head which is mechanically tuned to the knock-identifying frequencies. Usually piezoelectric, the sensor allows the ignition controller to retard the timing until knock ceases.

Integrated systems. Combining the fuel and ignition controller allows greater flexibility in system management design, but with greater complexity. Recent systems have eliminated the last remnant of traditional ignition systems, the distributor. Using either a mini coil on each cylinder or coils shared between two cylinders firing on both the power and exhaust stroke, this technique was used on the Citroen 2CV since its introduction and on Japanese motor-cycles for several years. Reducing the length of the high-tension leads in this way has the added benefit of reducing electrical noise pollution.

Catalysts impose considerable constraints on the fuel control system; misfiring, due to over-weak mixture or mistimed ignition, will destroy the catalyst very quickly

More accurate timing is obtained using a toothed wheel (often the starter ring gear) with an inductive or variable-reluctance sensor to provide 1° or 5° markers. The half-engine-speed indication, needed to show which stroke a cylinder is on, is obtained from a similar sensor on a camshaft.

All the sensor inputs are used by the central processor to optimise and control the total engine as an entity. Facilities to control exhaust recirculation and secondary air bleeds can be incorporated in the standard unit, with the hardware only added for markets which require it. Most commercial units are fully redundant, in the best avionics tradition.

Further constraints. It now seems that three-way platinum exhaust catalysts will become the European emission control standard. These catalysts impose considerable constraints on the fuel control system; misfiring, due to over-weak mixture or mistimed ignition, will destroy the catalyst very quickly.

The significant pollutant outputs from an engine are carbon dioxide, carbon monoxide, nitrous oxides, unburnt hydrocarbons and heavy metals, mostly lead. The last can be eliminated by removing the lead-based additives from the fuel used to inhibit "knock". Unfortunately, these additives also provide some of the lubrication for the upper engine, but that is not an electronically soluble problem. Nevertheless, current EM systems greatly reduce the major pollutant outputs.

A large aftermarket has sprung up to

supply re-mapped "chips" for engine management computers, offering enhanced performance but inferior pollution. With turbocharged engines, power and torque gains of 50% are possible and such modifications are undetectable. Since they are frequently offered by the original dealer to close a sale, there is no effect on the warranty either. .

Forthcoming CARB (California Air Resources Board) regulations will require that cars are fitted with monitoring systems to ensure that pollution control remains effective for the life of the vehicle. These systems will have to monitor catalyst efficiency, misfiring, primary and secondary air systems, fuel system, oxygen sensor efficiency, exhaust-gas recirculation flow rates and even CFC leakage from the air conditioning. Any component deemed to affect the vehicle's pollution achievement must also be monitored. Where the passengers will sit in amongst all this new equipment is not made clear. It doesn't sound cheap, either.

Meanwhile, manufacturers are making tentative, unforced steps towards treating the vehicle as a whole, by partially integrating all the systems to provide further features at minimal cost. For example, my car has at least three separate ambient air-temperature sensors to give inputs to the fuel-injection system, the air conditioning and the trip computer; I feel sure they could all share just the one.

Current Vauxhall/Opel Senators link the engine and automatic gearbox to retard the ignition momentarily to smooth up-shifts by reducing torque output. Rover's electronically controlled auto box disengages first gear when the brakes are applied with the car stationary to reduce "creep". It also inhibits the torque-converter lock-up clutch when the engine is cold to improve flexibility. These features apart, it appears to gain few other benefits from electronic control.

Future developments. Experimental systems already exist using directly actuated valves controlled by appropriate electronics. This potentially offers total engine control, with variable valve overlap providing a huge power and torque band. This is claimed to eliminate the need for a gearbox, since the engine could provide useful torque at zero speed. The only significant problem is that, if the system fails, the engine is usually totally destroyed. ■

In a future issue Tom Woodford will report on other areas of autoelectronic development, where technology is blurring the distinction between whether we are driving the car or whether the car is driving us!

BITSTREAM CONVERSION

The bitstream bandwagon has done for CD what CD did for the turntable. Much cheaper to produce than standard parallel ladder A-to-D converter chips, the machines which contain them sell at higher prices. Why? Stan Curtis explains.

Two systems initially dominated the market: Philip's PDM system and the Technics version of the MASH system. More recently Sony have introduced their PLM system, which in some respects can be considered to be a second generation MASH system. Yamaha is about to launch its own system in the very near future.

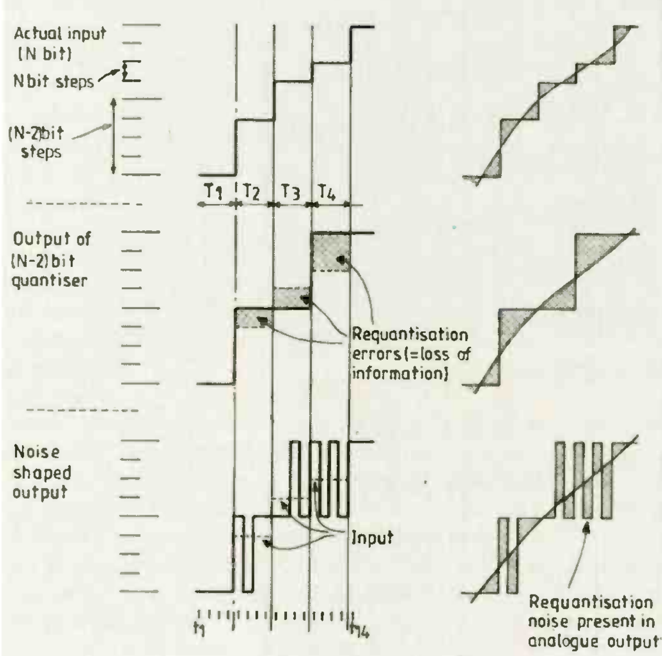
These systems have been developed to overcome the need for expensive and difficult to manufacture 16-bit dacs. For example a 16-bit dac has to generate an MSB current that is accurate to one part in 65,536 and maintain this resolution over a wide temperature range and lifetime. Glitch noise can also arise at the transition of the MSB.

Bitstream dacs replace closely matched current sources and resistors with a system the output of which is primarily dependent on the movement of signal level from the previously sampled value. In other words, delta modulation.

To convert from a 16-bit code to, say, a 2-bit code appears simple enough; all that is needed is a quantiser which allocates the incoming code to the nearest of the four possible output levels. The problem is that now the signal is represented not by one of 65,536 levels but by just four: the reconstruction of, say, a sinewave would be extremely coarse and the resulting waveform grossly distorted.

The errors resulting from the transition from many steps to few are termed quantisation errors and manifest themselves as noise in the output signal. Thus instead of the typical 96dB signal-to-noise ratio of a 16-bit conversion, it reduces to 13dB, the signal-to-noise ratio at the output of a 2-bit converter. Thus it would seem that low bit converters are unusable for most practical applications. What makes them practical is the application of a technique called "noise shaping".

Fig. 1. Operation of (N-2) bit quantiser and first order noise shaper (Technics)



Noise shaping first made its appearance in the communications field in the mid-1970s and is the basis of all the different "bitstream" dac systems now in use for digital audio. Noise shaping is rather like applying negative feedback to correct for amplifier errors although in this case there is no spare gain available. Instead the sample rate is increased to give several samples where originally there was one, and the corrected signal is then fed through an integrator so that the sample to sample corrections are "smoothed out". **Fig.1** gives an example of the process.

This illustrates a simple case of 9-bit input data and 7-bit output data. It can be seen that although the T=1 sample is generated accurately the T=2 and subsequent samples are reproduced at the next nearest level and so quantisation errors result. However, if we increase the number of output samples by a factor of four, some noise shaping may be applied to compensate. There is again no error in the first four samples t_1-t_4 (=T_1) but the sample t_5 is too high in level. As a result the next sample, t_6, falls in level to compensate. This is remembered in the integrator as an over-correction in the negative direction so the output rises for t_7 and t_8. Thus it can be seen that the net error over the sample T_2 is (+1,-3,+1,+1)=0. In this way the quantisation errors are completely corrected; the four times increase in the sample rate has given the same benefit as two extra bits of resolution.

However although the errors are cancelled over a full sample period (e.g. time T_2) there are still individual errors in the quarter time periods (e.g. time t_6) which give rise to quantisation noise Now though, because of the increase in sample rate, the noise spectra has been increased by the same factor.

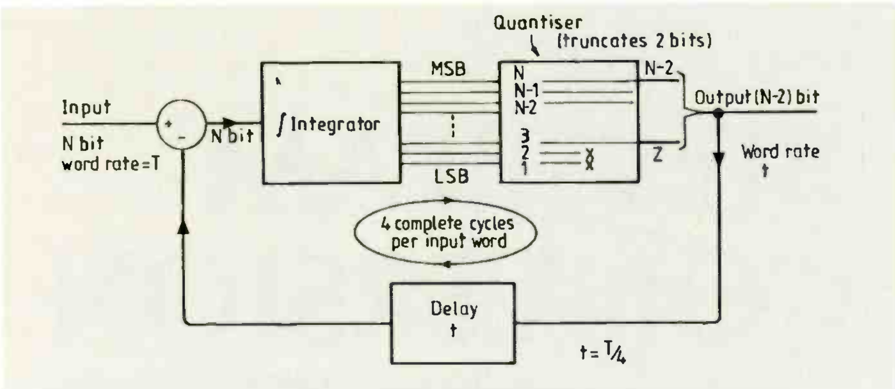


Fig. 2. Diagram of first order noise shaper (Technics)

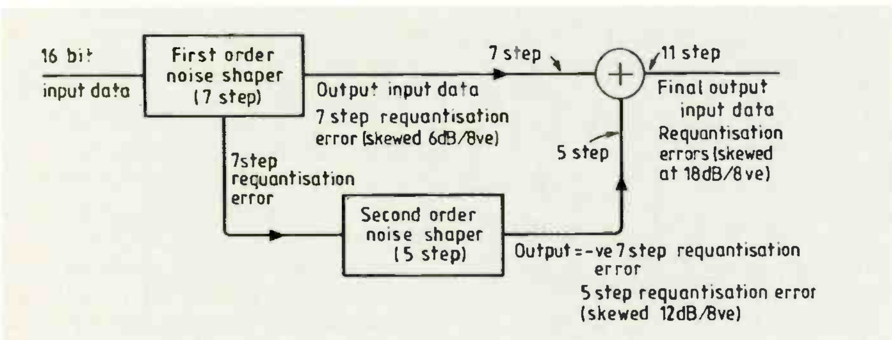


Fig. 3. Combination of first and second order noise shapers used in Technic's MASH system

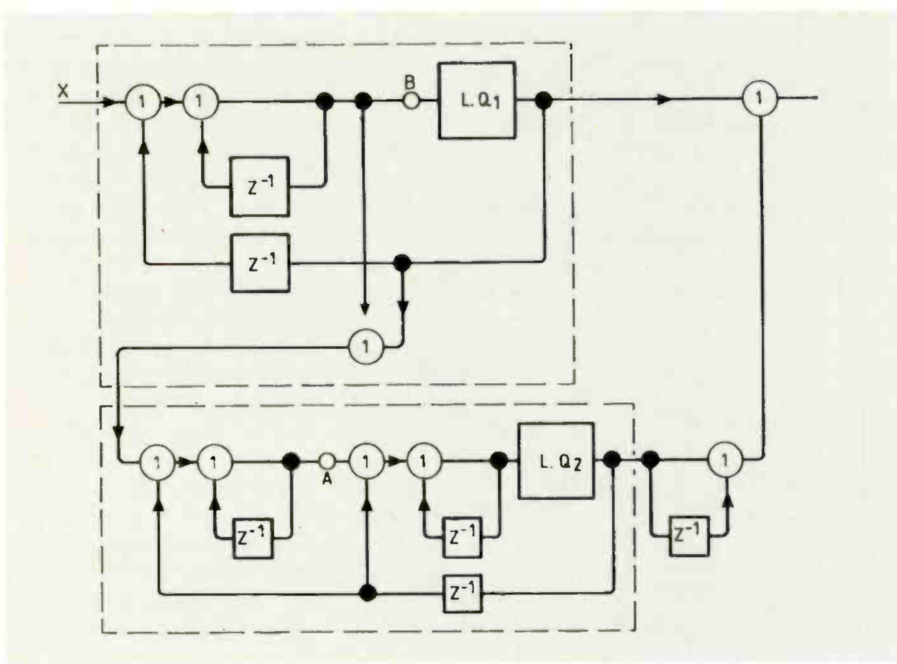


Fig. 4. Third order noise shaping schematic (Sony)

Thus, if the original sample rate were 44kHz, the noise energy which was spread over that band will now be spread over a 0 to 176kHz band so reducing the noise level in the 0 to 20kHz audio band.

Indeed, in this "first order noise shaper" (as shown in **Fig. 2**) the output noise spectrum rises in frequency at 6dB/octave.

In a practical noise shaper, this process can be performed by taking the error (the truncated two bits in the above example) and feeding them back to be added to the next sample before it too is requantised.

A further step is to incorporate a low pass filter into the feedback loop so boosting the high frequencies. Since the total noise energy remains the same, more of the requantising noise will now be at high frequencies and, consequently, there will be less in the audio band.

By combining two loops a second order noise shaper can be made, the output of which has the noise energy increasing at 12dB/octave with frequency. Technics have gone one step further by using an iteration of the MASH system developed by the Nippon Telegraph and Telephone Corporation (NTT) in Japan. Here separate first and second-order noise shapers are combined together (as shown in **Fig. 3**) to give requantisation noise distributed at 18dB/octave with the result that, within the audio band, the noise level is theoretically below that achieved with conventional linear 16-bit conversion.

Figure 4 shows a typical third-order noise shaper and **Fig. 5** the latest version of the NTT work as used by Sony. This system is termed "extended noise shaping". With the conventional noise shaper the first integrator in the second stage may sometimes be overloaded unless the output of the second stage has three or more possible levels. Sony solves this problem by providing an "extended feedback pass" loop so that the first integrator receives ordinary feedback data together with data which passed the quantiser in the first stage so preventing overload. The technique claims to improve dynamic range by 16dB in the audio band achieving an exceptional 118dB.

The main characteristics of the noise shaping sections of the most popular bitstream converters are: Philips PDM 17-bit input data at 256 times sampling quantised to 2 levels (one bit) using a second order noise shaper; Technics MASH 18-bit input data resampled to 32 times sample rate quantised to 11 levels (three and a half bits) using a third order noise shaper; Sony PLM 16-bit input data at 64 times sampling quantised to 2 levels (one bit) using a third order noise shaper.

A great deal of flexibility exists in the design of noise shapers with the option of introducing digital filters into the feedback loops and the use of 4th or even higher orders. However it is very easy to have unforeseen stability problems arise, usually as a result of an overloading of one register in the system. Then, in the best traditions of feedback systems, a momentary peak in one data sample can cause serious errors to be spread over a large number of the following samples.

Unfortunately this is one area where listeners have heard problems before the designer was aware that he had a problem! As an aside, it is worth mentioning that the same principles can be applied very successfully to the design of A-to-D converters. The writer is currently involved in some interesting work in this field and so it hoped to cover the subject in considerably more detail at a later date.

Crucial though the noise shaper is, it only represents one part of the system and, having requantised the data to just a few possible levels, it remains necessary to convert them accurately to the equivalent analogue voltage.

The three systems implement the conversion stage in different ways. Philips uses a PDM (pulse density modulation) system. Here, as shown in **Fig. 8,** two control signals are generated to represent the "1" and "0" of the data stream, and these control signals are locked to a clock signal. These signals feed cmos switches which govern the charge on two small capacitors (C_1 and C_2) each of about 2.7pF in value. During the negative half of the clock, C_2 is charged and C_1 is discharged. If the data is then a "1" then the capacitor is charged during the positive half of the clock by taking a fixed amount of charge from the node at the input of the operational amplifier. But for a data "0," a fixed amount of charge is transferred to the node from C_2. The output of the amplifier is a smooth continuous voltage due to the integrating action of the low-pass filter components.

One major problem with the Philip's PDM system is the audible idling data generated at low signal levels or in the absence of a signal. This has been partially suppressed by adding an out-of-band dither signal to the data but, in the first version of the PDM, this dither generated audible background noises. Philips subsequently revised the signal characteristics to around 352kHz at a level of -20dB. Other theoretical problems of this system include a difficulty in guaranteeing stability without reducing the noise margin, and the difficulty of achieving better than 50% modulation.

Technics have gone for the familiar pulse width modulation technique where the output level is proportional to the width of the pulses. In effect a low-pass filter is then all that is needed to perform the conversion. There are 11 steps of quantisation and thus 11 possible widths with the leading edge of the pulses all tied to a crystal clock. In this case the clock is run at 758 times the sample rate. e.g. 33.7MHz.

In theory there is zero uncertainty in the timing so the PWM converter is linear to better than 115dB below peak level e.g. better than 19-bit resolution. Unfortunately the system is prone to some errors which limit the linearity attainable in practice. There is also the problem of ripple on the supply lines and the ability of the supply to recover before the next switching edge.

Finally, the Sony pulse length modulation (PLM) system. Again the conversion to analogue is largely performed by a low-pass filter which is fed by "1" pulses; the time period between them is modulated by the signal data.

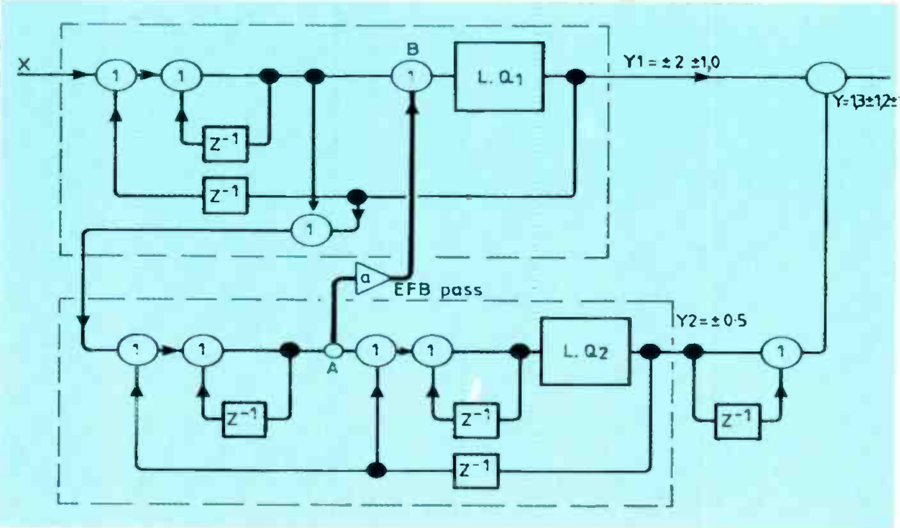


Fig. 5. Sony extended noise shaping (Sony)

Seven different pulse lengths are possible and are tied to a clock running at 45 MHz, 1024 times the sampling rate. Obviously there are close similarities between the PWM, PLM and the more recent PEM systems.

In practice all of them seem to suffer from degree of even-order harmonic distortion, although the explanations offered by the individual manufacturers are different, a situation which does not inspire confidence. To quote a Sony document: "We think this distortion is caused by the asymmetric modulation structures of 1 and 0 when modulation is applied to the length of the 1 pulses." However, these distortion problems can be overcome to a degree by operating two converters in a push-pull configuration and this fix has been adopted by both Sony and users of Technic's MASH chips in higher priced CD players.

It is interesting to reflect that the primary motivation behind the introduction of low-bit converters was to save money. They can be mass produced with low-cost cmos technology with a very high yield factor and with no need for device selection. Almost as an unexpected bonus, the manufacturers discovered that the technology could be simply extended to give a performance which in many respects is superior to that offered by conventional

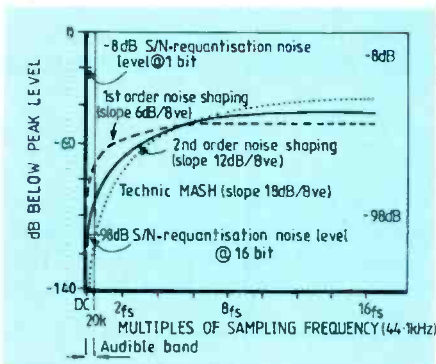


Fig. 6. Noise distribution of various noise shapers (Technics)

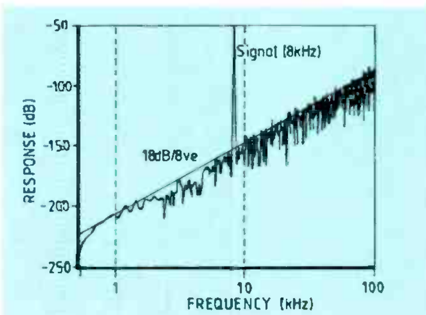


Fig. 7 Spectral noise of third order noise shaping with EFB, theoretical noise shaping circuit only (Sony)

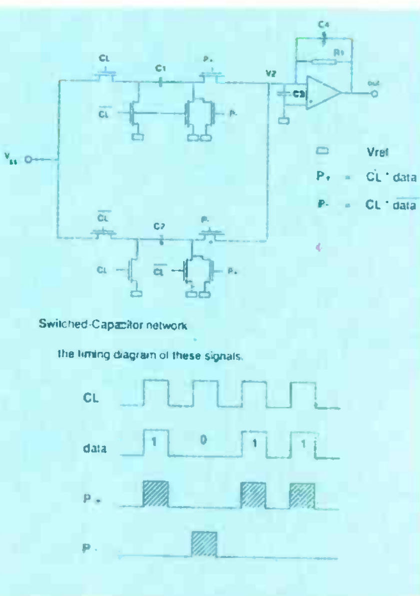


Fig. 8 (left) Conversion system used in Philip's PDM (Philips)

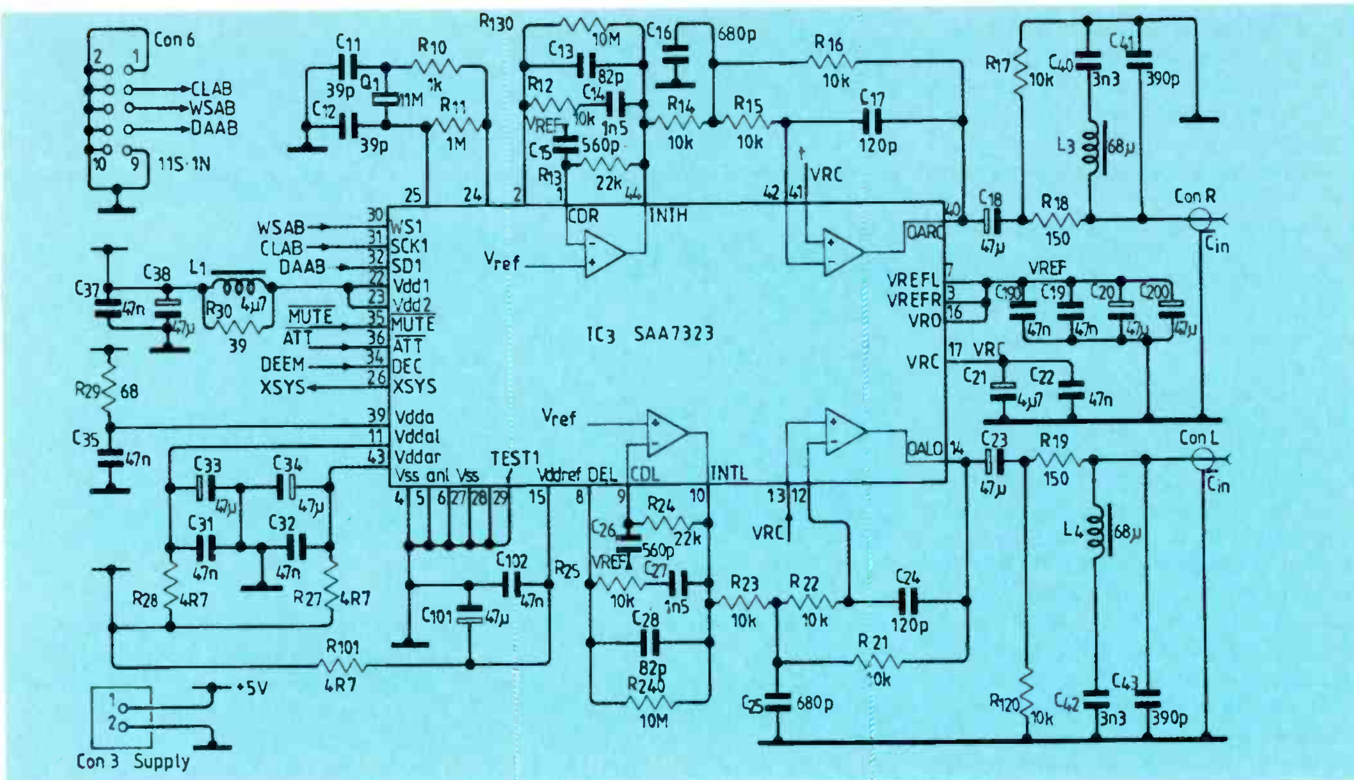
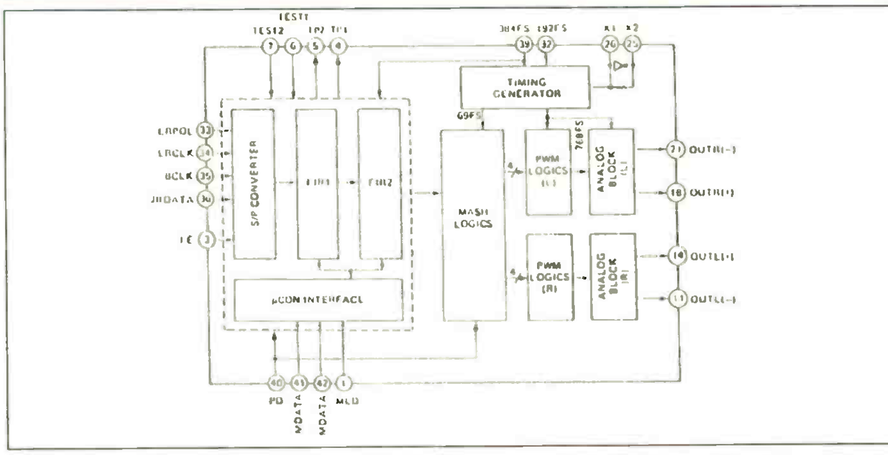


Fig. 9. Application of PDM system (Philips)

linear D-to-A converters.

Better performance for much less money is an engineer's dream come true.■



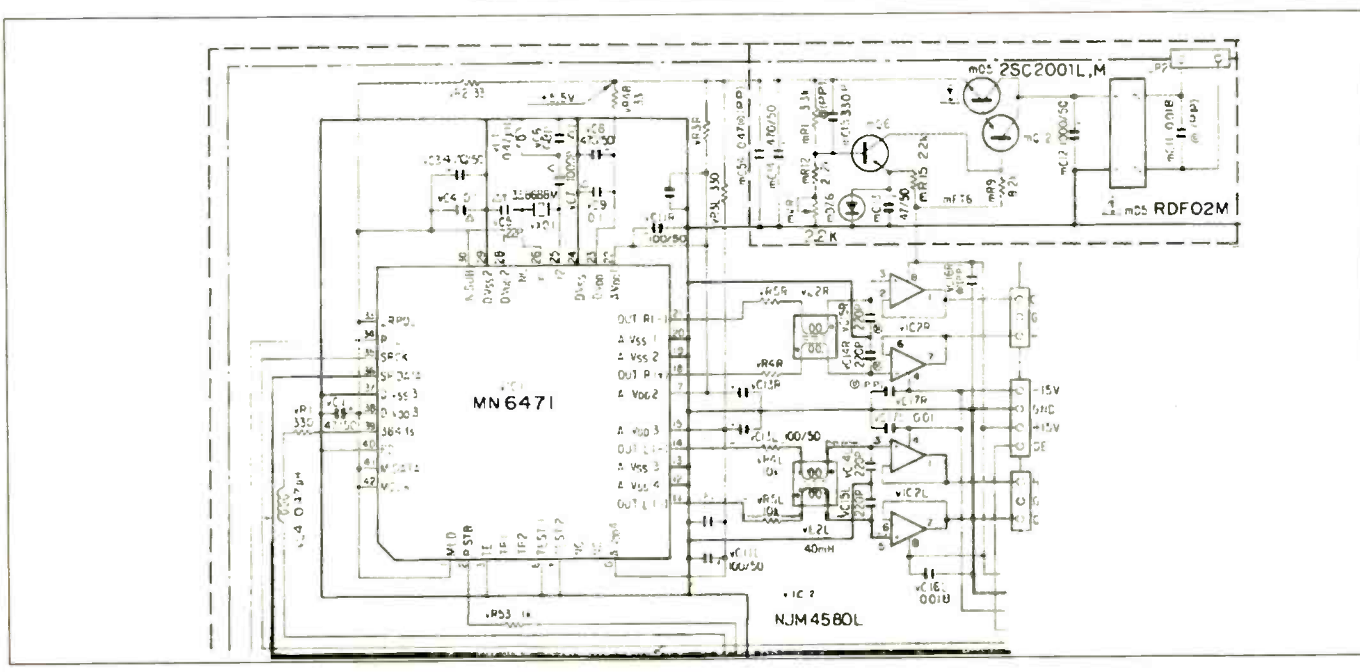


Fig. 10 Application of MASH system in Sansui CD player (Sansui). The functional block diagram of the A-to-D converter is shown on the right.

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CIL PCI 6380 I/O Units for HP-IB.	£150
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CHESSELL 4001 Multi-function Data Logger/Chart Recorder. (Up to 30 inputs).	£1750
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CHESSELL DC INPUT Board with SIMM Module for 4001.	£225
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STAG PP39 Universal MOS EPROM Programmer (Includes RS232 Inter-face).	£375
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Magic of CFAs

I read with interest your article on the crossed-field antenna (CFA: working assumption *EW + WW* Dec 90 pp.1094-1099), prudently published under the heading "Hypothesis".

In the authors' highly speculative explanation of the operation of the CFA, there is supposed to be a magic difference between the two pairs of plates that makes one pair produce an E-field while the other produces an H-field.

In fact, of course, both pairs of plates and their feed wires produce a combination of E- and H-fields that the authors have failed to address. As a result, the published "theory" cannot be taken seriously.

Practical use of the antenna is probably of more interest to most readers and on this score the absence yet again of firm evidence about the CFA's radiation efficiency must be construed as significant in view of calls for such evidence over a long period.

Radiating efficiency of electrically small antennas is usually poor and nothing has yet been published which would prove that the CFA is an exception.

Alan Boswell
Chelmsford

Speed-of-light cops

John Ferguson's letter (Nov 1990 *EW + WW*) will be proved every day by the police right here on earth. Before the 21st century rolls around many highway patrol officers will be using the much more accurate laser speed traps instead of radar equipment: but can they possibly work in the face of relativity theory.

A laser operates on only one frequency in the wide-ranging electromagnetic spectrum of visible light.

Lasers are very accurate clocks. If the frequency of the laser never changes how can the receiver get higher or lower frequencies depending on whether your car is closing or opening on the laser trap? The laser signal leaves the trap at c (the speed of light) but it returns to the trap at c plus or minus V — the radial velocity between the trap and the target or your car.

All we must change in Maxwell's basic equation of c = wv is to assign the fixed value to w (wavelength or space) the laser always radiates and then measure the v (frequency) reflected and received from the target.

Then c' = c±V and ±d = wv-c where c' is the reflected signal speed and d is Doppler.

Notice c is still a constant to the source but not always to the target if there is any radial velocity or Doppler.

John W. Ecklin
Alexandria
Virginia
USA

Power lines crossed

John Wilson (*EW + WW* Nov Research Notes - Case builds against power leukamia pp.936) misrepresents both the science and significance of the model for magnetic-field interactions with ion-binding proteins proposed at the June Bioelectromagnetics Society meeting in San Antonio by Valeri Lednev, Donald Edmonds and myself.

The model is in no way based on cyclotron resonance, as Wilson asserts, but on the Larmor precession of an ion's vibrational pattern within a protein binding site. Nor does the protein calmodulin modulate the movement of calcium in and out of cells.

On the contrary, calmodulin is itself activated when it binds calcium ions.

What we propose is that a magnetic field, amplitude-modulated at the cyclotron frequency (twice the Larmor frequency), may change the ion-binding affinity of the protein by disturbing the bound ion's vibrational pattern, with consequent effects on the protein's biochemical activity.

This model offers a possible basis for explaining certain reported (but as yet unreplicated) frequency-specific biological effects of magnetic fields, such as enhanced motility of marine diatoms.

It may or may not have more general application; time will tell. But there is no present justification for claiming it as a "perfectly adequate basis for explaining the way in which AC fields could cause childhood leukaemia", and still less for attributing that claim to the researchers involved.

There is equally no justification for claiming that power-utility research funding, either in this country or abroad, has been stimulated by the model.

The question of possible health effects of power-frequency fields is a serious one and it has for some years past been seriously addressed by power utilities and other responsible authorities. National Grid's biological studies programme, outlined in your November issue, was planned long before the San Antonio conference.

Dr J C Male
National Grid Research and Development Centre
Surrey

John Wilson replies *Obviously I cannot defend any factual errors that crept into the piece, nor can I take issue with the paper's author. I do, however, find people working in this area singularly disinclined to attribute significance to their work — the same sort of scientific caution that attended smoking and cancer a decade ago.*

Whatever Male says about misrepresenting the significance of his work, it must surely be obvious that any process by which magnetic fields affect the fundamental behaviour of biological cells must also, potentially, have the basis for causing disease.

