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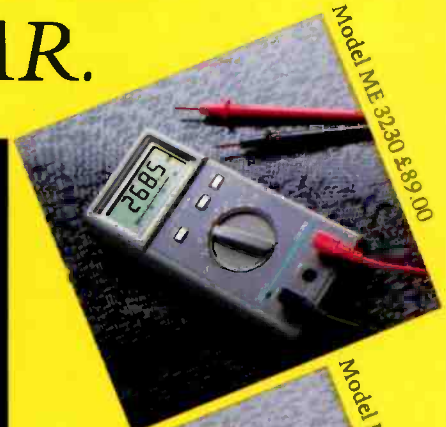

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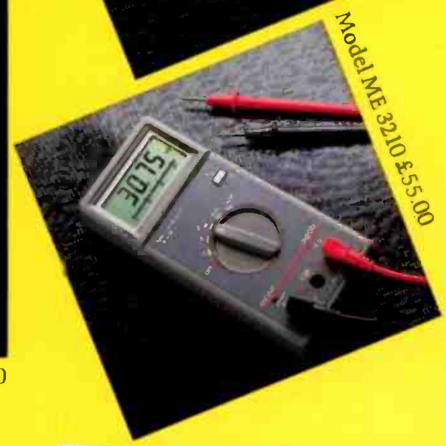

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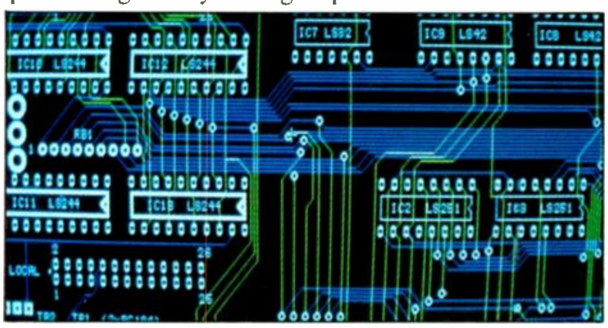

CAD special feature starts p85

REGULARS

In next month's issue. Semiconductor technology has reached the point where homodyne reception for FM signals has acquired commercial importance, for instance in the radio paging market. Ian Hickman describes both the system and its modern implementation.

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Dat's a fact

Should domestic tape recorders be able to reach the hiss-free professional standards of the studio? "Of course", say the manufacturers of digital audio tape machines, soon to be available for £600 from your local hi-fi shop.

"Over our dead body", says the music industry, trundling out the old war horse last seen in action throwing stones at cassette makers. Remember the slogan "home taping is killing live music"?.

So while the rest of us strain our ears for assurance that the tape hiss on our present music systems really is unbearable enough to justify junking the hi-fi and starting again with dat, we can settle down to watch the restaging of a traditional battle — inevitable technical progress versus the status quo. The music industry apparently lives in a nightmare world where only one person buys a CD which everybody else passes around to tape. Whether dat represents a discernible improvement is questionable, a debate which will fill the pages of audio and music magazines for many months.

The point is that consumers should be allowed to make their own judgement. But the music industry would not have it so. Already in the US song-writers, concerned for their loss of royalties, are resorting to the courts in an attempt to prevent dat making it into the home. At the same time the industry is mobilising for a concerted campaign to prove that dat will halt music-making in its tracks (if you will excuse the pun).

The fact is that dat is here and, like any advance made in technology, it cannot be unmade. Such progress will inevitably emerge in one form or another no matter how long it is suppressed. The stance of the music industry is not dissimilar to that of unions in the newspaper industry faced with new technology, or workers in the car industry faced with automated production. Or Captain Ludd and his followers seeing mechanisation of the textile industry as robbing them of their livelihoods.

In all cases the technology was developed and available. Its implementation was only a matter of time, and when change came it was traumatic. Unfortunately, this reaction is all too common. Groups who see themselves under threat immediately buttress their defences in an attempt to turn back the tide.

In the case of dat some record or tape sales will be certainly be lost. A few people might argue that manufacturers must have already taken account of that in charging such exorbitant prices for compact discs.

Much better than building barricades to turn back the tide of change would be to build boats to sail on it. The music industry should accept dat, then get back into the market place with software packages that are simply more attractive than their pirate dat alternatives.

Jonathan Campbell

First-ever climbing robot

Watching a robot climb a perfectly smooth vertical wall and then head off along the ceiling is a somewhat uncanny experience. It conjures up the notion of a very much oversized housefly, apparently defying the force of gravity.

What's even more uncanny, viewed from the point of view of an electronics engineer, is that the robot doesn't of necessity contain a single piece of silicon. Reliability is the explanation offered by Professor Valery Gradetsky, Head of Laboratory at the Institute of Problems in Mechanics, in Moscow, who built a prototype recently demonstrated at London's South Bank Polytechnic.

It's all in fact part of a research programme involving scientists and engineers from both institutes who've been working on this collaborative project for over three years now.

The point about the absence of silicon is that the robot works using pneumatic power and pneumatic control signals fed along its multi-pipe umbilical. The unit shown in the picture weights 7kg and walks using five steel and rubber suckers. It can move up, down, sideways or rotate. Using the attached spray gun it can also paint the wall or ceiling with great precision — a wonderful tool for graffiti artists!

Professor Frank Evans of the South Bank Polytechnic points out that this robot, which can carry twice its own weight, has a number of other potential uses, primarily in the construction industry. Being devoid of electronics (except in the static control box), the robot can work in areas of high electro magnetic fields, high temperatures or high levels of nuclear radiation. Cleaning and inspecting operational transmitters and nuclear power plants are two obvious applications that spring to mind.

The point about the absence of electronics isn't, of course, to belittle the role silicon will play in the future development of this climbing robot; merely to suggest that we could all sometimes do with being reminded that silicon isn't the answer to every engineering problem. Gradetsky's point about reliability is also worth bearing in mind when considering the largest robot capable of traversing the ceiling. It weighs 70kg and can carry its own weight!

Further developments, involving the interchange of academic staff between London and Moscow will concentrate (one hopes!) on the development of equally reliable control and guidance systems. These will allow the robot to interface, not just with its manually-operated control box, but with computerised guidance systems. In that way, what is currently able to make a good job of painting the factory walls will eventually be able to undertake complex tasks on, under or over the factory production line.

A sticky problem, solved without electronics.

Fourier transforms yield new moons

By mathematically teasing apart an intricate string of bright spots along a narrow outer ring of Saturn, astronomers at Stanford and Cornell Universities have detected evidence of undiscovered moons circling the plant. These add to Saturn's 18 known moons. According to the team [*Nature*, Vol. 345, no 6277], the bright spots represent waves of higher-density clumps in the rings produced when the tiny new moons periodically sail close to the rings in their orbits.

An analysis was undertaken of a composite series of images containing about 140° of the narrow F ring of Saturn taken by the Voyager 1 spacecraft on its Saturn flyby in 1980. The F ring, about 80 000km above the planet and detached by about 3500km from the main rings, is the outermost of the multitude of concentric Saturnian rings. The ring consists of material ranging from dust-sized grains to football-sized chunks of water ice.

In their analysis, the astronomers first plotted the complex waxing and waning in brightness of the ring along its length. Their plot immediately revealed two very narrow, bright, clumps which moved within the ring. The scientists then analysed the other brightenings along the ring using a Fast Fourier Transform, to separate the pattern of brightenings into its periodic components.

The FFT revealed that the brightenings consisted of a complex of five periodic waves. Some of these waves could have been produced by orbiting moons that periodically swoop close to the ring, leaving a signature of their passing each time as their gravitational field produces a clumping of material.

One of the regular waves detected in the analysis was due to the known moon Prometheus, whose orbit brings it near the F ring and which is believed to help confine the ring. Two other waves were apparently due to the interaction, or beating of waves of different frequencies and did not directly result from the gravitational influence of moons.

However, the scientists postulate that one of the remaining waves was produced by an undiscovered moonlet, presumably smaller than the Voyager spacecraft could detect directly. Such a moon would have to be less than about

10km in diameter and have an eccentric orbit, passing close to the F ring occasionally, to have caused such disturbances.

The final wave could not be explained easily. The wave's characteristics were such that the moon that causes it would have to lie well within Saturn's ring system, where it would have caused perturbations that have not been detected by scientists studying the rings. Or else, the moon's orbit would have to be more elliptical than is explained in the Saturnian system.

The existence of the new moons, as well as other complex features of Saturn's rings cannot be confirmed until the Cassini probe to Saturn reaches the planet. This orbiter is scheduled for launch in 1996, will reach Saturn in 2002 and make observations until 2006.

Self-induced wiring repairs

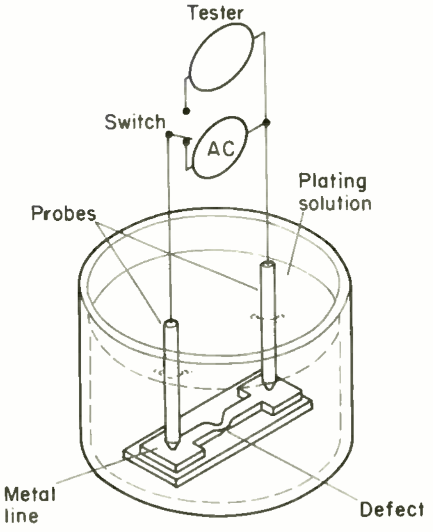
Researchers in the USA have invented a process in which a defect in wiring between ICs can induce its own repair [*Applied Physics Letters* 11.06/18.06.90].

Until now, near-open circuit defects have often proved difficult even to locate. The new self-induced repair process, recently patented by C Julian Chen of the IBM T J Watson Research Centre, involves a novel variation of electroplating. When a sufficiently high current is passed through a wire with a constriction, more heat is generated at that location than elsewhere on the wire, because the thinner the wire, the greater its electrical resistance and the slower the heat dissipation. As a result of the temperature rise that occurs, a deposition process is induced and the constriction becomes plated with metal such as copper that is transferred from cooler parts of the wire through the plating solution, or electrolyte. So little material is needed to fill up a constriction that there is no appreciable effect on the rest of the wire.

There are a number of advantages of the new process. For example, it is self-locating — the position of a defect along a wire need not be known. All that is necessary is to apply an AC source to the ends of the wire.

The process is also self-terminating — when an incipient open-circuit or constriction becomes sufficiently plated, its resistance drops, no further excess heat is generated at the defect location and deposition ends. Also, multiple constrictions on the same wire can all be repaired at the same time. The most severe defect heats the most and gets plated the most until all the defects have comparable resistance.

Finally, the process produces high-quality plating, with a very good continuity between the original and plated materials. In addition to its use in



An electrolytic solution to defect repair in IC interconnection wiring?

repair of constrictions and incipient open circuits, the process is the basis of a two-step procedure for the repair of complete open circuits and for making customised interconnections. That procedure begins with the application of a thin film of organometallic material over the area where repair or a new interconnection is desired. A focused laser beam then draws the exact path of the new line on the film, thereby decomposing the film and leaving a thin metallic residue in the shape of the desired line as an initial interconnection. The remaining undecomposed organometallic film is removed with a solvent. The circuit needing repair or customisation is then placed in the same kind of electrolytic cell as used for repairing constrictions and the self-induced repair is then carried out.

Chen believes that the self-induced repair process could even be applied to the repair of defects in interconnection wiring between components on integrated-circuits themselves, in addition to the wiring between them.

Some sum

Two mathematicians, Dr Arjen Lenstra and Dr Mark Manasse of Bell Labs, New Jersey and the Digital Equipment corporation of Palo Alto, California have successfully factored a 155 digit number into its three constituent primes. In so doing they used a thousand interlinked computers, crunching away steadily over a five week period—all to prove that messages encoded in 150 digit codes are not as secure as is generally thought. Many codes used by banks and the military depend on very big prime numbers chosen in secret and multiplied together.

Hitherto, factoring such huge numbers would have taken centuries, but has been speeded up using a method called a number field sieve, developed by Professor John Pollard in Britain.

If you feel like checking Bell Labs' sums, the figures – subject to errors in data transmission – are as follows:

13,407,807,929,942,597,099,
574,024,998,205,846,127,479,
365,820,592,393,377,723,561,
443,721,764,030,073,546,976,
801,874,298,166,903,427,690,
031,858,186,486,050,853,753,
882,811,946,569,946,433,649,
006,084,097.

=

741,640,062,627,530,801,
524,787,141,901,937,474,
059,940,781,097,519,023,
905,821,316,144,415,759,
504,705,008,092,818,711,
693,940,737.

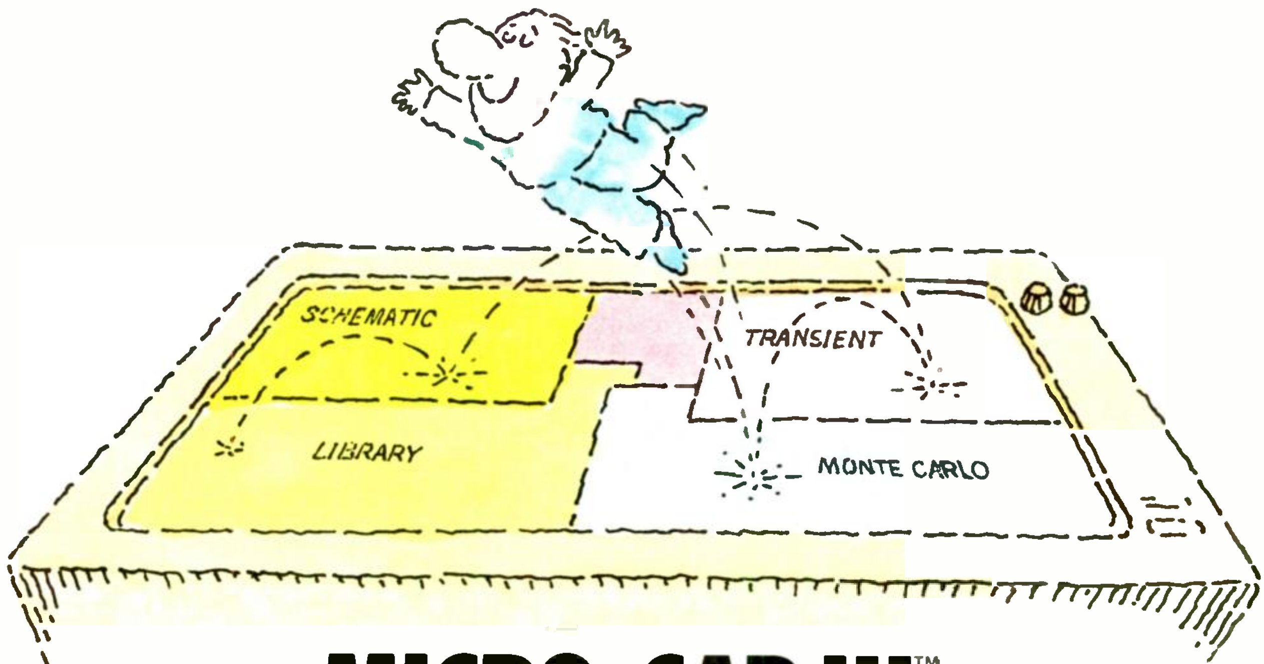
×

7,455,602,825,647,884,208,
337,395,736,200,454,918,
783,366,342,657.

×

2,424,833.

. . . though I must say if it took that much effort to appropriate a few bob from my bank account, I'd feel the villains had earned their crust. Manasse says that to crack the above number (the so-called Fermat number which equals $2^{512}+1$) would cost $200 million in commercial computer power.



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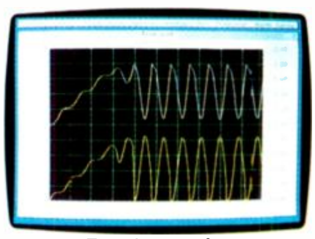
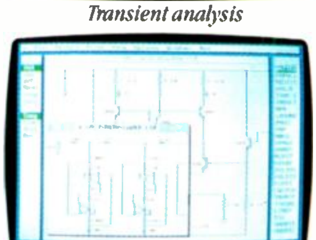
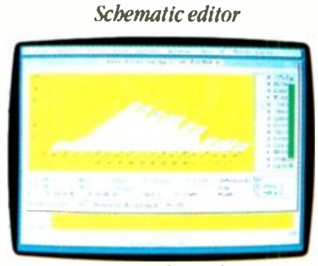


Transient analysis



Schematic editor



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Hope for Hubble?

Since long before its launch, the NASA/ESA Space Telescope has experienced a catalogue of problems, but over its first two months in space it looked as if the technical hitches were being overcome one by one. They all appeared to be operational problems of the sort that could be overcome by careful reprogramming of computers: first, the antenna that became entangled in a cable and later, the oscillatory motion that threatened to blur the pictures. In photographic parlance it was a bit like teaching a novice to use a Hasselblad.

By the middle of June, even the usually succinct ESA press statements were beginning to betray a touch of excitement. The Faint Object Camera (FOC) had successfully taken its first engineering test pictures. One of these pictures (opposite) shows a group of stars in the open cluster NGC 188, about four degrees from the Pole Star. Approximately 5000 light years away, this is the oldest known open cluster, having an estimated age of 12 thousand million years — more than half the age of the Universe. The other picture (for comparison) shows the same cluster photographed through the unavoidable turbulence of the atmosphere by a good ground-based telescope.

According to ESA Project Scientist Dr Peter Jacobson, "It was extremely exciting to take the first real open-shutter FOC exposures looking through the telescope after having waited all these years." Sadly, that optimism proved to be misplaced when, only a week or two later, NASA announced that the Hubble Telescope had a design fault that couldn't be corrected from the ground.

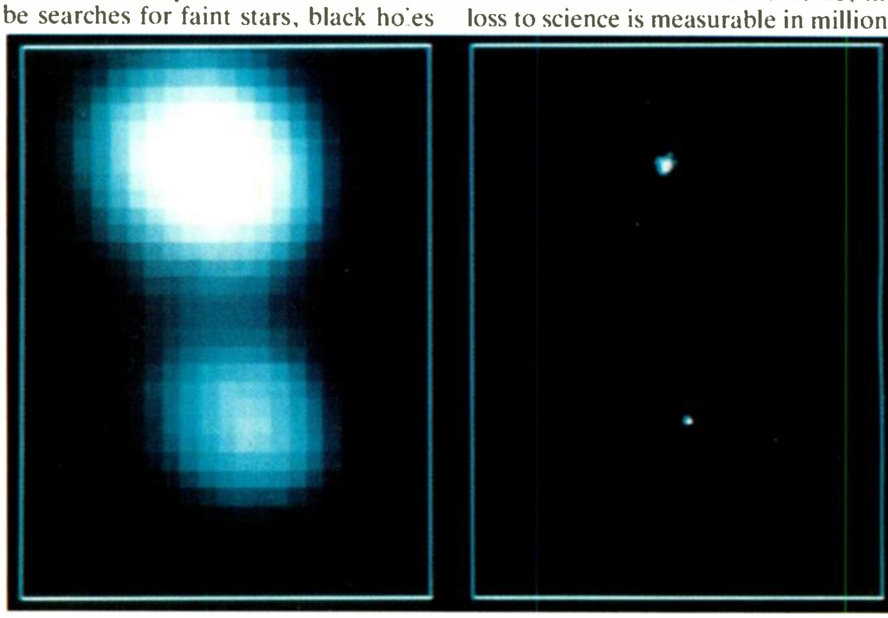
The problem appeared to be that the curvature of one of the mirrors — probably the secondary mirror — didn't quite match that of the other. The result is a defect well known even to elementary students of optics; spherical aberration. Quite how a $2 billion optic came to have a problem more usually associated with a Box Brownie isn't entirely clear, but what it means is that instead of being ten times sharper than ground-based pictures, the snaps taken in space will only be marginally better.

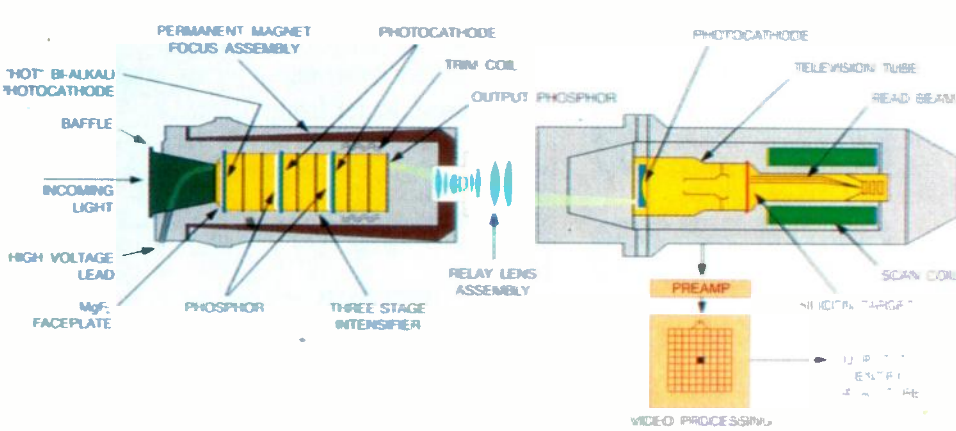
Such a reduction in definition means, according to early estimates, that roughly half the telescope's planned work will be impossible. Ruled out will be searches for faint stars, black holes and planets elsewhere in the Universe; in fact some of the more fascinating work that astronomers had been hyping themselves up for.