No-one knows precisely what triggers the process of carcinogenesis, so (logically) any interaction could provide "a perfectly adequate basis".

I understand all too well why power utilities are cautious on this one, though re-reading my piece, I don't think I either over-played or under-played the significance of this research.

Doppler shifted

The heretical speed-of-light theory that I proposed in an earlier letter (*EW + WW* Nov 90 p.950) brings into question the Doppler equations.

Suppose a space-ship travelling at a speed V relative to Earth, at position S transmits laser pulses, repetition frequency f towards an observer O (ø° to space-ship travel) on earth.

According to SR theory, the observer O would measure the speed of the pulse to be c and the pulse repetition frequency to be F where $F = f\sqrt{(1-(V^2/c^2))}/(1-(V/c).\cos ø)$.

But the "heretical" theory takes account of the fact that the observer's receiver cannot detect the space-ship at its true position. Instead, it will detect it at an earlier position P in its track, such that the time taken for the space-ship to travel from P to S is equal to the time taken for a pulse to travel from P to O.

The resultant velocity vector v is the sum of three vectors:

V in space-ship direction of motion: c.cosø in direction of motion and c.sinø transverse to V, hence

$$v = \sqrt{(V^2+c^2+2cV.\cos ø)} \qquad (1)$$

According to the proposed theory, the observer at O would measure the pulse repetition frequency to be F where F/f = v/c

Substituting, we obtain

$$F = f\sqrt{(V^2/c^2+(2V/c)\cos ø+1)} \qquad (2)$$

Equations 1 and 2 yield very different results if V is a large fraction of c.

We could find out which is correct by carrying out a test, using an airborne pulsed laser and ground-based electronic equipment, to measure the variation of PRF with V and ø.

Such a test, which would not be particularly expensive to carry out, would certainly resolve the long-standing controversy over SR theory

John Ferguson
Surrey

Cuk more thoroughly

TS Finnegan's article on Cuk converters in the January issue (*EW + WW* Cuk: the best SMPS?) was interesting, but he erred on a few points.

Performance does not depend on inductor currents remaining continuous, nor on the capacitor ripple remaining low. They make analysis easier but both L and C can be reduced to quite small values before the converter looses performance.

Coupled inductors do not have to have a 1:1 turns ratio. This error was corrected by Cuk in a later paper which perhaps the author had not read. The quoted equations for effective inductance hint at this — true requirement is n = k.

The designer should not make the turns ratio close to unity because very small changes in n or k can lead to wild variations in

performance, with the expression taking on, essentially, any value.
It is much better to choose a non-unity turns ratio, say 0.8. The coupling factor of k=0.8 can then be obtained by spacing the windings inside a pot-core or by using concentric toroids as indicated in one of Cuk's patent applications.
The principle of inductor coupling to reduce ripple can be applied to conventional switching topologies, but as Cuk has shown, there is then the additional requirement that the inductor currents do remain continuous.
The author hints that the frequency response could be a problem, but it should not normally cause a worry and a feedback loop can be constructed with very little compensation.
An important feature of the converter is that it can obtain high bandwidths. One of Cuk's patent applications is for a switching audio amplifier.
The author did not address some of the criticisms that the newcomer to Cuk converters may raise.
At first sight the transistor and diode undergo a greater stress than they would in a conventional topology converter.
But this is not so and needs to be pointed out and explained.
Other important points are that the output ripple current does not depend on the load current; that the inductors can "run dry" without problem; and that the lower ripple current means that a lower switching frequency can be used.
But the most important point not addressed by the author is that if the Cuk converter is so marvellous why does it not feature strongly in published designs of power supply? Why has it not displaced all the other topologies?
In its simple form, the Cuk converter uses the same components as a buck-boost regulator — they are just rearranged a bit — so it cannot be called difficult or expensive.
The answer cannot simply be that it is patent protected. Cuk's patents are not all currently in force throughout Europe, and in any case they are not watertight.
I'm sure that author would have been more convincing to newcomers to the Cuk converter if he had actually produced a practical circuit claiming so-many watts per cubic inch, and so-much radiation and ripple current.
Having given a good introduction to the subject I would recommend that any prospective designer read the references that Finnegan gave, and the papers which they, in turn, reference.
Cuk's four US patents are also essential reading. The history and evolution of the Cuk converter, and the "integrated magnetics" make fascinating reading and deserve wider publicity.
David Gibson
Leeds

Man with the golden ear

Referring Peter Baxandall's letter in December issue *EW + WW* I find it frustrating, however interesting, to attempt to follow the current debate on subjective equipment testing — the "golden ears" problem.
Peter Baxandall is an outstanding engineer and Martin Colloms, his chosen adversary, an experienced equipment reviewer. Trouble is that truth of the kind being sought is not discovered by assertion and counter-assertion; the method of debate is simply inappropriate.
Audio dealers of any repute have a range of experience amongst their staff that provides the basis for choice of products handled.
Among such dealers certain products seem to stand out for the subjective quality they afford the listener, and there is some unanimity on this.
For example, I could name a well-known power amplifier that is — among dealers — unanimously preferred to another well-known amplifier* that has had some technical trumpets blown for it in this journal.
The only way forward is a statistical analysis of data. If a serious effort were to be made by a responsible engineering body to correlate a whole range of responses we might end up with a predictive test where choices became repeatable and statistically significant.
Most interesting would be whether such repeatability could be correlated with laboratory tests of equipment performance — but that is quite a different question.
John Greenbank
Haslingfield
Cambridge

**Quad current dumping amplifier*

VLF reflection

I should like to add some more information on the 1.6, 2.2 and 3.3kHz continuous signals about which I have asked for more information (Letters *EW + WW* Feb 90).
With all three signals, time duration between the start of each new train of pulses was either 10ms or 20ms (50Hz) and the initiating pulse seems to be synchronised to all three signals, irrespective of the waveform of their resultant train of 10-12 damped waves. The exception is when the pulse occurs before the train of waves has completely decayed.
At first, the 20ms time duration suggests that the signals might be something to do with power transmission lines. But apparently companies do not use these frequencies for monitoring purposes. However it would seem reasonable to suggest that the pulse generator, whatever it may be, is powered and triggered by the 50Hz mains power supply and this would rule out the possibility of the signals originating in the USA.
Signal strength shows little change when the distance between the earth rods is increased to 150m by extending the base into adjoining farmland.
This is incompatible to LF and VLF stations, known to be radiated as Hertzian waves, where signal strength is directly proportional to base length.
Orientation of the base makes no significant difference to signal strength, but this also applies to LF and VLF signals. However, unlike LF and VLF stations, a ferrite rod inductor antenna gives no readable signals. As with the capacity antenna, this could be because the receiver amplifier did not have enough gain.

• Since writing the original letter, I have found man-made signals extending from 1.0kHz down to 250Hz (lowest frequency covered by my tuner). The strongest and most consistent signals were on 253, 455, 660, 715 and 1.0kHz.
Their waveforms, like those already mentioned above 1kHz, change from a typical damped wave train, where each train consists of up to 10 waves with 20ms between the start of each chain, to more or less continuous waves. At times the waves have a complex "envelope" which indicates amplitude modulation, though "kinks" may possibly indicate some form of phase modulation.
Frequencies were checked on the double beam oscilloscope by superimposing a signal derived from an audio oscillator. As a third check, the tuner output was connected to a battery powered amplifier and loudspeaker which enabled the various tones to be clearly identified by audible means.
660Hz signal was generally the strongest, developing about 150mV p-p across the oscilloscope, but with periodic dramatic increases.
They are not spurious signals, generated by switch-gear or machinery, but show every sign of being intentionally created, moreover they are present 24 hours a day and seven days a week.
As already mentioned, with signals above 10kHz, increasing the length of the earth base gives a proportional increase in the strength of signals known to originate as Hertzian waves.
For example, with the 135m long base in conjunction with the appropriate tuner, 198kHz (Radio 4) delivers more than 12V to the oscilloscope, about seven times the strength with the 35m base.
However the proportional increase falls off with decreasing frequency, nonetheless, the 60kHz time signals still give about 3.0V and the 16kHz "submarine" communication station, about 1.3V.
All measurements were made with the earth base coupling coil not connected to the common earth; connection to the common earth made no noticeable difference to the signals.
Now, with the unidentified signals below about 3.0kHz, increasing length of the earth base from 35m to 135m brought no significant improvement in signal strength. But when the coupling coil was disconnected from the common earth, the oscilloscope indicated a dramatic fall in signal strength, though the battery amplifier and loudspeaker (notwithstanding non linear response of the ear) indicated no significant difference to the loudness of the tones.
Nonetheless, it does seem to indicate that in some way, the power line

CIRCLE NO. 117 ON REPLY CARD

CIRCLE NO. 118 ON REPLY CARD

CIRCLE NO. 119 ON REPLY CARD

earthing system contributes the major length of the base, and this being considerable, swamps out relatively short changes made to the length of my base.

Signals were only received when my earth base and the mains earth form a complete earth loop; capacity and inductive coupling gave no signal.

George Pickworth
Market Harborough

Distorted history

The recent article by Greg Ball on "Distorting power supplies" (*EW + WW* Dec pp.1084-1088) addresses an important aspect of amplifier design.

But much of what was discussed has already been openly published in the technical literature, and I suggest that the lack of reference material was a serious omission.

Colin Cherry[1] describes a similar problem and also gives a similar Fourier analysis. However, this work concentrates on mutual coupling of signal paths though some interesting observations are made about minimising interaction.

The same problem is also discussed in two of my own publications. In an AES Convention[2] the problem of power supply variation under class B operation is addressed where the rectification process is recognised. Where a bridged output stage is powered from a common power supply, equal and opposite supply variations can result which together with a symmetrical output stage, aid reduction of power supply induced distortion as it appears as a common mode signal across the loudspeaker.

This advantage is not realised if separate supplies are used for each half of the bridge stage.

Finally, the comparison of high feedback and low feedback designs requires qualification to ensure the basis of a fair comparison and also to identify the system elements to enhance supply rejection.

Reference should be made to a recent AES paper[3] for a discussion of the basic circuit parameters relating to power supply induced distortion.

The analysis is appropriate for both the case of self-induced power supply distortion via output stage commutation and for the case where mains induced distortion and radio frequency components appear on the power supply rails.

But for the case of RF we must recognise that the actual amplifier-circuit will probably bare little resemblance to the everyday low-frequency models drawn on a piece of paper!

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2 Hawksford MOJ, Pontoon amplifier constructions incorporating error-feedback location of floating power supplies, 78th Convention of the AES, preprint 2247 (A-14), May 1985

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MOJ Hawksford
Dept of Electronic Systems Engineering
University of Essex

Maths misogyny

The "problem" of a scarcity of women (*EW + WW* Comment Dec 90) who are capable of doing engineering or science and who are interested in such work has bedevilled feminists.

It is a situation that points up one of the more ridiculous positions often taken by feminists: women may be better than men but men are never better than women.

Despite all the efforts of social scientists to make gender-related difference disappear, girls consistently perform in tests at half a standard deviation or so lower in mathematics and spatial ability than boys.

Note, young girls often outperform young boys in mathematics classes. This early success, which falls off markedly as the children get older and mathematics gets harder, probably occurs because girls are more obedient than boys and consequently do their homework.

But while girls can get good grades in elementary mathematics classes, few express a liking for the subject.

Like it or not, women consistently express a preference for people over things, for relationships over workings, for helping over tinkering.

This shows up long before children go to school and experience the cultural pressures you cite in your editorial.

Females precocious in mathematics are so rare as to be almost nonexistent. And where are the world-class women mathematicians or female international chess grand masters?

Any claims that recent testing shows the mathematics-ability gap between the genders is closing are suspect.

Firstly, overall mathematics scores have been dropping for both genders, narrowing the gap in absolute but not relative terms. And secondly, in the US at least, feminists are constantly pressuring testing organisations to revise their tests when the results show gender-related differences.

It turns out that the hardest factor to "control" (in the social-science use of the term, not the hard-science sense) in testing is not race, religion, or class, but gender.

Testing organisations respond to complaints by mixing the proportions of questions that boys do well on with questions girls do well on so that boys' and girls' scores come out equal. Not the same thing as concocting a gender-neutral test, eh?

Charles H Small
Newton
Massachusetts
USA

Social engineering

I believe there are several causes for the situation described in your December editorial (Teaching women a lesson).

Anyone who can wield a spanner or a soldering iron is called an engineer. So "lay" people associate their local car mechanic with engineering, and a telephone or washing machine technician is called a service engineer, again with a degrading effect.

A qualified engineer should be entitled to the same status and place in society as medical doctors and lawyers; preferably even better! Trades Unions such as the AEU should be forced by law to drop engineering from the title unless they are able to prove 100% qualified engineer membership.

The ignorance of school teachers about the engineering professions must be rectified.

My own remedy for this is for the Dept of Education and Science to arrange for ALL teachers to work for at least one year in an industry relevant to their subject(s).

At least they would have some rudimentary knowledge of the world into which their pupils are to operate.

Industry must co-operate in this. Secondary education would be much improved if industry were able to second suitable staff to assist in teaching specialist subjects to pupils. This could be on a cooperative basis where several small companies group together to sponsor an employee on a year's sabbatical at a local school, where he/she could teach an appropriate subject and assist in career counselling.

Engineers need to do their own advertising too, using TV and radio. Companies should offer "open days" where schools are hosted. Too many engineers are poor self publicists. A TV series made "to order" about engineers could well work wonders - Capital City on ITV probably has 90% of today's youth aiming at "yuppy" status.

However no improvements to the position of the engineer can be achieved without a commensurate increase in status and salary packages.

For its part the Department of Trade and Industry must become more MITI-like, following the Japanese example of whole hearted cooperation between Industry and the Public Sector.

One final thought - how many professional engineers are members of parliament?

Charles Treen.
West Sussex

Umist the point

While applauding the general tenor of your Comment "Teaching Women a Lesson" (*EW +WW* Dec 90), I must point out a potentially damaging error.

Umist has, in fact, no "unfilled" places in engineering, electronics or physics. We happen to be one of the universities which both fills places in those subjects and does not drop standards of required "A" levels to do so.

Nonetheless there is a national problem of recruiting women into science and engineering courses and we at Umist not only make special efforts to encourage girls into our courses and back initiatives like the Wise programme, but also have as our Vice-President, Baroness Platt, a distinguished aeronautical engineer and former Chair of the Equal Opportunities Commission, who would not allow us to backslide should we wish to.

T Yates
Director of Information
Umist
Manchester

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CIRCLE NO. 132 ON REPLY CARD

FM RADIO: PLAYING A BETTER TUNE

John Linsley Hood examines the beginnings of FM radio design, starting with the reasons for its adoption, a comparison between AM and FM and techniques for FM demodulation

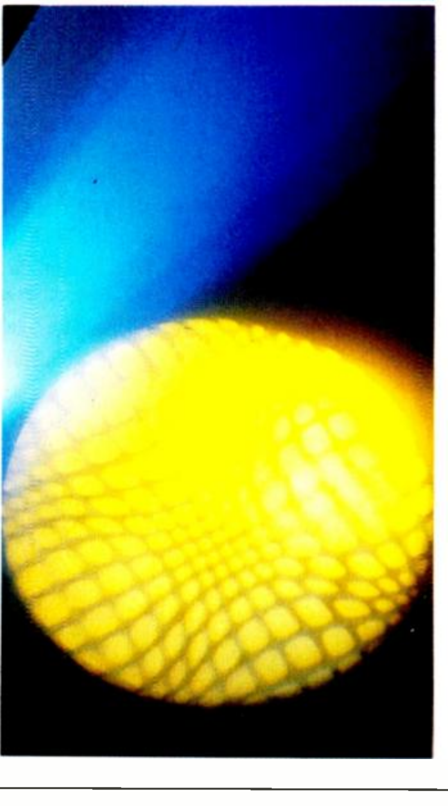
In the early years of radio transmission and reception, almost all the broadcast signals intended for domestic news and entertainment were transmitted on either the long-wave (150-285kHz) or the medium-wave (525-1605kHz) bands, because the available technology and hardware was really only suitable for use at relatively low radio frequencies.

Although each transmitted signal might occupy some 30kHz of bandwidth and the total available space in these two bands is only 1215kHz, the poor sensitivity of the average receiver and the relatively small number and low effective radiated power of the transmitters meant that there was very little likelihood of interference from broadcast transmissions on adjacent frequencies.

However, this situation could not last. National pride, and a praiseworthy desire to improve the service, led to a continuing growth in the number and power of broadcast transmitters, while the ingenuity of engineers brought forth receivers of greatly increased sensitivity. The predictable result of this was that interference from transmitters on adjacent frequencies became increasingly troublesome, particularly at night, when the reduction in density of the lower layers of the ionosphere increased the skip distance and the likely reception area of the more easily refracted LW and MW signals.

With the advent of the 1939-45 war and the desire of hostile nations to exploit the ability of radio broadcasts to encourage and inform their own populations and to discourage, mislead or simply annoy their adversaries, the situation became chaotic.

So, with the end of hostilities, the so-called Copenhagen Plan of 1948 was drawn up to try to regulate the use of the available transmission frequencies for LW and MW broadcasting in Europe. Sadly, even after this agreement, the provisions of the plan were largely ignored where they conflicted with national interests, even before the basis for the proposed frequency allocations was overtaken by events.



In particular, the military occupying powers of the three western sectors of Germany felt that the allocation of MW broadcast frequencies for their sectors was grossly inadequate and they made the sensible decision, based on experience in the USA, to build a chain of FM stations in the 88-100MHz VHF band to serve the needs of the West German population.

FM versus AM

The basic concept of modulating the frequency of a broadcast signal (FM), rather than its amplitude (AM), was due to the same remarkable Major Edwin Armstrong of the US Army Signal Corps who had conceived the idea of positive feedback (regeneration) as a way of augmenting RF signals and of providing stable RF oscillator systems, and who had also invented both the superhet and super-regenerative types of radio receiver.

FM has many advantages in use, but is much more extravagant in its need for transmission bandwidth than AM, in that while an AM transmission carrying a constant-amplitude 15kHz signal will require a transmitted bandwidth of 30kHz, (f±15kHz), an FM transmission would require a bandwidth of at least 240kHz (f±120kHz), to carry the same information without substantial constraints on modulation depth. In both cases, if the 15kHz signal is modulated in amplitude, the bandwidth requirement will be increased still further.

Clearly, FM broadcasts would be impracticable on the already overcrowded LW and MW bands, but quite feasible on the higher radio frequencies which wartime developments in components and circuitry had now made available. In this context, earlier experimental work in the USA had shown that 70-80MHz was the lowest frequency at which VHF broadcasts could be expected to be free from unwanted interference, since sporadic-E ionospheric effects brought remote transmitters within reception range.

In the light of this experience, some provisional VHF frequency allocations had been agreed, of which Band 1 (41-68MHz) had been earmarked for television use, leaving Band 2 (initially 88-100MHz, but later extended to 108MHz) available for VHF domestic radio broadcasting.

At that time, VHF broadcasting was very much a new and untried medium in Europe so, as the authority for radio broadcasting in the UK, the BBC made some preliminary trials from Alexandra Palace in 1945-46, in which the performance of AM and FM was compared at 45MHz and 90MHz, in respect of signal to background noise ratio at the receiver, and susceptibility to impulse type interference. FM transmissions were shown to be markedly superior in both of these aspects.

In spite of the results of the BBC's Alexandra Palace experiments, of which a summary was published in *Wireless World* in October 1946, there were still some misgivings among the UK engineering fraternity on the general acceptability of an FM broadcasting system, because of the need to use more elaborate and costly receiver circuitry and the practical difficulties presented by drift in domestic receiver alignment and tuning.

To help resolve these doubts, larger scale trials were made, beginning in the summer of 1949, in which the BBC Third Programme was broadcast for a few hours each evening from Wrotham in Kent, simultaneously on FM at 90.3MHz and on AM at 93.3MHz (*Wireless World*, June 1949, p. 221).

The Government's Television Advisory Committee, which had been charged with recommending a VHF sound broadcasting system, was reported in an editorial comment in *Wireless World*, December 1952, to be still divided on the question of AM vs FM. These uncertainties probably delayed the nation-wide adoption of this system although, by this time, the relative technical merits of these competing systems were quite clear.

To summarise: AM is the simpler system to use, both in transmission and reception; it uses familiar circuit technology, which makes for less expensive receivers; and it is more economical in its use of the available RF bandwidth. FM allows a significantly lower receiver background noise level, whether caused by devices and circuitry or impulse interference, since these noise sources are predominantly amplitude modulated.

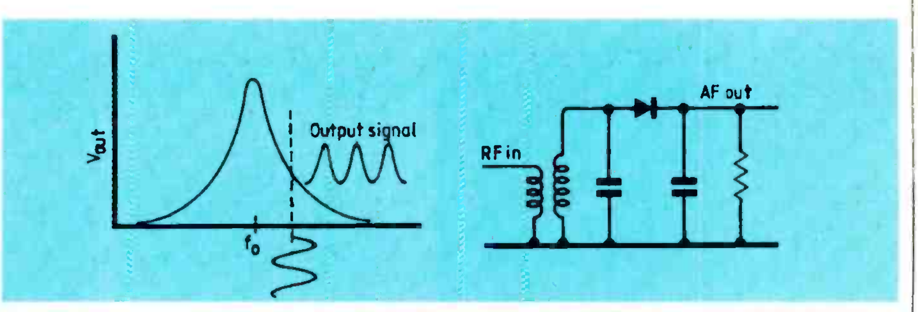


Fig. 1. Simple slope detector, in which the receiver is tuned to one side of the carrier. Considerable distortion was produced.

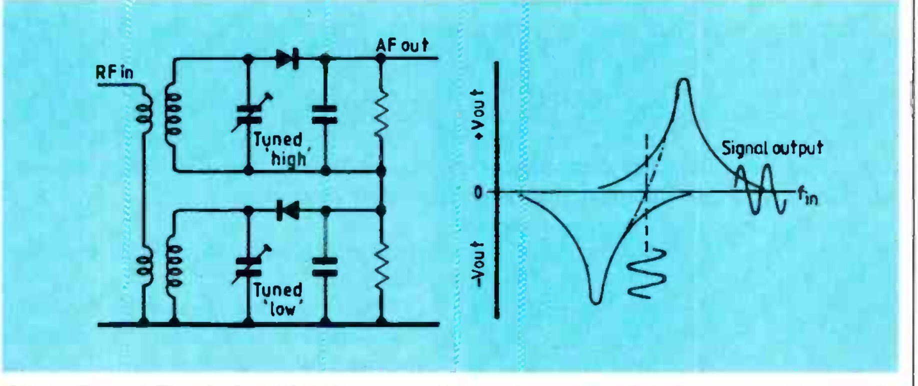


Fig. 2. Round-Travis demodulator, consisting of two of the Fig. 1 circuits connected back-to-back, to some extent cancelling distortion.

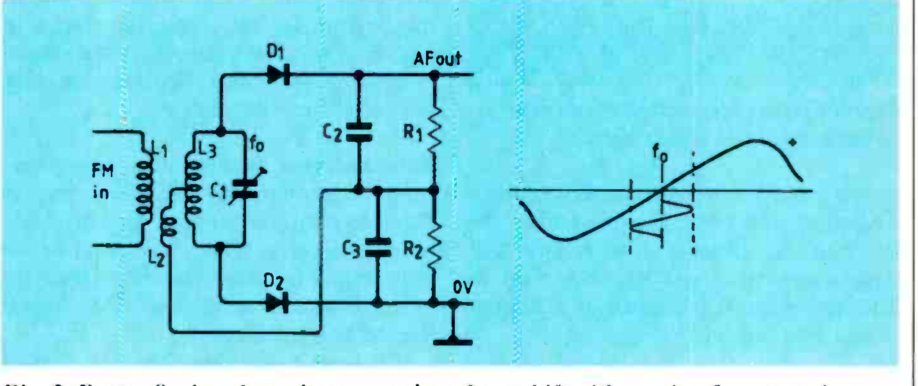


Fig. 3. Foster-Seeley phase detector, using phase shift with varying frequency in a loosely coupled tuned circuit.

FM is also largely immune to fading, particularly if an amplitude limiter circuit is used in the IF stages of the receiver, and it offers scope for lower-distortion demodulation systems. Also, with a suitable FM demodulator circuit (also known as a discriminator) a further unique benefit is conferred, in that a stronger signal can completely suppress a weaker interfering one, thereby eliminating the major existing problem in radio reception.

The necessary superiority in amplitude required from the wanted signal, to cause this to happen is called the capture ratio, which can be very small (<1dB) with a well designed demodulator system.

One must assume that the technical advantages of FM were also obvious in practical tests, since the VHF-AM broadcasts of 1949-50 were soon abandoned, while experimental broadcasts from Wrotham continued on FM only until May 1955 when work beagan on the commissioning of a national network of FM transmitters.

FM demodulator systems

Slope detection. The easiest way to convert a change in received signal frequency into a change in output voltage is simply to tune the receiver so that the received signal sits on the skirt of the response of a simple tuned circuit, as shown in **Fig. 1**. This technique, usually called slope demodulation, was widely used in early FM receivers, but the demodulated output signal would suffer from substantial, mainly even-order, harmonic distortion because of the curve of the resonance characteristic.

Round-Travis detector. If two such tuned circuits are employed, one tuned

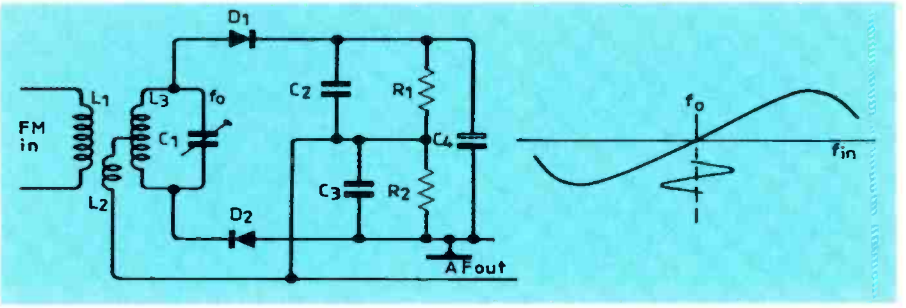


Fig. 4. Ratio detector. Since output is proportional to ratio of diode outputs, rather than their sum, AM rejection is improved

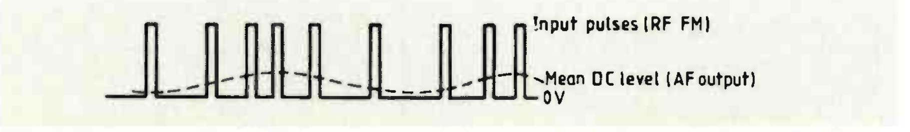


Fig. 5. Pulse-counting FM demodulator. Pulses are derived from FM signal, AF output being proportional to average level and therefore frequency.

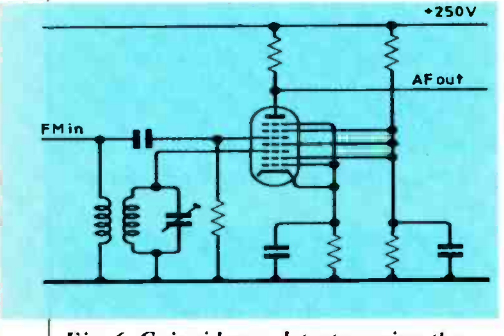


Fig. 6. Coincidence detector using the nonode–a nine-electrode valve.

above and the other below the resonant frequency, the distortion caused by the curve of the response characteristic will largely cancel out, as shown in **Fig. 2**. This arrangement is known as a Round-Travis demodulator.

Foster-Seeley discriminator. Most contemporary FM demodulator systems make use of the fact that the phase of the induced voltage on a loosely coupled tuned circuit will alter if the frequency of the induced voltage moves above or below the natural resonant frequency of the tuned circuit.

In the simple Foster-Seeley demodulator, shown in **Fig. 3**, this characteristic is combined with the further effect that the voltage developed across such a secondary tuned circuit will, when at resonance, be in quadrature (90° or 270°) to that of the input signal.

This leads to the possibility that, if the input voltage is applied to the centre tap of a tuned circuit, which is arranged to feed a pair of diode rectifiers, the input signal will either add to, or subtract from the output rectified voltage from each diode, depending on whether the input signal frequency is above or below the resonant frequency of the tuned circuit. This circuit will therefore give a voltage output which will vary with the input frequency.

However, since the output from the demodulator is the sum of the voltages developed by the diode rectifiers, such an arrangement could offer little AM rejection in the absence of some preceding amplitude limiter stage. A modification of this layout, the ratio detector shown in **Fig. 4**, in which the polarity of the diodes is reversed, was more popular in the early days of FM receiver design.

Ratio detector. In this, the output derived from the junction of C_2 and C_3 is proportional to the ratio between the two diode output voltages, which is related to the input signal frequency but not directly to its amplitude, its sensitivity to AM signals thereby being reduced.

If a large-value capacitor, C_4, is connected across C_2 and C_3, a pulse of AM interference will cause both diodes to conduct more heavily, momentarily increasing the damping on the secondary tuned circuit and lessening its output. The output voltage from the Foster-Seeley demodulator is higher, for a given input signal level, and it also has a rather lower harmonic distortion (typically 1% rather than 3%) when correctly tuned. However, because of its better AM rejection, the so-called ratio detector circuit of **Fig. 4** was more popular in early receivers.

Pulse counter systems. If the incoming signal can be converted into a stream of identical, unidirectional pulses having a narrow aspect ratio, as shown in **Fig. 5**, the average DC level of this pulse stream will be proportional to the frequency of the signal, so that a simple RC network would be able to demodulate it. Moreover, such a system should have a very linear relationship between output voltage and input frequency.

Clearly, the sensitivity of such a system based on a 90MHz carrier frequency and a ±75kHz modulation width would be far too low, at a maximum average DC level change of 0.17%. By the use of a superhet system, the centre carrier frequency could be reduced to around 500kHz and the modulation sensitivity would be increased to a usable 33%. Several receiver circuits using pulse-counter techniques were proposed, such as that due to Scroggie[1].

Gate-coincidence detector. As noted above, there is a change in the phase of the voltage induced in a loosely coupled tuned circuit, as a function of its input frequency. The direct use of this effect had been explored in a demodulator in the earlier years of FM by causing it to modulate the anode current through a multi-grid valve, but the requirement for a special type of valve, a nonode, had discouraged its use. **Fig. 6** shows a typical circuit for such a system, described by Amos[2].

With the evolution of multiple transistor arrays, this type of system became much easier to employ and the gate-coincidence detector shown in outline in **Fig. 7a** is now the most widely used demodulator system in FM receivers. In this, the phase shift in the output voltage E_2 of the tuned circuit L_1C_1, on either side of its resonant frequency, is used to generate a differential voltage output by modulating the current stream through a group of transistors arranged in ladder form.

In the absence of an output voltage E_2 from the quadrature coil L_1, or if this is truly in quadrature with the incoming signal E_1, the currents through R_1 and R_2 are identical and there is no differential output voltage. If the phase of E_2 alters in relation to E_1 as a result of a change in E_1 frequency, the equal division of the currents through R_1 and R_2 is disturbed and there is a voltage output.

With the simple quadrature coil system shown in Fig. 7a, the non-linearity of the demodulator circuit can be as low as 0.5%, but figures of 1-2% for ±75kHz deviation are more common. Elaborating the quadrature coil circuit as shown in Fig. 7b is claimed to allow THD figures as low as 0.1% for the same modulation depth, although this will depend critically upon the phase/frequency linearity of the preceding frequency-selective circuitry.

Such gate-coincidence demodulator systems are normally fabricated on a single IC, along with a high-sensitivity IF amplifier/limiter circuit and features such as off-station noise muting, outputs for automatic gain control, automatic frequency control and signal-strength indication. **Figure 8** shows a typical contemporary IC system, that used in the RCA CA3189.

Phase-locked loop demodulator. A technically interesting, though seldom used, method of demodulating an FM signal is that in which a phase-locked loop, of the kind shown in **Fig. 9**, is used to force a linear voltage-controlled oscillator into frequency synchronism with the incoming signal. If the relationship between the DC control voltage for the VCO and its output frequency is truly linear, then the variations in the control voltage of this oscillator are an accurate replica of the modulation of the input RF signal.

Also, so long as the VCO remains in lock, its control voltage, which provides the AF output, is only related to the frequency of the incoming signal and is completely independent of its amplitude. This gives a very high degree of AM rejection, as well as removing a secondary source of signal distortion.

This technique has always attracted me and I described an early receiver using this demodulation method[3]. The basic problem in using a PLL demodulator is that, on the edges of the signal-capture band, the audible noise generated by a mis-tuned FM signal as it swings into and out of the PLL capture range is very high and effective out-of-band muting systems are needed. Nevertheless, within these limitations, a PLL demodulator can offer high linearity, high sensitivity and excellent S:N and capture ratios.

Early FM receiver designs

With the adoption of an entirely new broadcasting system, at least so far as the UK was concerned, engineers needed to become familiar with the circuit techniques used in RF amplifiers, oscillators and frequency changers operating at frequencies in the 88-108MHz range and also with high-gain IF circuitry operating at the now-conventional value of 10.7MHz. Achieving adequate gain and stability was, in both cases, much more difficult than at the lower frequencies with which they were familiar.

Considerable thanks are due to the BBC and those of its engineers working in this field for the circuit designs and accompanying explanatory information which they published during the early years of this period, such as those due to Spencer[4,5] and Amos and Johnson[6,7,8] of the BBC Engineering Training Department. A typical high-sensitivity FM tuner design of the mid 1950s, using a pentode RF stage, a pentode additive mixer with separate oscillator and two 10.7MHz IF stages driving a balanced ratio detector was also described by Amos and Johnstone[9,10].

I built a receiver using this circuit, at the time, for my parents. However, I had not paid sufficient attention to ventilation so that, in spite of my best efforts to establish optimum values for the temperature compensation capacitors, it continued to suffer from frequency drift in the tuning setting, first in one direction and then in the other, due to the differential warming of the various components in the circuit during use. This gave point to some of the earlier reservations which had been expressed by engineers about the likely problems with stability of tuning when VHF broadcasting was first mooted.

A circuit which was somewhat more economical of components, and was therefore perhaps rather more typical of contemporary commercial design, was also described at this time by Hampson[11] of Mullard Ltd. This used a basically similar circuit layout, though with a self-oscillating pentode mixer, and is shown in **Fig. 10.**

Another successful FM tuner circuit published at this time was the very popular Jason design, described in Radio Constructor in 1955, which used a double-triode cascode RF stage rather than a pentode, which gave an improved input s/n ratio. A later design, due to Spencer[11] of the BBC Research Dept, was noteworthy in that it showed a complete FM radio circuit, using a Foster-Seeley demodulator preceded by a dynamic limiter stage, in which the component complement was reduced to the four valves plus rectifier typical of existing domestic AM radio sets.

However, in general, with all valve-operated tuner designs, stability of tuning, particularly over the first few minutes following switch-on, always left something

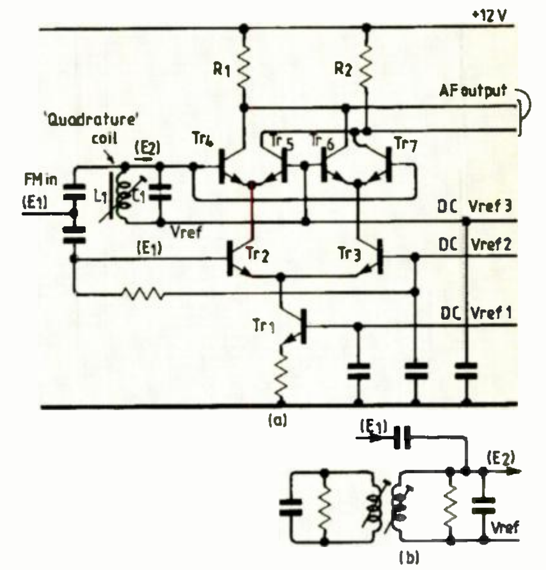
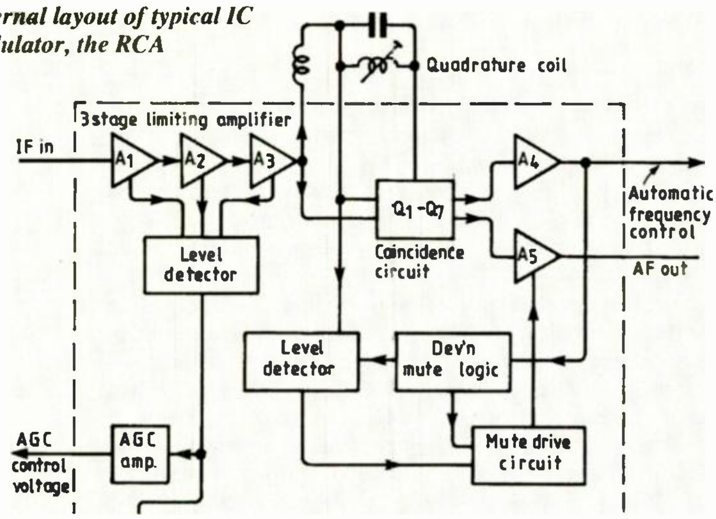


Fig. 7. Modern IC gate-coincidence demodulator, the most common type now in use. Use of a parasitic tuned circuit coupled to the quadrature coil (b) improves linearity.

Fig. 8. Internal layout of typical IC FM demodulator, the RCA CA3189.



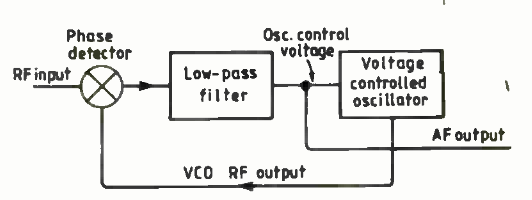


Fig. 9. Bolock diagram of simple phase-locked loop, where VCO control voltage forces oscillator into step with input signal, control voltage being AF output, assuming linear control voltage/frequency relationship.

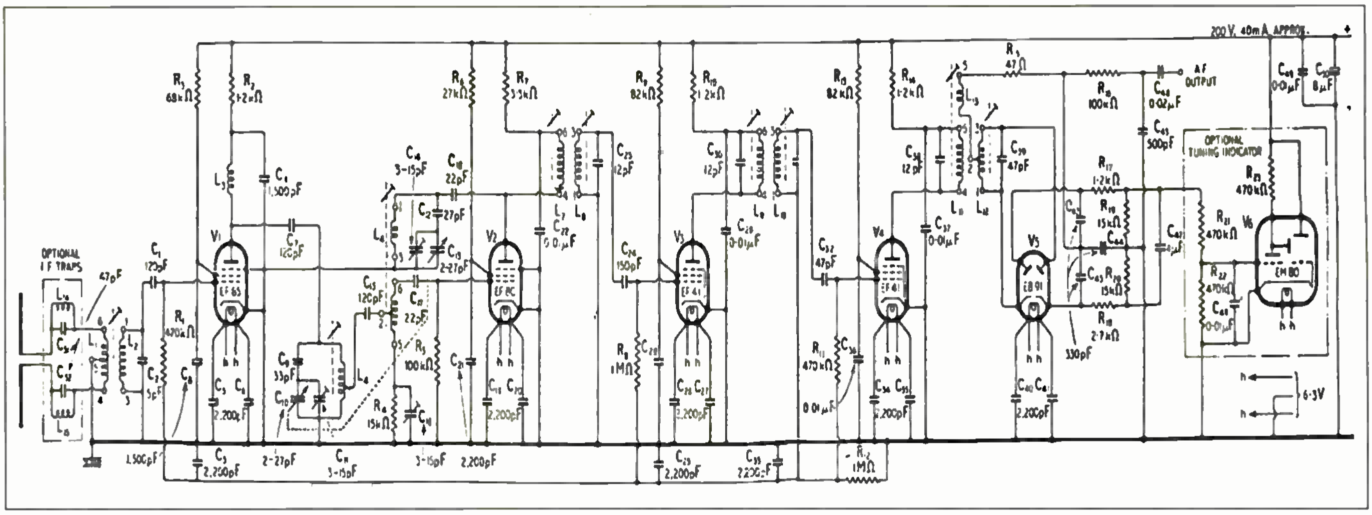


Fig. 10. FM receiver circuit by L. Hampson, published in this journal in 1955.

to be desired; for example, the quoted drift for the Spencer design, which was typical of its genre, was 38kHz during the first eight minutes. The advent of cool-running transistor circuitry offered great hopes for improved performance in this respect.

Transistor FM tuner designs

Because of the difficulty in making reliable transistors with physically thin base regions using simple diffusion systems, most early transistors had a relatively poor HF performance, so that while devices were available, such as the Mullard OC170 which could be used in 10.7MHz IF amplifier stages, there were none which could be used as RF or mixer stage components.

An early solid state design which avoided this difficulty was described in 1960 by Harvey[13,14], also of the BBC Research Dept. A balanced-diode mixer was coupled directly to the aerial circuit, as shown in **Fig. 11**, without any preceding RF amplifier stage. Oscillator radiation into the aerial circuit was minimised by the mixer design.

Phase/frequency characteristics of tuned circuits

The linearity of the demodulation of an FM signal by a gate coincidence type of detector of the kind shown in **Fig. A** depends largely on the linearity of the relationship between the phase of the input signal and the voltage developed across the loosely coupled quadrature coil which provides the other input to the circuit.

An ideal frequency/phase relationship for this application would be as I have shown in line m in **Fig. B** Unfortunately, in real life, a more typical phase/frequency curve would be as I have shown in line n, for which I have also shown the related voltage/frequency response in **Fig. B** Such a sharply tuned circuit will give a phase-shift response which is too abrupt and which also has an S-shaped characteristic, which would give rise to third-harmonic distortion in the recovered audio signal.

Adding a damping resistor across the quadrature coil, as shown in Fig. A2 will make both the voltage and phase/frequency curves less steep, as shown in line r in Figs. B and **C** and will thereby improve the linearity of the demodulator, but at the price of reducing its signal voltage output.

An alternative approach, frequently recommended for this application, is to add a secondary coil as in a band-pass coupled tuned circuit, as shown in Fig. A3. However, potential users are warned not to employ this technique unless they have access to adequate instrumentation, such as an FM oscillator or distortion meter, since if the secondary tuned circuit is incorrectly tuned, the effect of the added tuned circuit may disappear.

Moreover, if the bandpass coil is over-coupled, the resultant double peak in the tuned circuit response can put a kink into the phase response, as shown in line s, which would cause some very unpleasant audible effects. However, if the tuning, the degree of damping and the coupling coefficient are all correct, a much more linear response can be obtained, as shown by the response curve t.

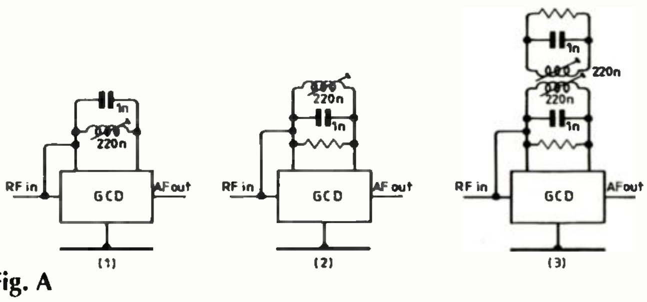


Fig. A

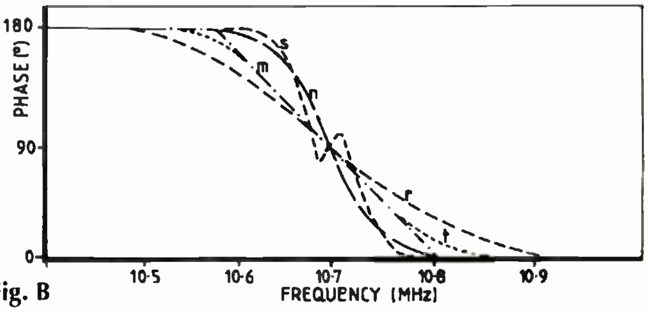


Fig. B

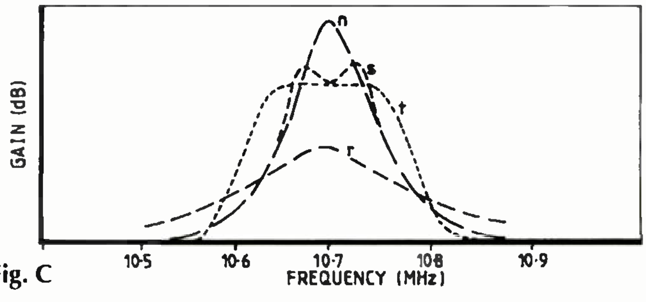
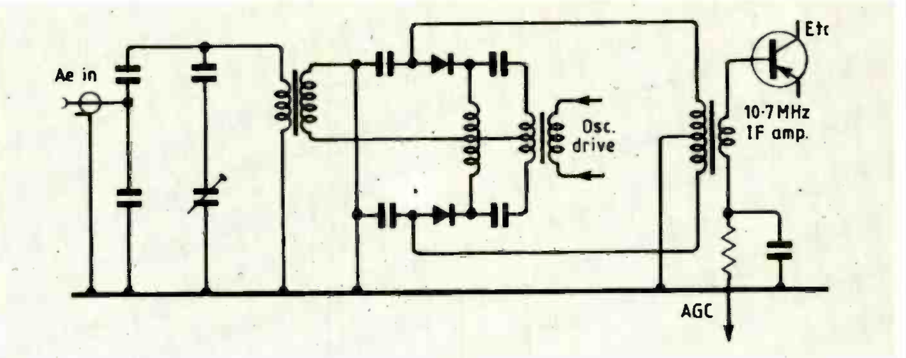


Fig. C

Fig. 11. Since, in 1960, no VHF transistors were readily obtainable, this circuit for a mixer by R.V.Harvey of the BBC was coupled directly to the aerial.



This circuit used the same low-distortion dynamic-limiter/Foster-Seeley discriminator combination used by Spencer. No figures were quoted for frequency drift, but the author described it as "quite small".

Predictably, the evolution of transistor and integrated-circuit technology led to a period of rapid change in FM receiver design during the later 1960s and 1970s before this type of circuitry began to settle down to a fairly standard layout, based on well proven component types and application systems. I will explore this period in a further article. ■

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Voice under the water

Withstanding pressures of ten thousand pounds per square inch, lying at the bottom of an ice-cold ocean, telephone cables must provide at least 20 years of service. The development of long-distance submarine telephony has been a bold and exacting feat of engineering. By Professor David Bell.

Once world-wide radio telegraphic services had been established in 1926 through the high-power Post Office Rugby transmitter, the next target for advancing technology was a telephone communication link between Britain and North America, the two areas which could communicate with minimum language difficulty.

The Rugby carrier at 16kHz could not accommodate the two 3kHz channels required for a telephone circuit so a single circuit was set up with carrier frequencies of 58.5kHz in one direction and 61.5kHz in the other. It used 20kW transmitters and an aerial with a gain of 17dB.

Since demand exceeded capacity the next move was to shortwave radio via the ionosphere, using frequencies between 9 and 20MHz. This provided only four circuits, since three frequencies were necessary for each to suit ionospheric conditions which depended on time of day, time of year and sun-spot cycle.

This era deserves to be remembered for the engineering of MUSA (Multiple Unit Steerable Antenna) for reception, allowing the main beam of the directional aerial to be aimed at the angle of elevation most appropriate to the current ionospheric conditions. The individual units of the array were rhombic aerials, the operation of which is not critically dependent on frequency. These were strung out in line towards the transmitter; the angle of elevation was varied by modifying the phase differences between the aerial units and the receiver. The angle of radiation was varied automatically to find the strongest signal to combat multipath propagation. In the days of valves this needed a line of eight-foot racks, 110 feet long, which contained 1079 valves.

MUSA was an engineering enterprise of epic proportions, but at least all the equipment was accessible for adjustment, replacement or repairs. The proposal to lay a transatlantic cable, containing many valve amplifier repeaters to remain submerged on the ocean floor for 20 years without access was a more daring one. In emergency it was theoretically possible to cut the cable, pull up the ends and splice in a new repeater and length of cable; but this would be an expensive operation and not to be contemplated more than three times at most in the life of the cable.

The first transatlantic telephone connection by cable required two cables, one for each direction of communication, in order to minimise the complexity of the repeaters. A repeater had to be inserted whenever the cable attenuation had reduced the signal level to a minimum acceptable margin above noise. The cable itself used polythene dielectric in the coaxial cable with a copper conductor.

At the time the cable diameter of 0.62in was said to represent the heaviest cable which could conveniently be handled. However some of the later cables were of larger diameter as well as using more repeaters. One of the factors limiting the number of repeaters in a cable is the provision of power; the units are fed in series through the centre conductor of the coaxial cable. For TAT 1, with 51 valve repeaters per cable, this required 4000 volts overall which was supplied as +2000V at one end and -2000V at the other relative to local earth. In addition, differences in earth potential between the two ends could require a further 2000V from a supply unit. (If this sounds an incredibly large voltage for an earth potential, remember that it is between two points about 2000 miles apart so that it represents only one volt per mile.)

TAT 1 came into service in September 1956, providing 36 telephone circuits through two cables with a total of 102 submerged repeaters; its two cables were laid over a distance of 1950 nautical miles between Oban in Scotland and Clarenville in Newfoundland. It is interesting to note that Oban had been chosen as the UK terminal in the days of transatlantic radio because a northern location reduced the incidence of atmospherics.

The success of TAT 1 led to its duplication by the installation of TAT 2 in 1959. In 1961 a twin-cable link between UK and Canada, known as CANTAT 1, used the same type of cable as TAT 1 and 2 but now ventured to consign more repeaters to the ocean depths where the temperature is 2.5°C and the pressure about 10,000 pounds per square inch. It used 90 repeaters in each cable, spaced at 23nm compared with the 38nm of the earlier twin cables. The arrangement provided 80 circuits.

All later links used a single cable and followed a route further south, typically New Jersey to Cornwall, with the exact path determined by survey of the ocean floor contour. An arrangement of four filters, two low-pass and two high-pass, allows a single amplifier in the repeaters of a single-cable link to be effective for signals in both directions. The arrangement is shown in the diagram.

Cables TAT 3, US to UK, and TAT 4, US to France, used a standard known in the Bell System as SD, with a nominal cable diameter of one inch and repeater spacing of 20nm to give a greater bandwidth which, when halved, (for two directions) could provide for 140 circuits. However progress based on increasing the number of repeaters was limited by the practicability of providing power supplies of ever-increasing voltage.

The first major breakthrough came with the use of germanium transistors requiring only 13.1 volts per repeater. This made possible the use of 363 repeaters at a spacing of 10nm in TAT 5, which, in a cable of 12 inches nominal diameter, gave a bandwidth of 6MHz and a capacity of 820 circuits (plus several service channels for diagnosis and control of the system).

Four years later in 1974 the Canada-UK link, CANTAT 2, took advantage of the shorter route to reduce the spacing of its 345 repeaters to 6nm and so increase its capacity to 1840 circuits. This was followed in 1976 by the use of silicon transistors in TAT 6, with 700 repeaters spaced at 51nm to give 4200 circuits in a bandwidth of 29.5 MHz. The cable diameter was 1.7in. Note that in spite of the reduced voltage requirement for transistor repeaters—12V each in TAT 6—the total requirement was over 9kV when one allows for voltage drop along the cable.

TAT 6 was followed by TAT 7 of similar characteristics so that TAT 1 to TAT 7 spanned the eras of thermionic valve and

Optical submarine cables will use signal regenerating fibres to replace discrete component repeaters

Leap in the light

By the middle of the decade international carriers will be able to draw on trans-Pacific optical transmission systems carrying 2.4GBit/s. This represents the equivalent of over 300,000 simultaneous telephone calls per pair of optical fibres. The world's first transatlantic optical cable, TAT-8, which went into service in 1988 can carry 40,000 simultaneous telephone calls.

The new systems will carry 600,000 simultaneous conversations on a single four-fibre cable. Scientists in the research laboratories of AT&T and British Telecom have already demonstrated the high-speed optical transmission techniques required in terrestrial systems. However, transferring these to the special demands of an undersea system presented special problems.

In optical communications systems digital information is carried as a train of light pulses through the fibre. To support the 2.4GBit/s transmission rate these light pulses need to be very short. As the optical pulses travel through the fibre they weaken in signal strength and become stretched, making the information they carry indecipherable. The signals in existing submarine systems operating at 140Mbit/s need to be electronically reconstituted every 40 miles or so. A 2.4GBit/s transmission rate would be impractical with conventional systems as it would require too many repeaters on the sea bed.

To overcome this, researchers have developed an all-optical amplifier which can reconstitute the optical signal without the need for electro-optic conversion on the ocean-floor. The optical amplifiers developed by BT and AT&T boost the optical signal as it travels through a short length of fibre which contains traces of the element erbium. The signal gains its optical energy from a high reliability semiconductor laser that "pumps" the amplifier.

The high efficiency of these optical amplifiers means that there will be fewer ocean-floor repeaters: even with a transmission rate of 2.4GBit/s amplifiers can be over 100km apart.

Another important property of optical amplifiers is that they give the network designers complete freedom to upgrade the capacity of the system without modification. Unlike conventional electronic repeaters, optical amplifiers can support a number of data rates. Last year, BT demonstrated a land-based system using erbium amplifiers that transmitted a data rate of 20GBit/s over 100m. The company expects the first practical implementation of such as high capacity system in a submarine cable before the end of the century.

Scientists at AT&T have looked even further into their crystal ball with a laboratory experiment which demonstrated that it was possible to send ultra narrow optical pulses—each less than one trillionth of a second in duration, called solitons—6000km in a loop of erbium doped fibre acting as its own regenerator.

Scientists are rising to the challenge of underwater telecommunications systems. There is now the possibility that optical signals will one day cross the Atlantic in a single leap without any need for sea bed regeneration. Then the engineers might have invented themselves out of a job.

Richard Wilson Electronics Weekly

transistor repeaters.

TAT 8 is a radical development in two respects: it uses optical fibres instead of electrical conductors. The repeaters are effectively regenerators which send on new digital pulses to replace the attenuated ones. The system uses two fibres per link, one in each direction, with a total of four fibres (two pairs) in the cable.

TAT 8 was the first transatlantic optical link, though cables had previously been laid between various points in the Pacific. An advantage of the optical-fibre system is that it is possible to have a submerged splitting point where a cable can be divided between two destinations, but a sea earth must be provided near the splitting point. This would not be possible with an electrical cable because of problems in providing isolation for the signal while maintaining DC power in the separate branches of the lines.

Trans-atlantic telephone cables installed since 1956

Year	Cable	Circuits	Repeaters	Spacing (nm)
1956	TAT 1	36	2x51	38
1959	TAT 2	36	2x51	38
1961	CANTAT 1	80	2x90	23
1963	TAT 3	140	175	20
1965	TAT 4	140	175	20
1970	TAT 5	820	363	10
1974	CANTAT 2	1840	345	6
1976	TAT 6	4200	700	5.1
?	TAT 7	(similar to TAT 6)		
1988	TAT 8	40,000	200	18

TAT 8 uses one pair of fibres to link the US and UK with the second pair handling traffic between the US and France. The cable has a common run for 3160nm and a splitting point 166nm from France. A further pair of fibres runs from England to France via the splitting point. A shore-controlled switch at this point allows any pair of fibres to be connected to any other, providing some possibility of by-passing a failure at some part of the route. The system has a maximum transmission rate of

Rare earth on the sea bed

Researchers at AT&T's Bell Labs have developed a means of boosting the power of optical signals without using electricity. Their Erbium-doped fibre amplifier is being used in a trial undersea cable running across the Pacific to Tokyo.

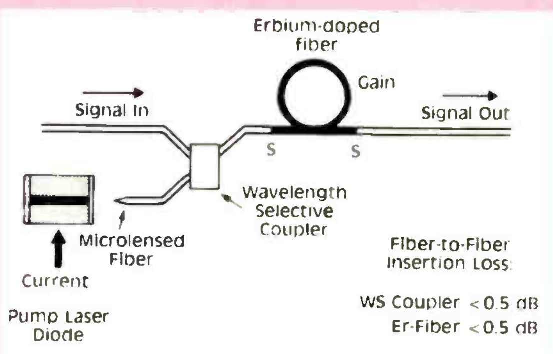
The new device amplifies the light signal passing along the fibre without drawing power from batteries. This means that the operating companies can leave the cables alone for longer periods because the routine maintenance does not need to include changing the batteries.

The problem was how to find a structure which would provide a lased output, a cavity which would oscillate at a convenient frequency when excited by photons. Structures developed by Japan's NTT already exist with outputs at 980nm.

This is a problem because most commercial fibres transmit at 1300 or 1500nm and so the NTT amplifier would force a change in fibre characteristics.

Bell Labs produced a light-driven amplifier based on a silicon fibre doped with Erbium. A pump laser is used to create a population inversion in the energy levels of the erbium-doped fibre. The photons of the incoming signal cause the electrons to drop to the lower energy levels when the two collide, producing an output signal. The US researchers breakthrough is in using a structure which produces inversion at 1480nm. The erbium doping introduces an extra energy level into the process, so that the pump laser does not force electrons directly to the energy at which stable inversion occurs. The electrons are allowed to decay naturally into the stable state from which the incoming signal forces them.

John Zyskind, one of the team which developed the amplifier, said that erbium doping also allowed them to build a more compact device: "You have got to get a very high pump intensity. A lot of work has focused on trying to optimise the waveguide design. If you increase the index difference between the fibre and the waveguide, you can use a smaller core, giving a more confined pump."



Bell Labs uses a molecular chemical vapour deposition (MCVD) technique to dope the silicon fibre. "Not all techniques lend themselves to getting the erbium into the silicon." according to Zyskind. "There is still the issue of how compact you can make the waveguide. You need to confine the erbium to the core but there is a limit to how much erbium you can put in before multi-photon processes set in.

The 980nm lasers have better noise characteristics than the AT&T devices. "But the differences are not tremendous" said Zyskind. "The difference in noise is ldB, between 3 and 4dB. The 1480 lasers avalanche more quickly and you can be more confident of the effects.

"The 980 laser needs to use strain layer quantum wells. You have to mount the fibre on a GaAs crystal with a different crystal structure to make the strains. But you don't want to relieve the strain by having the bonds break."

Zyskind envisages this type of lasing fibre will be hard to manufacture repeatably. In the long term, Bell Labs believes that the light driven repeaters will be less complicated and so easier to maintain than today's devices.

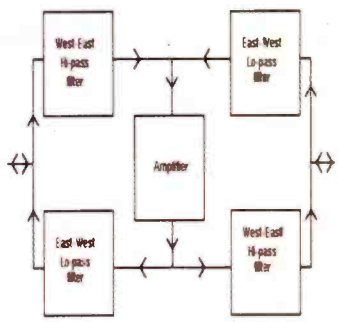
The use of dispersion shifted fibres will also help by allowing even more compact waveguides to be used. ***Rob Causey Electronics Weekly***

295.6Mb/s, allowing space for supervisory circuits while accepting inputs at 280Mb/s on each pair of fibres from the inland telephone services. The repeater spacing is 18nm.

Every repeater regenerates on each of the four optical fibres using a photo diode detector, an integrated-circuit amplifier and a semiconductor laser requiring 6V.

The capacities of the successive transatlantic cables, from 1956 to 1988, are shown in the table as numbers of independent circuits. However, a channel multiplexing technique was developed to increase the effective number of channels. Called TASI (time assignment speech interpolation) it operates on the principle that in normal conversation, the channel in one direction is silent while speech flows in the opposite direction, and occasionally both channels are silent for a short time. TASI takes over temporarily silent channels to form additional circuits, adding up to 40% extra capacity to a cable.

Future high-capacity cable links, whether overland or submarine, will use optical fibres for the foreseeable future. The trend submarine cable development is to increase the distance between repeaters with the ultimate target of a transatlantic link without submerged repeaters. In electrical cables the repeater spacing also affected bandwidth, but this effect, which also occurs in optical fibres, is far less significant. The achievable bandwidth is very great, indeed comparable to the building up of super-groups from existing telephone systems. Experimentally bit rates up to 1Gbit/s have been used over distances of hundreds of kilometers without repeaters.



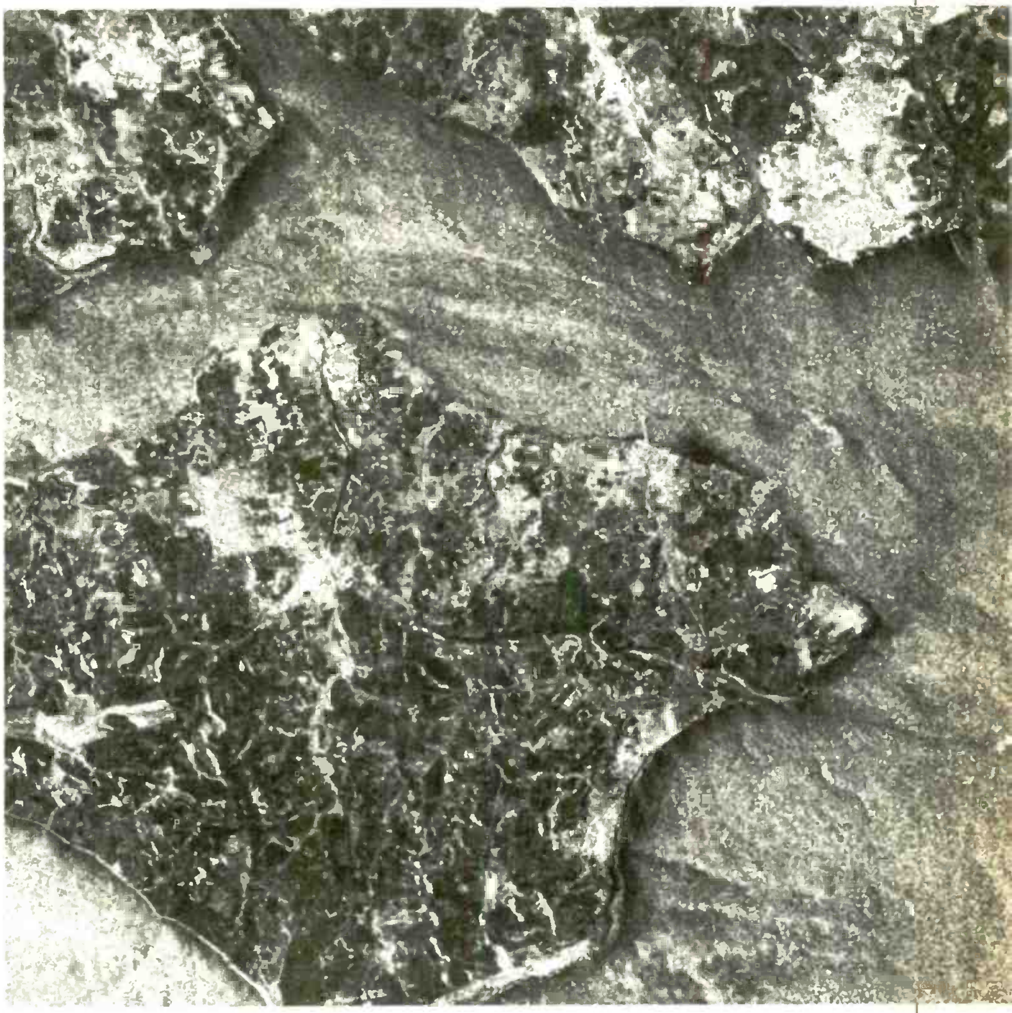
The arrangement of an early submarine repeater. Bi-directional amplification using a single amplifier was obtained by splitting each path into two frequency bands.

There are two new techniques which were not developed in time for inclusion in TAT 8. The first is the use of a laser travelling-wave optical amplifier, i.e. a laser structure with the reflection coefficients at the ends of the active region so reduced that, although there is still gain in the optical transmission band, the feedback is not enough to sustain oscillation. (c.f. the use of "reaction" to increase the sensitivity of early radio receivers.)

Such an amplifier can be used after the bit-modulated laser to increase the transmitted power, or as an in-line amplifier simplifying regeneration of the digits.

The second is the replacement of on/off keying by differential phase shift modulation which makes it possible to accept a lower signal/noise ratio at a receiver. Of course the phase of an optical signal goes around the clock may times over the transmission path and is liable to variation due to temperature effects so that signalling by phase shift would be impossible. However the average received phase can be followed by an automatic phase control system: the changes due to differential phase shift keying can be detected without reference to the absolute phase at the receiver. ■

Picture of the Isle of Wight taken by a synthetic-aperture radar and digitally processed at RAE



ARMLESS PURSUITS

The millions spent on military hardware is set to fall. Organisations that have existed to service the arms industry must now turn their technology to more peaceful pursuits, says Dom Pancucci

Britain's defence research community is going commercial. From April 1, the four non-nuclear establishments will combine into the Defence Research Agency (DRA) and start life as a body formally separate from the Ministry of Defence, with its own financial targets. One of DRA's primary goals is to double its civilian business in the next five years.

Global military spending will plummet in the 1990s and competitive tendering will rule the market, defence systems becoming increasingly high-tech and specific to different tasks. DRA will have to provide cost-effective R&D to a tight brief and this new ethos will open up its expertise to commercial exploitation. As a technical consultancy, the DRA will serve fields as diverse as neural computing, environmental monitoring and telecommunications more efficiently, in addition to working for its MoD and European military clients.

To prove its ability to present a common theme, DRA held a showing of its surveillance work at the MoD in London late last year. All DRA establishments were present, comprising the Royal Signals and Radar (RSRE), Royal Aerospace (RAE), Royal Armament Research and Development (RARDE) and Admiralty Research (ARE). Nigel Hughes, DRA's chief executive designate, explained the new structure. "Our objective is to combine resources to give the customer the best possible deal. We will be paid for results and this will both sharpen up customer decisions and lead to clear relationships", Hughes said.

Ninety per cent of initial DRA turnover will come from the MoD, but this could drop to around 70% by 1995 if non-military income builds up to plan. Surveillance was chosen to mark the inaugural DRA event because it will become more important for the military and represents the chief technology crossover point for civilian applications.

Military technology has obviously made its way into commercial products before, but the formation of DRA should allow a smoother transfer in future. Costly military failures, such as the Nimrod airborne early warning system, are also unlikely to be repeated. Deadlines will be final and not flexible dates.

At the heart of all DRA surveillance research is the work of the RSRE, which develops much of the core microelectronics and signal processing used by the agency's groups. RSRE is one of the primary meeting points with the commercial world in DRA, already collaborating extensively with industry. The establishment has also developed devices such as the Viper processor, which it claims is error-free, and the DAP (distributed array processor). Both are used in civilian electronics, controlling railways and digital signalling.

RSRE projects embrace advanced materials through to sub-systems, and substantial funding comes from the Department of Trade and Industry and business partners. Current activity includes a joint venture with British Telecom and Plessey (Caswell) on bipolar transistors, with 50% DTI funding; another is a project with Plessey, STC and the DTI, to obtain damage-free data through cables. The group is seeking European deals with Germany's Daimler Benz and Thomson of France. RSRE is active in the European Community's technology programmes such as the JESSI chip joint venture and Esprit, where it is helping to develop superior materials growth techniques.