What won't be affected is the work that doesn't depend on sharp imaging — spectroscopy for example. Studies into the chemical composition of distant stars and gas clouds will still therefore be possible.

It isn't the end of the Hubble Space Telescope, though. Already NASA is considering the possibility of servicing it in orbit on a shuttle flight, possibly as soon as 1993. One idea is to fit what amounts to spectacles over some of the experimental packages such as the FOC. That way the defect could be corrected.

Whatever the eventual outcome, the loss to science is measurable in millions of dollars. And the cost of sending up an astronomical optician would probably be two orders of magnitude greater still. This, coming only a few months after the partial failure of the European Hipparcos star-mapping satellite, must inevitably make astronomers everywhere begin to doubt the hitherto unquestioned benefits of putting their eyes in the sky.





Principle of the ESA Faint Object Camera, which is made up of two separate cameras with vidicons and image intensifiers. One magnifies by a factor of two; the other by up to twelve.

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

C in the pilot's seat

A new control station for unmanned aircraft is to be developed by the Royal Aerospace Establishment.

Unmanned aircraft (UMAs) intended for reconnaissance have been under development by the RAE for many years and this new station will make fullest use of the facilities offered by the aircraft's telemetry channels to control, navigate and interrogate the craft. UMAs are effectively radio-controlled model aircraft with several cameras.

The control station is to be a VME-based system (VME provides the bandwidth needed), having three colour displays with touch-screen overlays, an LCD display and tracker ball. Telemetered data will be displayed and graphics will be extensively used; for example, a digital map will allow the operator to navigate the UMA and to display its track. The touch-screen and tracker ball will control the aircraft via the telemetry link. An operator will not have to "fly" the UMA, since the aircraft is stable and needs only to be directed; the system is effectively an enhanced autopilot which will respond to the operator's commands while maintaining stability.

Software engineers from Signal Computing of Guildford, a member of the BASYS Group, will assist the RAE to design the control station, all the software being written in C and in modular form to simplify future expansion or maintenance and to be consistent with the RAE preference for C in control applications.

Existing ground control station for unmanned aircraft at the RAE. The new design will include better displays and allow the operator faster and more complete control.

RAE's experimental unmanned aircraft. Pictures Crown copywright.

Serc computer will boost UK's science capability

Installation of the first Intel iPSC/860 parallel processing "supercomputer" in Europe by the Science and Engineering Research Council (Serc) will provide a significant boost to British Science. Serc, which has installed the computer at its Daresbury laboratory, says the cost-effective, high-performance machine will allow researchers to tackle new problems previously felt to be impracticable.

The iPSC/860 is theoretically capable of performing 1.9 billion floating point operations per second, which is greater than the rate of significantly more expensive conventional computers.

Within the iPSC /860, each of the 32 processors is an independent computer built around the Intel i860 chip. Over the last three years, Daresbury Laboratory's Advanced Research Computing Group (ARCG) has established a lead in programming parallel computers for scientific applications using the second-generation Intel iPSC/2 and other machines. Serc says it is to extend this lead, and to help British universities and polytechnics undertake new research, that it has purchased the new machine. The high performance of such computers is achieved at a reduced cost by using off-the-shelf components as opposed to computers such as the Cray which use special electronic devices to gain speed.

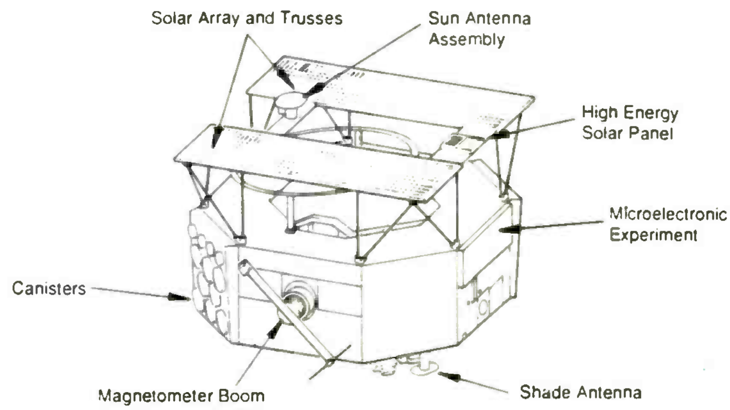
In addition to the ability to carry out cost-effective computation Serc says new applications include pharmaceutical and polymer modelling; engineering applications (finite-element analysis and computational fluid dynamics) and research on bulk materials and surfaces.

Clouds throw light on Earth's magnetism

Clouds, so often the bane of earth-bound observations, will be the subject of intense scrutiny by scientists over the next few months. But these are not the usual white fluffy sort, heralding wet weather and wellingtons, but clouds of luminescent ions "seeded" from a satellite which researchers hope will answer fundamental questions about the earth's atmosphere and magnetic field.

The seeding will be carried out over the next nine months as part of a programme of experimentation by the US Combined Release and Radiation Effects (Crres) satellite launched in July. The intention is to form a series of clouds by injecting chemicals into the atmosphere. The chemicals ionised by the sun's UV will elongate as luminescent indicators along the earth's magnetic field lines, making them visible.

Half the 14 experiments will be carried out at altitudes ranging from 1200 to 21 000 miles, with the rest at between 240–300 miles. Scientists are hoping to reveal more about the magnetosphere — the layer above the ionosphere at around 620 miles up — which is filled with energetic charged particles.



When a cloud of energetic particles from a solar flare hits the magnetosphere, a geomagnetic storm can occur, disrupting power systems and long-distance communications. This can have a severe effect on complex satellites carrying delicate electronics and sensors, and other geostationary space-craft which are susceptible to damage from solar energetic particles, limiting operational life-span. Crres should show up how these effects occur.

As the basis for the research Crres is carrying 24 canisters of chemicals such as barium, lithium, calcium and strontium, and for each experiment, one or two canisters will be ejected by the spacecraft. Approximately 25 minutes later, after the canister and spacecraft are far enough apart to

Superfast devices are not just crystal gazing

IBM is claiming a development that could bring closer the production of extremely fast transistors based on silicon enriched with germanium. Researchers at IBM's Thomas J Watson Research say they have developed a greatly improved method of growing thin crystal layers of germanium on silicon. The process could bring forward the practical production of silicon-germanium crystal alloys.

Earlier this year IBM announced it had fabricated, from silicon enriched with a few percent germanium, the world's fastest experimental transistor, operating at 75 000GHz, or nearly twice as fast as the previous record.

However the problem with growing conventional germanium crystals to more than three atoms thick is that they tend to clump or ball-up, rendering the product useless for electronics. But IBM scientists say they have discovered a way to coax the germanium to lie flat on the silicon.

The process starts with a thin layer of silicon, then before growing the germanium a single atomic layer of antimony is added. The antimony rises to the surface and forces the germanium to grow flat underneath it in a mechanism christened surfactant-mediated epitaxy.

The antimony acts as a surfactant, changing the surface properties of the silicon and making it chemically more stable, so that germanium can grow more smoothly.

Epitaxy is the growth of one crystalline layer on top of another. Growing the germanium-silicon crystals using molecular beam epitaxy, IBM has successfully produced flat layers of germanium 10 atoms thick on silicon, with a perfect match between the crystal structure of the germanium and the silicon. Earlier, the researchers successfully used arsenic as the surfactant to grow layers of germanium on silicon and believe they will eventually find a broad range of surfactants that work well in their surfactant-mediated epitaxy pocess. The new process makes feasible the use of silicon-germanium crystals in a wide range of applications. Combined with silicon, germanium-silicon alloys could offer potential applications in transistors, lasers, photo detectors and diodes.

prevent contamination, the canister will release its chemical vapours, creating ionised luminous clouds initially about 60 miles in diameter.

By observing the motion of the clouds, scientists will be able to measure electric fields in space, to monitor how these fields interact with charged particles to form waves and to improve understanding of how the Earth extracts energy from the solar wind. These clouds will be studied by instruments on the ground, in specially equippd aircraft and aboard Crres itself. Crres releases will be augmented by releases from sounding rockets to conduct further experiments.

The programme is a joint venture of Nasa, through its Marshall Space Flight Center, and the Department of Defense's (DOD) Air Force Space Test and Transportation Program. Nasa's role in the mission is the release of tracers; the DOD experiments will measure the natural radiation in space and its effects on microelectronics.

The satellite was built by the Ball Aerospace Systems Group, Colorado. The scientific instruments and investigations are being supplied by scientists from institutions throughout the United States, Europe and South America.

Eastern Europe telecomms bonanza in the balance

Thawing of relations with Eastern Europe, the cause of so many jitters in an electronics industry facing defence spending cuts, could be the making of Western communications, according to an industry analysis. But the lack of commercial infrastructure, which supports Western telecoms growth, could dampen hopes for early commercial private circuits, alternative networks and value-added services in the east.

The conclusions are part of an assessment of telecoms growth in Eastern Europe carried out by Communications and Information Technology (CIT) Research. CIT says that the opening up of Eastern Europe holds out the twin prospects of significantly increased international traffic and modernisation of old telecoms equipment. Both could prove particularly attractive to Western companies coping with over-capacity and escalating R & D costs.

But against this should be weighed the fact that the relative discipline of government defence contracts was being exchanged for the disorder of a vastly expanded civilian market.

A comparison of Western and Eastern European communications shows two markets virtually unrecognisable as the same industry. CIT estimates the total West European telecomms market was worth ECU123billion in 1989, making it one of the largest industries in Europe.

A rough valuation of the telecomms market in Eastern Europe produces a figure of only ECU10billion. Even applying Western costs and tariffs, the value of the Soviet and East European business would only be ECU25billion.

Only 30% of the combined GDP of the USSR and Eastern Europe is derived from service related industries (both public and private), whereas the proportion in Western Europe is 60% — twice as high. However, CIT says that more encouraging in the short term are opportunities in manufacturing, where Eastern Europe can offer space, labour, and plant capacity, and in basic telephony for the domestic and small business markets. CIT notes that the economies of Eastern Europe must develop communications if they are to become productive and competitive, but they must simultaneously develop the high business users of telecoms services — the banks, insurance companies, retailers, and so on — to support the system.

All VDUs must meet new safety levels

An EC Council "Display Screens Equipment" directive (90/270/EEC) laying down minimum safety and health requirements for work with VDUs, must be adopted by all member states by December 31, 1992 (HMSO, L156, #4.).

Workstations put into service after this date must meet the requirements, but those already in service will have four years in which to comply.

Employers will be obliged to carry out an analysis of workstations "to evaluate the safety and health conditions to which they give rise for their worker, particularly as regard possible risks to eyesight, physical problems and problems of mental stress."

Workers will be able to request eye tests before and while they work on VDUs, with "corrective appliances" introduced if necessary.

On radiation the directive states: "All radiation with the exception of the visible part of the electromagnetic spectrum shall be reduced to negligible levels from the point of view of protection of workers' safety and health." Dr Michael Lowell, of the Health Policy Unit of the Health and Safety Executive, said the wording indicated a wish to placate accepted concern by workers over possible health hazards rather than being based on an actual evaluation of the current scientific evidence. However, the July issue of *MacWorld*, the US monthly for Macintosh users, gives extensive coverage of the issue after tests revealed very high levels of ELF fields from some of its machines.

Mr Lowell said it would be "up to individual member states to decide whether to specify maximum levels of radiation from screens.

Under the new directive, employers will also be required to keep employees informed on all aspects of safety and health relating to their workstations and to consult with them or their representatives on all measures to be taken in complying with all matters covered by the directive.

Course notes

The Royal Television Society is running part II of its course of training for engineers starting January 7 1991. This second part deals with special applications of television engineering in a series of lectures taking place one evening a week at the IBA in London. The 25 lectures and a book based on the lectures offer a valuable training opportunity for new engineers.

Essential areas such as video amplification, the TV camera, NTSC and PAL colour signals are covered and up-to-date information on terrestrial, satellite and cable systems is presented. New technologies such as HDTV are also examined.

For further details contact *Mandi Startup, Royal Television Society, Tavistock House East, Tavistock Square, London WC1H 9HR Tel: 071 387 1970.*

BIOELECTROMAGNETICS AT SAN ANTONIO

Electromagnetic fields can be both hostile and benevolent to life. Roger Coghill reviews the papers presented at the BEMS meeting held in June

At a time when reduced scientific research funding is depleting laboratories everywhere, it is pleasing to report an annual research conference where delegate numbers increased by over 40% on last year. The latest Bioelectromagnetics Society meeting, held this June in San Antonio, Texas, reflects increasing interest in this fledgling science which interfaces electronics with biology.

Bioelectromagnetics looks at organic life from the viewpoint of electronic physics, rather than the more traditional electrochemistry; it is concerned with, for example, how electromagnetic fields may prove hazardous to the cells of which we are all composed.

Only in the early 1980s did it become apparent that even very weak EM fields can significantly inhibit the ability of white blood cells (e.g. T-lymphocytes) to defend our bodies from foreign invasion. Unfortunately, research since then has been patchy and no one has yet offered a proven mechanism by which such effects are engendered.

Cyclotron resonance

Researchers worldwide have been exploring how charged particles (ions) can interrupt or proliferate the essential cell division without which we cannot repair the 500 million or so cells which die in any adult each day. Physicists find it difficult to accept that weak EM fields can interact with living fields.

One solution, called ion cyclotron resonance (ICR), proposes that, at certain frequencies at which, for example, the charge-to-mass ratio q/m is set equal to that for ionised potassium K^+, specific biological effects like calcium efflux are observed, provided that the direct-current magnetic field (B_0) is also taken into account. The general formula

$$f_0 = \frac{q}{2\pi m} B_0$$

describes this and would equal 14.9Hz when the Earth's DC magnetic field is $38\mu T$. However, the hypothesis faces considerable difficulties: the mass used in the calculation is "naked", that is it does not include any water molecules; the cyclotron resonance orbit at 15Hz is too long; and the energy associated with any ICR interaction is extremely small because the energy of a particle in cyclotron resonance varies as the square of the radius of the orbit.

It may be that the ion is precessing, and the rate of precession is influenced by an interacting AC magnetic field from some external source; Doctor Lednev of the USSR's Academy of Science reported experimental support for this refinement of the ICR hypothesis. Until biophysicists can identify a sound predictive model or mechanism for these bio-effects, researchers cannot be sure in which direction to orient their work; is it frequency, field strength, power density, or some other factor — or even a combination of all?

This search for a mechanism has been accelerated by recent pronouncements of the US Environmental Protection Agency that power-frequency EM fields at least may be carcinogenic and it was reliably reported that radio and microwave frequencies were only excluded from the statement at the last moment on political grounds.

Biosynthesis

Meanwhile, other research is inexorably piling up the evidence, not only for hazardous consequences from EM exposure, but also for therapeutic applications. Martin Blank and Reba Goodman from Columbia University presented evidence of the electromagnetic stimulation of biosynthesis, which is another way of saying that EM fields can cause cells to make proteins. After analysing these new proteins the researchers found them to be more highly charged, both positively and negatively, than controls. If the same impact occurs in haemapoiesis (the making of blood) then there could be agglutination problems, and in fact one epidemiological survey by Milton Zaret has already identified cardiovascular problems associated with "electronic smog". Even in biology there is no such thing, it appears, as a free lunch.

A team from Oregon State University tantalisingly described their protocol for measuring melatonin levels in female lambs raised beneath a 500kV transmission line (the highest in the UK is 400kV). It had been observed that power-frequency EM fields can significantly depress the normally high nocturnal levels of the pineal hormone melatonin, which mediates the seasonal breeding reproductive response. The question was: would the power lines delay the onset of puberty? Since the experiment is still in progress, no results are yet available from this crucial research.

On a happier note, a team including Ross Adey from Pettis V.A Hospital, Loma Linda, reported their work on bone cell proliferation stimulated by very weak electric fields. Here, too, the protein and its RNA message were increased substantially, the effect peaking at around 14Hz. By itself this is not a novel finding, since similar work has

already been reported both *in vivo* and *in vitro*; it is the probing of the mechanisms by which these effects occur that such studies are important.

Another positive effect of EM fields was reported by Richard Bentall of Bioelectronics Corporation, Maryland. He tested guinea pigs with a new form of electronic "bandage" which emits 26MHz pulsed RF energy, and found an 18% improvement in their wounds' ability to resist splitting open again (dehiscing).

His prototypes may lead to major benefits in post-operative surgery, especially since the final size of the wound scars was also reduced in the actively treated group.

Brain control

For those of us who believe that the cell cycle and many related bio-effects are ultimately under cerebral control, one paper by Lisa Higgs and her colleagues at Colorado University's Department of Psychiatry will prove significant. They treated 18 awake patients in a double-blind crossover trial with 20 minute bursts of low-energy emission therapy (LEET). Although no effect was observed on beta, delta, or theta waves, their 28-channel EEG machine recorded significant changes in alpha-rhythm activity in the exposed group during the eyes-closed condition and these particular brainwaves were decreased by up to 50% in amplitude.

"Physicists find it difficult to accept that weak EM fields can interact with living fields."

Dosimetry

In the field of dosimetry there were inevitably a few surprises as field theory and current theory continue to converge; for example, where voltage sources are used to excite antennas. Carl Durney and colleagues from Utah University defined an electric circuit representation that is equivalent to Maxwell's equations, in which mesh currents are directly related to magnetic fields, and voltages to electric fields. The equivalent circuit consists of a parallel RC combination along each edge of a Yee cell and an inductance cutting across each corner of the Yee cell, and is valid both in the time domain and the frequency domain and in any frequency range, including the optical.

Other papers in the dosimetry section included a presentation by Walter Reed Army Institute of Research (WRAIR) of photonic electro-optical probes for measuring E-fields inside biological subjects during exposure to a single EMP pulse. By contrast, Om Ghandi presented his prototype meters for the assessment of hazards up to 100MHz, including a contact current meter (0–300mA).

Another BEMS section addressed the possible hazards from MRI machines. Here, the results were ambivalent, with the Lawrence Berkeley Laboratory reporting no significant alteration of the blood/brain barrier's permeability, while in another paper they detected alterations in calcium metabolism of rat thymus lymphocytes. Another team from Western Ontario found that time-varying magnetic fields at ELF frequencies alter $Ca^{2}+$, whereas RF and static (0.15T) fields do not. Since positively charged calcium is an indispensible concomitant of normal brain function, and since occasional curious side-effects have been noted following MRI brain scans, the finding may prove significant.

It is difficult to do justice to the 160 papers from eight countries (including Russia and China) which were presented at this BEMS annual meeting. One is very conscious that its members are probing some of the most fundamental mechanisms of organic life, and that electronic physics rather electro-chemistry may ultimately solve some of biology's major remaining mysteries. ■

CIRCLE NO. 131 ON REPLY CARD

COMPUTING EASTER

After years of seclusion behind the Curtain, Eastern Europe's computer industry is emerging into the harsh light of commercial reality. Robert Farish of *Computer Talk* surveys a world previously hidden from Western eyes

Technological development did not completely stand still in the industries of Eastern Europe while they were under communist control. As companies now fall over themselves to sell into these markets, it is worth reflecting on the state of the computer industry behind what used to be the Iron Curtain.

Years of concentration on military or prestige projects has led to severe under-investment in all types of civilian hardware manufacture and a widening technological gap with the West. A shortage of hard currency and Western bans on the export of all but the most basic computer technology have created a chronic shortage of microprocessors, reflected most obviously in a lack of minicomputers and workstations.

When they can afford one, large commercial or academic organisations will have a communist-made mainframe for number-crunching applications. Almost all other work is performed on PCs, which have been freely exportable for sometime now. The few minicomputers in existence are usually manufactured in the GDR or the Soviet Union, are expensive, inflexible and handicapped by an export ban on multi-user operating systems like Unix.

The most technologically advanced states in Eastern Europe are the Soviet Union, the German Democratic Republic, Czechoslovakia and Hungary; education has been a priority in these countries and the number and quality of graduates in pure sciences, engineering and mathematics is extremely high.

This has inevitably shaped software development in these countries. A background in advanced mathematics has influenced the writing of some very efficient software, programs typically having a very good speed/memory-space ratio. Applications have a tendency to use memory space very

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concisely and, since they are forced to use PCs with very limited memory and low clock speeds, programmers have learned to get the maximum out of every line of code.