Device development

At the London surveillance show, RSRE displayed some of its most advanced work in optical and high-speed electronics, as well as gallium arsenide processes for high-power and microwave circuits. "We are concentrating on light emission from silicon, which has so far been impossible with a semiconductor", said Sukhdev Gill, an RSRE microwave devices engineer. "By some processes with silicon we have managed to produce quantum wires and get red light emission. This is a first with silicon wafers." Circuitry totally based on optoelectronic silicon would allow for very high speed signal processing. Quantum wires produced by the RSRE are 15,000 times thinner than a human hair and are grown by chemically leaching silicon in an anodising cell.

Silicon also suffers from parasitic qualities which partially degrade signals. Gill said that RSRE is looking closely at this problem. "One approach is putting silicon on an insulator. This not only provides radiation hardness but reduces parasitics, leading to higher speeds", Gill explained. Combining the optical work with such high-speed electronics will follow. RSRE is also keeping faith with gallium arsenide; Gill admits that the market has not reached its predicted level of success, but believes adequate niche markets will appear in Europe. With high power-efficiency qualities, gallium arsenide devices are ideal for both phased-array radars and hand-held communications, because they handle microwaves cleanly. "Gallium arsenide is good for mobile telephones because it only uses power to put out a signal, with no other dispersion", he said. This energy efficiency is also crucial in modern radars where the array is made up of many small cells, each requiring a precise number of watts.

Older hybrid microwave devices are now giving way to monolithic microwave integrated circuits (MMICs) made out of gallium arsenide for active-array radars. This is leading to smaller modules and lower production costs. RSRE has played a key role in developing MMICs, which have also allowed the introduction of digital beam-forming techniques.

"Our objective is to combine resources to give the customer the best possible deal. We will be paid for results and this will both sharpen up customer decisions and lead to clear relationships"

Radar

Integrating the results of different surveillance systems is another key area of research at RSRE and transputers are being used to mix optical, acoustic, microwave and electronic signals into a form which is coherent to the user. Transputers are being used to digitise and read maps and in the development of air traffic control systems. While RSRE provides many of the electronic building blocks for systems, the other three establishments tailor technology to fit different surveillance needs. ARE has developed a single phased array radar for warships, replacing three traditional radars. Called MESAR, the radar is claimed by ARE to be the first of its kind under full software control. "MESAR can be used on land and sea and in the air, simply through changing the processing", said Bill Levett of ARE's MESAR group. "It allows for accurate waveform control on transmission and processing on the return signals. This sorts out targets from radar clutter,and is politically important because in combat you don't want to get neutral targets involved."

The US has shown particular interest in MESAR and may be envious of its ability to identify types of aircraft, given that the USS Vincennes shot down an Iranian Airbus in the Gulf a few years ago. The Aegis integrated computer system, linked to the ship's radar, failed to identify the Airbus as a civilian aircraft, believing it to be a fighter-bomber.

That mistake cost the US dear in terrorist revenge attacks. When warships are fitted with MESAR, which may happen within the next five years, the systems controlling weapons will be independent from the radar. This allows for a minimum of error, as the officers in charge of the ship's weapons will exercise complete control, assisted by the best possible information. MESAR is one project which will not transfer to civil applications because of its relatively high cost and power consumption, which is around seven kilowatts. Yet it shows how establishments in DRA can collaborate.

ARE has taken RSRE's DAP processor to run the heart of the MESAR system. Developed with Advanced Micro Technology (AMT), which was originally part of the computer company ICL, the DAP device processes data at hundreds of megaflop/s and controls distributed 80486 processors on the MESAR sub-systems. Wave computational hardware from Siemens-Plessey completes the main electronics platforms in the radar. "We now have computational power at a price we can afford. Microwave and control circuitry are coming together at the right time", said Levett. The MESAR project also reveals the new customer-oriented bias in DRA. Software for the working prototypes of the radar has been written in the Ada language, extensively used for computer-aided software engineering. Customers with specific applications for MESAR can therefore emulate solutions to fit their particular software requirements.

Satellite surveying

Mapping the Earth from space is a key area of work in RAE which has clear civilian uses. Optical infrared sensors and radar are both techniques used by RAE's space division to work with Continental and US satellites, as the UK has no orbiting hardware. RAE believes that environmental problems, like the shrinking Amazonian rain forest, could be tracked with radar.

Agricultural land yields could also be monitored using space radars, which have an advantage over optical systems because they remain unaffected by adverse weather conditions. RAE technology to map from orbit uses synthetic aperture radars (SARs) to produce a waveform profile of any surface it is targeted on. The characteristics of the waveform patterns are then translated optically into images.

In May, the European Space Agency will launch BRS-1, a satellite equipped with SARs made by Marconi Space Systems and using RAE design. The satellite will concentrate on maritime monitoring and its radars will be powerful enough to detect even small vessels through the wake they leave in the ocean.

DRA has a long way to go before it can truly claim it has branched away from its military roots. It has yet to settle issues such as the intellectual property rights covering processes it may contract out in the future. But at least the so-called peace dividend will allow some of the advanced techniques traditionally enjoyed by the military to see light in the wider world. ■

MODELLING WITH MATHCAD

Adept says that MathCAD 2.5 will produce a document containing equations, text and plots, the equations being solved as they are typed. Ken Smith investigates the claims

Engineering, with any degree of precision, requires mathematical techniques to analyse and model real-life situations. Time-consuming tediousness and the probability of error make any assistance with such calculations very welcome indeed to most practical engineers. The advent of the scientific calculator was one such stride forward and, amongst others, MathCAD is another much larger leap.

Unlike many other software packages in the modelling, simulation and design fields, such as the specialised Codas, MathCAD is a completely general tool, which the operator can adapt to any situation requiring mathematical analysis. While not as powerful as Mathematica, which does symbolic maths, transposition, integration, etc., MathCAD handles formulae, numbers, units (and their conversions) FFTs, text, plots and more. A plot of the first five Bessel functions appears in **Fig. 1** and an enlarged version in **Fig. 2**

Installing MathCAD

The package contains a very comprehensive, 260-page user guide; a reference booklet with all the (numerous) menu commands, operators, built-in functions and error messages; a quick-reference card for memory jogging while you run the program; and last-minute notes on bugs and changes.

MathCAD is contained on two 5.25-in disks or on one 3.5-in disk. Installation proceeds in a standard way by setting up a directory on your machine's hard disk (MCAD, say), then copying all the files from the master disk(s) to this directory. No complications arise, as the software is not copy-protected.

HARDWARE REQUIREMENT

Compatible PC, XT or AT computer, including PS/2 series; PC/MS-DOS 2.x upwards;

CGA, EGA, VGA or Hercules mono; 512K ram minimum, 640K recommended, hard disk recommended. Two floppies minimum;

Maths co-processor supported, but not necessary. Supports a wide range of printers and plotters via included drivers.

Typing MCAD auto-executes the program, which detects your graphics system, sets up the configuration and displays the appropriate initial screen. The few graphics cards that may fail the auto-select can be manually set up by backslash options. You can vary the screen colours from the default values by changing a set of foreground and background (/Fnn and /Bnn) numbers at start-up. These colours can also be changed by a (Ctrl-D) operation while running. MathCAD takes all available memory in default. To limit the amount taken, you type /Lnnnn (Kbytes) at start-up.

Setting up with floppies only is just as simple, but more tedious while program running. The usual injunction to place the master discs in a safe place and only run from the copy obviously applies.

Running MathCAD

With directory MCAD in place, you can load an existing file at switch-on by entering MCAD *filename* (return). To start a new file, or merely run the program as a "no-file" calculator, you simply open the start-up screen, which is filled with an indefinite number of invisible "windows", called regions. Entering numbers and symbols, together with the operators and especially the definition operation (a colon, not the =), automatically generates an equation region. Symbols may be constants such as pi (entered as p) or variables.

A simple text editor is incorporated for descriptive blocks. Such text is entered after striking the double quote key ("), the result being a text region; to leave the text region, you simply move the cursor out of the box. Other regions include the two types of plot: 2-D plots and surface plots, plus the sketch region.

Regions can be viewed as rectangular windows by toggling (Ctrl-V) and grow or shrink according to material entered or deleted by the keyboard. They can overlap, but line insertion commands can separate them again. Equation regions must contain definitions of all variables somewhere above the line of execution; in other words, MathCAD works by sequentially evaluating each region from top to bottom of the document. Use of the "=" sign instructs the program to calculate a result. You would use "=" in a simple calculator mode, or at the end of a chain of definitions and substitutions.

The usual practice with data entry and command structures results in a learning curve of some hours, and MathCAD has numerous instructions. Equation editing and entering parentheses takes a fair amount of practice, but the quick-reference card proves particularly useful after initial familiarisation. A large number of examples can be called up as files, which is a simple process and needs only three keystrokes: (F5) calls up "file to load" on the screen top bar, then typing (*)(return) brings up the scrolling menu. Finally, pressing (return) again, loads the file which is highlighted in the file list.

The brief description above of driving MathCAD from the keyboard does not in any way absolve the user from a full knowledge of mathematics and the manipulative techniques required. What the software does is to enable rapid number crunching and the exposition in graphical form so useful in analysis and modelling. To this end (in common with some more specialised software), the vector and matrix operations come into their own. (Imagine evaluating the product of, or inverting 10 or 15 row/column matrices on a piece of paper).

Available functions and operations

In addition to processing equations, either real or complex, MathCAD enables you to work with quantities, in either manual or auto mode. In auto, the calculation is executed as soon as the cursor leaves the region, which can result in very long repeat processing times. The manual mode enables the user to carry out all changes before executing the whole calculation once at the end, by typing (Esc) calculate (return) or simply (F9). The range over which a calculation (strictly speaking over a domain — the range then follows), is made is determined either by running the independent variable through a series of values using a subscript notation, or by setting up the running series as a vector.

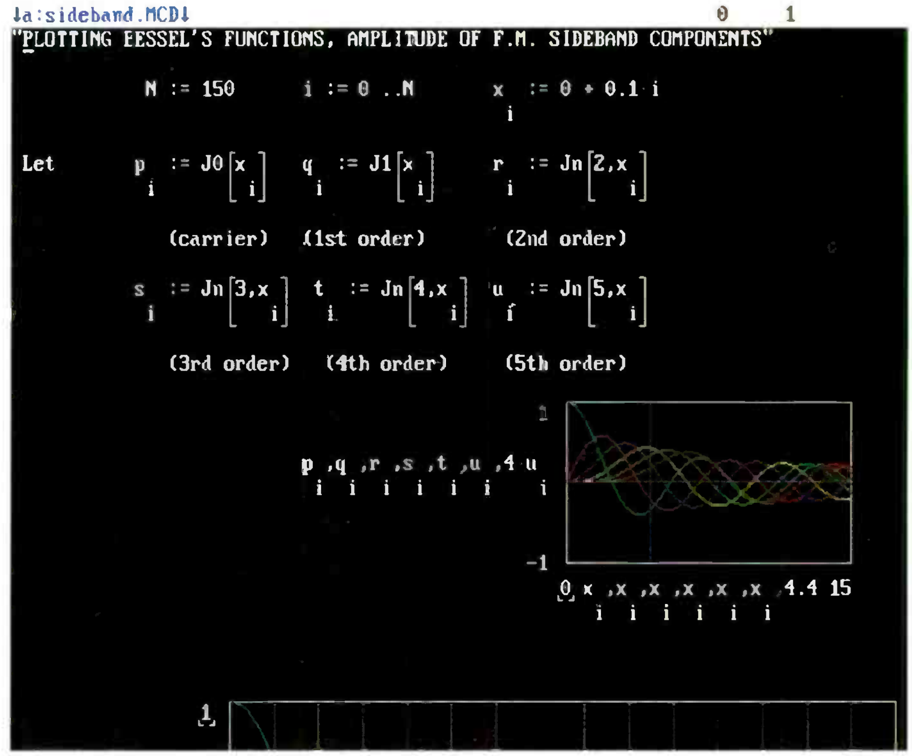


Fig. 1. Two-dimensional plot, showing multiple traces. Complexity of MathCAD is well illustrated in that the traces are of the first five orders of Bessel functions. On small plot, vertical marker at x=4.4 cuts curves at ordinate values corresponding to sideband amplitudes in FM with 4.4 as modulation index.

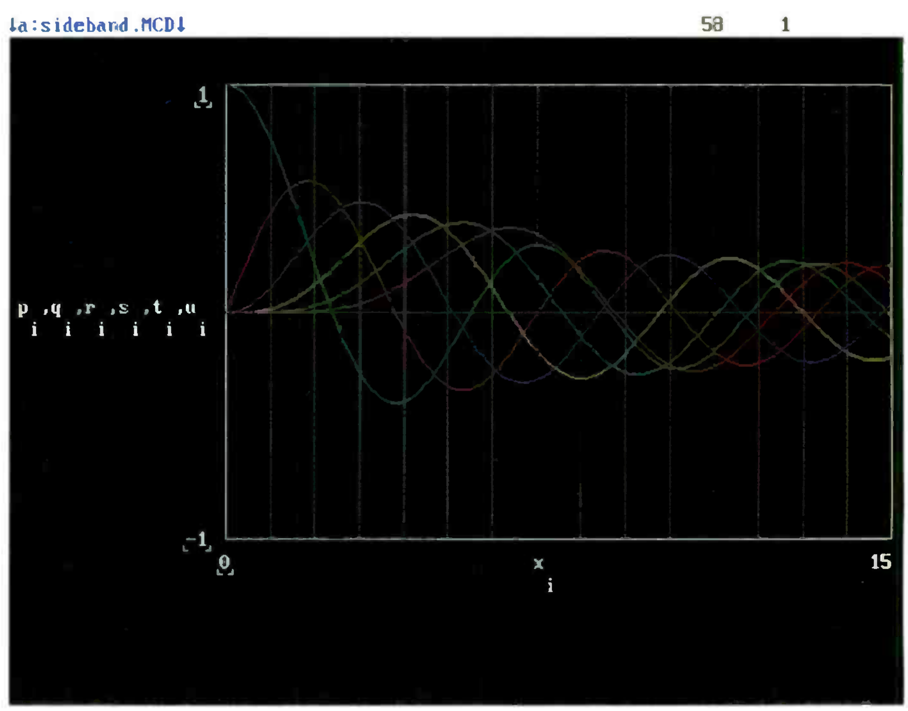


Fig. 2. Enlarged plot of traces in Fig. 1, without vertical marker.

Solving equations is facilitated by invoking a specific function called "root".

MathCAD's power to carry out vector manipulations has already been mentioned. In addition, the program can handle sums and products over a range, similarly to running through a loop in a programming language. It carries out numerical differentiation and integration and all the transcendental functions are available, as are random numbers, statistical, sorting and interpolation functions, together with a real or complex fast Fourier transform and inverse implementation. The availability of Bessel functions is very useful to comms engineers.

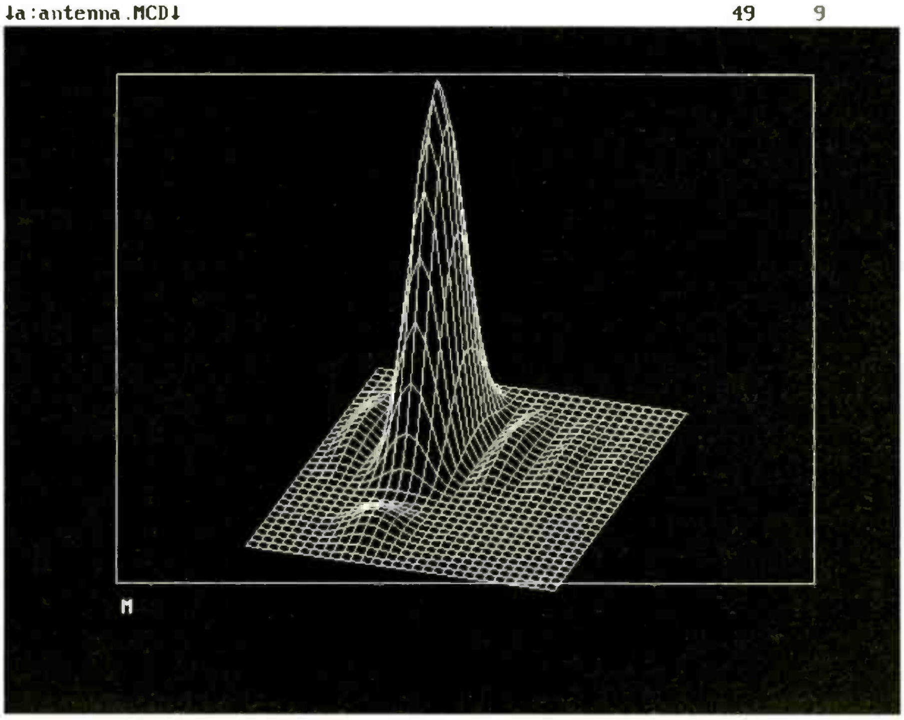


Fig 3. Full screen plot derived from the expression in Fig. 4. It describes the beam power lobes of an aerial system.

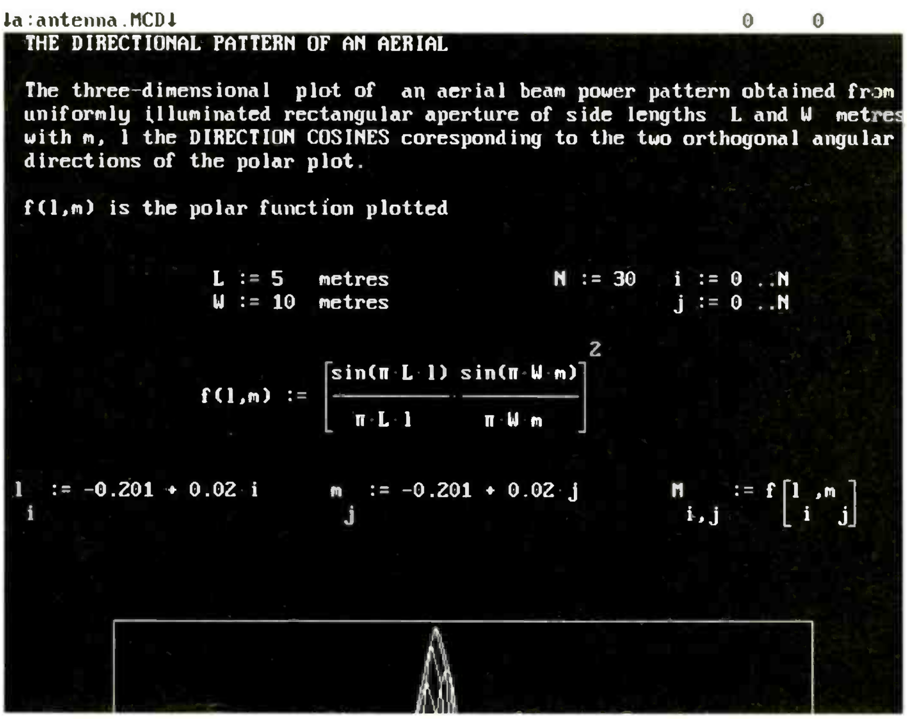


Fig. 4. Function of two variables describes beam pattern of an aerial. Matrix is set up with required number of rows and columns and value of function inserted at each element position by MathCAD.

Seeing your work

One of the most valuable extensions to this version of MathCAD is the surface plot function, shown in **Fig. 3** with the function describing it in **Fig. 4**, the ordinary plot function available in earlier versions still being available.

The new 3D perspective view proved most useful in visualising a function of two variables; in the example shown, the power pattern from an aperture aerial has been plotted. Direct plotting yields a "wire-frame" net which appears transparent (and confused). One of the options in formatting plots hides the reverse side view and gives a solid representation, as illustrated. The direct plot is fairly slow, but the hidden-lines plot took many minutes, since a calculation is carried out on each point to determine whether it lies in the hidden region. I did not try using a co-processor, but a useful increase in speed would be probable.

The way MathCAD plots plane or 3D representations rests on a standard computing technique of either a vector list for the ordinates or an array distribution, each element containing x,y information from the row/column numbers and the value of the element corresponding to z. **Figure 5** shows how the graphics plots the ordinate z above the x-y plane containing the matrix array. Instruction "join" connects adjacent points with a straight line in both x and y directions.

A further extension of MathCAD 2.52 enables graphics compiled by cad drawing programs and saved in HPGL format to be converted into MathCAD format (using a program called MCSTRANS). A sketch region is created on the MathCAD screen and the converted graphic simply imported into it. The drawing can then be formatted from within MathCAD.

Conclusions

MathCAD contains rather more detail than this short review has covered. A frequency/phase response can be plotted and polar, including Nyquist, plots can be set up with a few keystrokes. MathCAD can do everything that, say, Codas can do, but initial setting up of the model is more intricate, as the software is generalised. Presentation is not so attractive in some ways, and the page layout varies with the skill and preference of the user. On the other hand, large text regions can be incorporated into the document, as can graphics, so MathCAD can produce papers and articles directly.

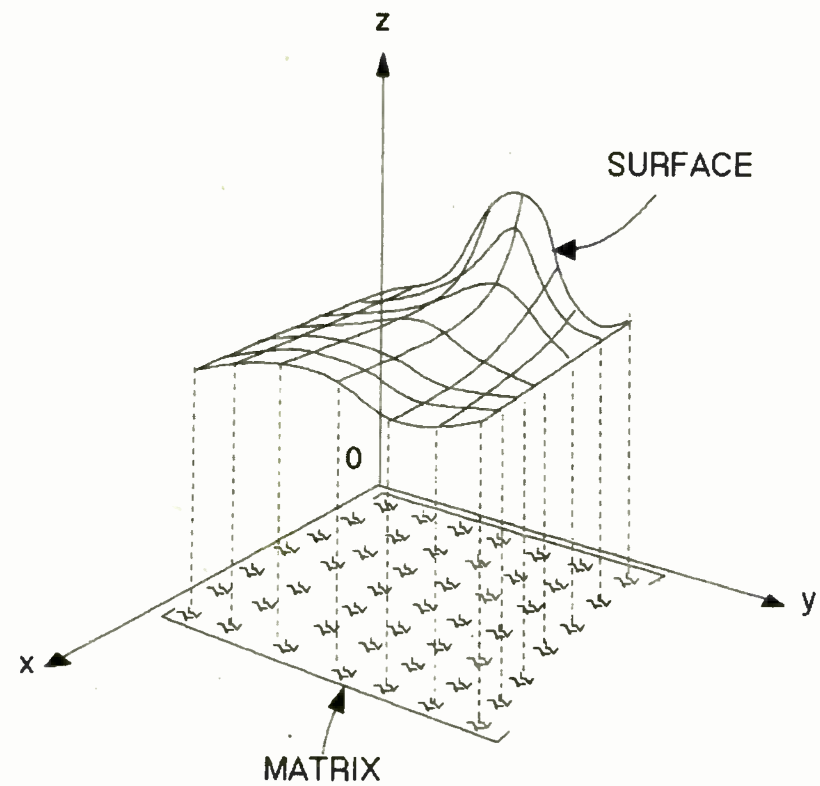
Fonts used on screen and in print-outs

SUPPLIERS

MathCAD is manufactured by MathSoft Inc. and marketed in the UK by Adept Scientific Micro Systems Ltd, 3 Letchworth Business Centre, Avenue One, Letchworth, Herts. SG6 2HB. Telephone: 0462 480055

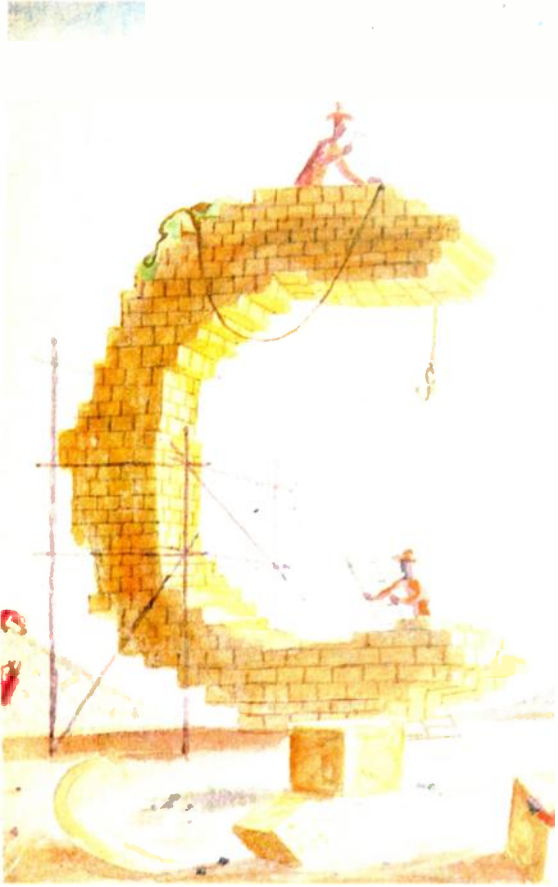
The MathCAD package costs £375.00 for a single user, application packs £75.00

Fig. 5. MathCAD plots surfaces by an x,y matrix method shown here. All plots are on Cartesian axes system and polar coordinate equations need conversion to x,y,z as part of programming.



appear a little clumsy, as subscripts and superscripts appear too low or too high respectively, as well as being in the same type size as the main symbols. It is regrettable that the authors have not incorporated even the flexibility of that obtained by say, the low-cost CHIWRITER technical wordprocessor.

However, these are quibbles. The program is so powerful that, for the rather modest outlay, any electronic engineer with an IBM or compatible should not be without this package. This is especially true in that a support package (Electrical Engineering) is available, though not reviewed here, as well as a newsletter, with tips, techniques and news sent every three months. ■



INTERFACING WITH C

PART 11

Having examined autocorrelation theoretically last month, Howard Hutchings now goes on to the practicalities of using it in the detection of signals in noise.

Interfacing with C

An accompanying set of 57 source code C listings presented with this series is now available on disk, price £25.50+VAT. We will shortly be publishing a book "Interfacing with C" written by Howard Hutchings and based on the series, but containing additional information on advanced processing techniques. We are now accepting advance orders, price £14.95.
Prices include post and packaging. Please make cheque or company order payable to Reed Business Publishing Group and send to Lindsey Gardner, room L333, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Credit card orders can be phoned through on 081-661 3614 (mornings only).

Generating random noise and computing the ACF

Much of this chapter has been rather theoretical, but abstract concepts or hard-to-believe phenomena can be demonstrated quickly and with clarity using the PC. It is a simple matter to generate random noise and autocorrelate, before finally displaying the processed output graphically on the monitor. This form of hands-on experience appears to help many engineers climb steep learning curves with the minimum amount of assistance.

The following example will generate random noise as a sequence of integers in the range 0 to 255. The range is deliberately restricted to the requirements of an 8-bit A-to-D converter. The ACF will be calculated and displayed using the shift-multiply and summate structure, although the order has been modified. Refer to the controlling for-loop for details. In order to emphasise the impulsive nature of the ACF, it was necessary to modify the position of the origin. The details are explained in the annotated **listing 7.5**.

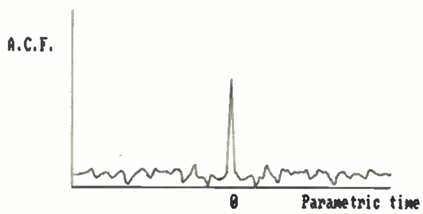


Fig. 7.11. Screen dump of ACF of random noise generated using listing 7.5.

```
/ ***********************************
*    ACF WITH COLOUR GRAPHICS      *
*    RANDOM NOISE GENERATOR        *
*********************************** /
#include<stdio.h>
#include<graph.h>
#include<math.h>
#include<stdlib.h>
/*-----------------------------------------
   THE FUNCTION rand() IS IN THE
   STANDARD LIBRARY
-----------------------------------------*/
#include<time.h>
/*-----------------------------------------
USED TO DETERMINE INITIAL SEED WITH
   time()
-----------------------------------------*/
#define RANDMAX 255
#define PI 3.14159
#define N 320
main()
{
struct videoconfig screen_size;
int x, k;
double sum[N + 1], contents[2 * N + 1];
int randnum;
double noise;
srand((unsigned)time(NULL));
/*-----------------------------------------
   FUNCTION srand() IS USED TO
   DETERMINE STARTING POINT OF
   PSEUDO-RANDOM SEQUENCE
```

```
-----------------------------------------------------*/
for(;;)
{
_setvideomode(_DEFAULTMODE);
_setvideomode(_HRES16COLOR);
/*---------------------------------------------------
                     EGA MODE
-----------------------------------------------------*/
_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);
/*---------------------------------------------------
                 DRAW X & Y AXES
-----------------------------------------------------*/
_settextcolor(3);
_settextposition(4, 13);
_outtext("A.C.F.");
_settextposition(14, 50);
_outtext("Parametric time");
/*---------------------------------------------------
            COLOUR AND POSITION TEXT
-----------------------------------------------------*/
for(x = 0; x <= 641; x++)
{
/*---------------------------------------------------
             GENERATE SYNTHETIC DATA
-----------------------------------------------------*/
randnum = (rand() % RANDMAX) + 1;
/*---------------------------------------------------
      MODULO OPERATOR RETURNS THE
        REMAINDER OF THE DIVISION
-----------------------------------------------------*/
noise = randnum * 5 / 255;
/*---------------------------------------------------
              SIMULATE 5V MAXIMUM
-----------------------------------------------------*/
contents[x] = noise;
}
/*---------------------------------------------------
                 ACF ALGORITHM
-----------------------------------------------------*/
for(k = N / 2; k >= 0; k--)
{
sum[k] = 0;
for(x = 0; x <= N; x++)
{
sum[k] += contents[x] * contents[x + k] / N;
}
_setcolor(14);
_moveto(k + 160, -7.2 * sum[k]);
_lineto(k + 160, -7.2 * sum[k]);
_moveto(160 - k, -7.2 * sum[k]);
_lineto(160 - k, -7.2 * sum[k]);
}
/*---------------------------------------------------
REPOSITION THE ORIGIN TO THE MIDDLE
              OF THE X AXIS
-----------------------------------------------------*/
_settextposition(16, 20);
printf("Mean square value = %f\n", sum[k]);
getch();
/*---------------------------------------------------
               HIT ANY KEY TO EXIT
-----------------------------------------------------*/
}
}
```

Anatomy of the program

The random-noise generator is seeded using the function time(), which returns the calendar time as the number of seconds elapsed since January 1 1970. Initialisation is achieved using the function srand(), which determines the starting point of the random sequence. To ensure that the generated number is in the range 0 to 255, the modulus operator (%) was used. This specifies that the first operand, in this case rand(), is divided by the second operand RANDMAX and that the remainder, not the quotient, is returned. The remainder will always be less than the divisor which, in this example, is 255.

Using autocorrelation to detect noise-corrupted signals

Detection of weak periodic signals corrupted by white noise can be achieved using autocorrelation. Consider the signal processing implemented by the system in **Fig. 7.5.** Here the input signal $x(t)$ consists of two components — $x_1(t)$, a small amplitude periodic signal;

and $x_2(t)$, a random signal modelled as white noise. As usual, the autocorrelated output is given by:

$$r_{xx}(\tau) = \lim_{T\to\infty}\left[\frac{1}{T}\int_{-T/2}^{T/2} x(t)x(t+\tau)\,dt\right]$$

If the noisy input is written as $x(t) = x_1(t) + x_2(t)$, the autocorrelation function can be expressed:

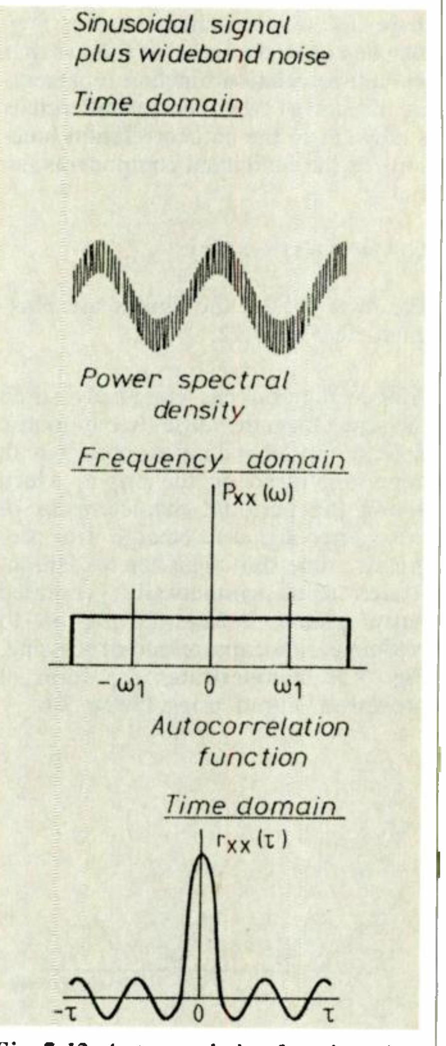


Fig. 7.12. Autocorrelation function of a sinusoidal signal corrupted by wide-band white noise.

$$r_{xx}(\tau) = \lim_{T\to\infty}\left[\frac{1}{T}\int_{-T/2}^{T/2} (x_1(t)+x_2(t))(x_1(t+\tau)+x_2(t+\tau))\,dt\right]$$

$$= \lim_{T\to\infty}\left[\frac{1}{T}\int_{-T/2}^{T/2} x_1(t)x_1(t+\tau)\,dt + \frac{1}{T}\int_{-T/2}^{T/2} x_1(t)x_2(t+\tau)\,dt\right.$$

$$\left. + \frac{1}{T}\int_{-T/2}^{T/2} x_2(t)x_1(t+\tau)\,dt + \frac{1}{T}\int_{-T/2}^{T/2} x_2(t)x_2(t+\tau)\,dt\right]$$

hence:

$$r_{xx}(\tau) = r_{11}(\tau) + r_{12}(\tau) + r_{21}(\tau) + r_{22}(\tau)$$

The first and last terms represent the autocorrelation functions of the signal and noise respectively. The two middle terms symbolize the autocorrelation functions of the uncorrelated signal and noise components. Since these signals share no common characteristic, they may be equated to zero. It follows that the autocorrelation function representing the sum of two uncorrelated signals is the sum of the autocorrelation functions of the individual components, so that:

$$r_{xx}(\tau) = r_{11}(\tau) + r_{22}(\tau)$$

The facts behind the figures are illustrated in **Fig. 7.12**.

Autocorrelation has effectively sifted the signal from the noise. In parametric time, the wideband noise appears as an impulse centred on the origin, which allows the periodic characteristics of the wanted signal to emerge with progressive time shift. This can be demonstrated using synthetically generated noisy signals, before moving on to real-time data capture and processing. **Fig. 7.13** demonstrates the form of processed output using **listing 7.6**.

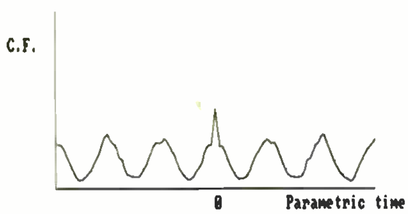


Fig. 7.13. Synthetically generating a sine wave of amplitude 2V and frequency 500Hz, together with random noise of amplitude 5V, using listing 7.6.

Listing 7.6

(FIG 7.13)

```
/ ***********************************
*  GENERATING A SINEWAVE 2V PEAK   *
*  FREQUENCY 500 Hz. PLUS RANDOM   *
*    NOISE 5V PEAK. T 25 MICRO-SEC  *
*********************************** /
for(x = 0; x <= 641; x++)
{
randnum = (rand() % RANDMAX) + 1;
noise = (double)randnum * 5 / 255;
contents[x] = 2 * sin(2 * PI * 500 * t) + noise;
t = t + 0.25e-4;
}
```

ACF with real-time data capture and graphics

Autocorrelation of real signals requires the accumulation of a large number of sequential samples prior to processing. The maintenance of an historical record and the looking back in time before computing the current output is a familiar problem — but one already solved earlier with the help of Fourier transforms. As before, the Blue Chip Technology high-speed data acquisition card ACM-44 will be used.

This peripheral board is configured to process unipolar signals in the range 0–5V. The base address is selectable in the prototyping region of hexadecimal 300 to 3FF. Data capture and storage is realised inside a controlled for-loop. A sampling interval of 25μs is achieved by writing to the 8-bit A-to-D converter to start conversion — strobing. This is followed by storage in a primitive array, declared as the data type int. The structure of the program has already been explained in connection with the FFT of real signals. The sampling rate could be improved by writing a data-grabbing routine in assembly language, leaving the number crunching and graphics to C.

Listing 7.7

```
/ ***********************************
*  ACF OF REAL SIGNALS. SAMPLING   *
*      INTERVAL T = 25 MICRO-SEC    *
*********************************** /
#include<stdio.h>
#include<graph.h>
#include<math.h>
#include<conio.h>
#define N 320
#define BASE 768
main()
{
struct videoconfig screen_size;
int x, k, temp[2 * N + 1];
double sum[N + 1], contents[2 * N + 1];
outp(BASE, 1);
/*-----------------------------------------------------
                SELECT CHANNEL
-----------------------------------------------------*/
for(;;)
{
_setvideomode(_DEFAULTMODE);
_setvideomode(_HRES16COLOR);
/*-----------------------------------------------------
                  EGA MODE
-----------------------------------------------------*/
_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);
/*-----------------------------------------------------
                DRAW X & Y AXES
-----------------------------------------------------*/
_settextcolor(3);
_settextposition(4, 13);
_outtext("A.C.F.");
_settextposition(14, 50);
_outtext("Parametric time");
/*-----------------------------------------------------
          COLOUR AND POSITION TEXT
-----------------------------------------------------*/
for(x = 0; x <= 640; x++)
{
outp(BASE + 2, 0);
/*-----------------------------------------------------
              START CONVERSION
-----------------------------------------------------*/
temp[x] = inp(BASE + 2);
}
for(x = 0; x <= 640; x++)
{
contents[x] = (double)temp[x] * 5 / 255;
}
/*-----------------------------------------------------
              ACF ALGORITHM
-----------------------------------------------------*/
for(k = 0; k <= N; k++)
{
sum[k] = 0;
for(x = 0; x <= N; x++)
{
sum[k] += contents[x] * contents[x + k] / N;
}
_setcolor(14);
_moveto(k, -7.2 * sum[k]);
_lineto(k, -7.2 * sum[k]);
/*-----------------------------------------------------
            PLOT AND SCALE ACF
-----------------------------------------------------*/
}
_settextposition(16, 20);
printf("Mean square value = %f\n", sum[0]);
getch();
/*-----------------------------------------------------
            HIT ANY KEY TO EXIT
-----------------------------------------------------*/
}
}
```

Autocorrelation in the real world

To get the most out of this chapter, apply the program and process the ACFs of real signals. The code to generate the ACF is relatively compact and much of your effort will be directed towards improving the display or making the system more sensitive. I had a great deal of fun processing corrupted signals using the random-noise gener-

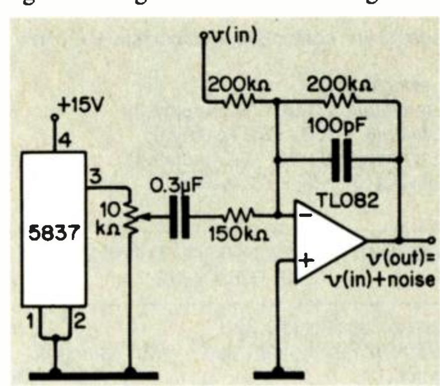


Fig. 7.14. 5837 digital noise generator produces 10V pulses whose durations are random integer multiples of 20μs. Feeding the random output signal through a 10kΩ potentiometer allows the amplitude of the noise to be attenuated before it is added to the output of the signal generater in the summing amplifier/low-pass filter.

ator (**Fig. 7.14**) together with a general purpose function generator. My efforts are reflected in the oscilloscope photographs and screen-dumps shown in **Fig. 7.15**.

The cross-correlation function

When a deterministic signal is applied to the input of a linear system, the output will be related in some way to the input. For example, a step input will produce the familiar exponential response if the system is first-order. If the amplitude of the step is doubled, then so is the output response with no change in signal shape. It is important to realize that this simplistic test characterizes the system as linear. Recognize that this does not imply a straight-line relationship between the input and output variables. It implies rather that the input waveform and output response are related by a linear differential equation.

If these results are extended to stochastic signals, it can be concluded that when a signal from a random process is applied to the input of a linear-signal processor, the output will be connected in some way to the input. Autocorrelation identifies similarities in amplitude and frequency, although it fails to reveal the phase characteristics of the system. This restriction can be overcome by modifying the autocorrelation function, and cross-correlating the input and output signals. Cross-correlation is defined by:

$$r_{xy}(\tau) = \lim_{T\to\infty}\left[\frac{1}{T}\int_{-T/2}^{T/2} x(t)\,y(t+\tau)\,dt\right]$$

where the input signal $x(t)$ is multiplied by the processed output $y(t+\tau)$ and the product is averaged. The operation of integration gives the long-term average of the product. If each coefficient is plotted, this produces the cross-correlation function which reflects similarities of the amplitudes, frequencies, and phase angles of all the components in the integrand.

What does all of this mean to the engineer slaving over a hot soldering iron? Correlation is essentially a filtering operation, performed not in real-time but in parametric time. The correlation coefficient is an index of similarity between two waveforms.

Convolution, correlation, and filtering are a triad of signal-processing operations and should be thought of collectively, rather than independently. This instructive approach will unify your perception of linear-signal processing. Most of the signal-processing operations described in this book are illustrated in **Fig. 7.16**. Examine the concepts carefully, run them over in your mind until they become clear, and then apply them.

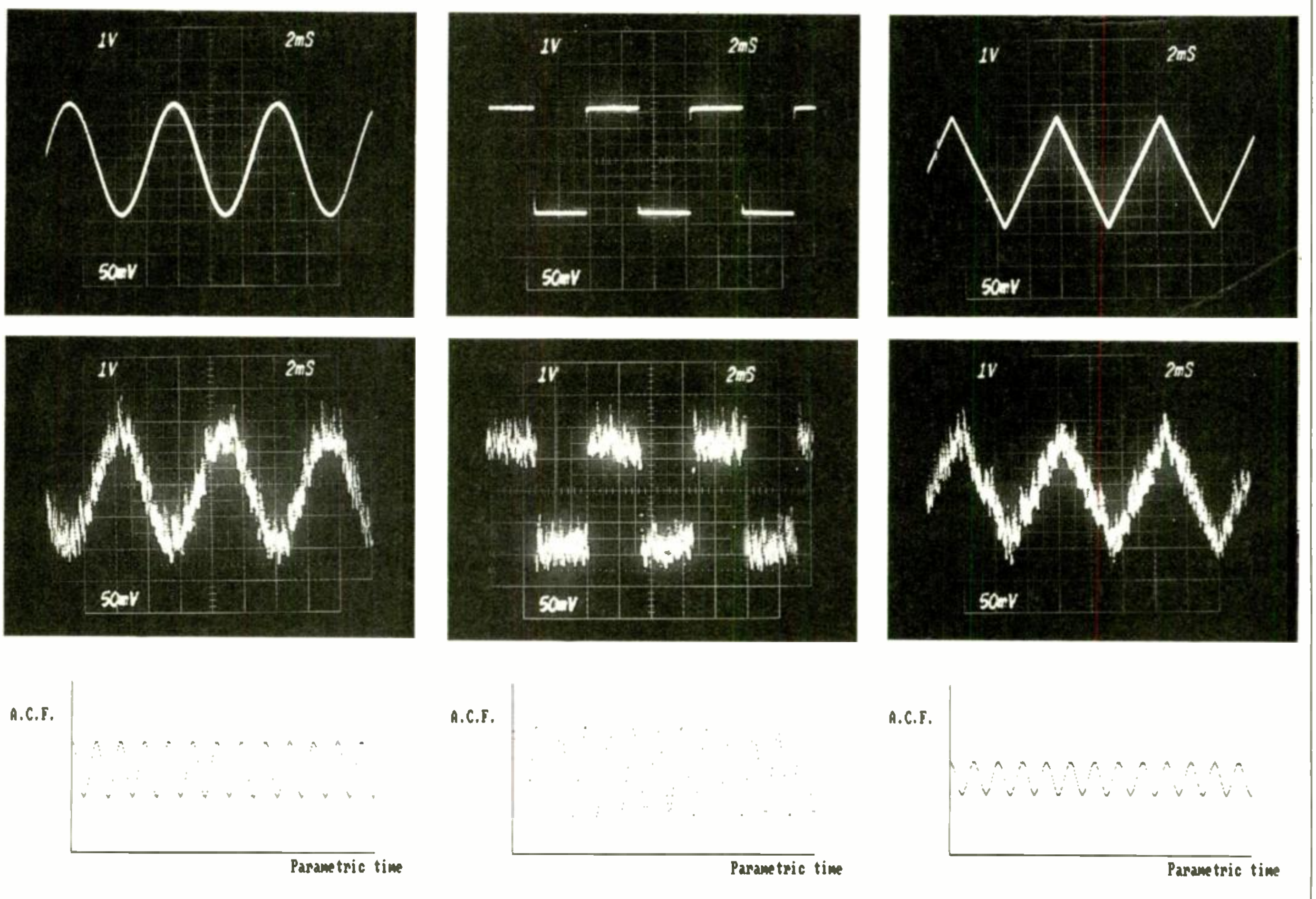


Fig. 7.15. Oscilloscope display of 3.5Vp–p, 150Hz clean sine, square and triangular waves (top). Middle row shows "dirty" signals made up from "clean" signals plus random noise and at bottom are screen dumps of monitor using listing 7.7.

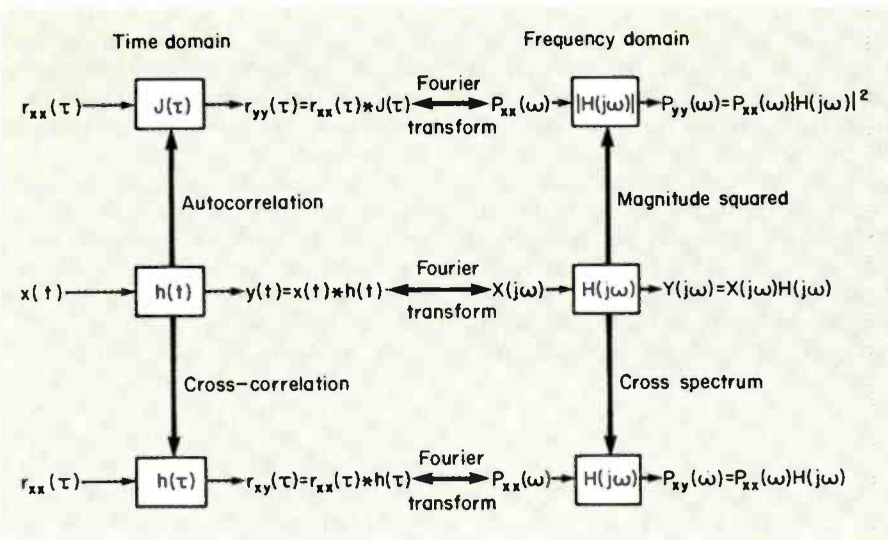


Fig. 7.16. Summary of convolution, autocorrelation and cross-correlation signal-processing operations in time and frequency domains.

This form of system characterization may be compared with the impulse-response testing of continuous systems. Remember, an impulse function is described by an infinite number of frequencies, represented as in-phase cosine components. Driving the system with an impulse will test all the frequencies in the band simultaneously. Any modifications in the amplitude and phase of the output will characterize the frequency response of the system. Unfortunately, it may be impossible to identify practical systems in this way. This is because the amplitude of the impulse necessary to obtain a measurable response overloads the system and results in non-linear processing. It may also be prohibitive to reduce the amplitude of the impulse because the response will be obscured by system noise.

System characterization by white-noise input-output correlation has been used successfully in a variety of systems. These include chemical process control, the measurement and control of the dynamic characteristics of aircraft, the response of large buildings to wind buffeting, electronic circuit response, the dynamics of a nuclear power plant, and the dynamics of a diesel engine.

System testing and characterization using random noise

The output of a linear-signal processor in the frequency domain has been shown to be the product of the Fourier transform of the input signal $X(j\omega)$ and the transfer function of the system $H(j\omega)$:

$$Y(j\omega) = X(j\omega)\,.H(j\omega)$$

The transfer function is given by:

$$H(j\omega) = \frac{Y(j\omega)}{X(j\omega)}$$

Multiply the top and bottom lines by the complex conjugate $X(-j\omega)$, often denoted by $X^*(j\omega)$

$$H(j\omega) = \frac{Y(j\omega)\,.X^*(j\omega)}{X(j\omega)\,.X^*(j\omega)}$$

$$= \frac{Y(j\omega)\,.X^*(j\omega)}{|X(j\omega)|^2}$$

Recognise that $|X(j\omega)|^2$ is the input power-spectral density function $P_{xx}(\omega)$ and that $Y(j\omega)\ X^*(j\omega)$ is the cross-spectral density function $P_{xy}(\omega)$. (Parseval's theorem may help).

Notice in **Fig. 7.16** that the transfer function of the system $H(j\omega)$ is given by the cross-spectral density function $P_{xy}(\omega)$ divided by the input spectral density $P_{xx}(\omega)$.

$$H(j\omega) = \frac{P_{xy}(\omega)}{P_{xx}(\omega)}$$

When the input signal is modelled as white noise, the power spectral density has constant magnitude equal to the mean-square value of the noise over the frequency range of interest. This provides an attractive method of system characterization. The frequency-transfer function of the system is given by the cross-spectral density function divided by a constant.

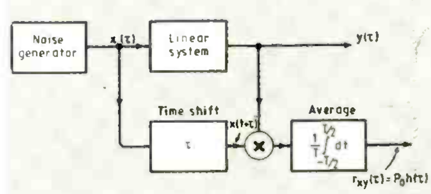
$$H(j\omega) = \frac{1}{P_0}\,P_{xy}(\omega)$$

The time-domain model of the signal-processing operation is obtained from the inverse Fourier integral relationship. Taking inverse Fourier transforms of both sides:

$$h(\tau) = \frac{1}{P_0}\,r_{xy}(\tau)$$

Clearly, dividing the cross-correlation function by the mean-square value of the random-signal input gives the impulse response of the system. The signal-processing operations are illustrated in **Fig. 7.17**.

Fig. 7.17. Signal-processing system diagram, demonstrating how to obtain the time-domain impulse response h(t) by white-noise cross-correlation.



Order out of chaos

Lies, damned lies, and statistics, I hear you cry. Having patiently and diligently worked through the formidable analysis, it remains an abstraction. You do not believe a word of it — you remain unconvinced and sceptical. Is there no way forward? Perhaps hands-on experience will help. The next step is to demonstrate wideband white-noise system characterization practically, using the PC with a random-noise generator and multiplexed A-to-D.

Data acquisition is straightforward using the Blue Chip peripheral board ACM-44. This provides a 16-channel, software-controlled multiplexer prior to the A-to-D. The fundamental idea is really quite simple. Stimulate the system using wide white noise, and capture and store $2N + 1$ sequential samples of input and output data. Do this before cross-correlating and displaying the impulse response graphically. Obviously, the minimum cycle-sampling time will be increased on account of the increased software overheads. Select channel, start conversion, read A-to-D and store the result — which will need to be cycled through twice on each pass of the loop. The minimum cycle-sampling time of the system (100μs) was measured using the method outlined in Chapter 6. Because the idea is to demonstrate principles, it would be unreasonable initially to investigate the characteristics of an unknown system. For this reason, a first-order low-pass system was used which had a time constant of 5msec as the circuit under test. **Fig. 7.18** illustrates the signal-processing system diagram.

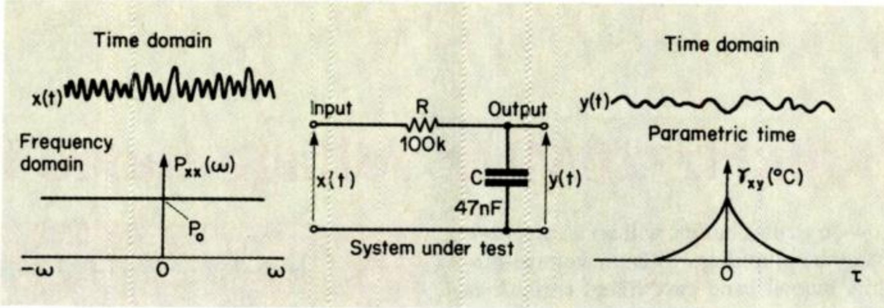


Fig. 7.18. Typical input/output waveforms, showing time-frequency and parametric-time relationships of white-noise cross-correlation.

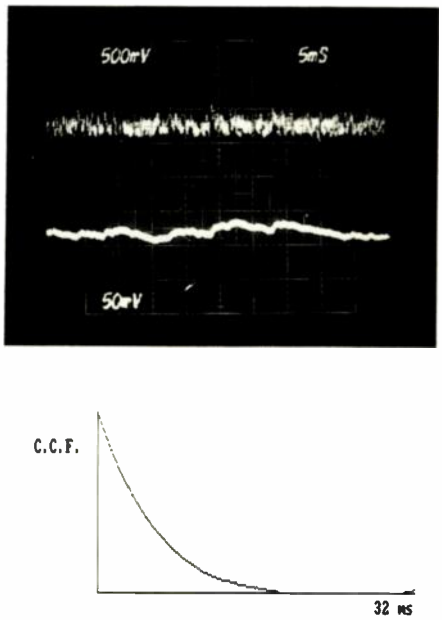


Fig. 7.19. Practical system characterisation using wide-band white-noise cross-correlation. At (a) is oscilloscope display of output from random noise generator (top trace) and modified noise after processing through system under test. Impulse response displayed on the monitor (b) is obtained by cross-correlation using listing 7.8. Time constant of system is 5ms.

Fig. 7.19 indicates the results achieved using **listing 7.8**. The upper trace of the oscilloscope display shows the output of the random-noise generator (Fig. 7.14) which was used as a source of wideband white noise. The lower trace is the modified output of the system. Correlation between input and output, before the CCF is plotted, produces the impulse response graphically on the monitor. To obtain a measurable response, it was necessary to increase the gain of the output channel A-to-D by a factor of 10. For software demonstration, this additional complication can be avoided by connecting an amplifier with a voltage gain of 10 (say) in cascade with the filter.

Listing 7.8

```
/ ************************************
*  WIDEBAND WHITE-NOISE SYSTEM   *
*  TESTING : CROSS-CORRELATION   *
************************************ /
#include<stdio.h>
#include<conio.h>
#include<graph.h>
#include<math.h>
#define BASE 768
#define N 320
main()
{
struct videoconfig screen_size;
int x, k;
int input[2 * N + 1], output[2 * n + 1];
double inputcontents[2 * N + 1],
outputcontents[2 * N + 1];
double sum[N + 1];
for(;;)
{
_setvideomode(_DEFAULTMODE);
_setvideomode(_HRES16COLOR);
/*----------------------------------------------------
             EGA MODE
----------------------------------------------------*/
_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);
/*----------------------------------------------------
          DRAW X & Y AXES
----------------------------------------------------*/
_settextcolor(3);
_settextposition(4, 13);
_outtext("C.C.F");
_settextposition(14, 56);
_outtext("32msec");
/*----------------------------------------------------
      COLOUR AND POSITION TEXT
----------------------------------------------------*/
for(x = 0; x <= 640; x++)
{
outp(BASE, 1);
/*----------------------------------------------------
          SELECT CHANNEL 1
----------------------------------------------------*/
outp(BASE + 2, 0);
/*----------------------------------------------------
         START CONVERSION
----------------------------------------------------*/
input[x] = inp(BASE + 2);
/*----------------------------------------------------
        STORE SYSTEM INPUT
----------------------------------------------------*/
outp(BASE, 2);
/*----------------------------------------------------
          SELECT CHANNEL 2
----------------------------------------------------*/
outp(BASE + 2, 0);
/*----------------------------------------------------
         START CONVERSION
----------------------------------------------------*/
output[x] = inp(BASE + 2);
/*----------------------------------------------------
        STORE SYSTEM OUTPUT
----------------------------------------------------*/
}
for(x = 0; x <= 640; x++)
{
inputcontents[x] = input[x] * 10 /(double)255;
/*----------------------------------------------------
   INCREASE GAIN OF I/P CHANNEL BY 2
----------------------------------------------------*/
outputcontents[x] = output[x] * 50 /
(double)255;
/*----------------------------------------------------
  INCREASE GAIN OF O/P CHANNEL BY 10
----------------------------------------------------*/
}
for(k = 0; k <= N; k++)
{
sum[k] = 0;
for(x = 0; x <= N; x++)
{
sum[k] += inputcontents[x] *
outputcontents[x + k] / N;
_setcolor(14);
_moveto(k, -90 * sum[k] / sum[0]);
_lineto(k, -90 * sum[k] / sum[0]);
}
getch();
/*----------------------------------------------------
       STRIKE ANY KEY TO EXIT
----------------------------------------------------*/
}
}
```

References

(1) G. R. Cooper and C. D. McGillem. Probalistic methods of signal and system analysis. Holt, Rinehart and Winston 1971.
(2) W. E. Bryan and T. K. Black. Statistical measurements today. *Electronics and Power.* I.E.E. June 1971.
(3) K. Beauchamp and C. Yuen. Digital methods of signal analysis. Allen and Unwin. 1979.
(4) H. J. Hutchings. Linear systems and random inputs. E & W.W. April 1988.
(5) Electronic Signal Processing. T326. O.U. Press 1984.
(6) D. M. Auslander, Y. Takahashi and M. J. Rabins. Introducing Systems and Control. McGraw-Hill. 1974.

200kHz-20MHz voltage-tuned filter

Low-cost cmos buffers will act as transconductance amplifiers to form voltage-tunable, biquad band-pass filters variable in frequency over a 100:1 range. Such circuits do not need external passive components, will operate at higher frequencies than switched-capacitor circuits and are electrically tunable (*E&WW*, August 1987, p.795-6 and June 1989, p.612).

Figure 1 shows a high-Q band-pass filter using one buffer which can be tuned from 200kHz to 2MHz by a tuning voltage of 2.5-3.2V. The transistor increases the swing at 2MHz to 1V, instead of the 30mV from a cmos stage, improving the S:N ratio and dynamic range by 30dB. Current drawn is 250mA at 3.2V.

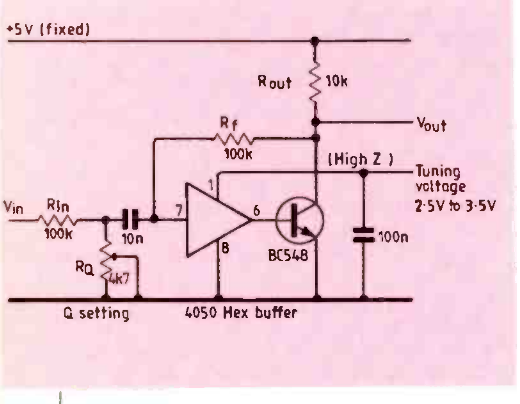


Fig. 1. 200kHz-2MHz tunable bandpass filter.

Gain is 40dB when Q is around 100, Q being determined by R_Q. Biquad circuits give higher Q at higher frequencies, which makes the bandwidth constant over the tuning range and therefore well suited to integrated, inductorless receivers.

In the receiver circuit of Fig. 2 an input voltage of 2.5-10V tunes the band-pass filter from 200kHz to 20MHz, the buffer used here having a 15pF input capacitance instead of the 80pF in the Fig. 1 circuit to give higher-frequency operation. Constant bandwidth is given by adjusting R_{QHF} at 10MHz and C_Q at 1MHz; the circuit gave a 100kHz bandwidth. Current per stage is 16mA at 15MHz, falling to 0.5mA at 2MHz. Output voltage must be limited to 30mV to avoid slew-rate distortion.

Ian Hegglun
Manawatu Polytechnic
Palmerston North
New Zealand

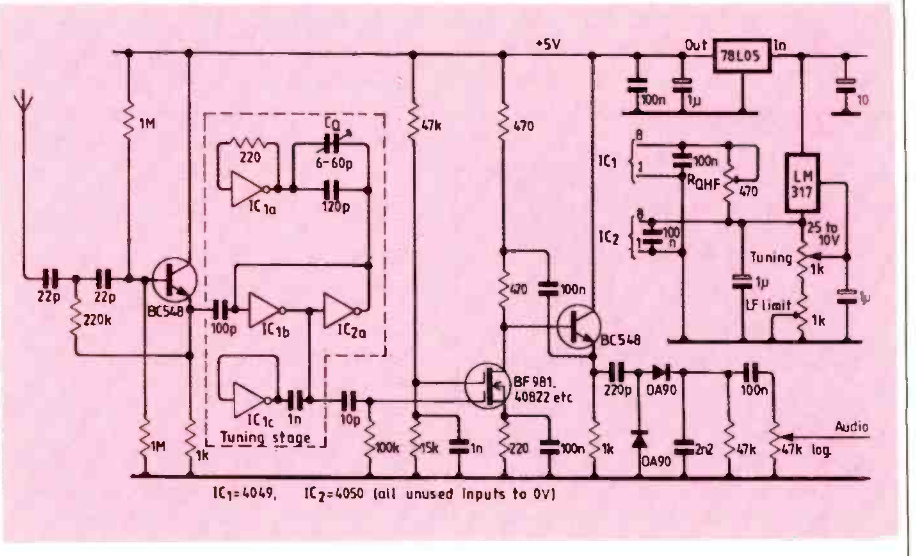


Fig. 2. Receiver using 200kHz-20MHz filter.

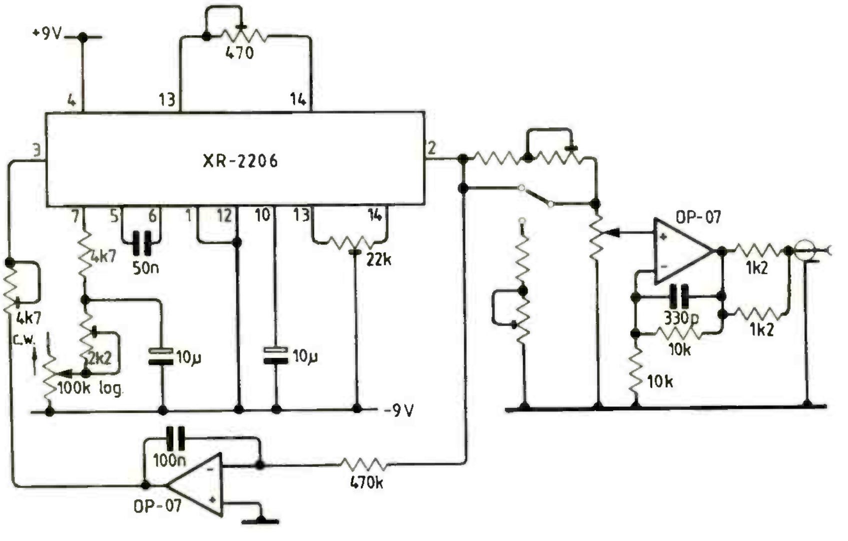
Offset cancellation in the XR-2206

According to the data sheet on the Exar XR-2206 oscillator, the DC level at pin 2 is "approximately the same as the DC bias at pin 3", pin 3 being connected through an amplitude-setting resistor to either mid-rail or 0V. In the example I used, the difference was about 200mV.

Incorporating a blocking capacitor would have meant amplitude changes with frequency, so I overcame the problem by treating the offset as an error, which is compared with 0V by the low-pass filter/integrator between the output (pin 2) and pin 3. The corner frequency is chosen to be well below the minimum frequency of interest. Filter amplifier OP-07 was chosen for its low V_{os} and it was not necessary to use its offset trim.

The rest of the circuit is simply a buffer, whose input impedance is high enough to make the level control linear. Switching provides outputs of 10mV, 100mV or 1V RMS into 600 ohms. In my case the frequency range, set by the components on pins 5, 6 and 7, is 200Hz to 4kHz.

D. M.Bridgen
Reading



Fast asynchronous data input to the PC-XT

Direct memory access for real-time processing is arranged using the I8237A-5 DMA controller built into the PC-XT, carrying out exchanges on four independent channels, one of which is free. Communication with 16-bit asynchronous peripherals is difficult, since the PC-XT has an 8-bit data bus. Using the method described, the time for each data exchange is 2.1ms per channel.

Figure 1 shows one solution to the problem, the timing diagram being shown in Fig. 2. When the peripherals fix valid data, logic 0 appears on the DATA READ line. D-type flip-flop IC_{3a} going to logic 1 on the rear edge of the /DR signal. After receiving the request for data exchange DREQ1, the controller establishes an active logic level on /DACK1 that opens the tri-state buffers IC_1,IC_2. Signals /DACK1 and A0 control the multiplexing of the 16 bits of the peripheral's data bus in two bytes, the high byte being recorded on an even address and the low byte on an odd one.

/IOR controls D-type IC_{3b} to ensure the transmission time of one DREQ1 request for the two multiplexed bytes and establishes the wait state for the next request. As an example, Fig. 1 shows the 10-bit D-to-A converter AD571 as the input device, the high six bits of the 16-bit word not being used here.

To initialise the I8237A, the assembler program shown can be used.