But, without the pressure of a commercial environment, programmers found themselves with a task, a limited budget and generous amounts of time. This often led to the pursuit of many dead-end projects; and to the fact that many hundreds of well educated computer-science graduates are now kicking their heels in universities across the continent.

Microprocessors

Eastern Europe needs chips more desperately than almost any other Western export. Archaic manufacturing techniques and dated plant meant that the old Eastern bloc was unable to manufacture microprocessors of sufficient capacity or in large enough quantities.

The communists tried hard, but largely failed in their attempts to copy Western designs. Since they are bound by no international copyright agreements, they have been attempting to manufacture versions of c-mos and n-mos processors throughout the 1980s. Iskra, the most widely used Soviet made personal computer, uses the K1810VM8 processor which, to all intents and purposes, is a domestically produced Intel 8086.

Cocom, the Co-ordinating Committee on Multilateral Export Controls, restricts the export of most chip technology to the Soviet Union and Eastern Europe. This shadowy, Paris-based body does not publish its own lists; the "Cocom list" is, in effect, only what companies can glean from published material put out by their own governments — in the UK, the Department of Trade and Industry – which get their advice from Cocom. Since the relaxation in the Cocom regulations last July, the DTI says that chip exports will now be easier (particularly to East Germany, since the West German government will be vouch for their destination), but heavy restrictions are still in force.

The reasoning behind the ban is to prevent the sale of products which could have military uses. Since virtually all electronics components could have military applications, Cocom also decides on how "bundled" the technology is. Thus IBM is able to sell some of its 3090 mainframe computers to the Soviet Union, whilst Intel is still prevented from selling its relatively modest 8080 chips there.

Western microprocessors do get into the Soviet Union and have done so for many years. Countries of the Pacific rim are not bound by Cocom (which includes all the members of Nato plus France, Australia and Japan) and a Soviet can buy virtually anything on the streets of Singapore of Taipei. The problem has not been one of access but of cash; to buy chips this way communist organisations not only took big risks but needed large amounts of hard currency. This has made any kind of volume imports unrealistic.

Since the Soviet Union does not release production figures for microprocessor technology, it is difficult to measure the success of attempts to clone Western designs. However, published Soviet sources show comprehensive copying of TTLS, ECL, CMOS, PMOS, IIL and NMOS technology (see tables). An Intel spokesman confirmed that he had seen copies of the 8080 and 8086; Intel still exports no chips to Cocom listed countries.

East Germany is technologically the most advanced state in the region. State-owned Kombinat-Mikroelektronik boasts the largest chip production of any organisation in a communist country; in the last decade it ploughed half of its R and D resources (a total of 15 billion Ostmarks) into developing a one-megabit memory chip. The huge

". . . education has been a priority in these countries and the number and quality of graduates in pure sciences, engineering and mathematics is extremely high."

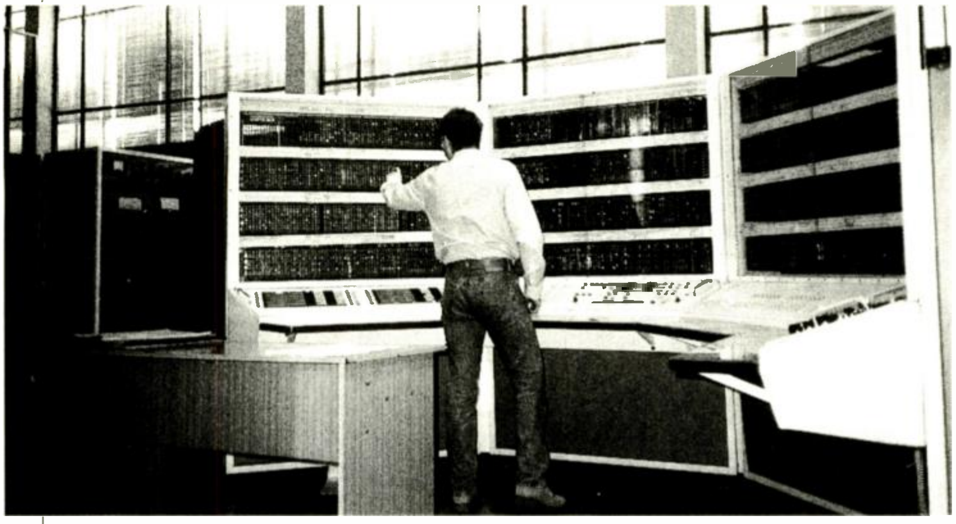
electronics conglomerate Kombinat-Robotron has managed to produce small numbers of Intel 80286 clone chips. Intel confirms this, but the says that this product is based on a multiple chip set. Yet these projects painfully expose the inadequacies of Eastern European high-technology industries, since neither processor ever went into mass production.

Most factories are not automated and a lack of cad tools means R and D is very slow. These countries simply do not have the machines to produce up-to-date microprocessors. There is a desperate need for PC processors equivalent to the Intel 80386 for cad applications, yet only in the last few years has volume production of 64K memory chips begun.

Jeff Grammer, Eastern European manager of Californian-based Chips and Technologies, visited a factory which was part of the Buran Soviet space-shuttle project and now wants to earn some hard currency. He says that most of the processes, including injection moulding, were done by hand. "They may be able to switch over their military technology, but they have a hell of a long way to go," he says.

Computers

It is ironic that IBM, that great symbol of US international influence, designed most of the mainframe computers used in communist Eastern Europe. For



Academy of Sciences BESM-6 mainframe, last of this range of scientific computers, in the machine room of Moscow University.

commercial purposes, the standard designs were Western copies and by far the most widely pirated architectures were IBM's. For the last quarter of a century the communist bloc has been manufacturing clones of Western computers: copies of IBM, Dec, and Hewlett-Packard designs became the standard for enterprises throughout the continent. The extent of this enormous exercise in technology piracy was enormous.

The cold war has always limited the amount of Western high technology exportable to the Soviet Union and Eastern Europe. Controls in force for most of the 1980s were introduced in 1979 after the Soviet invasion of Afghanistan. Designed as sanctions, these were particularly severe.

Last July, Cocom announced significant relaxations. Cocom developed a scale for measuring computing power called PDR (processing data rate). Before that date, the limit for systems sold to the Soviet Union and Eastern Europe was 78Mbit/s. So severe was this restriction that only moderately powerful personal computers and very slow larger systems could legally be sold there.

Now that systems up to 275Mbit/s can be exported, a debate is now in progress in the Soviet Union as to whether at this stage any of its domestically produced computers are worth saving. In East Germany, Hungary, and Czechoslovakia, market forces are already coming up with the answer: no one is buying inferior copies now they can get the real thing.

Yet until last year, the communist world was effectively cut off from the mainstream of world computing and, somehow, computers needed to be produced.

Thirty years ago, all Soviet computers were entirely home-grown. In the mid 1950s, there were two centres producing them in any volume: the Academy of Sciences at Moscow University and the Ministry of the Radio industry (Minradioprom). The Academy of Sciences originated the BESM computer (Bol'shaia Elektronaia Schetnaia Mashina – large electronic calculating machine) which was scientific in orientation, while the Ministry produced the Minsk and Ural computers for industrial or routine data-processing purposes.

In the late 1960s, the Academy of Sciences lost much of its influence to the industrial ministries. The BESM line of computers was terminated with the BESM-6 and with it went much of the research and development momentum the project had generated. At the same time Minradioprom, which had no designs to replace the Minsk and the Ural, got top-level backing for what became known as the Riad project, the aim of which was to reverse-engineer the IBM System/360 family of mainframe computers. This range of computers was the Unified Series (abbreviated ES) and over the years the ES range was expanded with each major IBM mainframe release. This exercise became so extensive that computer historians Richard Judy and Bob Clough estimate that more ES machines are installed worldwide than any other mainframe family except IBM.

"... the practice of reverse-engineering Western design became normal procedure for all mass-produced Soviet and Eastern European computers."

Subsequently, the practice of reverse-engineering Western designs became normal procedure for all mass-produced Soviet and Eastern European computers. Only in highly specialised areas like military or space technology did the Soviets continue significant investment in the development of their own designs.

In the late 1960s, the Ministry of Instrument Making, Automation Equipment and Control Systems, (Minpribor), began work on copies of another US company's computers. In 1965 the Digital Equipment Corporation (DEC) began production of the world's first mass-produced minicomputer, the PDP-8. By the mid 1970s, Minpribor had a range of minicomputers called the ASVT, which emulated the PDP-8.

Later, a similar policy was adopted for personal computers: Agat, for example, is a clone of the Apple Macintosh (see table). However, a combination of the huge lead times in Soviet manufacturing and the absence of any domestically mass-produced disk drives, hard disks or fast processors means that the capabilities of these machines are extremely limited. Richard Handyside, UK Managing Director of cad/cam specialists Autodesk, says that no Soviet-made PC yet has a hard disk: "For four years we have been looking for a completely Soviet-built PC to run AutoCad (the company's main cad product) at trade shows and we still haven't found one", he says.

Despite the fact that many Soviet/Eastern European built PCs are not fully IBM PC-compatible, one rationale for the policy of reverse-engineering was to standardise the computer architectures used across the entire communist bloc. Bulgaria became a big manufacturer of mainframes, while the East German electrical and electronics conglomerate Kombinat Robotron became the biggest Eastern European manufacturer of DEC look-alike minicomputers.

Robotron's most recent DEC-compatible release is the K-1840 supermini, which emulates DEC's first 32bit computer released in 1977, the VAX 11/780.

The K-1840 super-mini is a source of

both pride and embarrassment to Robotron. On the one hand, the company needs to publicise the machine's capabilities, since it would like to sell software developed on it to DEC users in the West, and on the other hand the company is being forced to field awkward questions about its history.

Unlike IBM, which occasionally sold equipment behind the Iron curtain, DEC has not sold anything to socialist countries for half a decade. Only with the relaxation of export regulations this summer has it begun to establish Eastern European offices. How then do the East Germans explain the existence of the K-1840?

A Robotron spokesman denied that the company had ever illegally acquired or copied the VAX 11/780. "Robotron developed this computer independently. The similarity is created by the use of similar parameters and the functionality of the operating system," he said.

Incredible as it might seem, the communist bloc has always maintained the fiction that these computers were based on domestic designs; developers have even been awarded state prizes for their achievements. Yet the Soviet computing community has long been aware of the origins of the machines they use. Vladimir Butenko, a software developer based at Moscow University, got his first programming experience on an ES mainframe. He says it is rumoured that the technicians dismantling IBM machines sometimes could not work out what certain parts did. Rather than leave them out they still put them in the ES even though they wouldn't do anything.

It is not possible for Western companies to prevent copies of their machines from being made. Western patents are not enforceable in Eastern Europe, where there is little commercial law. Since there is no concept of intellectual property in the Soviet Union, 99% of all Western software there is pirated.

There is a fundamental flaw in the attitude that catching the West means simply getting hold of its most up-to-date technology; the infrastructure in the USSR is too inefficient and too primitive for this technology to be mass produced. In the West, companies called plug-compatible manufacturers (PCMs) also make IBM-compatible mainframes. They have traditionally competed with IBM by making their machines cheaper and more powerful, usually having their clone machines on the market within six months of an IBM product release. In contrast, the time lag for the last generation of Riad machines was over seven years. (See Table)

Vladimir Butenko of Moscow University is trying to compete with IBM in the Western database management market, which is already saturated.

Moreover, most Soviet computer professionals have little time for the ES computers, which are said to be unreliable, costly and difficult to get spare parts for. When western PCs first began to find their way onto the black markets of the communist bloc, it was not uncommon for factories to buy them as a replacement for an ageing Soviet-built mainframe.

A future possibility for the region is as a centre for computer assembly. Mariusz Jaworski fled his native Poland in 1984 with the secret police on his trail after he had been found illegally importing PCs into the country. He now runs SET, a flourishing business out of West Berlin which imports parts from Taiwan for assembly in a factory in Poland. He says a fully qualified electronics engineer in Poland earns one fiftieth of his equivalent in the US or Taiwan, and less skilled labour is equally cheap.

"East Europe could be the new Pacific rim. When these people know they will earn real money they will work hard for it", he says. PC assembly plants can now be found in most Eastern European countries.

Hungary also offers a few clues as to how the region's computer industry might develop in the future. In the 1960s the premier, Janos Kadar, struck a deal with Moscow. In return for the total suppression of all political opposition he persuaded Moscow to allow him to pursue a more liberal economic policy, which culminated in a major re-orientation of the Hungarian economy in 1968.

As a result, Hungary is further down the road to economic reform than her neighbours. Private companies have been allowed to function for a decade and legislation allowing co-operatives in 1981 has created a sizeable non-state sector. Not being classified as one of the "commanding heights" of the economy has enabled the computer industry to develop relatively unhindered by state interference.

Hungary is in the early stages of selling PC hardware to the West. Like all former Eastern bloc countries, it has a relatively large number of highly educated engineers who are paid only a fraction of what their equals in the West earn. Budapest-based manufac-

Marusz Jaworski, a Pole exiled for smuggling PCs, runs a West Berlin company importing components from Taiwan for Polish computers.

turers Controll and Muszertechnika have taken advantage of this fact to use a disproportionately large number of engineers in their PC assembly and support operations. Muszertechnika is unique among Eastern European hardware companies; no other organisation has refined its sales in the West to such an extent. The company now has subsidiaries in four non-communist countries and offices in three others. Each operation sells a different range of products and occupies a separate market niche.

Most impressive is the US overseas section. Because Cocom banned the export of all products using IBM's Micro Channel Architecture (MCA) the high-end models of the IBM PS/2 PC range were not sold in Eastern Europe. Yet despite this, Muszertechnika has developed an MCA add on board for the machine. Its M-DCB/2 SCSI controller board enables a PS/2 to act as a NetWare file server. Having found a gap in the market where there is as yet no rival product, the company is selling between 500 and 1000 M-DCB/2s every month.

Despite being the largest company of its kind in the country, Muszertechnika's operation is dwarfed inside the huge factory where it is based; the previous occupier was a state-owned scoreboard manufacturer which had gone bankrupt and Muszertechnika was the only company able to afford the rent. The company now makes scoreboards as well as computers.

Muszertechnika symbolises the transformation that is slowly taking place in Hungarian industry. Inside the shell of an inefficient and ponderous state enterprise, a new type of company is growing. Instead of producing high volumes at low quality, it is a high-tech company taking advantage Hungary's strengths: engineering and computing expertise.

Vice President of Muszertechnika, Tibor Hejj, agrees: "We are a small country and small countries can only compete in world markets if they have some added value, and added value is hi tech."

Software

In Eastern Europe there undoubtedly exists an extraordinary reserve of computing talent. After a while you become used to hearing, and begin to believe, that an entire factory was automated using the tiny Commodore-64 PC, or that the emergency system at a nuclear power plant is controlled by a twenty-year-old Soviet-made mini-computer.

"... you become used to hearing, and begin to believe, that an entire factory was automated using the Commodore 64."

Some have staked careers on this, as yet untapped, Soviet resource. Nathan Schor is a Database programmer from Boston with twenty years experience. Last year, he gave up a lucrative living to visit Moscow in search of programs and applications he could sell in the West. For Westerners like Schor, the Soviet Union recreates all the buzz and excitement of the advent of the PC in the late 1970s.

Last March he was on the hunt for anti-virus programs written by young hopefuls at Moscow State University or the plethora of software-writing co-operatives which have sprung up in the capital.

But in the USSR and other centrally planned economies in Eastern Europe there is a crucial difference: the absence of the computer user. The concept of the computer user evolved in the West during the 1960s when package software was first sold. An entire industry then developed around the production of software which any computer-literate third party could use.

In the USSR and Eastern Europe this never happened; the overwhelming majority of software written is only usable by its inventor. In a world where no market exists and labour is cheap, organisations simply employ a programmer to devise a system for them.

There are exceptions. Robotron has joined forces with the Berlin Academy of Sciences to develop a production planning application it calls Leitstand, which is a computerised version of the production planning chart used by manufacturing companies. The program, which runs on a PC, schedules each machine job, taking into account exactly how long it will take. A UK buyer of Leitstand, Roger Goldsmith of Oxbridge Communication Systems, says it is possible the concept could become universal. "The traditional approach to production planning software is to produce rough data. Leitstand gives an exact picture of what every machine will be doing," he says.

Yet Robotron, which employed 65 000 people, is now being dismembered. As its various parts are either written off or sold off, old relationships are severed and old channels of investment dry up. Most Western analysts believe that very little of this once huge operation will be worth saving. Tragically, fragile projects like Leitstand may now be lost.

Slousovice, a large agricultural co-operative in Czechoslovakia, has had an independent software department for many years. Using knowledge developed inside the company, it now sells PC-based software for cancer screening and drug design. One of its young programmers, Jiri Kripac, has written an application for AutoCad – the cad package from cad/cam specialists AutoDesk. Solid Model allows 3-D shapes to be generated, dissected and viewed in different planes without the need for an additional shapes memory.

This concentration on industrial design is no coincidence. There are strong domestic motivations for concentrating on manufacturing in both Czechoslovakia and the GDR. Prior to

JV Dialogue training centre in Moscow. JVD combines the talents of six Soviet programming organisations and the management skills of a Chicago company.

the 1989 November Revolution, the Czech government had a program called CAD 2000 aimed at boosting automation in the country's factories, the intention being to install 2000 cad workstations by the year 1990. Despite the revolution, many workstations were installed and cad/cam specialist Richard Handyside of AutoDesk says that CAD 2000 was a "qualified success".

The USSR is furthest removed from Western markets. Programmers all get their first experience at universities and most stay attached to these institutions; because of the huge cost of Western PCs, it is often the only way to get access to a computer. Once they graduate, many find jobs as "engineers" or "support staff". In reality, this usually means drawing a state salary for occasionally showing their faces and spending most of their time on personal projects.

Every Soviet programmer has an application he wants to sell, but none has more than an inkling of what this involves. Vladimir Butenko heads a co-operative at Moscow University which developed an operating system now in use at most of the oil rigs in the USSR. Butenko has spent a year developing a database management system which he wants to sell in the West. He puts his lack of success down to the inability of Western companies to recognise a product superior to IBM's DB2 database. For him it was not an issue that the database market in the West is saturated and that the world's largest computer company will spend millions of dollars marketing a product like DB2.

Because of its strong academic bias, the Soviet system also produces many prodigies. Schools and universities regularly hold competitions to find the best programmers.

Eighteen-year-old Ilya Kireenko finished second out of 600 entrants in the Leningrad software competition. He was subsequently recruited by the Novintech joint venture, which is developing Russian add-on products for Ashton-Tate's Dbase and Pagemaker from Aldus. In the last stage of the competition, each finalist had to write, debug and prepare documentation for a program in a single day. At a computer show held in Moscow last month (March), Ashton-Tate used Kireenko to check out the more promising software offered them by Soviet programmers.

Programmers the world over have a tendency to be slightly eccentric and the Soviets are no exception. It is a programmer's instinctive tendency to lose himself in his work, ignoring the timetable used by the rest of humanity. This is exaggerated in a country where life beyond the computer screen has so little to offer.

A generation of programmers who are now in their late twenties got their first experience using university mainframe computers. Since the number of users who have access to a mainframe is limited, the only way to get practice was to use them at night. The habit has stuck and the Moscow programming fraternity is still largely nocturnal. Peter Kvitek, who took part in the Microsoft debugging session, has his bed next to his terminal. He says the middle of the night is the best time to contact other programmers because you can be sure they will be up working.

The creative but rudderless Soviet programming community is reflected in the structure of the few operational computing joint ventures with Western companies. JV Dialogue is a federation of six Soviet organisations and Management Partnerships International of Chicago. The company has to be defined in terms of its ethos rather than its products: people are selected for their skills, their ideas and their total trustworthiness. Put these elements together and Dialogue believes that the chemistry between the individuals will produce something creative, and ultimately something marketable.

A similar approach is taken by the Euro-Soviet joint venture Interquadro. Advertising Manager Sergey Grib says that the company looks for individuals with initiative and accepts that large numbers of projects will not make any money. He admits that it is very difficult to focus the talents of his programmers and says the best solution is to send them abroad to instil some understanding of Western markets.

The majority of Soviet programmers, however, can only dream of working for a successful joint venture. For most, the only alternative to a university is to work for a co-operative. An ideologically acceptable alternative to private companies, co-ops occupy the substantial grey area between the state sector and the black market. Most act as computer resellers, buying PCs or components from the West and selling them with an operating system and some simple software.

In a state starved of Western technology, the money to be made from this activity can be huge. Until recently a mark up of 1000% was not uncommon. For a Cocom-listed machine, the profits can be even larger.

For programmers, the co-ops pay better wages than state companies and allow access to modern machines. In return for doing routine repair and maintenance work, they can feed and clothe their families properly and continue to develop their pet applications on relatively powerful processors.

The disadvantage is that almost all forms of contract in the Soviet Union are unreliable. Alex Martinuk, a Moscow programmer, agreed to write a computer horoscope for a co-op and was given an old Amstrad PC to work on. He says the program took him four months to write but when it was finished the co-op refused to pay him. "Good co-ops are not easy to find," he says.

But he adds that it doesn't pay to argue too much. Because potential profits from Western PCs are so huge, many co-ops guard their stocks with automatic weapons! ■

A press of fascinated Russian programmers at the Ashton-Tate Dbase and Pagemaker software stand in Moscow's Comtek'90 computer show.

Cad: computer aided destiny?

John Anderson shows that PC cad may give designers all the answers. But trouble looms if we stop asking questions.

PC cad originally grew out of mainframe, mini and workstation applications, and the trend has been to adapt cad tools from the more powerful computers to a PC environment. But the close interactive nature of work on a PC has also spawned a range of cad applications which are PC-specific.

First though it is useful to define cad. In mechanical drafting with 2-D, and some 3-D, cad the only advantage is reduction in rote, similar to word-processors in the office.

Such programs are more computer aided engineering (CAE) than cad. True cad is only where capture of the design is subsequently used for analysis, for example finite element analysis.

Synthesis: generation of new designs of electronic circuits and systems can be achieved through a number of cad strategies. Designs may simply be automated versions of hand-design methods using explicit mathematical formulae or, at worst, the solution of fully constrained simultaneous equations. Or they can be cad-exclusive, only really practicable with cad, such as Kalman filters, stochastic estimators etc.

A further approach is the optimal system, aiming for optimisation of design against a specific penalty function. Typical examples include filter design, optical systems and aeronautical engineering.

Analysis: performance evaluation is one of the key measures of a successful cad package with interaction allowing designs to be changed and effects evaluated.

Currently, interaction is limited to local domains such as a resistor value in a filter or the addition of a gate in a PLA. But this will eventually extend to a much higher level — ultimately the end product and different design strategies could then be evaluated on their global effects.

Simulation: in many companies breadboard prototypes have been replaced by circuit simulation and relatively low cost manufacture of autorouted PCBs.

Current Developments

On the testing side criteria can now be generated by the cad design process itself, producing, for example, logic test vectors for proving programmable logic systems. Similarly, estimates of circuit or system reliability can be obtained from cad, including aspects such as reduced reliability due to component self-heating.

In life-support and critical-control applications, design correctness can be

determined only by cad and this is an area of expected high growth. At the same time mathematical validation of designs will percolate into mainstream commercial products because it may be the only way to handle a design synthesised, analysed and simulated on computer.

Cad can also have a potent effect on quality. In the simple example of schematic capture, most post-processors can produce a design-rule check, looking for shorted nets, unconnected input pins and other drawing errors. But with cad, design-rule checks on PCBs are possible ensuring precise correspondence with the schematic as well as checking inter-track clearances.

Key to the future for cad, and in particular its use by the electronic designer, is vertical and horizontal integration.

Some integration has already taken place. Even circuit schematic capture includes several layers of integration; vertically to the PCB layout, through the netlist, and upward through back-annotation (transferring PCB changes directly back to the circuit diagram). Horizontal integration includes the bill of materials generated automatically by most schematic capture post-processors.

Pitfalls and education

So in theory, cad is making available the best engineering practice on the desk tops of most designers. But there are drawbacks. A poor engineer is still going to produce a poor result, and without a good "feel" for the engineering to help identify a bad solution, "mistakes" could be converted directly to hardware – remember no bread-board.

Though the underlying science remains unchanged, algorithms of implementation which determine results, are now part of the proprietary cad product and unknown to the user. So output from a cad program should be fully analysed and simulation-tested before converting to hardware.

Will young engineers, confronted with increasingly powerful cad tools, check whether, for example, a resistor value of 1.2GΩ is right and how or why the cad program produced that result?

It is worth remembering the story of the optical-lens optimisation cad program which produced a perfectly good optimisation except that one surface of the lens passed right through the other. The engineer who did not spot this design shortcoming actually asked the lens manufacturer to make it!

Databases control progress

For a specified design problem there will be many solutions, each with an associated set of attributes. Using cad it is possible to optimise on any number of criteria. Clearly it is useful to optimise on cost. But this can also be extended to weight, dissipation, speed, availability of components etc.

However, critical to all optimisations is an accurate and comprehensive database for every component, and this could prove a hurdle to cad. Without rigorous adherence to data transfer standards there is little hope for integration, except from a single vendor.

Within certain areas data formats are well defined even if not standard they are convertible, such as the Orcad netlist format or drawing interchange DXF format. But these domains are limited.

PC likely to stay

Improvements in computational power are already available through parallel computing using the transputer, or Risc-based workstations. But no matter how much greater the performance of these machines, it is the ubiquity of the PC which encourages the proliferation of cad programs for it and keeps the price down.

Until a higher performance computing standard is established the PC, or variants of it, will remain the mainstream cad base (measured by the number of units installed).

From the software aspect there is still plenty of scope for better algorithms. Typically, a small improvement in operation of an algorithm can deliver an order of magnitude improvement in performance without any change in computing power.

Eventually integrated cad packages will provide design engineering tools ranging from hardware definition languages (HDLs) for product definition, system synthesis, and analysis through to simulation and production test.

Components of such systems are already available but integration will only be possible with establishment of a unified inter-process data representation. This might come about through negotiation between vendors (unlikely), committee decree or the establishment of de facto standards by the dominant manufacturers.

But in moving to a terminal-based design and prototyping environment cad must never be shrouded in so much secrecy, in terms of its algorithms, that the engineer will not be able to understand the design limitations. ■

CAE for digital

Computer simulation for mixed-signal and analogue asic design assists development and helps engineers to anticipate future problems. Fred Etcheverry discusses the current crop of CAE tools.

analogue/asics

A designer who chooses asics is confronted with a dilemma: to bread-board or to simulate. Bread-boarding can usually test the circuit in real time in the system environment, but many asic vendors argue that simulation can anticipate manufacturing tolerances, flag over-stressed components and spot worst-case conditions that would elude most bread boards. For example, while Advanced Linear Devices offers its customers a bread-board kit, Plessey has discontinued bread-boarding and has moved to simulation.

By understanding the features of CAE tools, the design engineer will be better able to decide whether to bread-board or to simulate; whether to prepare the design on resident CAE tools for the asic vendor or approach the asic vendor with a functional block diagram.

Simulation

Currently, analogue design tools have many of the helpful features of digital tools for schematic capture, simulation, layout and test. Analogue simulators permit the designer to interact with the simulation by mouse-manipulated icons and computer-prompted forms over the displayed schematic. Designers may work hierarchically — top down design — simulating complex devices such as op-amps, or descend to the component level for a more accurate detail simulation. Sources and probes can be placed on the schematic at nodes anywhere in the simulated circuit; various analysis modules can be enabled by forms; and the simulation can be stopped, modified and restarted. Examples of such simulators are Analogy's Saber, the Dazix (Daisy/Cadnetix) VLAB with Apex and Valid Logic's Analog Work Bench (left).

Most analogue simulators are "Spice-compatible"; that is, they pass Spice-like files. Spice (Simulation Program with Integrated Circuit Emphasis) is a pioneer analogue simulator developed at U.C. Berkeley in the 1970s. It uses equation models and can simulate at the device or "detail" level, or it can simulate any model for which an equation can be written, solving the equations using an iterative Newton-Raphson algorithm.

This algorithm, however, contributes to a major Spice defect: often, solutions do not converge and will simulate anomalous oscillation. "Spice-derivative" simulators are a form of enhanced Spice which use algorithms that ensure a high degree of convergence. Non-Spice simulators use a completely different method, but are usually Spice-compatible.

Since analogue simulators achieve detail accuracy by massive number crunching, current simulators permit quick approximations of complex sub-circuits by behavioural or functional models. This is often referred to as "mixed-mode behavioural/detail level" or "mixed level". Analogue simulators permit "system" or "mixed-media" simulation of off-chip devices such as transformers, power supplies, tape heads and even non-electrical chemical, mechanical or hydraulic devices.

A serious problem with Spice is that detail-simulation time grows exponentially with increase in circuit size and complexity. To simulate accurately in a reasonable time, it is often necessary to port analogue simulations from a work station to a mainframe; Spice-compatibility assists interfacing.

CAE tools

CAE tools help the design engineer to develop test procedures during design and simulation. Testing of analogue and mixed-signal and mixed-media asics must be an integral process from design to manufacture. An exhaustive "test vector" cannot be generated; exercising each component will not guarantee success. Intergraph offers Analogue Waveform Editor, which can capture and modify signals from IEEE-488 analogue and digital instruments for use as design and test stimuli.

Analogue analysis modules are important tools for layout, testing and analysis of the design's "manufacturability". They allow the designer to improve yield and to become aware of each asic's vulnerability, assisting in the design of test stimuli that will examine the most probable causes of failures.

Statistical analysis modules permit the designer to explore the effects certain component tolerances have on the final IC. While running the simulation from the schematic, the designer may tighten some tolerances to increase yield or loosen others that have little effect on final performance, so making cost-effective trade-offs.

In Valid's Analog Workbench II, more than 100 user-programmable function blocks enable design to start at a high-level behavioural circuit description before device-level design starts.

Parametric plotting modules show the variation of parameters as a family of curves. Sometimes this is called a "what-if?" analysis which allows the designer to optimise circuit performance and keep the operating points well away from the "ragged edge".

Stress-analysis modules flag any components that approach or exceed maximum ratings during simulation. By keeping well within the safe operating areas, the designer can increase yield and long-term reliability.

Mixed-signal analysis

While there are many good analogue CAE tools on the market, integrated mixed-signal simulation is presently a challenge. Essentially, there are two approaches — extended-library simulation or coupled partitioned simulation.

Analogue circuits with a few digital components can be simulated by extending the libraries of present analogue tools to include digital behavioural models. Many vendors include a few simple logic devices in their analogue libraries. Since these are behavioural models, however, they cannot be simulated at the detail level and and may lack sufficient accuracy. Montage, a mixed-signal behavioural modelling simulator from Sierra Semiconductor, runs more than 1000 times faster than Spice. Sierra Semiconductor, however, guarantees that asics designed with certain restrictions will simulate accurately enough to produce successful chips.

Digital circuits with a few analogue components can be simulated by extending their libraries to include piece-wise linear approximation models of analogue components.

Circuits containing large numbers of loosely coupled analogue and digital components can be simulated by coupled partitioned simulators. In this method, the digital and analogue sections of the circuit are partitioned into separate simulators, the schematic being captured by both analogue and digital simulators, so creating separate netlists for each simulator. The simulators then pass signals representing the analogue/digital interface.

This solution has been partially successful for loosely coupled signals. "Loosely coupled" means that the outputs of both simulators are independent of the other, so that outputs fed from one simulator to the other must represent much lower impedance than the inputs that they drive to avoid loading effects; mixed-signal feedback loops are not permitted. Ted Corman, Senior Engineer at Viewlogic, and Michael Wimbrow, a software engineer at MicroSim, report coupling a Viewsim digital simulator with a MicroSim PSpice analogue simulator to create a successful mixed-signal simulation[1], which, they claim, can handle tight coupling. The advantage of coupled simulators is that they can use existing analogue and digital libraries.

Testing

Not only can CAE tools assist in the development of test criteria during the design phase, but they can even assist in building test capability on the chip. Testing mixed-signal and mixed-media asics requires more complicated testing than either digital or analogue, and an interesting scheme explored by National Semiconductor is to separate the analogue and digital sections of the chip — hardware partitioning. On-chip multiplexers then permit the analogue or digital connections to be brought out to the existing I/O pins.

According to Kenneth Dubowshi, National asic engineering section head, and Tom Wong, National strategic marketing manager, this scheme permits individual testing of analogue and digital[3]. These multiplexers can also be used to bring out buried nodes if an analysis module during simulation reveals that the node should be a critical test point. I/O pins are conserved by sequencing the multiplexer by an on-chip counter, pulsed and reset from only one pin. A disadvantage of this system is that the whole chip is not tested together, although this can be addressed by using simulation analysis to determine how each partition must perform to ensure total circuit success.

Simulation analysis can be used to specify and reduce the number of critical test signals during the design phase. An interesting scheme, described by Peter Bishop of ES2, is to design a test fixture on the chip[4] to provide post-fabrication testing in the target system and provide an in-service go/no-go test.

Tests developed during simulation analysis can be interfaced to ATEs. While several ATE machines are available for analogue or digital, the mixed-signal test market is presently dominated by Teradyne's A500 line. This may soon change, since LTX, which once dominated mixed-signal testing, is returning to the market with its new Synchromaster[5]. Both companies support CAE interfacing tools such as Teradyne's debugging and control tool, IMAGE. Integrated Measurement Systems (IMS) has just introduced the Logic Master XL, a mixed-signal verifier. An advantage of hardware partitioning is that it permits the use of existing "single-signal" ATEs.

Anyone testing analogue and mixed-signal asics must also consider the effects of the chip's final hardware configuration and field environment. Analogue and mixed-signal asic customers have a tendency to become locked-in to a particular manufacturer who supports their tools and understands their field requirements.

CAE/process interface

There are problems with the interfacing of different vendors' CAE tools and different asic vendors' processes: one is that, while there are digital CAE tool standards, there are few analogue standards; another is that analogue tends to be more process-dependent than digital. One suggestion to solve the first problem is to expand device-modelling languages now used for digital to encompass analogue and the second problem is now solved by each asic vendor providing libraries specific to its foundry process.

Competition, however, is driving asic vendors to increase libraries, port them to new processes, support transparent second sourcing, interface to customer tools and shorten development time. All of these goals are more difficult for analogue and mixed-signal than digital.

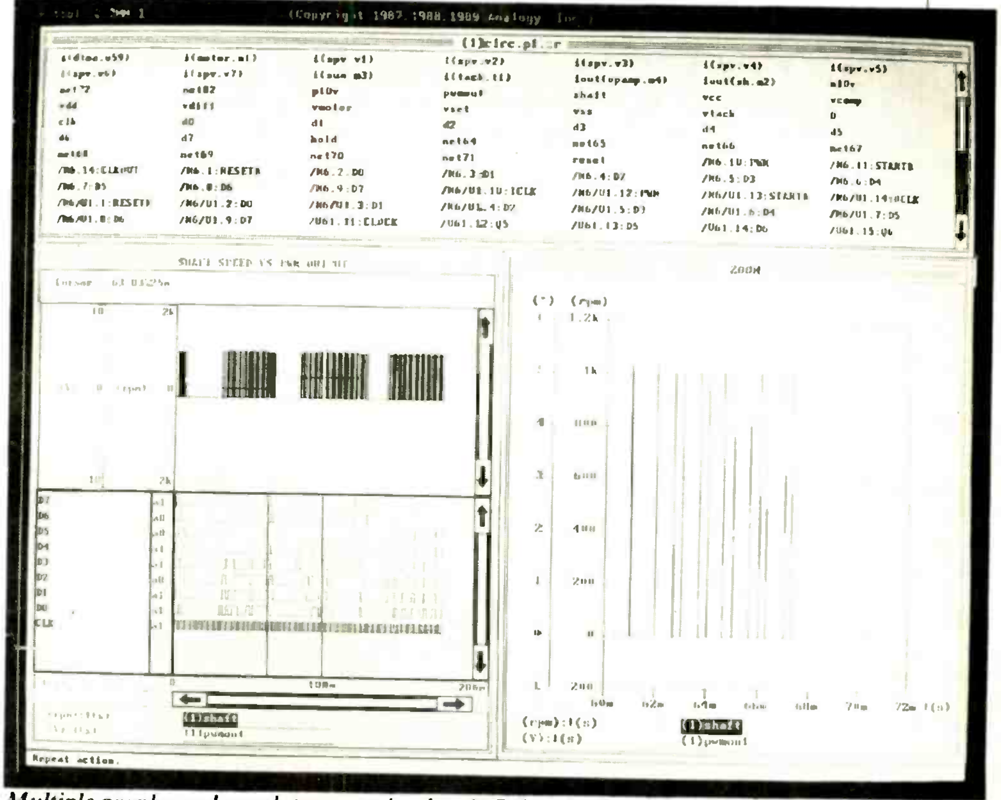
Plessey Semiconductor of Scotts Valley, California, formerly Ferranti Interdesign, is a pioneer in analogue and mixed-signal asic manufacture. In the early 1970s, the company developed Kit Parts, which was a hardware package of subcircuits and discretes used by customers to bread-board circuits. The company would then lay out their customers' successful circuits on their Monochips.

According to Phil Welsh, strategic market manager, CAE tools have reduced the turn-round time from the customers' input, which is now a block diagram, to first silicon; design iteration has been significantly reduced. The company or customer develops the design on an Analogue Workbench, using the company's Macrocell library. Complex analogue and mixed-signal designs are then ported to a mainframe Spice compiler and simulated to detail level before being set in silicon.

Phil recommends caution in using third-party tools, since analogue and mixed-signal CAE is more dependent on a particular silicon technology than digital, and not all so-called Spice-compatible tools look the same. Usually, the first silicon performs to customer specifications, but redesign is often caused by a disparity between customer specs and field requirements. Phil emphasises again the need for system-level simulation of the chip's interactive hardware.

The consensus of CAE design engineers is that all major CAE tool vendors will soon have integrated mixed-signal interactive simulators; recent mergers and acquisitions have joined diverse talents. With the development of analogue interface standards, integrated simulators may be constructed from the best of many vendors' tools.

Geoffrey Sampson, a principle engineer at NCR Microelectronics, described an ideal and a "dream" simulator[5]. According to Mr Sampson,



Multiple graphs and graph types on Analogy's Saber display. Left half shows motor shaft speed against PWM output and A-to-D values. On right is a zoomed portion of mixed-mode display.

this ideal simulator would be a true integrated design system for analogue, digital and mixed-signal. It would consist of a Spice-compatible analogue simulator that could interface to existing analogue model libraries, a digital simulator and libraries and a simulation controller to handle the coupling and synchronisation of the simulators. The dream simulator would be able to extract simulation models automatically from devices under test and be able to run in real time while interfaced to the whole system.

The market for integrated CAE tools is even greater than that of mixed-level asics. While the publication *Electronics Trends* predicts a 40% annual compound growth in mixed-signal asics, an integrated tool set will find additional use in solving clock-rate problems in faster digital. Probably, future tools will be general-purpose mixed-signal.

When one realises that shrinking electronic appliances into asics increases reliability, decreases cost and encourages new markets which simulates new tool development, the future of mixed-signal asics appears awesome.

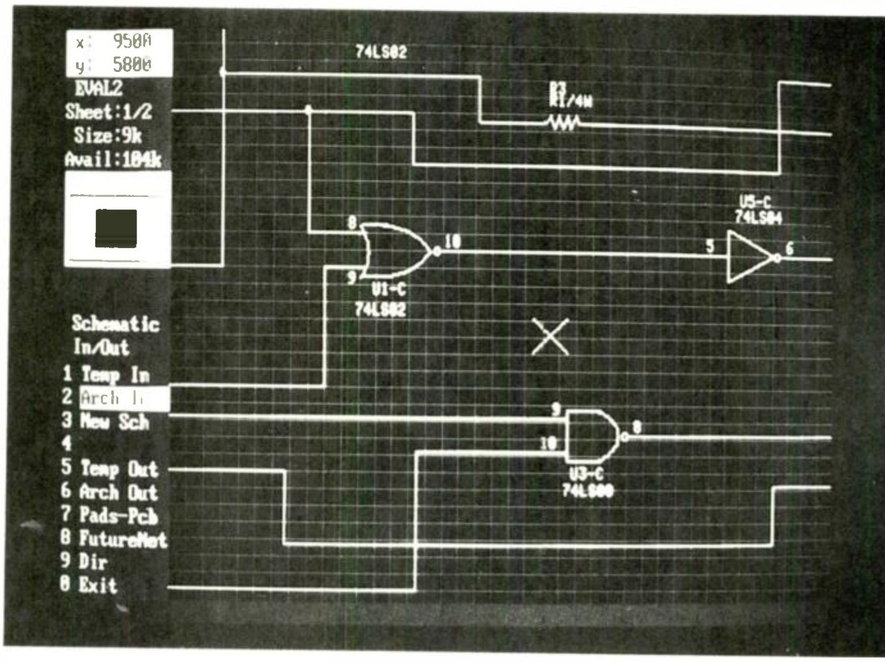
Exciting new ideas in mixed-signal asics are popping up everywhere. Sierra Semiconductor is placing eeproms and D-to-A converters on asic which can be individually programmed to trim off-sets and adjust op-amp gains[6]. Imagine a programmable asic with on-chip multiplexers, driven by uarts that receive serial data from a test/program pin. This asic could be one of a kind, or it could be used for field testing before mask production.