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Sofia
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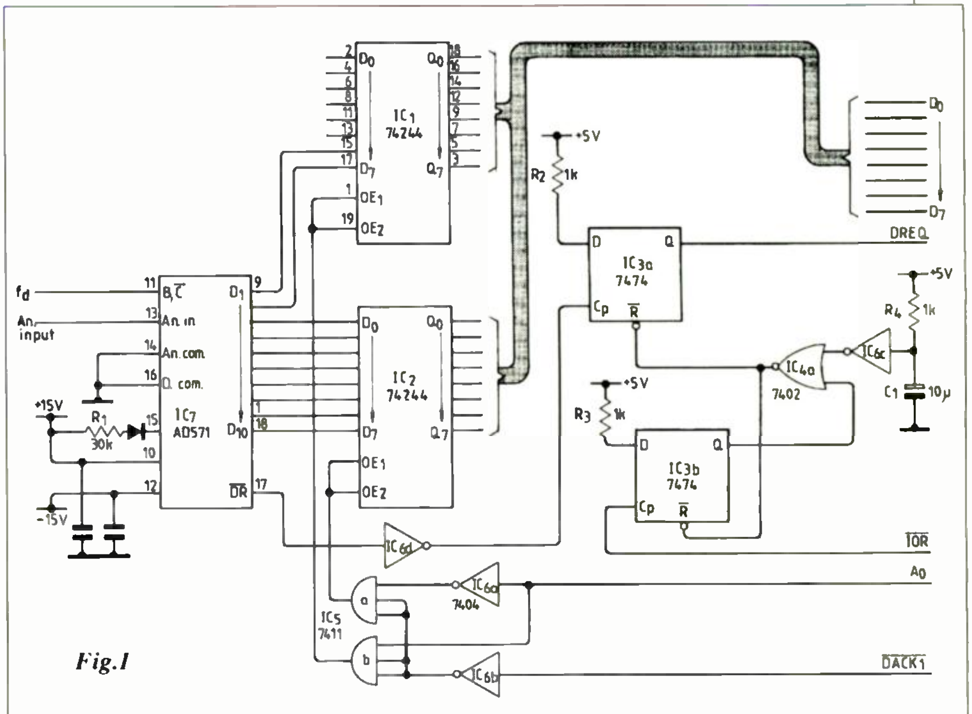

Fig.1

```
mov  al,00h
out  02h,al
out  02h,al
mov  al,ffh
out  03h,al
out  03h,al
mov  al,02h
out  083,al
mov  al,15h
out  0bh,al
mov  al,01h
out  0ah,al
```

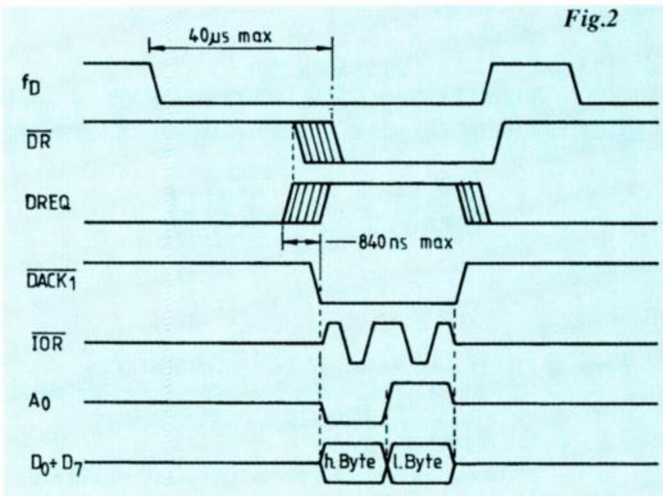

Fig.2

PWM motor control

A high drive frequency avoids noise from motor windings; this circuit operates at 20kHz.

Output from the oscillator is buffered by IC_{1c} and integrated by R_2C_2 to form a triangular wave. The input to IC1f is the combined triangle and DC level from IC_2, the triangle being shifted up or down to vary the width of the output pulse from IC_{1d}. DC from IC_2 is the result of comparing the mean value of the output from IC_{1d} and the demand input voltage, so stabilising the output.

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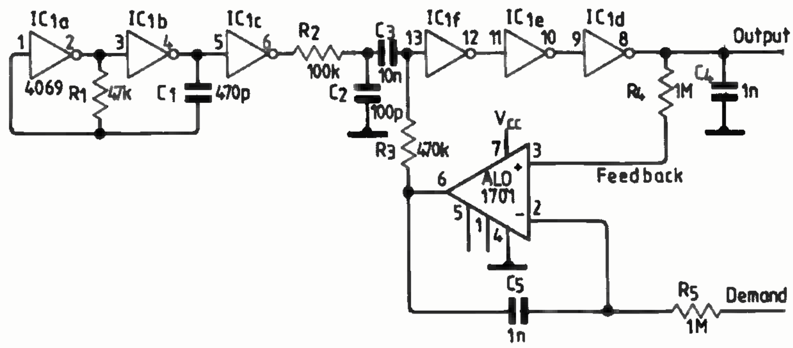

50% duty cycle divide-by-n

This simple divide-by-n circuit provides 1:1 mark:space ratio output for n=2 to 16.

In Fig. 1, IC_1 is an "up" counter, clocking on positive edges when its LOAD input is 1. When LOAD is 0, a positive clock edge loads the preset data. The carry output, RCO, becomes 1 and is connected to LOAD when the counter output first reaches 1111 after inversion by IC_{2b}, the next state being determined by the inputs A to D. This means that the number of counter states depends on the state of the presets. If, for example, A=B=D=1 and C=0, the progression is

1111:1011:1100:1101:1110:1111

When n is odd, both positive and negative edges are used to clock the counter to give 50% duty cycle. The X-Or gate IC_{3a} changes the trigger edge in use: when S = 0, the counter triggers on positive-going edges, S being determined by the preset data. Figure 2 shows the timing diagrams for n=3, 5 and 13.

Since IC_1 is an up counter, there are no locked states; regardless of its initial state, the counter always enters the chain automatically.

Yongping Xia
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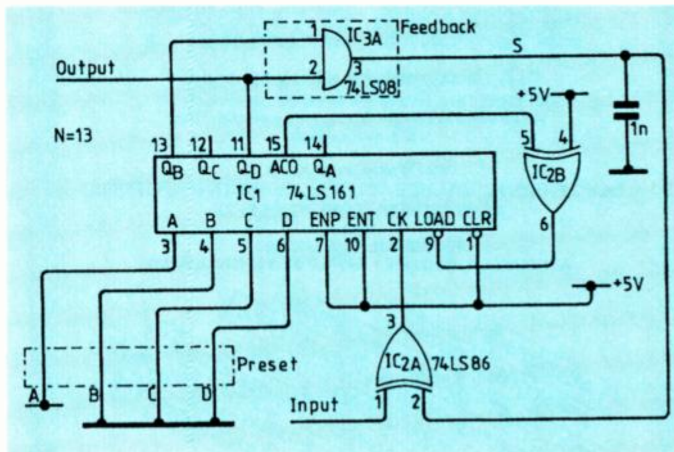


Fig. 1. Divide-by-n circuit, ratio depending on preset input.

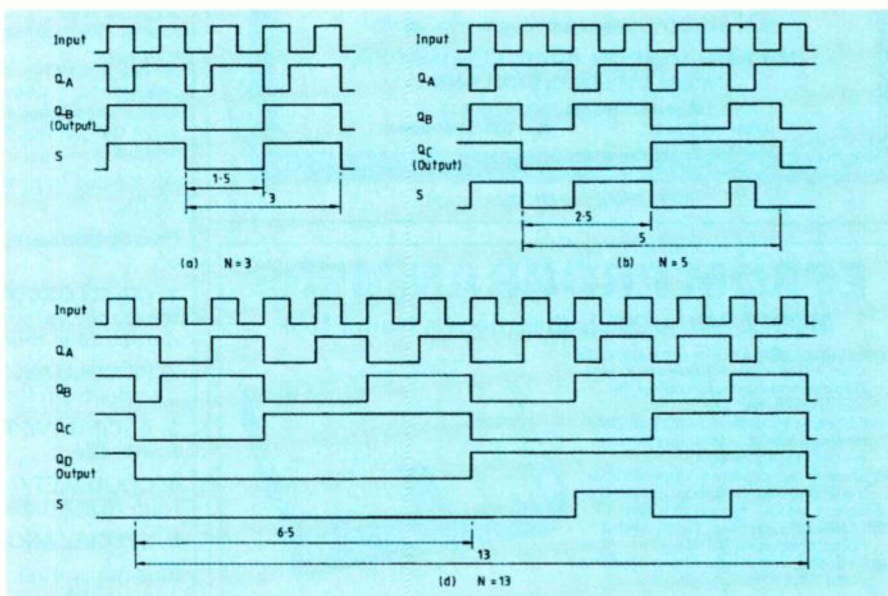


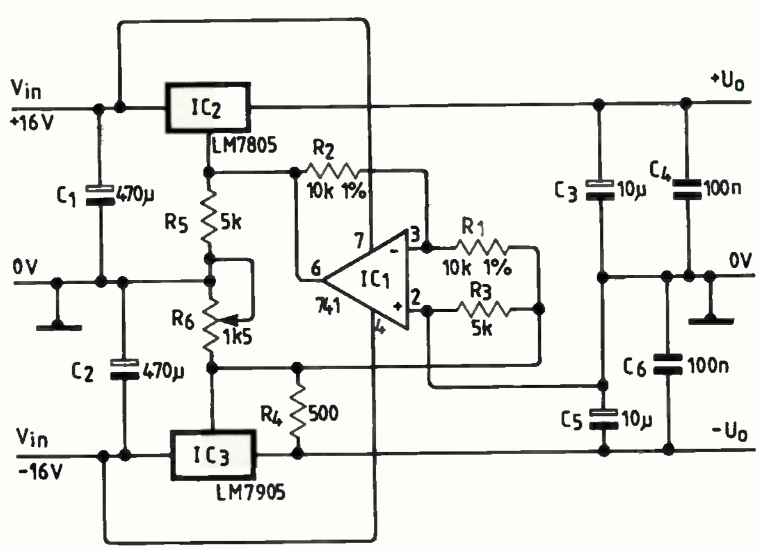
Fig. 2. Timing diagrams for n = 3, 5 and 13.

Adjustable, symmetrical voltage regulator

Using two fixed-voltage regulators, an op-amp and a few passive components, this circuit forms a simple, adjustable regulator giving a symmetrical output.

The 741,IC_1, acts as a voltage inverter, the voltage on the LM7905 common pin being inverted and fed to the LM7805 common, so that the two outputs vary together. Potentiometer R_6 adjusts both outputs.

Hong Yu Qing
Anhui
Peoples' Republic of China



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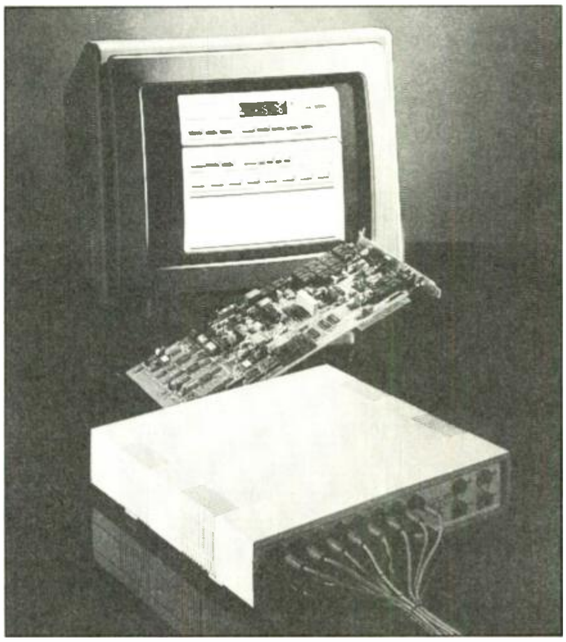

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74LS123	0.18	0.12	6821P	0.70	0.50
74LS125	0.14	0.10	6850P	0.68	0.48
74LS138	0.14	0.09	8251A	1.10	0.80
74LS148	0.30	0.20	8255A	1.20	0.95
74LS154	0.28	0.15	82C55A	1.30	0.80
74LS174	0.16	0.10	6502P	2.20	1.56
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High-speed 6-bit converter. MN5903 and MN5903A high-speed 6-bit monolithic flash A-to-D converters have conversion speeds up to 75MHz. MN5903 devices are pin-for-pin compatible with the AD9000 but signal-to-noise ratios are 38dB at 540kHz and 36dB at 35MHz. MN5903A is a stand-alone 6-bit A-to-D or terminating device for 7- or 8-bit applications. Unitrode (UK) Ltd, 081 318 1431.

Discrete active devices

Mosfet turn-off device. One MDC1000 device replaces zener diode, signal diode, a resistor and p–n–p transistor. It quickly discharges the gate-source and gate-drain capacitances when the input signal is removed and protects against overvoltage on the control line. A power mosfet can typically be turned off in tens of nanoseconds. MDC1000A $0.40; MDC1000B $0.35, and MDC1000C $0.70. Motorola Inc., 010 1 2 244 5504.

Small signal zener diodes. O5AZ series is an industry standard BZX79 compatible 0.5W diode in the DO-35 package. Zener range is 2.2 to 100V. Tolerance of ±2.5% available. Surface mount low-profile SOT-23 package O2CZ series offers zener voltages from 2 to 47V. Toshiba Electronics (UK) Ltd, 0276 694600.

Linear integrated circuits

High reverse isolation. QBH 4000 and QBH 125 each provide 35dB reverse isolation and together cover the frequency range 10MHz to 2500MHz. Both have 19dB gain and 4.5dB maximum noise figure. QBH 125 also has a high third-order intercept of +38dBm over 10MHz to 100MHz. Atlantic Microwave Ltd, 0376 550220.

Sub-miniature log amplifier. SL3521 log amp combines a single SL3522 die with a thick film hybrid containing resistors that are laser trimmed to adjust the log slope and DC offset. Log slope (mV/dB) can be adjusted to ±1% of a nominal value over the 70dB range. Similar adjustments can be made to DC offset. Less than 0.80ml volume. -55 to +125°C. 200 to 450MHz with a video bandwidth of 30MHz and noise of 10dB, linearity ±0.75dB. Prototypes £225. GEC Plessey Semiconductors, 0793 518000.

Dual and quad op-amps. MC33178 (dual) and MC33179 (quad) bipolar op-amps use high frequency p-n-p input transistors to provide low noise with low distortion and input offset voltage. 600Ω output and a short circuit current of 80mA. Drain current is 700μA per amplifier maximum and THD is 0.0024% at 1.0kHz. MC33178P, dual, DIP-8, $0.73; MC33178D, dual, SO-8, $0.79; MC33179P, quad, DIP-14, $1.11; MC33179D, quad, S0-14, $1.16. Motorola Inc., 010 1 2 244 5504.

Memory chips

Emulating forthcoming 4Mbit monolithic devices. Claimed to be the world's fastest 4Mbit static ram is the MS8512C ceramic module, functionally compatible with forthcoming 4Mbit monolithic devices due in 1992/3. It is organised as 512K by 8bit. Access-time options are 45ns for commercial devices and 55, 70 or 85ns for military parts. Typically consumes 275mW operating; 1mW standby. On-board decoding and decoupling capacitors. Hybrid Memory Products Ltd, 091 258 0690.

Microprocessors and controllers

ASSP for motor control. 8XC196MC microcontroller is designed to operate with three-phase AC and brushless DC motors. On-chip circuitry provides a three-phase, pulse-width modulator, or waveform generator. Its 16-bit core and integrated on-chip peripherals facilitate easier system designs. In addition 8XC196MC incorporates the architectural features common to all MCS-96 family members. Volume production second half of 1991. £8.35 for rom version. Intel Corporation (UK) Ltd, 0793 696000.

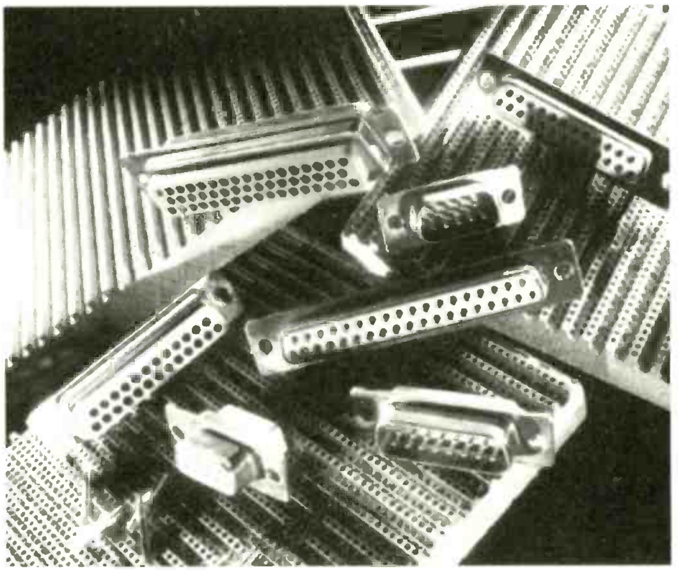
Flexible MCU. Motorola MC68HC705C8 (Hcmos) MCUs have parallel I/O capability with pins programmable as input or output, an on-chip oscillator with crystal/ceramic resonator, memory mapped I/O, selectable memory configurations and a Cop watchdog timer and clock monitor. With 24 bidirectional I/O lines and 7 input-only lines, both serial communications interface and serial peripheral interface systems are offered. 3.0 to 5.5V. Jermyn Distribution, 0732 450144.

Fast SCSI I/O processor. The 53C710 high performance SCSI controller offers synchronous data transfer rates of 10Mbyte/s, and is the first chip with a 32-bit bus-master direct-memory-access channel capable of 90Mbyte/s data transfers. It is approximately 50% faster than the 53C700 SCSI I/O processor and offers more programmable capabilities in Scripts. 160-lead quad-sided flat package. NCR Microelectronics Europe, 0049 89 632202.

Faster risc. A higher-speed risc CPU/FPA has the VR3000A central processor unit (μPD30310) and floating point accelerator (μPD30311) operating at 33MHz. By designing with the VR3000A pin out both the 33 and previous 25MHz devices may be used in the same slot. Bandwidth is 264Mbyte/s. 26Mips. Customers can program in C, compile the program and then debug. NEC Electronics (UK) Ltd, 0908 691133.

High-speed single chip microprocessor. V53 (μPD70236) processor, based on the V33 CPU core, can operate at an internal clock frequency of 16MHz, and has an instruction set compatible with V20-V50 processors. As with the V33, it implements instructions in hardware, increasing computing power to four times a V30 operating at 10MHz. Minimum instruction execution time is 125ns and bus cycle with no wait states is 250ns. It can address up to 16Mbyte of memory. Integrated DMA controller for up to four channels. NEC Electronics (UK) Ltd, 0908 691133.

AB Connectors promise high reliability and rugged design



Optical devices

Compact led. OEM-335A module is a compact 3.5 digit led DVM and incorporates a dual-slope A-to-D converter and driver, and choice of input sensitivity ratings. Sensitivity options are 100mV reference with 200mV full scale input sensitivity (OEM 335A), or 1V reference with 2V full scale input sensitivity (OEM 335B). Options are auto-zero, auto polarity and selectable decimal point. 10.16mm characters. Anders Electronics Ltd, 071 388 7171.

Ge/Si photodetectors. GMSi series devices contain a silicon detector mounted over a germanium detector, in a four pin TO-8 package. This provides "two-colour" simultaneous measurement of light over the combined detection wavelengths of Si and Ge. Wavelength-separation power meters and pyrometers covering the range 500°C to 2000°C are two appliications. Germanium Power Devices Corp.,010 1 508 475 5982

Opto-isolators. ISP321/521/621 family comprises single, dual and quad isolators in standard 4-pin, 8-pin, and 16-pin plastic dual in line packages in Japanese standard pin out configuration. Current transfer ratios from 50 to 600%. Isolation breakdown voltages are either 2500 or 5000V RMS, and continuous forward current is 50mA (max). Versions have separate channels, with no common connections for good signal integrity and minimum cross-talk. Isocom Components Ltd, 0429 863609.

Programmable logic arrays

PLD designs upgraded to FPGAs. Ales 1 converts PLD designs expressed as Palasm 2 source files into Actel netlists. It runs on PC386, Sun and Apollos and allows PLD users to preserve investment in multiple PLD designs, while taking advantage of the reduced cost and increased density of Actel FPGAs. Ales 1 works with Actel's Action Logic System and for the PC386 is available at $1095 (FoB California). Sun 4 and Apollo based Mentor systems, $1695. Actel, 010 1 408 739 1010.

Bi-cmos with 70 000 gates. BC-70000VH is a Bi-cmos gate array with 70 000 equivalent gates (2-input Nand). Gate delay time is from 200ps (without load) to 420ps loaded. I/O buffer gates have a delay of 1.4ns on input and 1.3ns on output. 50Ω termination. 360 signal connections, 200 output buffer pins. Supply voltage of -5.2V (-4.5V), 20W. Pin grid array package with 460 pins. Fujitsu Microelectronics Ltd, 0628 76100.

Programmable peripheral devices. PSD301 is a programmable chip that works directly with any 8-bit or 16-bit microprocessor by providing I/O ports, busses, address mapping, port tracking, 256K of eprom and 16K of sram on a single chip. It can be programmed on Data I/O. Available in CLDCC for prototyping and PLDCC for one-time programming. Commercial speeds of 150ns and 200ns. Micro Call Ltd, 0844 261939.

Power semiconductors

Low on-resistance. Manufactured by Siliconix, the SMP60N06-14 is a 60V, 60A device with a low on-resistance in a TO-220 package; the SMW70N06-14 60V, 70A, device is said to have the lowest on-resistance in a TO-247 package. Suitable for cool operation. Makers claim the record low on-resistances solve thermal problems previously limiting solid-state switches in automotive electronics systems. Barlec Richfield Ltd, 0403 51881.

PASSIVE

Built-in series resistors. FCT2000A series incorporates 25Ω resistors to save overall board space while reducing ground-bounce noise to less than 0.8V in PDIP packages, with similar reductions to undershoot and ringing. FCTA specifications. V_{OL} rating is 0.5V at an I_{OL} of 12mA (1.5V typical at 50mA). The V_{OH} rating is 2.4V at an I_{OH} of 15mA. Micrlog, 0483 729551.

Large can capacitors. GX series of large can aluminium electrolytic capacitors with a 5000h load life has an operating voltage range of 200 to 400V and temperature range of -40 to +150°C (200-250V), -25 to +105°C (400V). Capacitance is 82 to 1500µF ±20% at 120Hz, 20°C. Snap-in terminal form, case sizes range from 22 x 30mm to 35 x 50mm. Nichicon (Europe) Ltd, 0276 685393.

Audio capacitors. ES series non-polarised capacitors for audio equipment has an operating voltage range of 6.3 to 50V, capacitance is 0.47 to 1000µF, tolerance ±20% at 120Hz, 20°C. Maximum leakage current is 0.03CV or 3µA. Load life is 1000hr. The series is available in radial cases with sizes ranging from 5 x 11mm up to 16 x 31.5mm. It is resistant to most solvent cleaning agents. Nichicon (Europe) Ltd, 0276 685393.

0.1% tolerance. With values down to 0.005Ω, the Isabellenhutte Model PS/PLC precision resistors are non-inductive, two terminal, cost effective models for current sensing

Lowe Electronics' HF compact-size receiver is for point to point monitoring

applications. Tolerances ±1%, with 0.1% available on special order. Temperature coefficient is 50ppm/°C. 0.5 and 1.0W versions. Based on Manganin resistance alloy foil technology. Rhopoint Components, 0883 717988.

Electrolytic capacitors up to 550V. Manufactured by Nippon Chemi-con, SME-LG aluminium-electrolytic capacitors have values from 560µF to 680,000µF, tolerance ±20%. 11 DC voltage ratings between 10 and 250V. Insulation resistance is 100MΩ with dissipation factors of 0.1. RWE-LG series have voltage ratings between 350 and 550V DC. 100 to 12,000µF, components have a tolerance of ±20% at 20°C and maximum dissipation factor of 0.25. Leakage current of RWE types is 0.02CV or 5mA. Young Electronic Services, 06285 31417.

Connectors and cabling

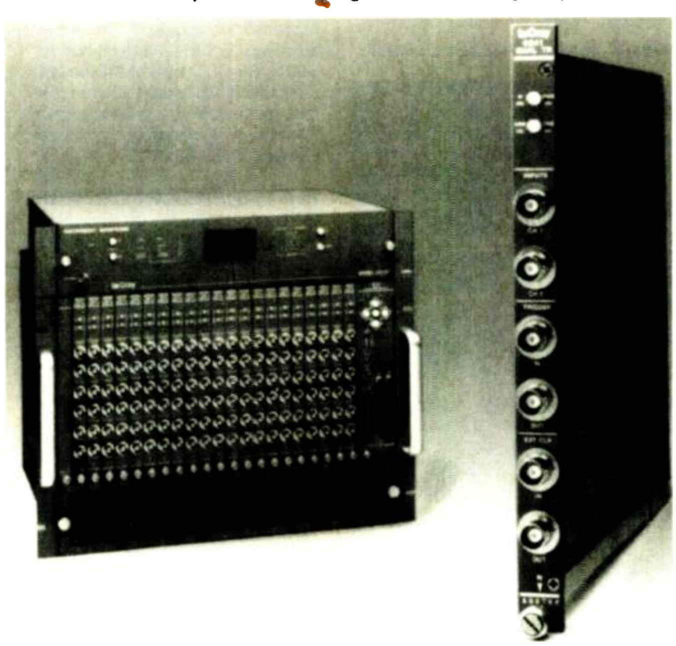
High-reliability. D-type connectors and accessories for high-reliability applications have rugged design combined with a temperature range of -55 to +125°C. Range has five shell sizes with from 9 to 50 ways. Connectors are supplied with optional solder, PCB or rear-removable crimp terminations. Contacts, which have a current rating of 5A maximum, are copper alloy with gold-over-nickel plating. AB Connectors Ltd, 0604 711451.

Filters

40dB ripple-current reduction. FMB 461 is an EMI filter module with 40dB ripple protection, occupying 2.2in^2 board area. -55 to +85°C temperature range. It is designed to reduce the input-line reflected-ripple-current of Interpoint's MHE, MLP, MTO, MTQ, MFW DC/DC converters. Used with the company's DC/DC converters, it reduces input ripple current by 40dB between 100kHz and 50MHz. Interpoint (UK) Ltd, 0276 23795.

Large case RFI filters. Arcotronics filters are in metal cases — with ground terminals connected to the cases — and meet HPF (25/085/21) climatic category (-25°C to +85°C). Voltage rating is 250V up to 400Hz. F.A1 types are general-purpose devices for asymmetric RFI. F.AM power line filters can attenuate symmetric, asymmetric, periodic or pulse shaped interference. High attenuation F.AK types can shield equipment from line-borne symmetric/asymmetric noise and reduce interference emission. F.AR types provide attenuation against broad band, high magnitude noise transients. F.AS filters suppress RFI generated by SMPS units. STC Mercator, 0493 844911.

46 channel 100MSample/s waveform digitiser from LeCroy Corporation.



Hardware

Lowest profile PGA sockets. 709/8000 series pin grid array (PGA) sockets has a profile of 2.8mm. Grid sizes range from 10 x 10 to 19 x 19. Fibre board versions range from 9 x 9 to 20 x 20 grids. Insertion force is 60g/pin. Clips are gold-plated, beryllium copper inside tin-plated brass socket bodies. Contact resistance is 10mΩ. Interconnection Products Ltd, 0433 21555.

Hazard protection. Schurter has developed a 5 x 10mm panel- or PCB-mounted fuseholder, type FBS, offering greater protection against live contact. It has a drawer-type carrier which slides into the fuseholder body. Rated voltage is 250V at 10A over -25°C to +85°C. Protection is IP40. Radiatron Components Ltd, 081 891 1221.

Instrumentation

Waveform digitiser. Model 6841 provides two channels of 8-bit digitising capability at 100MS/s digitising rate with 128K waveform memory per channel. One rack-mount card crate can house up to 23 cards, accessed via one GPIB address. Digitisers can be operated independently or synchronised with a common trigger. 50kHz trigger rates in memory segmentation mode. LeCroy, 0235 533114.

20MHz 'scope roll/refresh modes. SSI-2325 includes a dual trigger circuit with X-Y operation. It has a 6in CRT and a sampling rate of 10Ms/s. Inputs have a 1mV/div sensitivity with a 10 step attenuator, up to 5V/div. Rise-time is 17.5ns. Capabilities include a 2K word memory per channel, 8-bit vertical resolution, 2048 point horizontal resolution, and choice of roll, refresh, hold, save, CH2 and pre-trigger operation. Multitest Ltd, 0480 403617.

Digital earth-loop impedance tester. Heavy-duty instrument TEM 2200 HD can test earth loop impedance, earth bonding and wiring state, and earth electrode resistance. It has three resistance ranges: 20Ω (TN); 200Ω (TT); 2000Ω (EER), accurate to 0.5%. Waveform sensing circuitry requires only logging of the first result. It indicates wiring state, and look-up tables show prospective short-circuit measurements from known impedances. TMK Instruments, 081 908 3355.

Interfaces

Fibre-optics for STE-bus systems. CSTEFS interface card provides STE-bus users with two Fosil (fibre optic standard interface link) communication channels. Based on a 68681 dual uart and operating as an STE-bus slave, it can be driven by standard serial I/O driver software. Fosil to RS232C converter. Channels operate at up to 38.4kbaud. Fosil data links can span 2km, and use low-cost optical fibres. Anglia Technology, 0603 789432.

Power supplies

High voltage isolation DC/DC converter. HPR1xx series DC/DC converters deliver 750mW power with 750V continuous isolation. Designs achieve power density of 10W/in^3 and need 0.2in^2 of board area. A 170kHz push-pull oscillator in the input stage reduces beat-frequency oscillation problems when using with other isolated components. Burr-Brown International Ltd, 0923 33837.

UPS for mid-range computers. Pure Power E series offers a sinewave output with ratings of 10, 12 and 15kVA. Single conversion on-line design offers a voltage stabiliser-conditioner at all times with 90% AC to AC efficiency. Power consumption is lower, heat output is reduced, and reliability is 50,000MTBF. Start-up overload capability greater than 150%. Claude Lyons Ltd, 0992 467161.

Radio communications

Microwave. DTX series are wideband class A units with mosfet technology and range up to 1400MHz. Harmonics within the amplifier pass band are better than -20dBc: outside they are better than -30dBc. Range is 30dB/1W, 37dB/5W and 30dB/10W, with gain variation of less than ±1dB in each case. 120V or 240V AC. 85mm and 150mm high, 160 to 265mm wide and 220mm to 360mm long. 3.5, 5 or 7kg. BNOS Electronics, 0371 856681.

HF receiver. HF-235 is for point-to-point monitoring. Compact size with a 2U (88mm) x 19in panel, a high level of RF performance, optional remote control through a RS-232 interface, ease of assembly for multi-receiver installations and bespoke software to drive specialised monitoring requirements. Tuning by spin-wheel, front panel key pad and remote control. AM, CW, USB and LSB. FM and synchronous AM also available. Lowe Electronics LTd, 0629 580800.

Surveillance receiver and frequency analyser. MS3360 is an integrated swept superheterodyne receiver and spectrum/frequency analyser designed for elint activities. It operates over 0.5-18GHz, expandable to 0.05-40GHz. A large, flat screen electro-luminescent display allows complex analysis and measurement of signals in real time. Thorn Microwave Devices Ltd, 081 573 3888.

Programmers

PC programmer. PC101 is a modular programming system, based around an IBM-PC plug-in card, for 8- and 16-bit eproms. Any configuration can be plugged together. Two 8-bit modules can be configured for set programming of eproms in 16-bit applications. Between them the 8-bit and 16-bit modules will support single rail 24 to 40 pin devices from 2716 to 27C1024 and beyond. Eeproms and flash devices included. Trace Technology Ltd, 0234 266455.

Switches and relays

Video crosspoint switch. MAX456 monolithic cmos 8x8 video crosspoint aims to reduce component count, board space and cost. The switch contains a digitally controlled matrix of 64 T-switches connecting eight standard video input signals to any one, or all, output channels. Each output connects to eight internal buffers, capable of driving 400Ω and 20pF to ±1.3V at up to 250V/μs. It can be directly connected to four MAX457 dual video amplifiers, which can drive 75Ω loads. 2001 Electronic Components Ltd, 0438 742001.

Vacuum switches. MPL-600-V and MPL-601-V (model number determines terminal position) miniature SPDT vacuum switches handle loads up to 2hp at 240V AC. A miniature diaphragm-operated sensor is mounted to standard UL and CSA approved snap-action switches, field replaceable. Switches can operate from 7.5mmHg to 750mmHg. Mechanical life in excess of 10 million cycles. Eurosensor, 071 405 6060.

COMPUTER

Computer board level products

Graphics display system for PS/2 PCs. For applications including cad/cae and solid modelling, DrawingCard is claimed to be the fastest PS/2 graphics board in the UK. It is designed for IBM PS/2 and compatible machines running Dos and retails for £1395. DrawingCard processes more than 102,000 2D vectors/s and can draw faster than 14Mpixels/s. Resolution is 1024 x 768 pixels with a choice of 16 or 256 displayable colours from a palette of 16.7million. CalComp Ltd, 0734 320032.

Multi-tasking VME board. Running at 40MHz, the 6U VME board carries a single i860 processor, up to 16Mbytes of ram, a high speed local I/O bus supporting transfers at 160 Mbyte/s, and a VME interface. Multi-processor versions consists of a 9U VME with four i860 processor nodes and supports multi-board configurations with up to 16 processors. 1.2 Gflops can be achieved. Boards are designed for Sun 3, Sun 4 or other VME-based workstaion. Software includes real-time multi-tasking operating system; Fortran and C compiler. Computer General, 0256 881377.

High-integration i486 CPU board. iSBC 486/133SE board provides a 33MHz i486 CPU, SCSI peripheral interface and Ethernet networking on a single Multibus II board. The board boasts one iSBX connector for use with SBX modules, two serial ports, and one parallel port and comes with MSA firmware. With four Mbytes memory price is £4785. Intel Corporation (UK) Ltd, 0793 696000.

Real-time convolver for VME image processing. Eltec's RCO provides convolution, noise reduction and pattern matching in real time, with clock speeds of up to 15MHz. VME bus overload is avoided through an independent 16-bit parallel video interface bus (VIB). Convolution, rank value filtering and template matching available. Filtering and edge enhancement carried out with a kernel of up to 7 x 7, or 1 x 63 pixels. RCS Microsystems Ltd, 081 979 2204.