Preconditioning audio, by A-to-D signal processing, to compensate for hearing impairments is now a leading-edge in biomed. research. Before 2000, a hearing-impaired person might be diagnosed by their response to a computer-prompted audiometer. An asic audio preconditioner embedded in a moulded hearing aid might then be programmed, simulated and tested according to an aural prescription. ■

References

1. Corman, Tedd and Michael U. Wimbrow. Coupling a Digital Logic Simulator and an Analogue Circuit Simulator. *VLSI System Design*. February 1988, p.38.
2. Dubrowski, Ken and Thomas Wong. *VLSI System Design*. September 1988, p.60.
3. Bishop, Peter. Mixed analogueue and digital functionality on a single asic. *Electronics & Wireless World*. May 1989, p.489.
4. Dunn, Peter. LTX, Teradyne in Mixed-Signals Duel. *Electronic News*. April 10, 1989 p.1.
5. Sampson, Geoffrey. An Ideal Mixed-Mode Simulator. *VLSI Systems Design*. November 1988, p.70.
6. Lindsay, Gordon. Non-volatile digilin asic. *Electronics & Wireless World*. May 1989, p.493.

The netlist describes to a computer how components which make up a circuit connect together. It forms an essential part of virtually every serious electronics cad package. The diagram shown here was generated by PADS-PCB.



Shaping up the netlist

Netlists are crucial in linking schematics to circuit processing. Tony Wong shows why format is the fundamental factor.

A required logic function is usually described in the form of equations or an interconnection list (netlist) made up of components or basic elements and connections that describes the connectivity of a circuit. The description format is used as input to the database, and verification and debugging techniques such as logic synthesis, simulation and testing can be implemented by passing the netlist from the database to cad software.

For example, in an SDS (structured design system), once schematic diagrams have been created and stored in the database, the logic capture stage can be completed by extracting a netlist from the schematic with the NLE (Netlist Extractor) program. Buses are checked and resolved into individual nets and global signals are processed as needed. The extracted netlist is then written back into the data-base.

However each cad system has its own netlist format, with several formats used in commercial cad systems.

Netlist formats

Themis. This is an event-driven mixed-level simulator from Prime CAD/CAM its netlist describing a circuit in the manner shown in **Fig. 1**, with the netlist part of the input file as follows:

ELMT:N1:(NOR) A=INA B=INB Q=E
ELMT:N2:(NOR) A=INC B=IND Q=F
ELMT: N3:(NOR) A=E B=F Q=OUTPUT

In the input file, a Nor gate is defined before the circuit is described using the three Nor elements.

In the first statement N1 is the name of the element and the word in the bracket, its type. A and B are input pins of the gate which connect to the input terminals InA and InB. Q is the output pin of the gate and is connected to terminal E, which is input to pin A of gate N3. A single statement defines the connectivity of an element and the statements are in equation

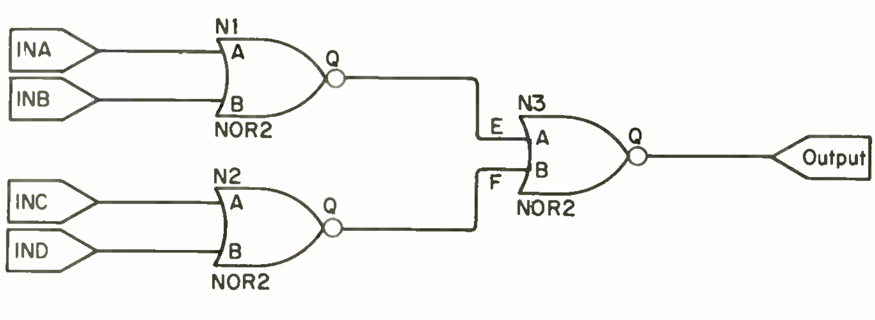


Fig. 1. **Themis** *example circuit. The netlist input file is simple and easy to debug.*

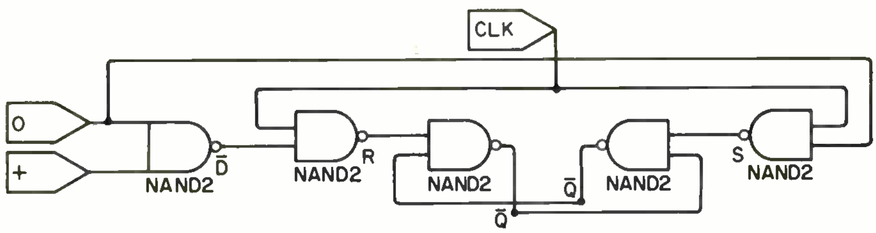


Fig. 2. **Classic** *example circuit.*

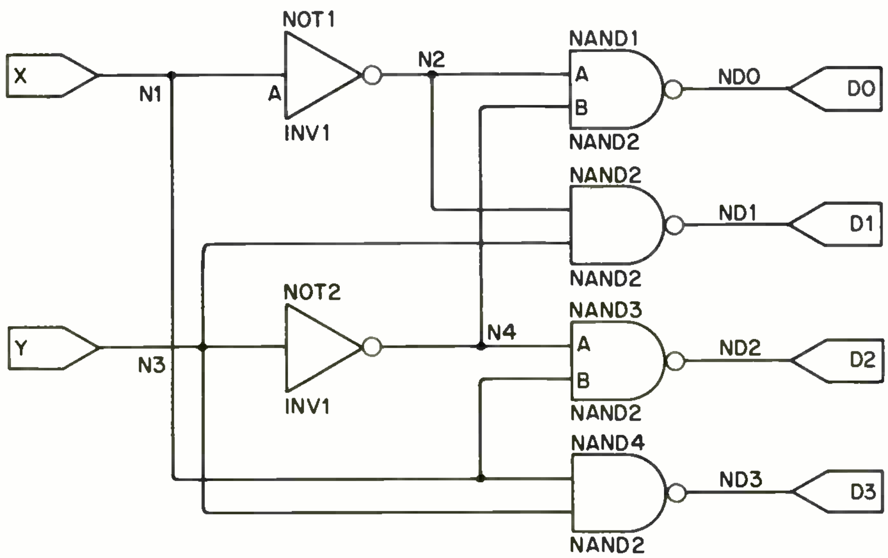


Fig. 3. A two-by-four decoder circuit. **SDL** *shows detail but nodes must be defined.*

form, so it is easy to write and debug the connectivity.

Classic. As an example of Classic, from Plessey Semiconductors, consider a circuit consisting of five Nand gates and a clock-signal-input (clk) to two of the gates **(Fig. 2)**

A1: NAND2 [$\bar{D}$,D,+]
A2: NAND2 [R,$\bar{D}$,CLK]
A3: NAND2 [3,D,CLK]
A4: NAND2 [$\bar{Q}$,Q,R]
A5: NAND2 [Q,$\bar{Q}$,S]

Each component gate is on a single line. In the first line, A1 is the gate and Nand2 is the gate type — a two-input Nand gate known to the circuit compiler. $\bar{D}$ is the output to Nand gate A1 and + indicates that an unused input is connected to the positive supply. In general a gate is described by its name, type and then its inputs and outputs, the latter being defined in the square bracket with the output always in first position.

Comparing with Themis, Classic is simple to understand with no need to define the input/output pin of the gate, avoiding complexity in description.

SDL. Figure 3 shows a two-by-four decoder schematic circuit with the netlist format of the SDL structured design language description (Silvar-Lisco software) shown as:

NDO=NAND1.Y, .DO;
N1=NAND3.B, NOT1.A, .X, NAND4.A;
N3=NAND2.B, NOT2.A, .Y, NAND4.B;
N2=NAND2.A, NAND1.A, NOT1.Y;
N4=NAND1.B, NAND3.A, NOT2.Y;
ND3= NAND4.Y, .D3;
ND2=NAND3.Y, D2;
ND1=NAND2.Y, .D1;

Netlist statements are based on the nodes (N1,N2,N3,N4) in circuit. Each statement starts from a node and describes all connections with that node, with the two inputs of the Nand gate given as A and B, and input of the Not gate as A. Y is the output for both types of gate.

In the first statement, ND0 is an output link connecting output Y of Nand1 to output terminal D0.

In the second statment, N1 is a node with four branches: to input B of Nand3; to input A of Not1; to input terminal X; and to input A of Nand 4. The same format is applied to nodes N2,N3 and N4, describing the circuit in detail, but in addition to defining gate inputs and outputs, also needing definition of nodes and output limits (ND0, ND1 etc).

Redboard. Racal-Redac's Redboard PCB design software **(Fig. 4)** defines

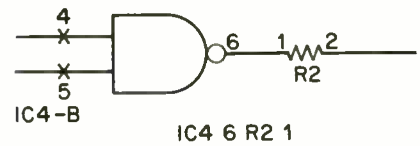


Fig. 4. **Redboard** *format for this circuit is IC4 6 R2 1*

inputs and outputs to the element by a number. IC4 is a gate type, recognised by referring to the database and 6 is the output pin of the Nand gate connected to pin 1 of resistor R2. Each element in the connection list describes a connection path in the format:

<name of component><pin number>

The format has two fields. If two components are connected to each other, it is only necessary to specify the name and output pin of the first component and then the name and input pin of the second component in sequence, e.g.

IC4 6 R2 1

The connection list entry for a connection net with three pins **Fig. 5** is

IC4 6 R2 1 R1 1

Ella. Figure 6 is an Electronic Logic Language (Ella) network of a bit-level half-adder. The explicit Ella description of this network, called the function declaration is,

```
FN HALF ADDER =
      (bool :inp2)→ [2] bool :
  BEGIN
      MAKE NOT  :  n1 n2,
           AND  :  a1 a2 a3,
           OR   :  o1.
      JOIN (inp1, inp2) →a1,
           inp1→ n1,
           inp2→ n2
           (inp1, n2) → a3,
           (inp2, n1) → a2,
           (a2, a3) → o1,
      OUTPUT (o1, a1).
  END.
```

First line is the function specification, indicating the half-adder has two inputs and two outputs of type bool. Remainder of the function describes the network. The Not, And and Or gates are

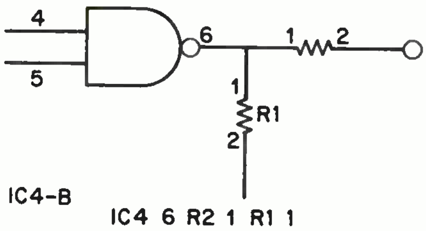


Fig. 5. IC4 6 R2 1 R1 1

specified in the Make statement, and these gates must already be defined or picked up from a library. Interconnections around the network are defined by a list within a Join statement, for example, inp1 and inp2 are joined to And gate a1. Output from the half-adder is given in the Output statement, and corresponds to output from gates o1 and a1.

Futurenet

In some cad systems such as Orcad, a Netlist program is provided which reads either a hierarchy, flat file, one sheet file structure, or an annotation file. The program generates a netlist in a number of selectable formats, such as Spice, Pcad, Salt, and Edif. But there is another format called Futurenet which is now being implemented in some new generation cad systems.

Most netlist formats support special pin numbering conventions. So, if the libraries have pin names as text, they must be converted to whole numbers, depending on the desired netlist format; Futurenet can carry out this sorting. In Orcad, Futurenet has two connectivity output formats, Pinlist and Netlist.

Pinlist is a part-oriented list so that each pin of a part will be listed with the net to which the pin is attached.

Netlist is a net-oriented netlist giving for each net, the part pins that are attached. The following is a portion of a Pad-PCB Futurenet netlist format :-

```
(SYM, 1 — 1, 2
DATA, 2, J1
DATA, 120, JO39 — 24
)
(SIG,,***132114, 1 — 1,,
PIN, 1 — 1, 2, J1, 25, 1
PIN, 1 — 1, 1, J3, 25, 1
```

(Sym is the key word for parts data, J1 is reference designation, and JO39–24 is part type. In this case, these part types must match the ones in the Pads-PCB library. (Sig is the key word for connections data followed by the signal name or bus signal name. In the next two lines, the last two fields give the net node. In this case, signal name 132114 contains the net J1.1,J3.1. This netlist format may require pin numbers instead of pin names in the library source file. But there are options which can be used when generating a Futurenet netlist such as the program to assign a Futurenet-compatible power attribute to power supply pins not in Futurenet format.

Another option is to specify the module's ports (input, output, and bidirectional) in Futurenet format with specific attribute values. In the Pads-PCB program, there is the capability to accept a Futurenet format file as an input. The Orcad system can generate a Futurenet netlist output file so users of Orcad can transfer the Futurenet output file to the Pads-PCB system.

The received file will be converted to Pads-PCB via the subdirectory and the Futurenet-in routine in the system.

Users of Schema Capture can also use the Futurenet output facility to transfer Futurenet files.

Futurenet output is limited by available system memory. IC design and fabrication has become increasingly complicated with the move towards to VLSI and to reduce production costs companies are resorting to joint ventures. IC system design may be performed by one company while logic design and cell libraries will be dealt with by others. Similarly, the chip could be manufactured in more than one location.

Unfortunately, because over the past few years there has been such a large growth in the number of cad/cae system and workstation packages, dissimilar systems are likely to be employed in each company. This may mean that only limited design tools can be used for joint ventures; making compatible netlist formats essential to make manufacturing more flexible. Although cad tools have helped speed development, most are poor at accommodating data exchange between different tools. This will only be solved by defining a standard format for data communication between cad systems. ■

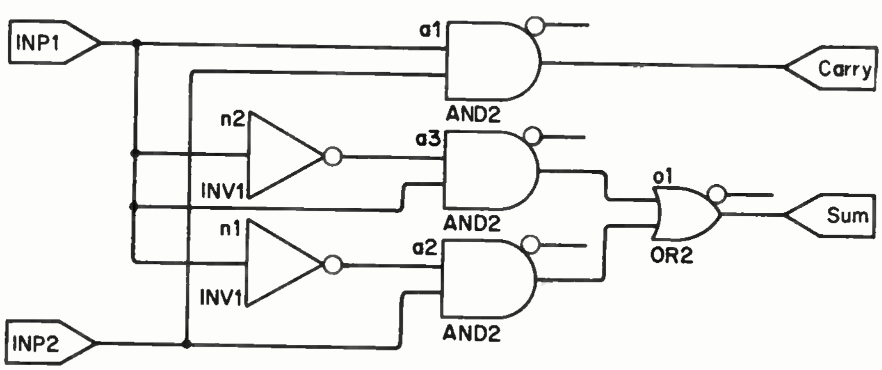


Fig. 6. Example half-adder described by **Ella**

References

1. SDL (The Structured Design Language). Reference Manual Document No. M-004-2, Silvar-Lisco, July 1984.
2. Pads-PCB Reference Manual, (FutureNet).
3. SDS (The Structured Design System) Reference Manual, Document No.M-001-3, Silvar Lisco, January.1985.

BOOK REVIEW

Signals: the science of telecommunications, by John R. Pierce and A. Michael Noll. If anyone should experience a need to recommend a book on electrical communications for the completely innocent, then this is the one.

Pierce and Noll have both been at Bell Labs and, probably as a consequence, the book concentrates on telephony and the applications of radio and television that are relevant to the field of communications.

It begins with an historical survey of development, quickly going on to describe the theory and techniques of telecommunications. Chapter 3, for example, provides a clear insight into the theories of Fourier and Shannon, including vocoders. Treatment throughout the book is at a level consistent with a readership of O and A-level students and indeed anyone who is interested in, but not educated in, electronics and the science of communications.

Where necessary, the essential mathematics and core concepts are presented in boxes in the text – an effective device to convey information without disrupting the flow of narrative, since the authors have produced what is effectively the story of electrical communications in an exceptionally readable form. The Scientific American Library, W.H. Freeman & Co. Ltd, 247 pages, hard back, £16.95.

Drafting made Easy

John Anderson delivers his verdict on the new cheaper and faster Easy-PC. It's definitely not cad – but it's not bad either.

Easy-PC is a low-cost PCB schematic and layout drafting program which first appeared last year (reviewed *EW&WW* July 1989 pp. 715-718). Since then the developer, Number One Systems, says it has speeded up drawing, extended the symbol library, and cut the price without losing professional output. The result is a computer-based 2D drafting aid which performs well. But users looking to make large improvements in their quality control and productivity may be disappointed.

The package comes as two 5.25in and one 3.5in floppy disks with an A4 ring-binder manual carefully laid out with tutorials for each program. Also included is a very useful listing, by layout, of the library symbols and a key-code summary sheet which is essential for the beginner.

There is no copy protection and installation should be simple; just create a directory and copy the files into it. In fact I found the software would not run with my EGA card (ATI EGA Wonder), needing a VGA card, though this should be no great drawback as most PCs have adopted VGA as standard.

Programs and library take about 725k of disk, with reasonable data compression so that hard disks will not become overloaded with storage-intensive bit-image files.

Set-up allows the user to configure the colour scheme, drawing defaults, and other attributes, though the colour scheme is limited. It allows only three combinations of four colours and is a serious drawback with a PCB having the maximum of eight layers.

Main menu options

Five option choices displayed on the screen include editing a schematic or layout, creating a symbol for a schematic or layout, or exit to dos.

Text or graphics modes are selected automatically depending on what is being displayed. The initial menu and selection of options is in text mode while pictorial information is presented in graphical mode. Switching between modes can be disconcerting as, with most VGA screens, the source synchronisation is momentarily lost causing the display to jump.

Commands are initiated by the left mouse button or return key, and exit by the right mouse button or the escape key. Actions are selected either through the mouse or by a direct key combination.

Using the mouse the cursor is moved to one of three small white squares at the top of the screen, bringing down a menu and allowing selection of an item. The method means there is more active space for drawing, but access is slow, which can be a nuisance because the XY working co-ordinates are lost.

Direct key combinations allow actions to be initiated with function keys, and/or specific alpha-key sequences, and a fast zoom and pan are simply selected by numeric keys 0 to 7 used to set the zoom level.

Problems solved?

Number One Systems' technical support is informed and helpful and when asked about some of the problems experienced agreed they had trouble with EGA cards but that these could normally be resolved by running in CGA mode.

Easy-PC does not produce any connectivity information such as netlists and this is not likely to be changed. But a new driver for HP Laserjet 2 will be available soon.

The technique for producing power-planes as intermediate layers was explained to me, using thick tracks to produce an area plane, and then selecting the appropriate pad to effect connection to, or insulation from, a layer. It sounds clumsy and I haven't tried it yet.

Conversion from other systems is possible at the Gerber plot file level where a utility, available separately, can convert a Gerber plot file to Easy-PC format.

Number One is working on a new product with connectivity and autorouteing, but this will be an up market product and as such not competing with this version of Easy-PC.

Speedy and flexible

One of the improvements promised by this latest version of Easy-PC is a much improved redraw speed. In practice even large complex PCBs and schematics are redrawn within a second or two. Panning across the screen is by redraw, rather than copy and part update, which makes the speed of the redraw algorithms crucial.

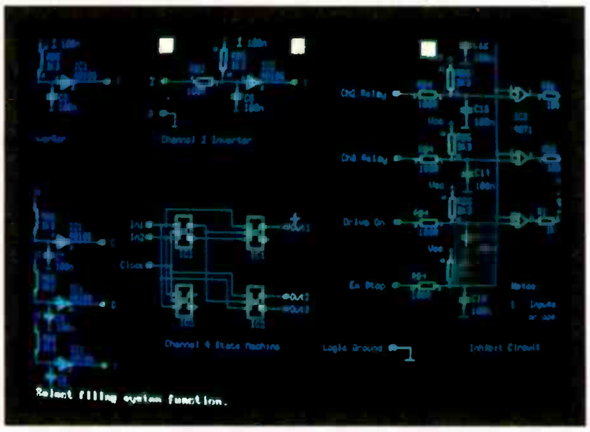
On the whole, operation speeds are reasonably fast, though access to the pull-down menus does slow down the rate at which the software can be driven.

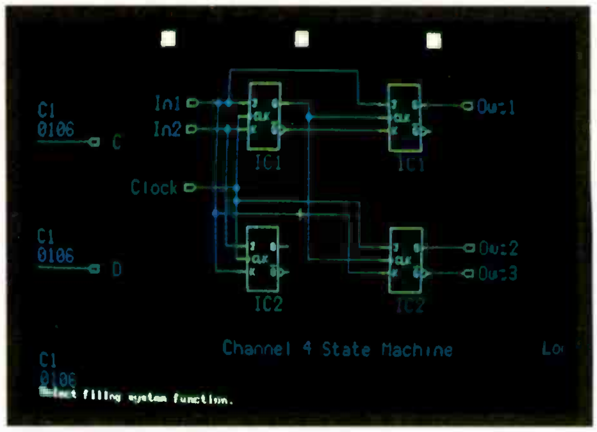
Schematic and layout component editing, available from the main menu, allow custom components to be built and the same interface is used for editing components, schematic or PCB.

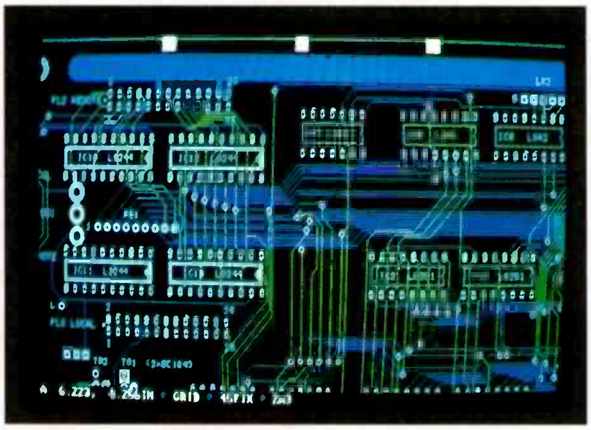
Schematic entry is all but identical to PCB layout, indeed some items look to have been left over. For example pads placed on the schematic layout turn out to be intended to be used as the wire junction indicator.

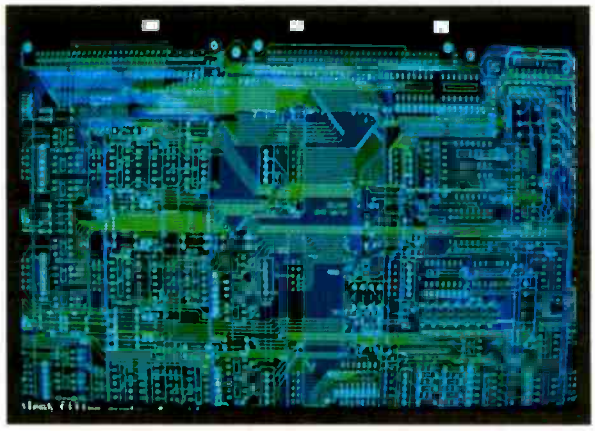
There is no bus-type line either, not needed as there are no net labels or generated netlist.

Editing facilities include block move, flip, copy, save and delete (though no undelete) and a high speed repeat facility which allows a track to be repeated at a different place – particu-









Circuit drawing and PCB layout with the Easy-PC. Top left and right schematics are samples of the software's capability; no bus lines can be drawn and there is no netlist extraction. Nevertheless, Easy-PC does provide a professional-looking board design, as shown in the two lower pictures. The package has been speeded up and reduced in cost since it was first reviewed in July 1989.

larly useful in laying out a memory plane.

Plotting

The only auxiliary files are associated with outputting to a printer, plotter or photoplotter. PCB files are in a proprietary format rather than ASCII, preventing integration of additional support software to analyse drill details, for example, before plotting.

Circuit diagram plotting is accomplished with a separate program, Easy-plot, and a word of warning before using it; make a note of the exact name of the PCB to be plotted. If you don't there is no exit from the program, no way to get a directory to choose the file, with rebooting the only way forward.

With the correct filename, the program gives adequate control over the final output, including rotation and limited scaling, though the speed of output is rather slow.

Quality of the result is good with a close correspondence to that presented on screen.

Not true cad?

This software package does little with the PC to aid design. Although schematic capture and PCB layout are integrated in that they are accessed from within the same program, and share the same user interface, they are not integrated operationally.

There is no netlist generation or checking, no bill of materials, and no design rule checks.

Cad packages should improve productivity and overall quality, and though Easy-PC will certainly produce a tidy plot of schematic and PCB, it does not tackle the productivity and quality aspects that are required from PCB cad.

It is low cost, with drivers for HPGL and Gerber, and as a computer based 2-D drafting aid it performs well. But as an introduction to PCB work on a computer it represents little more than electronic tracking tape, offering the professional user none of the productivity and quality advantages possible with PCB cad software.

Libraries are comprehensive and simple to use, but the user interface is quirky, with its white-square pull-down scheme rather than the industry-standard heading-banner.

With regular use its limitations and idiosyncrasies can become irritating, and work against the job that it is attempting to do.

However, its price recommends it to the educational and hobbyist market. If budgets can stretch it is worth looking at alternative products which can auto-route, generate and check netlists and offer the cad facilities that help get that PCB right first time. ■

Easy-PC, schematic capture and pc layout software costs £98+VAT Minimum hardware is a PC or PC-AT, running dos 2 or later, with a CGA, EGA or VGA graphics card. 512k is the minimum memory required. Optional mouse, printer, plotter and photoplotter. Number One Systems Ltd, Harding Way, Somersham Road, St Ives, Cambs PE17 4WR. Telephone: 0480 61778

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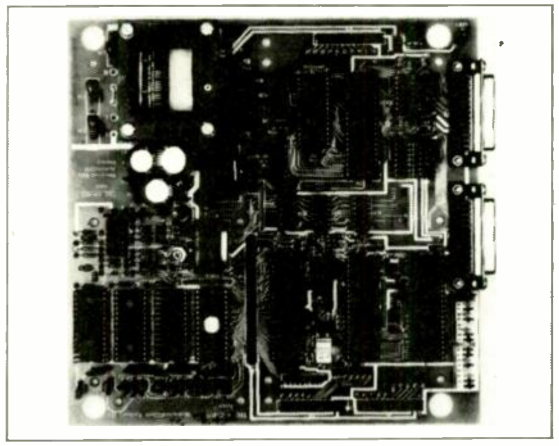

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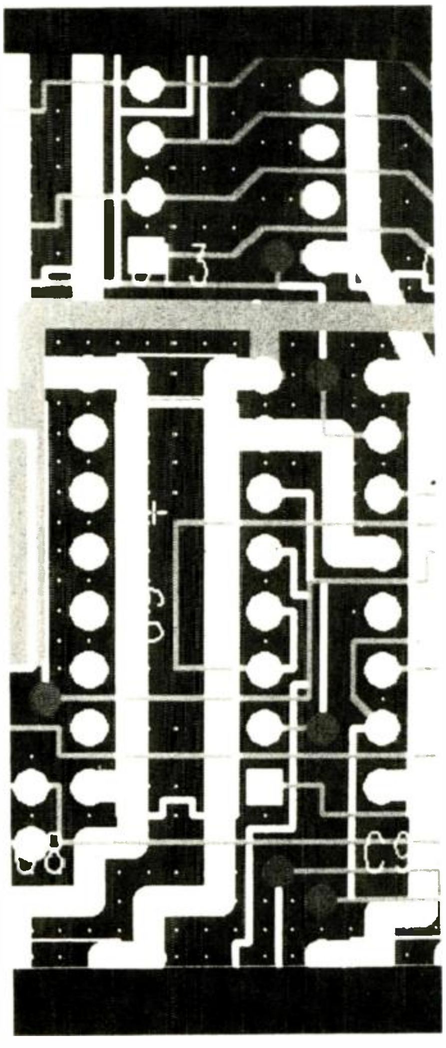


Where office workers have adapted to the new technologies with reluctance, engineers have leapt on to the bandwagon. From the first mechanical and architectural drafting packages, to the most complex electronics simulation software, cad has become an essential part of engineering life.

Trying to give an overview of such a diverse market is difficult and the survey which appears in the following pages is not comprehensive; no survey could be. But it is representative, and will give potential purchasers, a good feel of what is available, and where you can buy it.

So what can you get for your money? At the bottom end of the market come the basic drafting packages – some costing less than £100. These allow drawing of PCB layouts, or curcuit diagrams, very much as the job might be done manually, but using a mouse and screen.

Routing software, costing anything between £200 and £1500, is the next step. The job can be done manually, connecting points on screen, or, in the more expensive packages, automatically, with the computer checking against pre-defined PCB design rules. This type of layout software can often cope with highly complex multilayer and surface mount boards. But beware, even the most advanced workstation-based routers will not give 100% guaranteed completion. All leave a certain amount to the artifice of the designer, who may have to tweak the layout, or define areas where the design rules can be violated.

Adding facilities for drawing of a circuit on the screen, then having the computer pass it on to the routing software automatically (schematic capture) will probably cost as much as the router itself.

However the PC market is catching on to that word so much loved by the marketeers – integration, meaning that many vendors are now offering suites of software, offering as many features as the user will buy software modules, all designed to work together.

Having designed the circuit diagram on-screen, it makes sense to ask the computer to find out whether it will work before you go ahead and build it; enter the circuit simulator. Spice, the daddy of all analogue packages, weighs in at between £600 and £3000+ giving some idea of the range of configurations available, just in this single product. Most recent options include active filter synthesis, and optimisation for arbitrary transfer functions.

With any simulator it is worth thinking how well the package will model your circuits – will it look at component tolerances, and produce a worst case analysis? Are facilities like Monte Carlo statistics available?

In many ways, digital simulation is simpler because "on/off" circuits are easier to model. But, once again, it is worth considering the package's ability to cope with worst case timings, feedback loops and combinational logic, which can often cause problems.

One of the hardest jobs is simulating mixed-signal circuits, a task which the makers of Spice say it can now perform under dos. For those who need it, there is also a large range of niche simulation efforts so that, for instance, transmission line effects on digital PCBs can be modelled. To accompany the digital simulator, it is also possible to buy logic capture packages, which will accept inputs in many forms such as gate level description, Boolean equations, and, less often, state diagrams.

Once the electronics have been designed further levels of choice open up because the computer can perform thermal analysis, produce a bill of materials, and cost the job. In a fully integrated system, the design suite will talk to the machinery producing the PCB (plotters, drills, and so on), the packaging, the asics and PLDs.

There is obviously a lot that has to be weighed up before the right CAE packages can be selected to do the best job in a particular application. When you've waded through all these decisions, you can start thinking about designing your own products...

Acquisition-PC
Newly-released signal analysis and acquisition system.

ALS-View
Menu-driven, high performance tool designed to eliminate PCB re-plots.

Ares/Ares Autorouter
Advanced Routing and Editing Software. New high performance PCB design. EMS support is more or less essential for complex multilayers (640k soon runs out). Very powerful interactive routing facilities and object-avoiding ground-planes.

Boardmaker
Rules-based PCB design package for manual or autorouting. The router is gridless and uses the design rules and track widths to determine route placement. It is fully re-entrant and will simultaneously route on up to eight layers. Extensive design rule checking is employed to maintain user confidence and ultimate manufacturability.

Codas-II
Highly integrated, interactive package for designing and simulating feedback control systems. It includes time domain, frequency domain and root locus design environments, continuous and discrete time (computer control) systems and non-linear capabilities.

Curve-F
Polynomial curve-fitting designed for use with ECA-2. Transfer curves of components can be simulated by the

Package name	Manufacturer	Distributor	Price	Platform	Links to	Description	Manual/automatic/both	Design rule check	SM/through hole/both	PCB layers	Menus/windows/both	Mouse/keyboard/both	Object oriented	Manufacturing o/p	Test o/p	Bill of materials	Costings	Thermal analysis	Asic generation	Schematic capture	Simulation
Easy-PC	13	13	£98.00	PC.dos>2.1	N/A	PCB cad	M		B	2-8	M	B		CNC							
Pads-PCB	20	12	£600 to £8000	AT/386/486	Orcad Autocad Schema Cadstar Futurenet	Modular PCB cad	B	●	B	>8	B	B	●	A/W G Ex CNC		●					
Pads-Logic	20	5	£595	AT/386	As above	Logic capture					B	B	●							●	
Pads-2000	20	5	£7995	386/DOS3.3	Padslogic Aldec Microsim	Integrated PCB design	B	●	B	>8	B	B	●	A/W G Ex	●	●					
PCB Eagle	21	3	£335	XT/EGA/HD/M/PI/640	Autor'ter Scem Ed	Layout editor	B	●	B	>8	M	B	●	CNC G,Ex	●					●	
Eagle Autorouter			£260	As above	Layout Schem Ed	Autorouter															
Eagle Schematic Editor			£350	As above	Autor'ter L/O Ed	Schematics															
Design Engineer	8	8	POA	AT/EGA/M		Schematic cap					B	B								●	
Isis Supersketch	10	10	£69 to £99	PC/512/M. Supports SVGA, PS	Gem, DXF	Circuit drafting					B	B	●								
Isis Designer			£275 to £475	286/640/M/HD. Supports SVGA, PS	Area, Gem DXF, Net	Schematic cap					B	B	●			●	●			●	
PCB II			£69	PC/512/M. Supports SVGA, PS		PCB drafting	M		B	2	B	B	●								
Ares/Ares Autorouter			£275 to £475	PC/640/M. Supports SVGA, PS	Isis	Manual/Auto PCB router	B		B	>8	B	B	●								
Fastfoto/Fastmark	14	14	POA	MACII/Unix		Image storage & retrieval					B	B									
Sauna	29	18	£995	PC		2/3D thermal analysis												●			
SpiceAge	18	18	£245	PC	Tanspag	Simulation															A
Tanspag	18	18	£140	PC	SpiceAge, Net	Netlist translation															
Vutreca/Vutralca	18	18	Free	PC	Vutrax ECA-2 LCA-1	Schematic to simulation translation					M	M									
Plot-D/Print-D	29	18	£50	PC/HPGL plttr Laserjet	LCA-1 ECA-2 Curve-F	Printer & plotter utilities															
Curve-F	29		£120	PC	ECA-2	Curve fitting & modelling															
LCA-1	29		£450	PC	ECA-2 Plot-D Print-D Vutrax	Digital circuit simulation															D
ECA-2	29		£675	PC	LCA-1 Plot-D Print-D Curve-F Vutrax	Analogue circuit simulation															A
Vutrax S&A	22	18	£499	PC/M	ECA-2 LCA-1 Vutreca Vutralca VutraxPCB	Circuit description & schematic capture					M	B				●				●	

Package name	Manufacturer	Distributor	Price	Platform	Links to	Description	Manual/automatic/both	Design rule check	SM/through hole/both	PCB layers	Menus/windows/both	Mouse/keyboard/both	Object oriented	Manufacturing o/p	Test o/p	Bill of materials	Costings	Thermal analysis	Asic generation	Schematic capture	Simulation
Fastcad Easycad			£599 £125	PL/640	Various	Drawing/ Schematic								CNC		●				●	
Orcad/VST	25	11	£995	Dos2.0/HD/M/AT/640	Orcad/MOD Orcad/PLD Orcad/PCB	Digital circuit simulation					M	B			●						D
Orcad/PLD	25	1	£495	As above	VST,MOD,PCB,SDT	PLD design						K	●		●						D
Orcad/PCB	25	1	£1495	As above	VST,PLD,SDT,MOD	PCB layout/router	B	●	B	>8	B	B	●	CNC A/W	●	●					
Orcad/SDT	25	1	£495	As above	PLD,VST,PCB,MOD	Schematic capture (PCB)					M	B				●				●	
PSpice	24	1,16	£595 to £3100	Dos2.1/640	Schem cap packages, Hiwire	Analogue, digital and mixed sig simulation					B	B	●			●					ADM
Linesim		1	£695	PC		Transmission line analysis					M	B									ADM
Promise		1	POA	PC	PSpice	Circuit optimiser					B	B									A
ALS-View		1	£795	PC	PSpice	Circuit optimier					B	B									A
ALS-View		1	£795	PC	PCB	PCB plot					M	B		A/W							
Solo 1400	23	7,15	£12k	AT/Dos3.2/coprocesr		Integrated asic design package					B	B			●				●	●	AD
Rotring RDS40	27	17	£8617 upwards	286	Elmat	Circuit design parts lists, BOM, etc										●	●			●	
Protel Traxstar	26	9	£999	AT/EMS	Autotrax Schematic	Autorouter	A		B	>8	M	B									
Protel Schematic			£499	AT/640	Traxstar Autotrax	Circuit des/schem cap					M	B				●				●	
Protel Easytrax2			£199	AT-MAC	Schematic	PCB design/router	B	●	B	>8	M	B		CNC A/W		●					
Protel Traxview			£349	AT		Edits Gerber files & aperture table					M	B									
Protel Autotrax			£999	AT/HD	Traxstar Schematic	PCB layout/router & schem capture	B	●	B	>8	M	B		CNC A/W G		●				●	
Hiwire	31	16	£695	640/Dos2.1	PSpice Smartwork Orcad Schema Cadnetix	Schem design, PCB layout, router	B	●	B	>8	B	B	●	CNC A/W G		●		●			
Smartwork			£695	512/Dos2.1	Hiwire Orcad PSpice	PCB layout, router, a/w	B	●	T	1-2	B	B		CNC A/W G		●					
Schema			32	640/Dos3.2/AT/VGA	AutoCad	Schem capture, PCB layout, simulation, PLD	B	●	B	>8	M	M		CNC A/W		●				●	M
PCS	6	6	£100	380/coproc support		Design of process control systems															
Codas-II	6	6	£475	512/coproc support		Feedback control systs															
EE Designer	2	2	£4000	XT/AT/386	Maxroute PSpice	Fully integ electronics design, sim	B	●	B	>8	B	B	●	CNC A/W G	●	●	●	●		●	
Acquisition-PC	11	11	£960	PC		Signal anal and acquisit'n															
Boardmaker	19	19	£295 ro £495	XT/640/HD/Herc-VGA		PCB design, router	B	●	B	>8	M	B		CNC A/W							
vsDesigner	28	4	£419	PC/640-EGA M		Real time CASE tool					M	B									

Notes:
Figures in column five refer to memory requirements.
Abbreviations: M=mouse required; HD=hard disk required/recommended; PI=parallel interface; EMS=memory expansion required; Herc=Hercules Graphics; G=Gerber output; Ex=Excellon output; A/W=Artwork.

polynominal facilities allowing fast building of device models. Graphics editor with cursor controlled co-ordinate index.

Design Engineer
Lower cost schematic-capture package leading on to a full range of electronic, mechanical, electrical and publishing packages running on Intergraph's Unix Clipper workstations and servers.

Easy-PC
British design-award winning PCB cad program providing for circuit and schematic diagrams. Exceptionally functional, quick to learn and use, fast zooming and planning. Providing output to pen plotter, photoplotter, NC drill. Technical hotline support. Resolution 0.01mm, 30 routing layers, blind and buried feed-throughs.

ECA-2
Frequency and transient response of non-linear circuits with up to 500 nodes. Worst case and Monte-Carlo analyses. Can be invoked from within Vutrax.

EE Designer
Fully integrated system for electronics design. The entire suite is written by Betronex, ensuring smooth interfaces between schematics, simulation, PCB layout, manufacturing outputs etc.

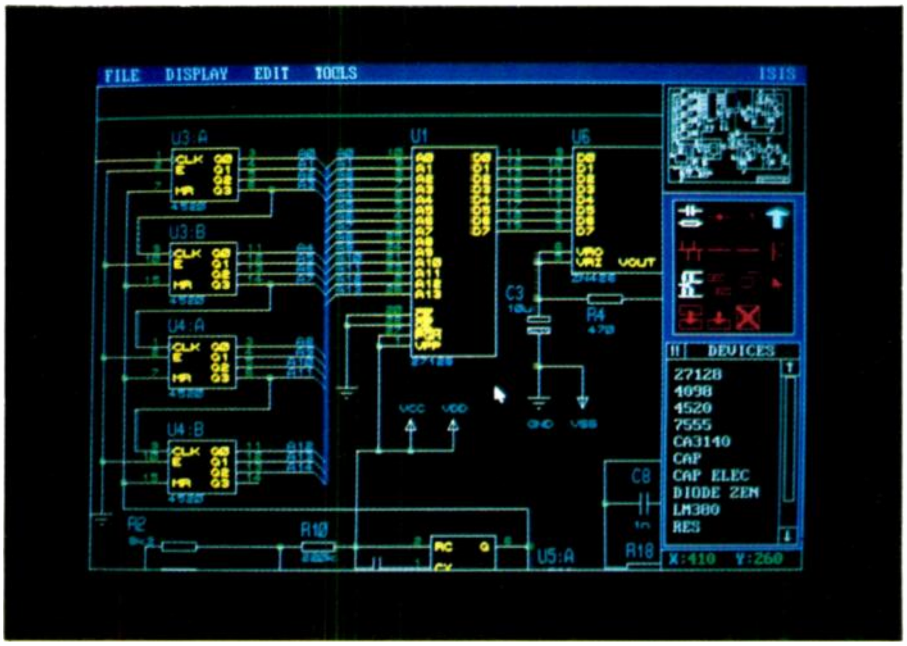
Fastcad-2D/Easycad
Fastcad and Easy cad were written by Mike Riddle, originator of the best selling general purpose cad package, Autocad. Easycad is a true subset of Fastcad which provides multiple interactive windows and a wide range of cad functions. Add-in packages can be seamlessly added. Both packages support DXF and can export to Pagemaker, Ventura and Wordperfect 5.

Fastfoto/Fastmark
Image storage and retrieval system, with fast powerful searching on a wide range of user-defined criteria. Input via video, scanner, etc. Suitable for documents and photographs, storage of thousands of compressed images on optical disk.

Hiwire
Integrated design package with rip up and retry autorouter, schematic design and PCB layout.