Computer systems

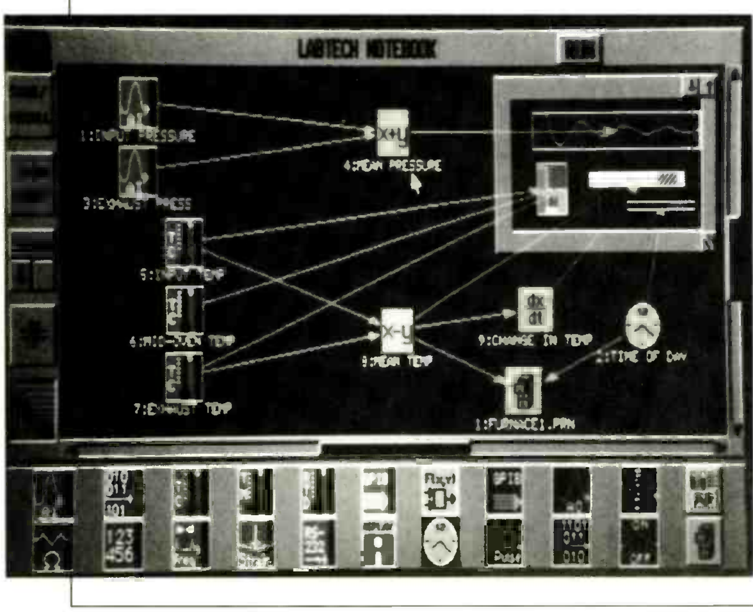
Client-server platforms for OEMs. Model 403E is an i486 microprocessor-based deskside server based on the Eisa bus for departments with 50 or more users. 402 is aimed at departments with up to ten users needing a department file server or a desktop engine. The 300 LPSX-16 small footprint 386 SX microprocessor-based platform enables OEMs to configure a Windows-based desktop platform at a low price. Intel Corporation (UK) Ltd, 0793 696000.

Software

Testing without libraries. Genesis uses AI techniques to generate test programs for devices having no standard library, handling devices up to 128 pins. It runs on DCA's Pro 1990 PC-based test systems and creates functional tests for unknown devices by generating a working out-of-circuit test for an IC, logic modules or complete sub-assembly. DCA Technology Ltd, 0730 60699.

Graphical front end for Notebook. IconView provides an object-oriented graphical user interface for Dos, Unix and OS/2 platforms. IconView Notebook and Control are the latest versions of the Labtech family of real-time computing products. The software communicates directly with Fairchilds' PC-LabCard data acquisition cards or remote devices via serial lines or the IEEE-488 bus. Dos versions require XT/AT/PS/2 with 640K ram and Dos 3.0; OS/2 versions need an AT/PS/2 with 4Mbyte ram and OS/2 1.0. Fairchild Ltd, 042121 6527. ■

Object-oriented graphical interface for Dos, Unix and OS/2, from Fairchild



CIRCLE NO. 123 ON REPLY CARD

CIRCLE NO. 124 ON REPLY CARD

CIRCLE NO. 125 ON REPLY CARD

500MHz with the SL6639

Plessey's SL6639 single-chip FSK radio data receiver is rated at 200MHz maximum operating frequency, being intended primarily for use in 153MHz paging receivers. Since the input amplifier dissipates most of the power, it was designed for minimum power consumption at 200MHz, but the two mixers on the chip possess a much wider bandwidth, which is more or less flat to 500MHz. Application Note AN98 from GEC Plessey describes an external amplifier to allow the chip to be used at up to this frequency in telemetry, alarms and in other security and paging applications.

In the SL6639, the amplifier uses the cascode configuration for high input impedance and high gain at high frequencies, Miller capacitance being greatly reduced. There is also a circuit that improves dynamic range by switching off the input amplifier if the input signal exceeds -30dBm by using a built-in AM detector to disable the input amplifier's current source. This prevents mixer overload.

In the external amplifier in Fig. 1, the internal current source is not used, R_1 being chosen to pass an extra 1mA. Essentially, the external amplifier is identical to the unused internal one, but uses BFR92A transistors at the higher current for higher speed. Base voltages for T_1 and T_2 come from the SL6639.

The dynamic range of the original receiver is preserved by the p-n-p transistor T_3. The 500mA current source in the SL6639, which is available on pin 20, is switched off at high signal levels. This current is used in the external amplifier to provide base current in T_3, which itself provides current to the amplifier. When, therefore, the current source goes off, the external amplifier is disconnected, but the receiver still operates on cross-talk through the amplifier. Of course, if the signal level is not expected to exceed -40dBm, T_3, R_2 and the current source are no longer needed.

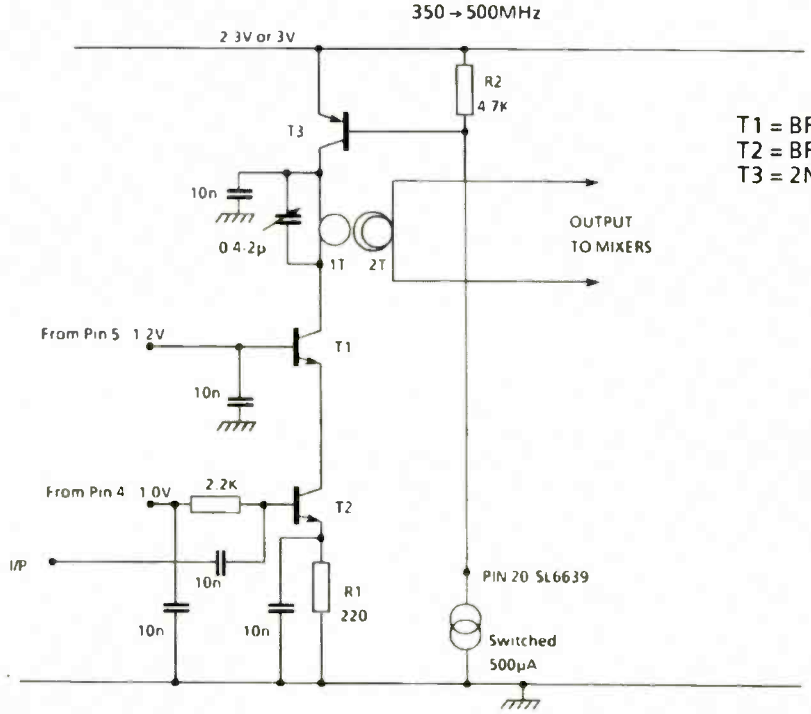


Fig.1. External HF amplifier for SL6639

To provide 180° phase-shifted inputs to the two SL6639 mixers, a transformer is the simplest method: at the frequencies of interest, a single-turn primary and a two-turn secondary are used, both of 4mm diameter and possibly formed in the PCB copper. Tune the primary for maximum reading on pin 28 of the SL6639, with a low-level input.

Since 500MHz crystals are not easily available, it is necessary to select the third overtone of a 150MHz type: Fig. 2 shows a suggested local-oscillator circuit using this method.

GEC Plessey Semiconductors, Cheney Manor, Swindon, Wiltshire SN2 2QW. Telephone 0793 518000.

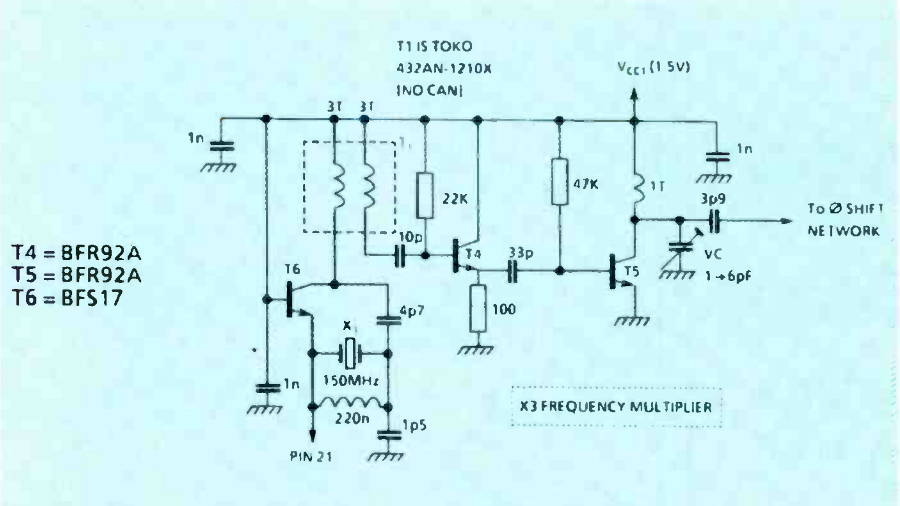


Fig.2. 450MHz local oscillator

Mosfets in high-side relay switching

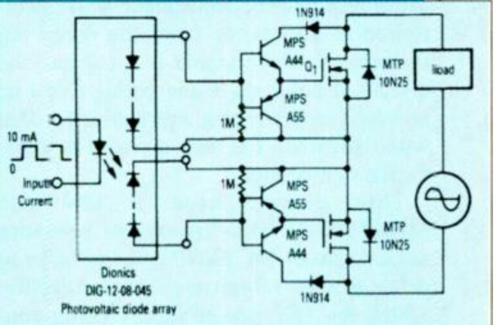
Using a mosfet for the high-side switching of relays or motors presents the problem of referring the gate drive circuit and supply to the mosfet's source, one solution being contained in the Motorola application note EB141/D.

Several techniques are currently in use: for example, gate transformers, bootstrapped supplies and optocouplers. All these techniques possess disadvantages at high duty cycles or in continuous "on" periods and an optocoupler needs its isolated supply referred to the mosfet source.

To overcome this latter disadvantage, photovoltaic diode arrays can be used, since they produce isolated outputs of 5V to 10V. A drawback is that their output current is a mere 5mA, which gives a fairly lethargic mosfet turn-on; noise from the load coupled to the gate through the mosfet "Miller" capacitance may cause spurious switching.

A complementary emitter follower on the diode array output improves performance, but a floating supply is again needed. If the voltage at the mosfet drain is now used for the emitter-follower supply, the floating supply is not needed, the drain voltage being high precisely when necessary — when the mosfet is off. Two such circuits, using 400V complementary small-signal transistors, form an AC relay. Mosfet turn-on time is decreased by a factor equal to the high-voltage n-p-n transistor's beta; in the circuit shown the fall time of the MTP10N25 is 200ms, allowing pulse-width modulation at less than 100Hz. The 1N914 allows V_{GS} to exceed V_{DS} as the mosfet turns on completely.

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



Emitter follower improves mosfet switching speed.

Quad high-side switch

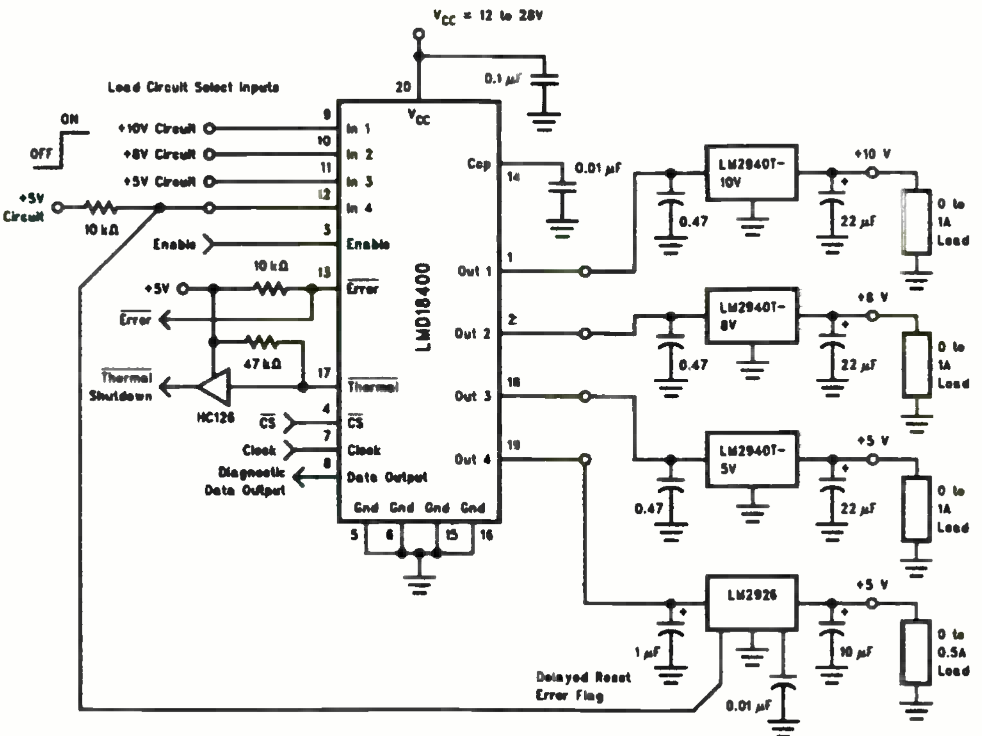
A fully protected quad high-side driver from National Semiconductor, the LMD18400 contains four common-drain d-mos n-channel power switches which will switch 1A continuous or 3A transient current to a common positive power supply.

LSTTL/c-mos logic-compatible inputs provide separate on/off control of each channel and a serial interface provides diagnostic data to the microcontroller driving the circuit.

High-side switches are used in industry and particularly in automotive design to switch power to loads connected to earth, the idea being that placing the switch between the power source and switched device avoids short-circuits in the wiring switching loads on accidentally. Additionally, a high-side switch can detect such a short and open the switch to prevent excessive current drain.

The diagram shows the LMD18400 used to switch multiple voltage-regulated loads. Reset flag feedback from the LM2926 regulator shown on output 4 forces the LMD18400 to act as a fuse for load faults on that channel.

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



Pressure sensor with current transmitter

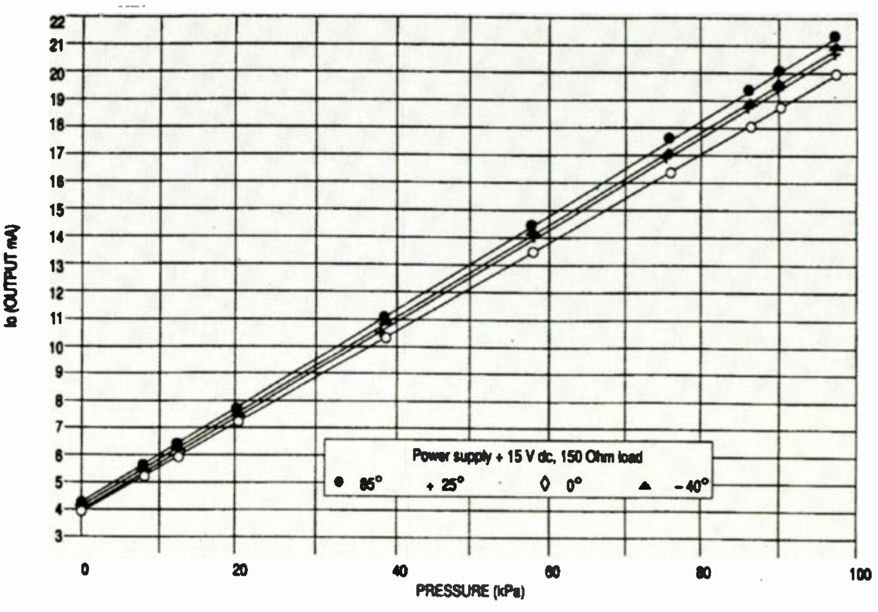
Measuring pressure in industrial processes often requires the transducer to be positioned at a distance from the receiving instrument. If the signal is a current, the effects of noise on a line perhaps several hundred metres long are easier to deal with than when the measurement is transmitted as a voltage.

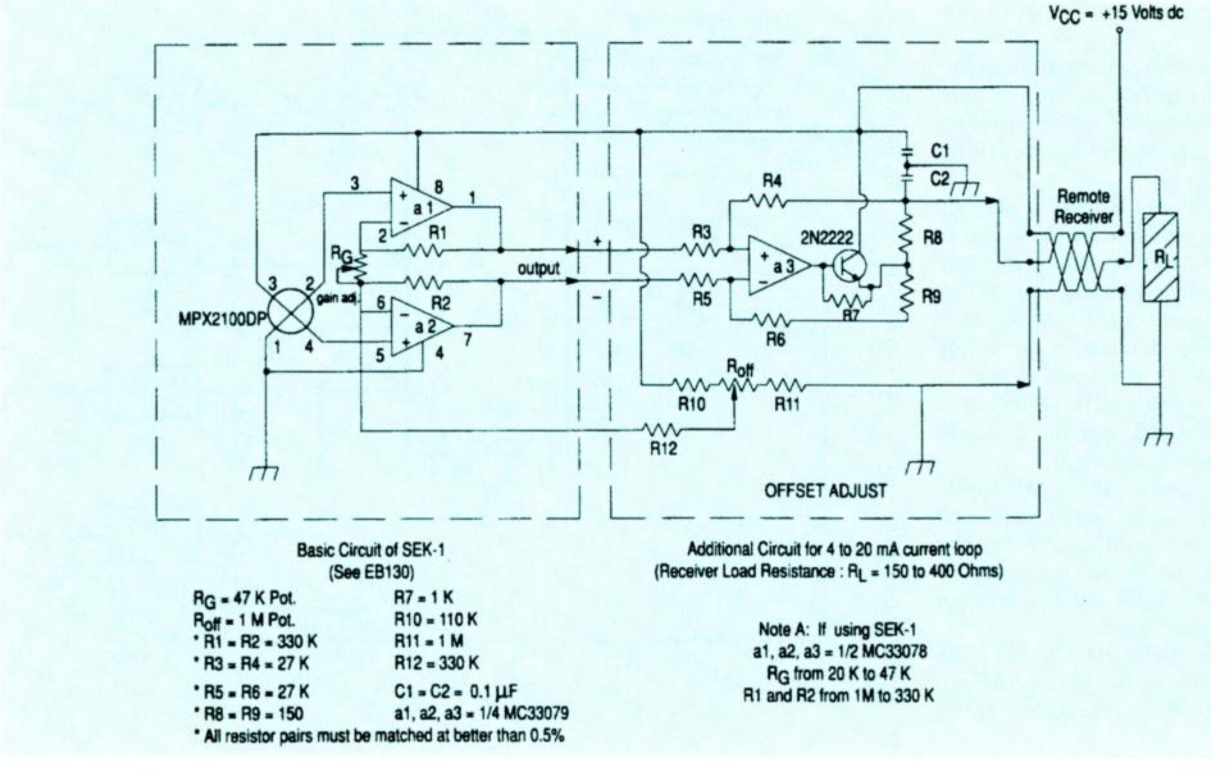
This circuit uses a Motorola MPX2100DP 100-kilopascal pressure sensor and an MC33079 quad op-amp to drive a 50m telephone line loaded by 150Ω, the 15V power supply being connected at the receiver end of the three-wire line. With the sensor used, temperature range is -40 to +85°C and pressure range is 0 to 200kPa and maximum error is better than 2% of full scale.

Two of the op-amps in the package form the true differential- amplifier first stage, available as a kit (SEK-1), which is directly powered by the 15VDC source. Voltage-to-current conversion is done by one of the other op-amps in the 33079 in a unity-gain circuit. Since the op-amps have a limited output current, a 2N2222 general-purpose transistor forms the current source, providing a 20mA output.

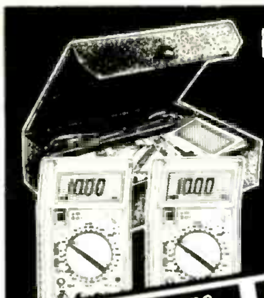
In calibration, Roff is adjusted to give 4mA for zero pressure and RG to give 20mA for full scale. A regulated power supply is needed, since the output varies in proportion to the supply voltage.

Motorola Ltd, European Literature Center, 88 Tanners Drive, Blakelands, Milton Keynes, MK14 5BP. App. Note AN1082.





METEX PROFESSIONAL DMM's



3½ and 4½ digit LCD large display (17 mm) Dmm's. AC/DC to 20 Amps ■ Resistance to 20 Mohms ■ 5 ranges AC/DC Volts ■ Hfe Transistor Test ■ Diode Test ■ Continuity ■ Auto Polarity and Zero ■ With test leads, Hard carry case and instructions.

MODEL	RANGES	BASIC	EXTRA FEATURES	PRICE
3800	32	0.5%	LD AC/DC UA	£26.50
3610	30	0.3%		£35.35
3630	30	0.3%	Cap Test	£39.60
3630E	30	0.3%	with Bargraph	£49.00
3650	30	0.3%	Freq. Count & Cap	£42.45
3650E	30	0.3%	with Bargraph	£50.50
4600	30	0.05%	Data Hold	£53.85
4630	30	0.05%	Cap. Test. Data Hold	£59.20
4630B	30	0.05%	with Bargraph	£67.25
4650	30	0.05%	Freq. & Cap & Data Hold	£63.25
4650B	30	0.05%	with Bargraph	£71.55
M818	True RMS Autoranger 3¾ Digit Data hold. Hi/Lo Frecuency			£43.15
M818B	As above with Bargraph			£49.85

"POCKET" TESTERS

3½ Digit, 12mm LCD digital meters £16.35
M2308 18 Range 10A DC £20.00
M23158 17 Range 10A ADC Cont. £23.72
M23188 23 Range 10 ADC Cont. Hfe £27.74
M2335 31 Range 10A/DC Cont £30.42
M2325 32 Range 10A AC/DC Hfe Cont.
M2355 32 Range 10A/AC/DC Hfe £34.57
Cont Freq
M2365 38 Range 10A/AC/DC £37.25
Hfe Cont Freq Logic Test £12.14
MX190 18 Range Dmm and Sig injector £12.14
ALT26 10ADC Dmm "Sturdy" £18.70
DM5 THIN Autorange Dmm £24.78
HC31 Pen Type Autorange Dmm
YF20 Dual Scale Sound Level Meter £32.85
120dB £30.65
225V VHS Video Head Tester £46.83
1065 Digital Lux Meter - 3 Ranges £8.65
07 Logic Probe £14.75
M625 Logic Probe/Pulser
300AC Clamp Meter 600A/300V plus £33.50
Range Lock. Resis Range
M265 Add on Clamp Probe £16.48
for Dmm's 0/1999 Amps £53.25
501 Electronic Insulation Tester 500V £70.88
504 Electronic Insulation Tester 1000V £41.88
KOm6 TR Dip Meter 1.5 to 250 MHZ £36.72
1062 LCD Temperature & Data hold £21.20
850 Mains Phase Tester
266 1000A AC Digital clamp meter £43.43
Data hold Resis. AC volts £29.35
261 Add on insulation tester for 266
3900TD LCD Dmm with Dwell and £41.70
Tach Ranges 20A AC/DC £36.20
KT50 LCD 8 Range Capacitance Meter £64.00
6060 LCD Digital True Power 6KW £5.74
213 12 Range MM £12.61
2070 19 Range MM 10ADC - Buzzer £26.77
5050E 41 Range FET MM £34.74
555 Sine/Sq. Audio Gen £89.00
PFM200A 200MHZ 8 Digit LED Counter £5.20
ORS10 "Dial" Resis Sub £9.53
OC/SC Open/Short CCT Test £13.87
X1/X10 Probe Kit

BENCH INSTRUMENTS

HAMEG SCOPES (with probes) £338.00
203/7 Dual Trace 20MHZ £610.00
604 Dual Trace 60MHZ £792.00
1005 3 Channel 100MHZ £610.00
205/3 Dual 20MHZ Storage £35.00
Carry Case
All Hitachi Models & Crotech Scopes available £249.00
SC110A 10MHZ Battery Scopes £375.00
1502 Dual 15MHZ Batt/Mains Scopes
FREQUENCY COUNTERS 8 Digit LED £109.00
MET100 100MHZ £135.00
MET600 600MHZ £178.00
MET1000 1000MHZ £204.00
MET1500 1500MHZ
FUNCTION GENERATORS £110.00
J500 0.1HZ to 500KHZ £149.00
J2000 0.2HZ to 2MHZ £110.00
TG101 0.02HZ to 2MHZ £160.00
TG102 0.2HZ to 2MHZ
PATTERN GENERATOR TV-VIDEO £209.00
Orion Pal VHF/UHF
BENCH DMM's LCD 3½ Digit £121.00
3210 True RMS 0.1% £99.00
3225 0.25% Basic £129.00
TM351 0.1% Basic
GENERAL £103.20
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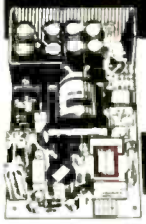

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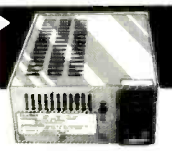

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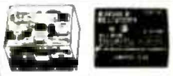

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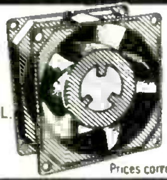

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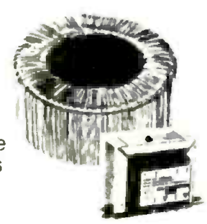

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ALIAS EPROM?

fastROM from Computer Solutions is claimed to emulate eproms for development applications faster and more effectively than other eprom emulators. Martin Cummings puts a system to the test.

Almost immediately after the invention of the read-only memory, someone decided he wanted to write to it. It was, after all, ambitious and a little unrealistic to expect the software to be a hundred percent correct and need no further updates once committed to rom. Simulated program runs and in-circuit emulators are all very well, but so often they do not flush out those last few bugs in the program. Hence the eprom, with its capability of erasure and reprogramming.

It was originally designed to store programs in memory for prototypes and short production runs, but quickly established itself as a tool to assist the microprocessor engineer develop and debug software. As the size of eproms has multiplied over the years, so the time to program them has also increased. Often, towards the end of an exercise, the changes are small and the wait for a revised eprom seems interminable. This delay in the development cycle can now be greatly reduced by using an eprom emulator.

Computer Solutions Limited specialises in supplying Forth development tools and fastROM complements this software. It emulates all popular eproms via a flat cable which plugs into the target board in place of the eprom itself, receiving data from the development computer through a standard, parallel printer port. As the name suggests, Computer Solutions "believe it is faster than other eprom emulators".

First impressions

FastROM arrives as a black box, floppy disk and manual. The unit is only slightly bigger than a TV remote control and in comparison with other emulators is pleasantly compact. Engineers will easily find room for fastROM, even on a desk full of circuit diagrams, computer, oscilloscope, PSU and data books .

Build quality is adequate. I feel sure that, were this a Japanese product, the alignment of leds with their windows would be more accurate, but this is not a serious matter.

At first sight, the manual appears sparse, being no more than five sides of well spaced-out notes. However, all you need is in there and, once up and running, there is little more to say.

Getting started

The unit comes with enough memory to emulate a 32Kx8 eprom (27256) but can easily be upgraded to 64K. My test application needed the full 64K so, after obtaining a suitable byte-wide ram, the first step was to unscrew the lid and fit the extra memory, guided by the brief but adequate instructions.

Once reassembled, connecting up is easy. The 28-pin header that plugs into the target board is thoughtfully supplied with a sacrificial socket; legs are often damaged when eproms or emulators are removed from the board or in handling and sockets are much cheaper to replace than flat cable assemblies.

A reset signal, which is provided, needs to be hooked onto a suitable track or pin on the target board to disable the application while data is being loaded into the emulator. It then gracefully starts the CPU running the program immediately after the transfer is completed. Both positive and negative-going reset signals are available.

Software supplied can be run from floppy disk or copied to a hard disk. Once running, a brief help screen can be displayed. The menu provides commands to configure, load files, dump and edit data. Several file formats are accepted by the emulator, depending upon the compiler you are running. Configuration takes only a few seconds but must be repeated after power-down, either manually or by running a batch file.

fastROM specifications

eproms emulated	2716 2732 2764 27128 27256 27512*
access time	150ns max
dimensions (mm)	85x145x25
file formats	pure binary, Intel hex format, Motorola S records, ASCII

system requirements
IBM PC, AT or compatible with parallel printer port.

** with memory upgrade*

Performance

Confronted by the boastful product name, I could not resist timing the transfer of data into the emulator but, at around one or two seconds for all 64K, it takes longer to remember the filename. At this point the benefits of an emulator become obvious. Compare one or two seconds with 10 to 15 minutes for each program iteration on an eprom, then multiply this by the number of program changes and you probably already have justification for using fastROM. This is particularly so if you take into account the reduced damage to the board resulting from fewer eprom changes and wear and tear on the eraser bulbs.

The software includes an editor to modify, byte by byte, the data in the emulator, which could be useful when making adjustments to constants in the code or fine-tuning look-up tables. In fact, the editor changes the code in the computer which then has to be reloaded into the emulator but, as loading is so fast, this is no problem. Data is displayed on the screen in groups of 256 bytes. Locating the offending piece of code is made as easy as possible by presenting the array in hexadecimal with the equivalent ascii characters alongside.

Changing bytes involves typing the address followed by the new data in hex. While this is no great hardship, it reminded me of systems I worked with 14 years ago and the experience could have been much more pleasurable if the cursor, guided by arrow keys, selected the byte and changes were performed by overtyping.

At the first attempt I found a curious feature of the editor. Data is presented and must be entered in hexadecimal, but the editor would only accept numbers from 0-9, dropping out of "modify" if higher hex characters were typed. Computer Solutions verified this and rang me back the next day to explain that the use of "caps lock" resolves matters. Apparently no one else has yet been caught out in this way.

When fully populated, the unit draws about 7mA from the target board socket; this should pose no problems and is only slightly higher than a cmos eprom. The extra milliamp or two is well worth the sacrifice to keep the bench clear of additional boxes and wires. Interestingly, fastROM must also draw power from the computer because removing power from the target board does not destroy the emulator's memory. On reflection, perhaps we should expect nothing less from an emulator of non-volatile memory.

```
HELP      ?              Displays this help screen

ASCII     BINARY         Selects the data format for loading and
INTEL     MOTOROLA        saving files

2716   2732   2764       Selects the PROM for emulation
27128  27256  27512

(L)OAD filename          Loads a file using the current data format
(S)AVE filename          Saves a file using the current data format

(D)UMP [ address ]           Dumps a region of memory
(M)ODIFY [ address ]         Modifies data bytes

LPT1  LPT2  LPT3  LPT4       Selects the output channel
UNIT0  UNIT1                 Selects the fastROM
32K  64K                     Selects size of fastROM
GO                           Starts emulation

END                          Returns to MSDOS
```

fastROM menu screen

Those who need 16-bit emulation can simply plug two fastROMs into their eprom sockets. Two units can be connected to the one computer parallel port, which involves crimping another connector onto the fastROM flat cable; full instructions are provided, but the supplier will do this for a small fee. The two units are then addressed independently by the software and a link on the fastROM PCB identifies it as the high or low byte emulator. Software will support further parallel ports, so more fastROMs could be simultaneously operated if desired.

```
*
*
*d 200
0200 32 ED F7 F1 89 46 F8 A1  1A 00 89 46 F6 A1 26 00   |2....F.....F..&.|
0210 F7 E3 8B C8 32 C0 8B FE  F3 AE 75 03 E9 40 01 C6   |....2.....u..@..|
0220 46 FA 08 8E 06 89 01 56  FF 76 F6 FF 36 12 00 FF   |F......V.v..6...|
0230 36 14 00 8E 06 94 01 26  C6 06 00 00 1E 26 C6 06   |6......&.....&..|
0240 01 00 B2 8B 46 FE 26 A3  02 00 8B 46 FC 26 A2 04   |....F.&....F.&..|
0250 00 A1 12 00 26 A3 05 00  A1 14 00 26 A2 07 00 26   |....&......&...&|
0260 C7 06 08 00 02 00 BF 0A  00 A1 1A 00 A0 B0 00 AA   |................|
0270 9A 4A 6E 6C 20 73 03 E9  EE 00 8E 06 94 01 26 C6   |.Jnl s........&.|
0280 06 00 00 1E 26 C6 06 01  00 03 00 46 FE 26 A3 02   |....&......F.&..|
0290 00 8B 46 FC 26 A2 04 00  A1 12 00 26 A3 12 00 A1   |..F.&......&....|
02A0 14 00 26 A2 07 00 8B 4E  F0 00 56 F6 E8 24 FD 89   |..&....N..V..$..|
02B0 56 F6 A0 C4 10 32 E4 F7  E1 26 A3 00 00 8F 0A 00   |V....2...&......|
02C0 8E 06 89 01 8B 46 0A 40  02 46 F8 00 D4 00 F6 36   |.....F.@.F.....6|
02D0 C5 10 8A D0 8B 1E 24 00  8A 76 FA FF D3 FE CE 75   |......$..v.....u|
02E0 03 D6 08 46 E2 F5 08 76  FA 8E 06 94 01 00 00 AA   |...F...v........|
02F0 9A 4A 6E 6C 20 72 71 83  7E F6 00 74 83 E9 7A FF   |.Jnl rq.~..t..z.|
*
*
*m 28d
028D  34
028E  35
028F  36_
```

Editing in progress. Hex is used to type in bytes, and ascii equivalent characters are shown at right. Capitals are needed for hex letters.

Four files are provided on the floppy disk, two of which appear to be superfluous but from their contents give a hint that they could be of use under the right circumstances. There is no explanation of the use of these files in the manual but, when contacted, Computer Solutions explained that the files provide a driver and some documentation to allow fastROM to be operated directly from the Forth operating environment as an alternative to the menu provided.

Conclusions

FastROM is compact, quick to get running and removes several frustrations from the life of a microprocessor engineer. For these reasons alone it will endear itself to many people and, at £195 for the 32K version, it is not difficult to justify on the grounds of time saved.

In all aspects it compares well with other eprom emulators on the market and its speed, small footprint and lack of external power supply are advantages that mark it out from the rest.

It has been designed by people who know what is needed and has been engineered to provide good value for money. The software supplied is a no-frills package, but offers all the features that are needed in a simple-to-use manner. For those developing romable code on a tight budget it is a useful tool for the job. ■

SUPPLIER

Computer Solutions Ltd, Canada Road, Byfleet, Surrey KT14 7HQ. Telephone 0932-352744. UK price £195 + vat.

News travels fast into the heart of the BBC

ENS, the BBC's new Electronic News-room System, which links journalists in the field to the news-room computer

BBC journalists working on assignment in the field can now file their stories directly into the News-room's central computer - from anywhere in the world.