Isis Supersketch
Circuit drawing package. Since its database operates at a higher level than a general purpose cad program (ie it deals in components, wires, terminals etc, rather than simple geometric objects) it is far quicker and easier to use. Features automatic wire routing and object oriented 2D drawing.

Isis Designer
No-nonsense schematic-capture package



Modern schematic capture packages provide a bill of materials and automatic component annotation. This screen from Isis Designer.

designed for use with most popular EDA software. Intelligent diagram editor speeds diagram entry, and Bom report is configurable. Component finder works across the whole design. Designer+ adds two systems for hierarchical design, automatic annotation and database-driven ASCII data import facility.

LCA-1
Digital simulation of circuits described by netlist, schematic or Boolean expressions. Propagation delays and their fast/slow uncertainty bands are fully modelled and may be asserted as a class (eg 4000 Series or TTL LS). Normal graphical output can be stored in text files to provide ATE test patterns.

Linesim
Predicts transmission line behaviour in digital circuit boards and cables. Intended for optimisation of traces and terminations, and technology choice before layout begins.

Orcad/VST
Allows designer to try out circuits before fabrication. Feedback and combinational logic supported. Includes stimulus generator, design linker and compiler.

Orcad/PLD
Programmable logic device design tool. Creates detailed logic from high-level descriptions, eg Boolean equations, procedural state machine programs, truth tables or schematics.

Orcad/SDT
Uses a hierarchical organisation of large worksheets by partitioning them into smaller parts – over 200 hierarchical levels. Can create and store over 100 keyboard macros. Schematic data can be transferred as netlists in more than 30 formats.

Pads-PCB
Suite of software providing schematic capture, PCB design, autorouting including rip up and retry, push and shove. Standard outputs. Three levels are provided; Pads Designer (£695), Pads PCB (£1895) and Pads 2000 (£7995).

Pads-2000
Full PCB design and layout, auto-place, auto-route, push and shove interactive router plus drill, plot and DXF interfaces. 1μm database resolution. Full Eco-processing with Pads Logic schematic capture as front end.

Pads-Logic
Logic capture system which interfaces to Pads-PCB and other cad, logic simulators and circuit analysis packages. It uses a true multi-sheet database and advanced hierarchical capability.

PCB Eagle
PCB design system handling board layouts up to 64-in, at a resolution of 1mil. and with up to 255 layers. The easy-to-use graphics interface includes many user-configurable features and autopanning, continuous zoom, DRC/ERC are provided. Numerous plotter and printer drivers (including Gerber) included at no extra cost.

PCB II
Simple, very low cost, PCB drafting. Operation similar to Supersketch, but since each was designed for a specific task, the overall result is better than one package designed for both PCB and circuit drafting.

PCS
A realistic simulation of typical process plant under three-term control. It incorporates many features found in the

real world, making it ideal for illustrating controller operation, tuning and plant behaviour.

Plot-D/Print-D
Output utilities allowing ECA-2, LCA-1 and Curve-F to produce high quality graphics output on either HPGL plotters or Laserjet and Epson dot-matrix printers.

Promise
Fast electronic circuit optimiser. Frequency response can be tailored, transient characteristics enhanced or DC conditions fixed in a few minutes.

Protel Traxstar
Grid-based costed maze autorouter with full rip up, re-route and smoothing capability. Works with Protel Autotrax files.

Protel Schematic
Streamlines drafting operations, improving productivity design proctice and documentation. Used on its own or with Autotrax and Traxstar to form a powerful PCD cad system, including circuit design checking. Evaluation packs available.

Protel Easytrax2
Newly released entry-level low cost package. Now includes autorouting, curved tracking, postscript, imperial and metric grids and 24-pin printer support. Also available on the Mac.

Protel Traxview
Utility program for editing and viewing Gerber files and Aperture tables. Includes panelisation.

Protel Autotrax
Version 1.5 now includes curved tracking, imperial and metric grids, additional routing strategies, Postscript printing and improved external polygon fill. Also available on the Mac.

Pspice
The Pspice family includes the circuit analysis and circuit synthesis packages. The circuit analysis package contains the Pspice circuit simulator and its options, and the circuit synthesis package contains the filter synthesis product, filter designer. Pspice is the only simulator to run both analogue and digital processes concurrently under dos. It has virtual memory capacity, filter synthesis and an optimiser for arbitrary transfer functions.

Rotring RDS40
Generation of circuit diagrams and associated documentation. Automatic cross-referencing, wiring lists, terminal diagrams, parts lists, bill of materials, project costing, ident, labels and cabinet layout.

Sauna
Provides 2D and 3D thermal analysis. Typical applications include temperature and heat flow mappings on heatsinks, PCBs and within enclosures. Natural and forced convection models are supported. No prior knowledge of heat transfer is required, but for advanced users, a more flexible finite element version, Sauna-MS, can be supplied.

Solo 1400
Design asics for manufacture in 1.7 or 1.1μm cmos. Includes comprehensive cell libraries, including analogue to allow design of mixed analogue/digital devices.

Smartwork
The original low-cost PCB artwork software, for entry-level two sides PCB artwork, using netlists from most popular schematic software.

SpiceAge
Provides electronic circuit simulation for design and education by performing DC, AC, time-dependent and Fourier analyses on linear and non-linear circuits using programmable signal stimuli or imported waveforms stored on file. This popular program now has a licence base exceeding 6700.

Tanspag
Netlist translation utility that allows popular schematic capture programs to produce a Spiceage description file. Takes as input a Tango compatible netlist. Thus programs such as Isis, Protel, Schema, Orcad, Tango and Boardmaker now have commonality with Spiceage.

Vutreca/Vutralca
Allows the Vutrax schematic editor to download data to either ECA-2 (analogue) or LCA-1 (digital) simulators. Facilities include default tolerancing, automatic model building and full tri-state open collector modelling with wire gate synthesis.

Vutrax and S&A
Provides a common circuit description. Feeds analogue and digital simulators and a full-feature design suite that includes 3-D visualisation and CNC output. ■

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Still video – still here?

Beating the news clamp down in China, or bulk storage of images; still video could provide the answer. So why the delays. George Cole reports

Consumers switched to video for home movies rather than the 8mm cine camera because, unlike video tape, film is expensive, can't be reused and the results can only be seen after processing. Yet in still-picture photography film reigns supreme.

Now electronics companies are challenging that position with still video cameras (SVCs) claiming to offer similar advantages over conventional film photography.

They will record pictures on a reusable magnetic disk, and shots can be viewed on a TV set or even sent down a telephone line or put into a computer. But there are drawbacks; SVCs are expensive at the moment (most domestic versions cost around £500), picture quality is much poorer than film, and there is a battle over a still video format.

However, the first consumer SVCs went on sale in Japan at the end of 1988, and in December 1989, Canon launched the Ion, the first (and at the time of writing, only) European domestic SVC. Recording is on to still video floppy disks in these systems.

Still video floppy

The still video floppy is a 47mm (2in) single-sided disk which looks like a miniature version of a standard 3.5in floppy (see **Fig. 1**). Each disk, which stores up to 50 shots, sits inside a hard plastic jacket with an erasure-prevention tab which can be broken off to prevent accidental recording. The disk is composed of a polyester base topped with a metal powder which provides a very high information packing density (see Table 1).

Still floppy disks are designed to store a mix of analogue video, FM audio and digital data, stored on-disk as a series of concentric tracks (**Fig. 2**). Tracks are read by a fixed head com-

Table 1. Still video floppy specifications

Data capacity	1.5Mbyte (unformatted) 0.8Mbyte (formatted)
Recording density	64kBPI (kilobits per inch)
Jacket dimensions	60×54×3.6mm
Weight	8.7g
Disk diameter	47mm
Total disk thickness	40μm
Magnetic layer thickness	4μm
Magnetic coating	Metal powder
Coercivity	1250 Oersteds
Remanence	1800 Gauss
Total number of tracks	52 (1-50 video, 52 cue, 51 blank)
Track capacity	16Kbyte
Video tracks radii	15.1-20mm
Cue track radius	14.9mm
Track width	60μm
Track pitch	100μm

History

Back in 1981 Mavica (MAgnetic VIdeo CAmera), the first SVC unveiled by Sony, looked like a conventional 35mm SLR film camera, with pictures recorded on a magnetic floppy disk. But Sony used the prototype to persuade other companies to join forces and develop a standard still video system, so in February 1983, 20 electronic, film and photographic companies formed the Electronic Still Image Video Camera Committee.

By May 1984 the group had grown to 32 companies and the basic specifications for a video floppy system (VFS) were agreed. These stated that the image quality was to be acceptable both for consumers watching on-screen pictures, and for printing.

That same year, professional photographers tested SVCs at the Los Angeles Olympics and several companies, including Sony, Fuji and Canon, began marketing professional SVCs costing thousands of pounds. In April 1985, Fuji introduced its TV-Photo system in Japan. Photographers shot pictures on conventional film which was processed in the normal way. But the images were transferred to a still video floppy and viewed on a TV screen, so that photographers could choose the best.

In April 1986, the committee, by this time numbering 42 companies, agreed on optional sound and digital recording systems and in July 1988, it announced an improved "Hi-Band" version.

Sony's Mavica, the first still video camera.

posed of amorphous silicon, gliding across the disk's surface to read, write or erase tracks. The head has two gaps 100μm apart to allow the recording or playback of two tracks simultaneously.

Recording the video signal

All SVCs use a CCD image sensor, with most composed of around 400 000 pixels. For comparison, a Polaroid print resolves around 10 million pixels and a 35mm frame some 20 million pixels. The VFS video floppy system (see History) video signal is analogue and is thus split into 525-line (NTSC) and 625-line (Pal/Secam) systems. NTSC still video recordings won't play on Pal equipment and vice-versa. In NTSC SVCs the disks spin at 3600rpm, in 625-line systems 3000rpm, corresponding to one field period of the respective systems. In Pal this gives the outermost disk track a relative writing speed of 6.28m/s and the innermost track a speed of 4.74m/s.

The video signal is composed of a luminance signal and two colour-difference signals (R-Y and B-Y), the three signals frequency modulated and multiplexed on to a single track. Luminance signal peak white is 7.5MHz and sync tip 6.0MHz, giving a carrier deviation of 1.5MHz (see **Fig. 3**). The two colour difference signals have carriers with centre frequencies of 1.2 and 1.3MHz and deviations of 0.7 and 0.5MHz respectively.

To maintain picture quality during demodulation, the VFS system uses a line sequential recording method which records the two chrominance signals on alternate lines – a method also used by the Secam TV system. Standard VFS format has a horizontal resolution of around 350 lines (see Table 2 for format comparisons), though with some cameras it may be possible to remove the chrominance carriers and extend the lower luminance sideband to produce monochrome pictures with a slightly improved resolution.

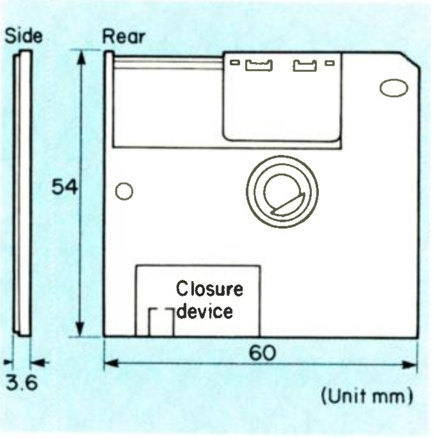

Fig. 1. Appearance of the VFS floppy disk

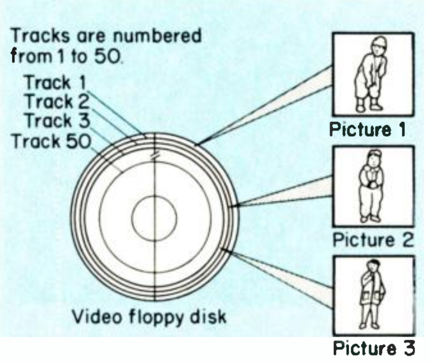

Fig. 2. Still video track format

VFS format offers field and frame recording modes, with field recordings occupying just one track, so that up to 50 field recordings can be made on one disk. The penalty is a loss of vertical resolution.

In the frame mode, two tracks are used for each recording, giving better picture quality, but reducing the number of stored pictures to 25. Some SVCs offer only a field mode, while others give users a choice. Still video floppies can store a mix of field and frame recordings and users can record, erase or reuse specific tracks.

Hi-Band VFS

Hi-Band VFS (Hi-VFS) improves picture quality by raising the frequency of the luminance carrier and widening the carrier deviation to 7.7-9.7MHz (**Fig. 4**). This improves the signal-to-noise ratio by around 2dB and increases luminance bandwidth from 4.5 to 6.5MHz, giving a theoretical horizontal resolution of over 500 lines. To improve picture quality, some companies, like Fuji, have produced Hi-Band cameras with CCDs of around one million pixels.

Hi-VFS is one-way compatible in that Hi-Band cameras can play standard recordings, but ordinary VFS cameras can't play Hi-Band recordings. Some Hi-Band cameras offer both recording modes, although Canon's Ion only makes Hi-Band recordings. Unlike the Super VHS and Hi-Band 8mm video systems, which require specialised tape, conventional still video floppies can be used for both standard and Hi-Band recordings.

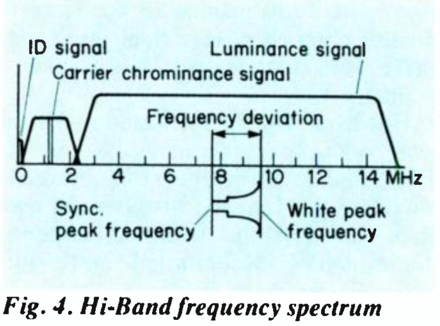

Fig. 4. Hi-Band frequency spectrum

Data recording

It's also possible to multiplex data on to the video track along with the video information, allowing text or numbers to be added to the picture. Four groups of data can be added.

First, field/frame identification – this uses two bits which are inserted at line 8 and are used by an SVC to identify the type of recording. Second, the track number uses seven bits inserted at line 28 and is used for locating shots. Third, the date uses 19 bits inserted at line 76 and can be in the form of year, month, day, or hours, minutes and seconds. Last, the user's area is inserted at line 158 and provides 27 bits in the field mode and 54 bits in the frame mode. This last allows the manufacturer to add particular information,

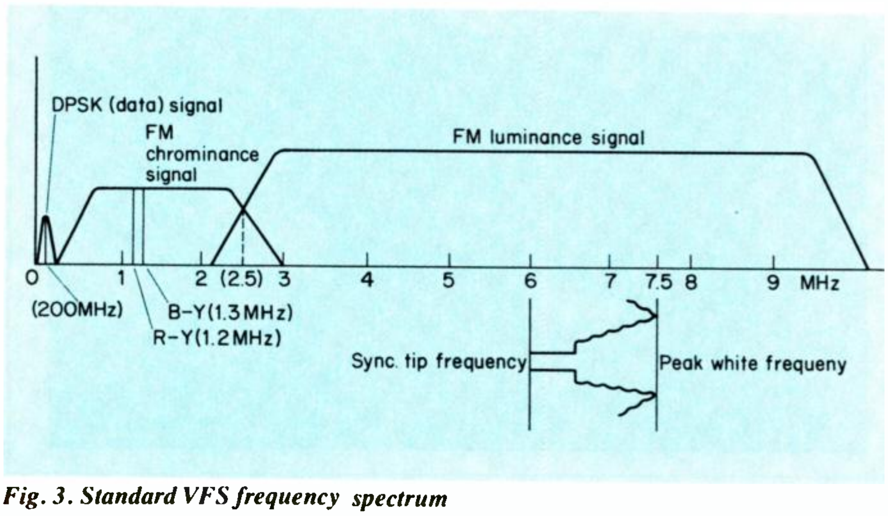

Fig. 3. Standard VFS frequency spectrum

Table 2. Format comparison (Pal)

Format	VHS	S-VHS	8mm	VFS
Parameter				
Tape width (mm)	12.5	12.5	8	-
Cassette size (mm)	188×104×25	188×104×25	95×62.5×15	60×54×3.6
Head drum/disk diameter (mm)	62	62	40	47
Tape speed (cm/s)	2.34	2.34	2.01	3000rpm
Video writing speed (m/s)	4.85	4.85	3.12	6.28 (1) 4.74 (2)
Video recording	2-Head azimuth			2 heads
Luminance signal Recording method	Frequency modulation recording			
FM carrier frequency (MHz)	3.8-4.8	54.-7.0	4.2-5.4	6.0-7.5
FM carrier deviation (MHz)	1.0	1.6	1.2	1.5
Horizontal resolution (lines)	260	400+	270	350
Shortest recording wavelength (microns)	1.3	0.8	0.6	0.8
Magnetic medium	ferric oxide	cobalt-doped ferric oxide	metal powder	metal powder
Coercivity (Oersteds)	700	900	1450	1250
Audio recording method	Linear/FM	Linear/FM/PCM*	FM/PCM	FM
Video track width (microns)	49	49	34	60

(1) Outermost track speed (2) Innermost track speed.
*This is a new specification that is not yet available on S-VHS hardware.

such as the exposure value of the shot, fast shutter speed, recording mode and so on. Because this information isn't standardised, a disk recorded on one SVC may not display all of its information on another make of camera.

The data stream phase modulates a 204.54kHz carrier and data can only be added during a video recording – it can't be dubbed on afterwards.

Audio recording

An optional soundtrack for still video pictures might at first appear odd, but it's worth remembering that most still images are destined to be viewed on a TV set rather than as a hardcopy print. Research carried out by still video companies has found that some people find it a strange experience to watch silent still pictures on a TV screen.

The audio facility allows users to add narration, music or sound effects. Since the video tracks are already hard pushed to store luminance, chrominance and data signals, and because of the possibility of cross modulation, the audio tracks are recorded separately. This means that up to 12 frame or 25 field recordings can be accompanied by sound.

To record sound in the equivalent of one disk rotation (i.e. 1/50s for Pal), time-base compression is employed. The recording process is shown in **Fig. 5**. The NR compressor is a 2:1 companding noise reduction system, and for time compression the signal is digitised and stored in a ram. Compression ratio is the difference between the read-out rate and the actual length of the sound period, and there are three ratios available in the Pal system: 1:272, 1:544 and 1:1088. These give around 5s of 10kHz sound, 10s of 5kHz sound and 20s of 2.5kHz sound respectively. After compression, the signal undergoes D/A conversion before being further processed. For playback, the reverse process is carried out.

SVCs offering an audio facility may offer an automatic or manual mode. In the auto mode, the sound is recorded about 0.5s after the shutter is depressed, while in manual, sound can be added several minutes after the shutter has been released. Some still video decks will allow audio dubbing too.

Data track

The VFS specification also includes provision for data-only tracks. **Figure 6** shows the track format. Each sector is composed of 4096 bytes of data and 1699 bytes of error correction. For recording, the bits undergo eight to ten bit modulation to remove DC components. At present, the only data track used is the cue track or data control track, which controls playback order, audio recording, etc, but future cameras may allow users to record a mix of computer programs, sound, video and text on the same disk.

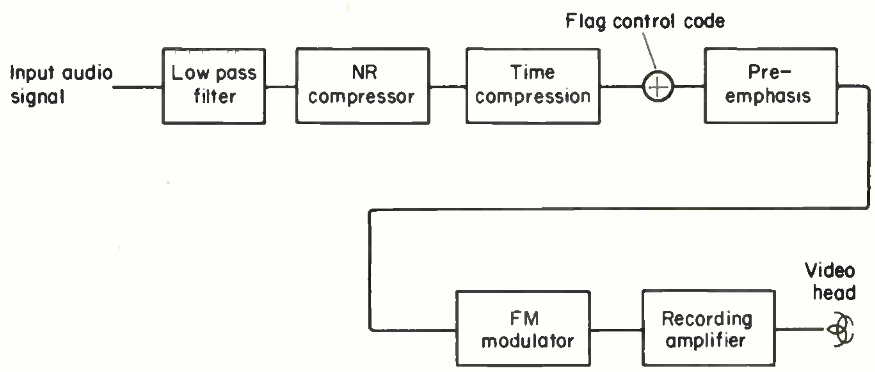

Fig. 5. Audio recording with still video

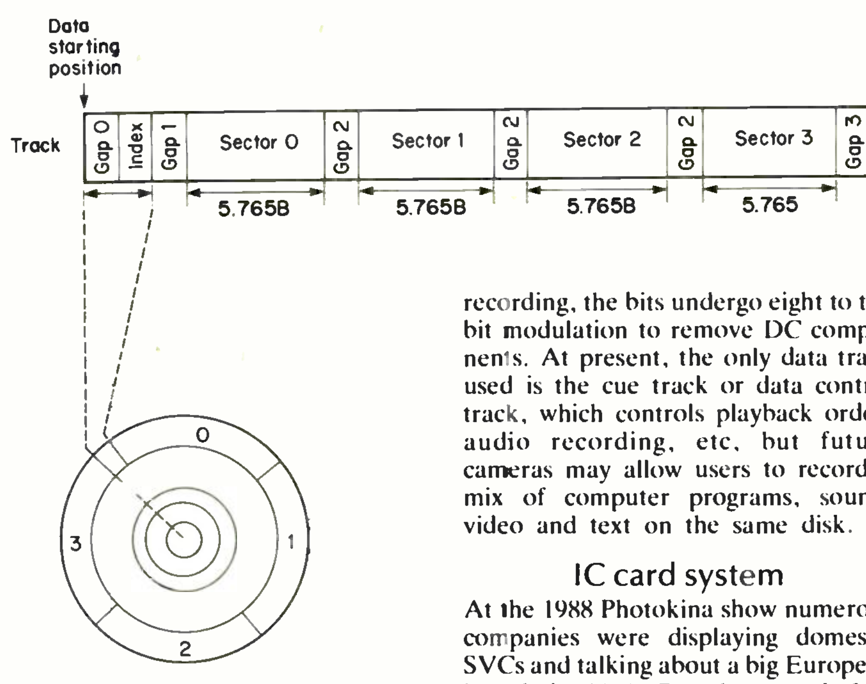

Fig. 6. Track format for data

IC card system

At the 1988 Photokina show numerous companies were displaying domestic SVCs and talking about a big European launch in 1989. But that was before Fuji unveiled a rival digital still video system that may well supersede VFS. The Fuji SVC recorded shots on to a 16Mbit scram card, around the size of a credit card. Toshiba later announced a similar system and the two companies joined forces to form the Fuji-Toshiba IC card system.