Laptop computers are supplied to journalists and a telephone line is used to make the link, but it is the design of the BBC's own system that enables the processing of stories, or obtaining of comprehensive information. Now journalists can access everything, from copy coming on the BBC's news-line services to full information on every item due for transmission on the main news.

"Journalists working in the field can dial in and see what is happening on the main system, write independently on the laptop and then plug in and transmit the data back to London," says Alan Perry, computer and office support manager for BBC news and current affairs.

At present, laptops are mostly being supplied to staff working overseas and the BBC is building up a stock of Toshiba 1200 XE machines, which come with a built-in modem. But allowing laptops access to central computing is only one way in which the BBC is engineering maximum flexibility into its news operation.

For example, as a political correspondent in Washington checks on the running order of stories for the Nine O'Clock News, staff working on Question Time can copy large chunks from the main database onto a PC and carry it to different locations - invaluable when this programme recently went on the road around Britain.

What has enabled the BBC to build this integrated system is that all parts of the news and current affairs directorate are connected on the same software as part of the Electronic News-room System (ENS).

At its heart lies the Basys operating software on three Dec 6310 computers, giving a uniform service to every user on the 850-terminal news and current affairs system, on a network supplied by 3-Com.

Basys was first used by the BBC in 1982 for radio news and adopted four years later by the television department. Supplied by Basys International, it was delivered as a scripting tool, but the BBC has changed it into a vast database and wordprocessing network.

When a user logs onto Basys, a three-item menu appears: item one leads into the vast radio and television news production system. Route two is the back-up and also acts as a gateway for the regional news teams. Journalist training is the third choice and can be used for testing and as emergency backup for radio.

Entering each part of Basys, the user can view anything, from the order in which the news will appear to what came through that day on the BBC's 14 permanent datacomms links with news agencies such as Reuters. And with each programme's running order listed - even to the extent of which news-reader will appear with a story - the BBC has a platform to make any changes and transfer any stories at will.

"You get the timing of the whole programme. The system is easy to use and understand and this is useful when stories develop on-air," says Perry. "Scripts are written as on a normal wordprocessor and downloaded to the reader's autoprompt, which the system treats as a printer."

With only 420 ports on ENS and 850 terminals to serve, Perry feels that a maximum load has been reached. The daily news programmes are connected all the time, with less frequent output, such as Panorama, linked-in according to need. Managing the traffic on Basys and troubleshooting figure large among Perry's list of priorities.

The BBC news and current affairs department does not employ any analysts or programmers and relies on tailored software packages. Without a software development team, the BBC has to rely on packaged products, like the personal editing terminal tool used by Question Time to down-load the Basys databases to PCs. These software products mostly come from Basys International.

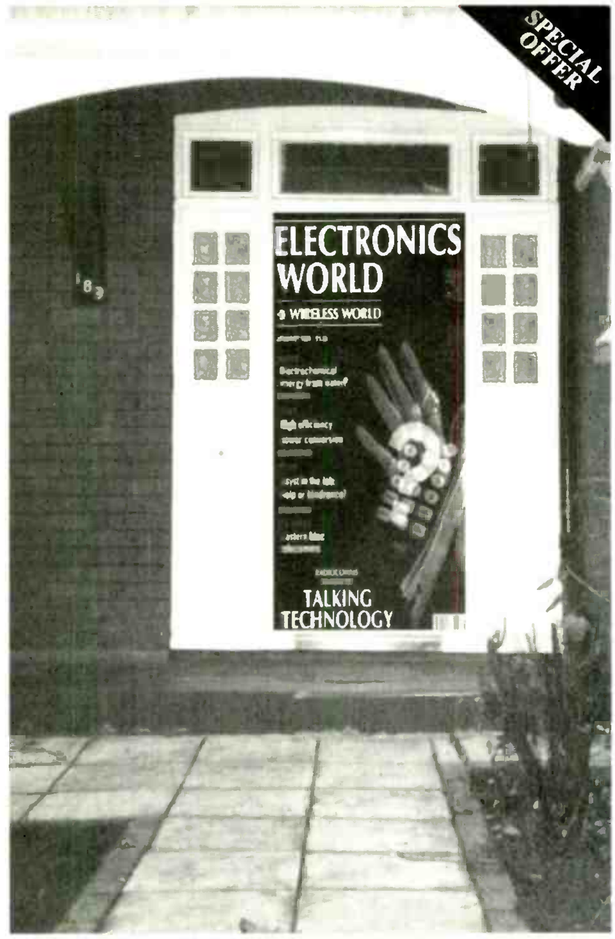
Security is another key issue for Perry and his team. This not only means that data must get through to the right people uncorrupted, but also that the right people get access to suitable parts of the system.

Each user of the ENS has a password which permits entry to files relevant to that person's work. This layered security keeps the key system files at the heart of ENS available only to management.

It also protects individual journalists, making it next to impossible for colleagues to grab each other's "scoop" story. Leavers are immediately removed from security listings to stop illicit entry from outside the Corporation.

The BBC is committed to Basys for the foreseeable future. Its simplicity cuts out the need for extensive training courses for new staff and helps ensure that problems are also kept as simple as possible.

"Obviously Basys is a lot more, but sometimes I feel the whole system is just a huge wordprocessor," says Perry.



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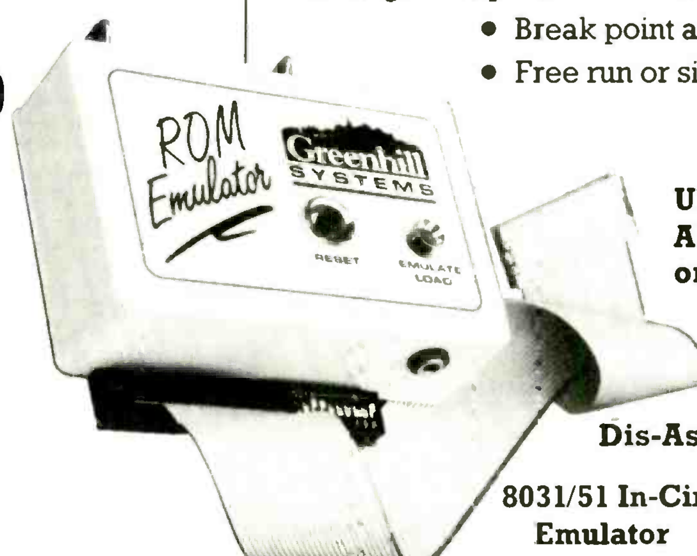

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ACL Field Intensity Meter Receiver type SR–209–6. Plug-ins from .5mc/s to 4GHz – P.O.R.
Tektronix TR502 Tracking Generator – 100kc/s–1800Mc/s – TM500 mainframe. P.O.R.
Marconi TF2361 Sweep Generator + + TM9693 0–300Mc/s + TM9694 – 220Mc/s–1000Mc/s – £350.
HP 11710B Down Convertor – .01–11Mc/s – £450.
HP 8640B Signal Generator Opt. 001+003 – 512Mc/s – £1200.
Narda Microline Sweeper model 9535C – 1–18GHz – £2000.
Singer EMA 910–11 data evaluation unit – EMA 910–10 FX selection units + EMA 910–12 FX selection unit. 1GHz–26.50GHz total FX coverage – £2000.
Marconi distortion meter type TF2337A – £150.
H.P. pulse modulator type 11720A – 2–18GHz. P.O.R.
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H.P. 8660C signal generator – 1–1300Mc/s. 86602B + AM-FM modulator PI 86632B – £2500.
H.P. 3720A spectrum display – £200 – **HP3721A** correalator – £150.
H.P. 3320A frequency synthesiser – .01Hz to 13Mc/s OPT001 – £250.
H.P. 5359A time synthesiser pulse generator – 10Mc/s – £400.
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H.P. 331A distortion analyser £150.
Marconi TF2331 distortion meter – £150.
H.P. amplifier type 8447A – .1–400Mc/s – £400. HP8447F – .1–1300Mc/s – £800.
H.P. frequency counter 5340A – 18GHz – £1000. Rear output – £800 – 20GHz opt – £1100.
H.P. spectrum analyser plug-in 8557A – .01–350Mc/s – £500 – OPT001 – £400.
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Tektronix 491 spectrum analyser – 10Mc/s–40GHz – £1000.
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Tektronix DC508A – 1.3GHz counter + TM500 mainframe – P.O.R.
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Tektronix mainframes – 7603 – 7623A – 7633 – 7704A – 7844 – 7904 – TM501 – TM503 – TM506 – P.O.R.
Tektronix oscilloscopes – 465B – 466 – 475 – 475A – 485 – 2215 – 2235 – P.O.R.

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Monitoring the oceans

Sonar and radar for data logging and evaluation of the surface and depths of the sea to assist oceanography, environmental protection, shipping and Defence surveillance is being increasingly pursued at a number of British universities and research establishments. This became clear at a recent IEE colloquium at which 12 presentations were made by speakers from five universities, three research establishments and four on behalf of the Institute of Oceanographic Sciences (IOS).

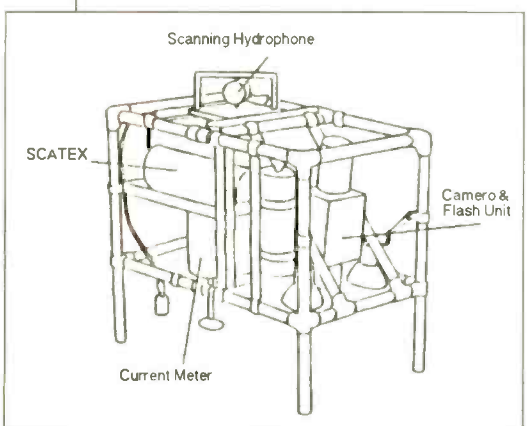
At the Fisheries Laboratory, a Ministry of Agriculture, Fisheries and Food team is developing a short-range, three-frequency echo-sounder and data logger for recording acoustic energy back-scattered by fine suspended sediments at a height of about 1m above the sea bed. The equipment is part of a large tetrapod submersible and a prime purpose is to estimate particle size in tracing possible movement of radioactive heavy metal particles near discharges from nuclear plants.

A 1W transmitter at 1, 2.5 and 5MHz provides pulses at a rate of 16Hz, with the acoustic back-scatter received on a sensitive superhet receiver. Transmitter breakthrough into the receiver's passband is prevented by operating the oscillator at twice the required frequency, then dividing by two only while a pulse is being transmitted.

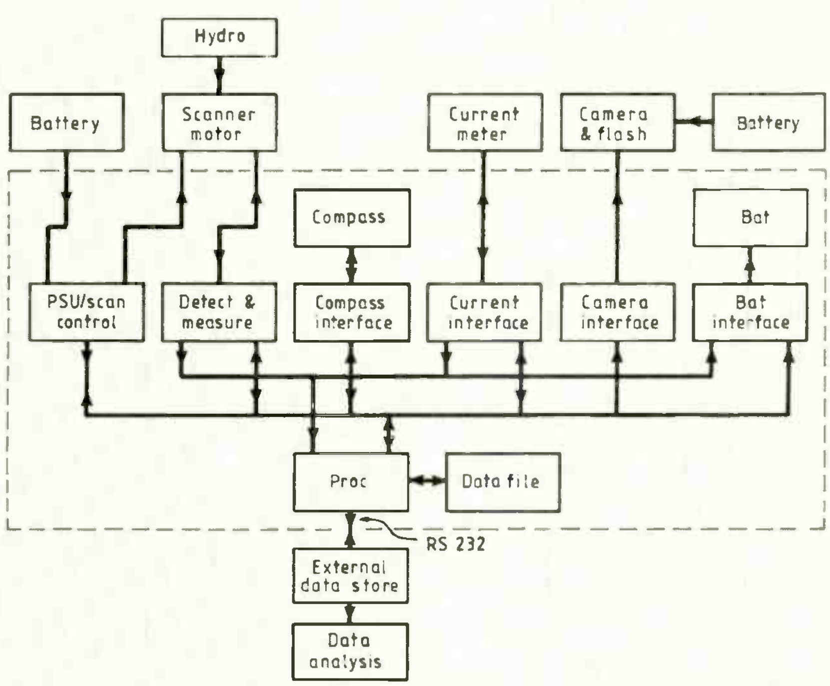
The receiver has an overall gain of 100dB and a 542kHz IF. Both receiver and transmitter use temperature compensated LC oscillator circuits, permitting rapid frequency changes.

At present the data logger uses a four-track cassette recorder (selecting data samples) but the team plan to change to solid state or disk storage and to increase transmission rate up to about 100Hz. Range is limited to about 120cm.

Only particle size is measured and the nature of the particles is analysed separately from samples.



Audos with scanning acoustic tracking experiment (Scatex). Scatex controls the camera, current meter and scanning unit, measuring the angular displacement of tagged fish and logging all instrument data.



Deep ocean studies

Aberdeen University researchers have developed a deep ocean submersible system (Audos) for acoustic tracking of fish living near the sea floor at depths of 4000-6000m.

Fish such as rat-tails (grenadiers) are attracted to bait, swallow miniature acoustic transmitters and are photographed by automatic flash cameras. Fish can then be tracked up to about 1km. Results are already showing that such fish actively forage for food rather than, as previously thought, passively await food particles descending from above.

The IOS Deacon Laboratory near Godalming is involved in the ambitious Nerc Autosub Community Research Project aimed at developing unmanned autonomous underwater vehicles (AUVs) for data gathering in the deep oceans.

First mission in a climate research programme is based on the concept of a "deep ocean long path hydrographic Instrument (Dolphin)" designed to navigate its way across an ocean, automatically conducting a continuous series of hydrographic measurements while undulating between surface and sea bed.

Early efforts have indicated that AUVs tend to show sufficient intelligence to get themselves lost!

One major requirement is an improved source of energy storage. Fuel cells are seen as the long-term solution with more conventional storage batteries available in the interim; lithium batteries are still considered too hazardous.

Digital audio broadcasting

New spectrum allocations are to be sought at Warc-92 below 3000MHz, for the German/French CofDM system (see RF Connections, *EW + WW* December 1990, p.1106) with sub-band source coding (Musicam).

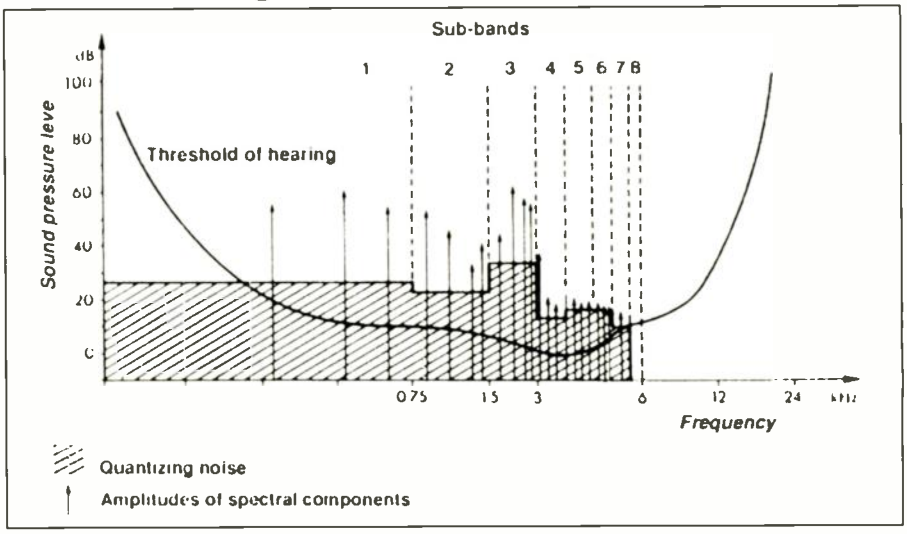
This uses 32 sub-bands, each 750Hz wide, taking advantage of the masking properties of the ear to compress each stereo channel to a bit-rate of 256kbit/s.

For television sound, despite the more hostile environment of the studios, the Nicam 728 digital system is proving capable of providing excellent quality stereo to the home.

EBU writers (see box below) point out that there have been some teething troubles where broadcasters have used the two channels independently as bi-lingual mono channels, since the receiver industry has not made provision for this facility.

They make the point that this shows the care that must be taken and they highlight the need for close co-operation between broadcasters and the receiver industry. What seems like a good idea in isolation can create havoc if receiver manufacturers have not been informed about the changes, or the specification has been misunderstood.

EBU broadcast-members have also been participating in a Race project to develop a digital integrated broadband communications (IBC) system for transmission of video and audio over ISDN telecommunications broadband fibre-optics links. IBC could be used both for direct delivery to the home — eventually superseding broadcast transmission to the home, though still required for reception in cars, etc. — and also for contribution and distribution circuits.



Basic principles of the Musicam sub-band sound coding system

EBU expresses concern that most proposals for IBC start from the premise that all signals (sound and vision) will be bit-rate reduced to a significant extent. While this is perfectly acceptable for distribution circuits (home distribution and studio/transmitter and intercity links) contribution circuits carry programmes which may be re-edited, re-mixed or otherwise processed. It may not be advisable to use powerful bit-rate reduction on such links.

Since 1989, EBU itself has been operating a "Euradio" system for sound programme exchanges, based on the Eutelsat satellite transponders already in use for the Eurovision network. This is designed as a digital sound contribution system, using 32kHz sampling frequency; 16-bit signal converted into 14-bit floating-point; with 1/2 error protection to give a 2048kbit/s bit-stream, with QPSK modulation.

Getting digitised sound to the home

Success of CD records and the arrival of R-Dat recorders is forcing broadcasters to recognise that a quantum leap in audio quality is now within reach of home listeners.

According to G T Walters and R Chambers of the Technical Department of the European Broadcasting Union, the goal of broadcasters is now "CD quality to the home!".

The problem, which Walters and Chambers go on to tackle in an introductory survey to a special issue of the *EBU Review - Technical* (June/August 1990) devoted to "Sounds of the future, is how to achieve this."

One approach is to extract the last drop of quality from existing systems such as pilot-tone FM stereo.

Weakest link in the broadcast chain tends to be the distribution networks between studio centres and transmitter sites, since analogue links still predominate.

But it is now possible to contemplate completely new methods of digital distribution and transmission to the home, taking advantage of digital technology to give transparent signal paths and/or the large increase of spectrum bandwidth available in satellite broadcasting.

However, channels currently allocated by ITU (International Telecommunications Union) to satellites, wide enough for high quality television, are: "far too wide to justify their use for single audio programmes, even of the highest quality."

But they do permit "sufficient sound programmes for the needs of a whole country to be put into a single satellite channel."

This is the aim of the German-developed Digital Satellite Radio (DSR) system. 32kHz sampling frequency, 16/14-bit floating-point sound coding, BCH(63, 44) error protection (plus extra protection for scale factors provide 16 stereo or 32 mono channels, with a total bit-rate of 20.48Mbit/s in a single satellite broadcast channel.

DSR has been in trial use in Germany on the Kopernikus communications satellite and on one channel of the DSB German TV-Sat. Receivers are already available.

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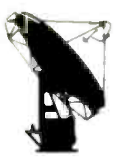
For further information, please telephone **Kevin Ryan** on **Reading (0734) 472742 ext 301.**

Please write for an application form (quote ref. 6846/WL) to **Personnel Department, BBC Monitoring, Caversham Park, Reading RG4 8TZ, or telephone Reading 472742 ext. 332.**

Application forms to be returned by March 7th.

WE ARE AN EQUAL OPPORTUNITIES EMPLOYER



Government Communication Headquarters

Radio Officer

Government Communications Headquarters (GCHQ) are specialists in all aspects of communications, from DC to light. We require skilled and motivated staff to undertake a wide range of duties to study these communications. As a **Radio Officer** you would be an essential part of our technical team, and would be trained to undertake a wide range of duties.

- We offer excellent training
- Attractive salaries (reviewed annually)
- Opportunities for moves within the UK and overseas
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- Good career prospects
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- Generous leave allowance
- Non-contributory Pension Scheme

To qualify you need or hope to obtain a BTEC National Diploma (or HNC/HND) in a Telecommunications, Electronics Engineering or similar dicipline. Special consideration will be given to applicants holding an MRGC Certificate. The C&G 777 (advanced) or other qualification incorporating morse skills would be advantageous but not essential.

You can apply if you have a minimum of 2 years recent radio operating experience and preferably be capable of receiving the morse code.

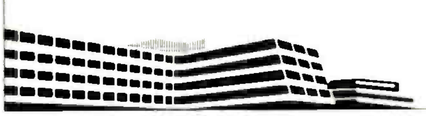
Age limit for experienced Radio Officers 18-45. Age limit for candidates who do not possess the full range of skills 18-40 (depending on background and experience). **Training Period:** Between 29-52 weeks.

Salary after training (over 5 years) £13,756-£19,998 with prospects for further promtion. Salaries include an allowance for shift and weekend working.

GCHQ is an equal opportunity employer

APPLICANTS MUST BE BRITISH NATIONALS

For further information and application form contact:
Recruitment Office, Room A/1108, GCHQ Priors Road, Cheltenham, Glos. GL52 5AJ or telephone (0242) 232912 or 232913



GCHQ

Audio Digital Technology

Is a small company specialising in the design and marketing of professional audio equipment.

A vacancy exists for a self-motivated engineer who will be responsible for a variety of design projects. Applicants should have the ability to work with the minimum of supervision and have experience of Digital/Analog Signal Processing, and some knowledge of professional audio equipment would be an advantage.

Successful candidates will probably have a degree, a keen interest in music and a practical approach.

Please send your CV to

The Coach House, Manor Road, Teddington, Middlesex TW11 8BG
Tel: 081 977 4546. Fax: 081 943 1545.

All replies will be treated in strictest confidence.

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We are the specialist agency for 'Radio Frequency' design or test Engineers working from 1MHz to light! We have hundreds of top positions throughout the UK, working on RF mobile comms (GSM, PCN, CT2), opto, satellite, mm-wave & microwave projects. Please contact our consultant **Simon Luttrell MSc** on **0494 792592**

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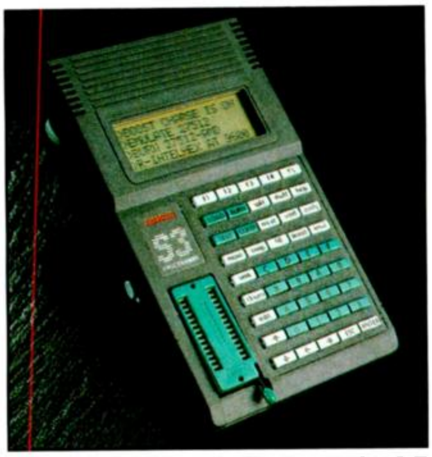
Dataman Introduces Omni-Pro at £395



S3 - The Best-Seller . £495

Wouldn't you like an EPROM Programmer that is Elegant? Stunning? Superb?

These are words used by engineers to describe S3. They often say S3 makes their expensive lab-programmer look stupid. How can we disagree? When designing S3 we tried to turn a boring bench-instrument into something more exciting: a compact, intelligent tool which could be used for New Product Development, with facilities such as Editing and Memory-Emulation. We made S3 small enough to slip in a pocket and battery-powered so that it would retain data and configuration, because we were sure engineers would want one each. And they do! S3 is now the best-selling programmer in the U.K.

S3 is likely to fill needs that you never knew you had! **We can send you an S3 today on FREE TRIAL - 30 DAYS SALE-OR-RETURN.**

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Optional S3 Developers Package

Software and Inside Information for engineers who wish to study and customise S3. No Secrets! Editor/Assembler (SDE see below), Circuit Diagrams, List of Calls and BIOS Source Code £195

S3 as a Development System...

The FREE Terminal Program which comes with S3 provides Full Remote Control from your PC. All keyboard functions are supported - such as Editing, Byte and Block Shifting, Split & Shuffle, Seek and CheckSum. S3 is also a Memory Emulator - it will substitute ROM or RAM in-circuit. You can try your program before committing it to PROM.

S3 as a Programmer...

S3 will program virtually any EPROM or EEPROM that will go in the socket. Without recharging, you can program 1000 modern fast PROMS or 100 ancient slow PROMS. Operation is continuous with a mains supply: S3 can be used while recharging. S3 does not monopolise your computer for copying, editing or programming PROMS. S3 uses latest high-speed programming methods and supports FLASH EPROMS. Program, Data and Configuration are retained while turned-off S3 has a ROM BIOS, but runs its main program in RAM. Software can be upgraded instantly from a PROM in the socket. SOFTWARE UPGRADES ARE FREE.

What you get with S3...

Mains Charger, Ring-Bound FactoFile Manual, Emulation Lead (plugs into your ROM socket), Write-lead (hooks-up your uP Write-Line when emulating RAM in a ROM socket), FREE Software Upgrades by BBS, Technical Support by Phone, Fax and BBS and a FULL THREE YEAR GUARANTEE.

Omni-Pro.................. £395

Programs BIPOLARS, PROMS, PALS, GALS, EPLDS, PEELS, IFLS, EPROMS, EEPROMS AND MICROCONTROLLERS. Tests SRAM, DRAM AND TTL/CMOS logic

Omni-Pro uses a short slot PC card to make fast parallel transfers of data. It is controlled by software with a professional look and feel. The latest quick-programming methods are supported. Any of the usual file-transmission formats can be used. Omni-Pro is compatible with all popular PLD compilers producing JEDEC files.

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What you get with Omni-Pro...

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SDE Assembler £195

Develop your New Product in an advanced Software Development Environment.

Dataman's SDE comprises a two-window Editor, fast Macro Assembler, Linker, Librarian, Serial Comms and an intelligent Make facility which automatically reassembles ONLY those files you have edited, links them and downloads to your Memory-Emulator or Programmer.
SDE works very well with S3.

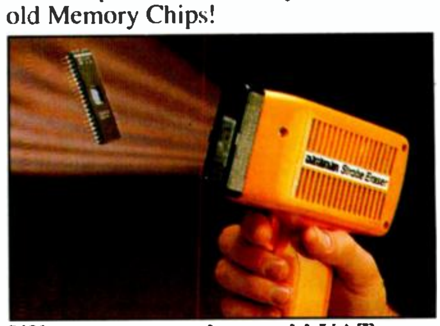
The Editor is pretty smart: it can tell you the Absolute Address of any line of the Source-File. The Assembler is pretty smart too: if it finds a mistake it puts you back in the Editor at the right place to fix it. SDE's Multi-Processor version supports all common micros - please ask for list. The Disassembler version creates Source Files from Object Code (e.g. from a ROM).
SDE IS NOT COPY-PROTECTED.

SDE Multi-processors & Disassemblers £695
SDE Multi-processors £395
SDE Single-processor £195

Strobe Eraser £175

Wipes EPROMS before you can say "Jack Robinson".

Our Flashy New Eraser wipes EPROMS clean in seconds. You can do it to chips on the bench, chips in-circuit or even chips in the Programmer. Tidy up your workshop tomorrow. Recycle all those old Memory Chips!



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CIRCLE NO. 103 ON REPLY CARD

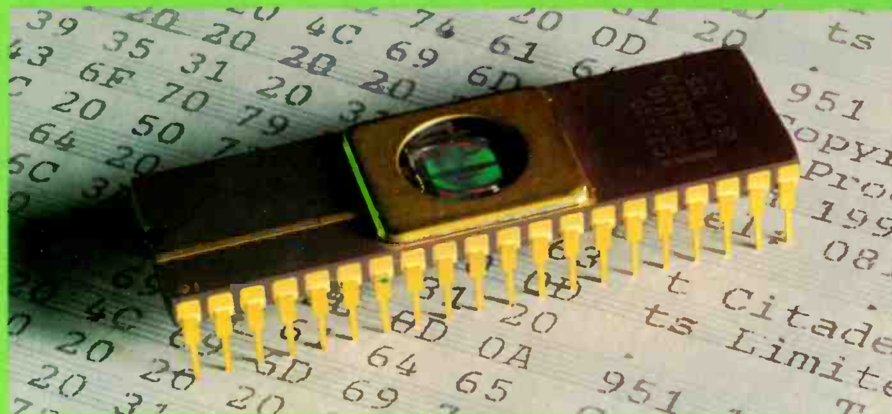
IC PROGRAMMING SOLUTIONS – from £139

For the IBM PC, install the interface card and programming socket, load the menu-driven software and you have a complete design system at your fingertips.

EASY TO INSTALL
The programmer comes with an interface card that plugs into any free slot of your PC. There is no DMA channel to worry about and it occupies limited I/O space. The programmer socket box is connected via a ribbon cable to the back of the interface card so that the socket box is external. After the interface card is installed the PC never need be opened again.

FEATURES
The menu-driven software is a full editing, filing and compiling package as well as a programming package. Save to disk and load from disk allows full filing of patterns on disk, to be saved and recalled instantaneously. Device blank check, checksum, program, verify, read and modify are all standard features. Hex to bin file conversions included for popular file formats including Intel Motorola etc. 2 ways/4 ways bin file splitter for 16/32 bit file data.

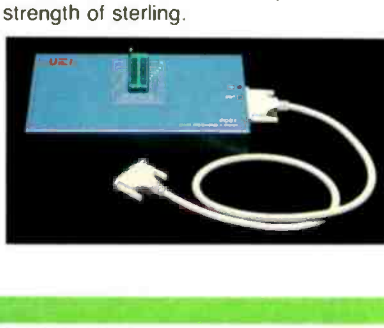
SOFTWARE DRIVEN
All software for the programmers is supplied on 5¼" low-density disks. The software can be copied onto hard disk using the DOS copy command. Programs are supplied for the various features and are menu-driven. All programming is done from the menu, no hardware switches are needed. Just select the type and manufacturer and the programming is done automatically. Free software updates for new types which are continually being added.

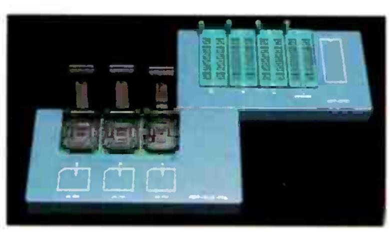


SUITS ALL PC's
The programmers will run on any compatible IBM machines such as XT's, AT's, '386 and '486. Whether it be AMSTRAD or COMPAQ the programmers will work. The software is text only monographic so is compatible with any machine.

DEVICE GUIDE	PC82	PC83	PC84
EPROM N/CMOS 2716-27010 (1 mBit) Vpp 12.5,12.9,21,25	√	—	√
EPROM 27513,27011,572000/4000,8764-87256,CYC2XX SERIES	√	—	—
EEPROM 2816,2816A,2817,2817A,2864A	√	—	√
EEPROM 9306,9307,9346,9356,93CS06,26,44,56,66,28256	√	—	—
BPROM 32×8 to 4096×8, incl. 63S080,7C28X,29X.	√	—	—
PAL 10,12,14,16,18,20-L,R,X,P,1,2,4,8,10 (20&24-pin)	√	√	—
GAL 16V8,18P8,20V8,22V10	√	—	—
EPLD 20G10,22V10, EP310,320,600,610,900,910,5C031,32,60,90	√	—	—
CMOS EPAL C16L8,R8,R6,R4,C18V8,C20G10,L8,R8,R6,R4, C22V10	√	—	—
MPU Z8,8748,49,50,51,C51,C52,C252. Inc. encryp. lock bits	√	—	—
Device testing TTL/CMOS logic, DRAM & SRAM	√	—	—
Selection of speed algorithm fast, intelligent, Intel etc.	√	—	√
Byte splitting for 16 & 32-bit files	√	—	√
Industry standard file formats	√	√	√
Hardware config. available for software design	√	—	√

PC82
Universal programmer. The complete designer's kit. This will program EPROMS, EEROMS, BPROMS, PALS, GALS, EPLD's, Z8 and 87XX microprocessors. A unique feature is the testing of logic parts such as 74LS393 etc. The PC82 can check and identify parts. Already programmed are the TTL & CMOS logic test vectors. Software is supplied to write vectors for most unique chips. One of the most popular programmers in the USA. Now lower price due to strength of sterling.



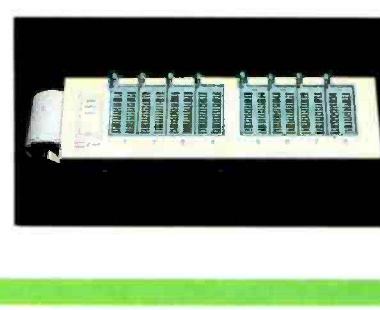


ADAPTERS FOR PC82
A range of plug-in adapters to expand the capability of the PC82.
PLCC for Pals, 4-gang Eprom, 4-gang Gal, & 4-gang Pal are popular examples from the extensive range.

TTL, CMOS, DRAM & SRAM TESTING
PC82 can test and verify any TTL/CMOS logic chip, DRAM & SRAM. The software will also identify a TTL chip. Do you have a few TTL chips aside not knowing whether they are working?

PC84 SERIES
PC84 -1, -4, -8 Eprom programmers only. The variant is only gang size. The -4 and -8 gang will program multiple EPROMs simultaneously. Device sizes are from 2716 to 271000 both C and NMOS. ZIF (zero insertion force) sockets are used on all models.

PC83
PAL programmer only. Will program most 20 and 24-pin types from TI, NS & MMI from standard Jedec files.



PRICE LIST

PC84-1 1 Gang Eprom	£139	PC83 Pal Programmer	£275
PC84-4 4 Gang Eprom	£199	PC82 Universal Programmer	£395
PC84-8 8 Gang Eprom	£299		

Please include £7 carriage plus VAT on all UK orders.
All pricing includes software, interface card, socket box and full instructions. (Prices do not include VAT or carriage)

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