The IC system offers a number of advantages over VFS – the cameras have no moving parts, which makes them more reliable; the digital images are not confined to specific TV standards; it allows easier interfacing with computers; picture quality is better; and there is no loss in quality when images are copied or transmitted.

Most industry observers felt that the IC system wouldn't reach the market for several years at least, but just before Christmas 1989 Fuji launched a professional IC card system in Japan. The system comprises a camera, memory card, player and DAT recorder used as a file system for storing over 1000 still images on a two-hour tape. (Incidentally, Sharp and Aiwa have also produced DAT still video storage systems.) The IC camera has a 400 000 pixel CCD and its pictures are claimed to have a horizontal resolution of over 500 lines.

The memory card stores 12 field or six frame images digitally compressed on to an array of 18 individual 1Mbit sram chips (9Mbit cards are also available). Fuji and Toshiba say that improved compression systems should eventually increase the number of stored images to 50.

Main drawback to the IC card system is its cost – the Fuji system costs over £20 000 and each card is over £2000. But its supporters say that as memory prices fall, it will become a viable commercial system. At the very least, the IC system has caused most VFS supporters to postpone European launches and probably persuaded some consumers to hold off buying an SVC. At present, most still video companies are consigning their efforts to the Japanese, American and professional markets.

ION, Canon's Hi-band-only SVC with RF unit, AC coupler and battery charger.

Still video applications

By using a still video transceiver, still images can be sent down telephone lines around the world. This was used to good effect during the unrest in China last year. When the authorities cut off conventional communication lines, some photographers sent their pictures by telephone. And because still images can be put into a computer (Canon's Ion stands for Image On-line Network), supporters claim it's ideal for desktop publishing and organisations that may need to store numerous images, such as advertisers, the police, hospitals and businesses.

RC-470 from Canon, a compact autofocus SVC which can take 20 pictures per second

Outlook

Eighteen months ago, still video was launched with great fanfare in Japan, but sales have been disappointing. This is because there are several drawbacks to the system. First, despite being promoted as a television product, users want hardcopy prints to carry around. What's more, print quality nowhere near matches 35mm film, or even 110 film.

Most video printers use ink-jet or dye-thermal transfer systems which are very expensive. NEC recently launched a "low priced" home video printer costing £1300, but still video needs a network of High Street printing shops. A still video camera just launched in Japan incorporates a black-and-white printer and doubtless we'll see the still video version of the Polaroid camera.

There's no doubt that still video faces an uphill struggle to establish itself on the domestic scene, but then the Japanese companies like nothing better than a good challenge. ■

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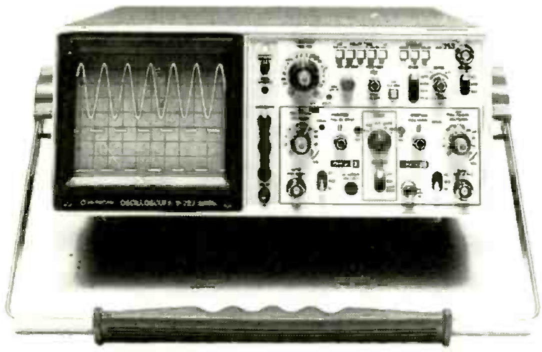

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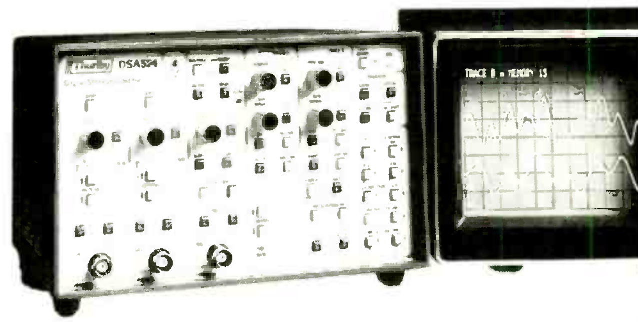

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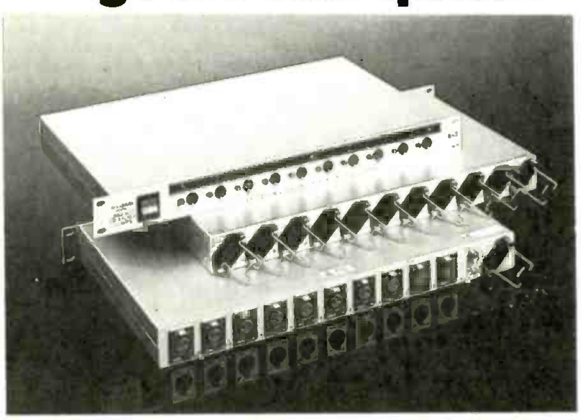

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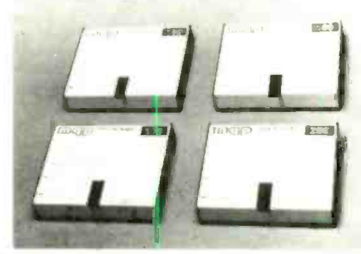

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Reducing crossover distortion

Michael McLoughlin presents the undistorted facts on why the amplified diode has had its day

Several disadvantages dog reduction of crossover distortion in Class B amplifiers where a separate output transistor is used for each direction of current. The classical solution is to use an amplified diode — a potentiometer with its three terminals connected to the three leads of a transistor — as a voltage source hung between the bases of the two output transistors.

As a result, these transistors continue to operate fairly well during crossover. But this arrangement needs initial adjustment, which can go wrong, and the circuit hovers on the brink of thermal runaway. Preventing runaway can involve an over-large heat sink. However before looking at alternative methods of reducing crossover distortion we should consider its measurement.

Measurement methods

Harmonic analysis is not a good method of displaying crossover distortion, because it conceals the causes. Better results are achieved by filtering out the fundamental, or by using the subtraction method.

To use the latter, attenuate the amplifier output until it is reduced to the size of the input signal, and display the difference. For example, in **Fig. 1**, connect R_8 to F, find the voltage difference between A and G, and multiply by 11 — the amplifier gain.

Whatever method is used, the distortion is more easily revealed if the output signal is small. So it seems sensible to take all measurements with an output signal of 1V peak. (1V RMS is a nuisance on the oscilloscope!)

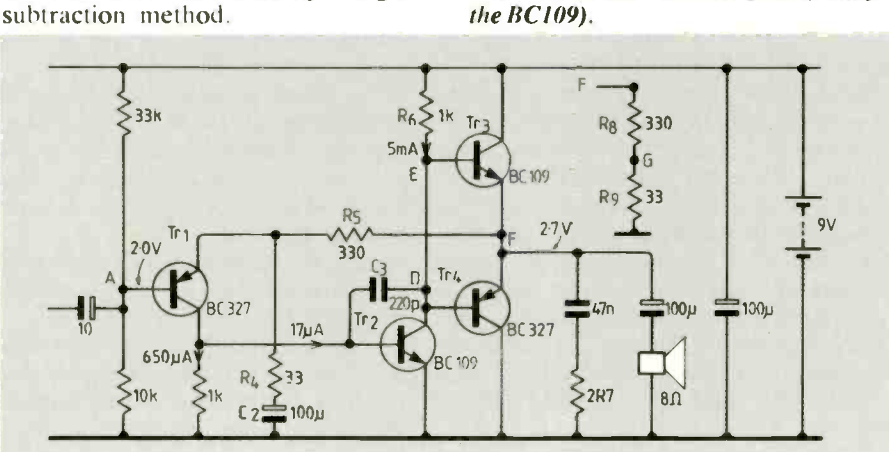


Fig. 1. Basic Class B amplifier without the amplified diode. At switch-on A jumps to 2.0V and F rises rapidly to 2.7V, leaving quiescent currents as marked (assume a median gain of 300 for the BC109).

10kHz seems to be a sensible test frequency, as crossover distortion is worse at higher frequencies. At an alternative of 20kHz many loudspeakers offer an impedance of more than twice their nominal figure, reducing output current and crossover distortion. So the standard signal for measurement should be a sinusoidal output of 1V peak at 10kHz. All oscillograms in this article follow this standard.

Trace A. Unmodified distortion: The output from point F (**Fig. 2** top trace), clearly shows crossover distortion. All further traces rely on the subtraction method as described above and for Fig. 1 this gives trace A. In fact the crossover distortion of trace A appears with some fundamental, due primarily to the imperfect matching of the potentiometer (R_8 and R_9) to the amplifier gain. But the crossover distortion is easy to pick out and draw, because of its shape and its agreement in time with the jumps of the top trace.

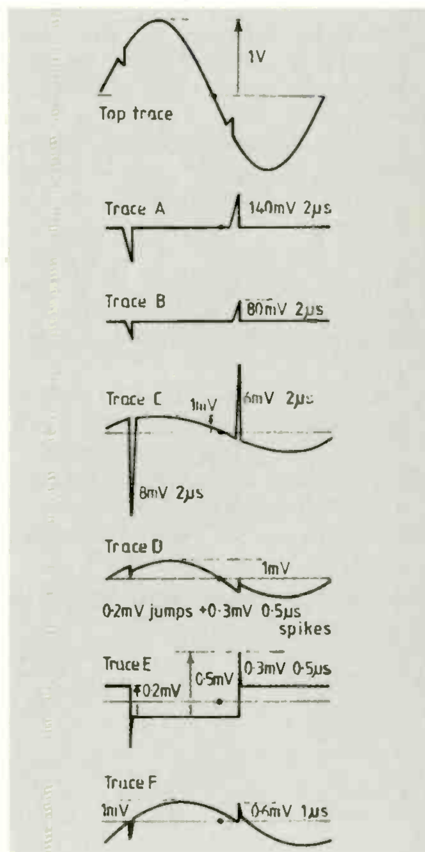


Fig. 2. Crossover distortion. The duration of any spike measured at 10% of its height is marked in µs. The top trace shows output volts. The other traces align in phase.

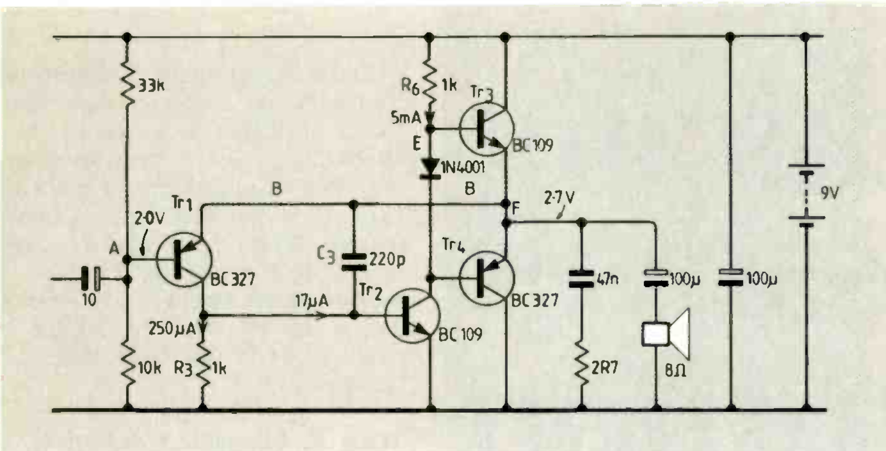


Fig. 3. Class B amplifier with low crossover distortion (trace E). High gain in the feedback loop means leads must be kept short to avoid 4MHz oscillation; lead BB is particularly sensitive. The 47n and 2Ω7 also help with stability. While experimenting display output from F to check for HF oscillation.

Trace B. Single diode: A voltage jump of 1.4V or so is needed at DE to effect crossover. This jump can easily be halved by inserting a silicon diode between D and E, halving the amplitude of the crossover distortion.

Trace C. Negative feedback: The normal way to reduce distortion is to increase feedback. Remove the feedback network R_5-R_4-C_2, and join Tr_1 emitter directly to F. This provides 100% voltage feedback to the input transistor. The voltage gain of the amplifier is lost, but that is easy to make up with an earlier class A stage.

The logic of the subtraction method is now easy to follow. In terms of volts F should follow A about like a slave; any difference is the distortion. So crossover distortion now appears as change in Tr_1 V_{BE}. That can be measured by using a difference amplifier (AC variety) attached at A and F (attach its positive input to the left of F). Result is a ten-fold fall in crossover distortion.

On trace C the crossover distortion appears as two spikes. These derive from capacitor C_3 in Fig. 1, there to reduce HF gain, preventing the HF oscillation that would otherwise occur. At high frequencies the transistor delays translate into large phase lags, turning negative into positive feedback.

With C_3 in position Tr_2 base acts like a virtual earth at HF, so Tr_2 voltage gain falls at 6dB per octave.

But C_3 also prevents points DE from rising rapidly in voltage. Rapid rise at DE pumps current down through C_3 into Tr_2 base, inhibiting rapid rise at DE. So Tr_2 collector is slew-rate limited by C_3. That will delay crossover, causing distortion as follows.

Trace D. Reconnecting the 6dB capacitor: Suppose a sinusoidal voltage is applied at A, and it has risen to 0V. Now DE should jump upwards instantly by 0.7V, but because of C_3 the points DE take time to effect that jump. While the jump is taking place F stays at 0V, but the signal at A continues to slew upwards, causing a growing error between the volts at A and those at F. When the jump at DE is finally completed, the crippling current flowing down through C_3 suddenly stops. The circuit reverts to type, with F slavishly jumping to the new voltage at A.

To summarise: a ramping voltage difference opened up between A and F, and then was suddenly chopped. That difference is the crossover distortion and explains each spike: a ramp which is suddenly chopped.

On trace C the chopping is slower than the ramp.

Once the cause has been traced, the spike can be tackled. Disconnect the upper end of C_3 from D, and connect it instead to F. Normally F follows D about, so C_3 upper plate is effectively connected as before. But during the crossover jump, F is stationary. The upper plate of C_3 no longer follows the rapid voltage change at Tr_2 collector and no disturbing current is now pumped down through C_3 which has been disconnected from the action.

But feedback is also disconnected during the DE jump, so C_3 is not needed to cut HF gain.

Reconnecting C_3 in this way yields a further thirty-fold reduction in spike amplitude.

Trace E. Revised amplifier with the changes so far proposed yields the amplifier in **Fig. 3**. Trace D shows the behaviour of Tr_1 V_{BE} during the cycle. The sinusoid visible is merely the V_{BE} needed at Tr_1 to drive the amplifier through its signal cycle (see below).

So the crossover distortion for the modified amplifier can easily be separated out, trace E. At this low level a new type of distortion appears; a square wave exactly out of phase with the signal cycle. Remembering that the influence of a spike is proportional to its length, then the spikes can now be ignored. The square wave is the residual crossover distortion.

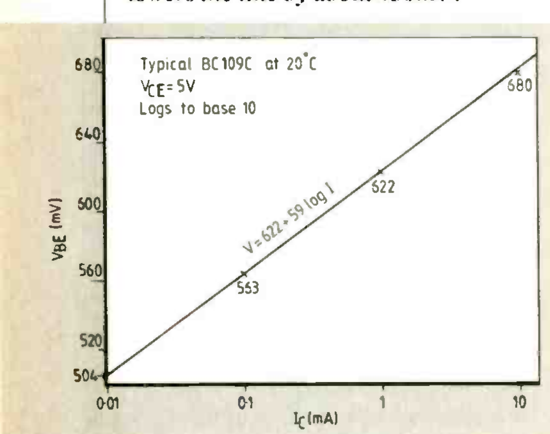
To tackle the square wave, its cause must first be identified. It comes from transistor V_{BE}, as shown in **Fig. 4.** From the formula in Fig. 4 one may readily deduce in sequence three results. Firstly, to multiply collector current by a factor F, the $\triangle V$ needed on the base is 60 $\log_{10}$ F (60 is usually written for 59, $\triangle V$ is in mV).

For small increases of collector current (F near 1) it then follows that $\triangle V$ may be calculated instead by assuming constant V_{BE} and a resistor R=25/I in series with the emitter. I is emitter current in mA.

Finally deduce that 1mV extra on the base increases I_C by 4%, a rule that may be used up to about 5mV.

The variations listed in Fig. 4 do not alter the slope of the line, and therefore have no effect on these formulae, which are quite accurate, of the 2% variety.

Fig. 4. Base volts required for collector current, with a typical BC109C. The line keeps the same slope, but may rise or lower by up to 10mV with a different BC109C, a different type of silicon transistor, or a 5°C change. Germanium lowers the line by about 450mV.



To study crossover refer to Fig. 3. Under quiescent conditions Tr_3 is on (to supply Tr_1) so E is at 3.4V. For crossover E must drop 0.7V to 2.7V, so current in R_6 increases from 5.6mA to 6.3mA which is a 12.5% increase requiring 3.1mV extra on Tr_2 base. Tr_1 must provide an extra 3.1μA to drive up by 3.1mV the PD across R_3, and of course Tr_2 base will take an extra 2.3μA (0.7mA/300). Tr_1 must provide an extra 5.4μA in all, 0.8% of its present current, requiring 0.2mV step on its base.

That step of the input signal brings about crossover, and has no effect on the output. So the step is lost, duly appearing as distortion in trace E.

It is not much harder to show that a total swing of 2mV is needed at Tr_1 base to drive the amplifier through the signal cycle, traces C, D and F. But note that the battery fell to 7V under the load. When +1V (the upper peak) is applied to the speaker, E has risen to 4.4V, so 2.6mA flows in R_6. 1mA of this is needed by Tr_3 base so Tr_2 passes just 1.6mA.

Next work out Tr_2 I_C max; then use the F formula . . .

Trace F. Current source: Point E in Fig. 3 needs to drop 0.7V for crossover, and 0.7mA extra from Tr_2 will produce that drop in R_6.

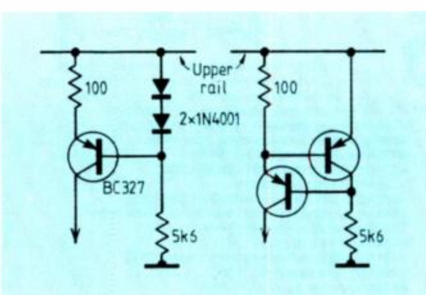


Fig. 5. Current source to replace R_6 in Fig. 3. The left circuit was used, but right circuit is better when there is significant dissipation.

But suppose R_6 is replaced by the 5mA current source shown in **Fig. 5.** Then when Tr_2 I_C rises quite slowly from just below 5mA to just above 5mA, point E must instantly drop through 0.7V. The difference between I_C and 5mA is base current for the transistors, and it must now change from one base to the other, requiring that 0.7V instant jump at E. Tr_2 enforces this rapid jump by extracting charge from point E.

Previously 0.7mA change in Tr_2 current was required for crossover. Now hardly any change in Tr_2 current is required, so hardly any voltage will be required at Tr_1 base either, and the square wave of trace E will disappear.

Trace F is the crossover distortion when the current source of Fig. 5 is inserted (C_3 may need to go to 330pF). In the figure no jump is apparent but on the oscilloscope a jump of about 0.01mV can just be seen — a twenty-fold reduction on trace D. Two small short spikes are left; the first of these shows there is a short time when the circuit stops lifting the output voltage.

A well known type of current source is the bootstrap, joining BB of Fig. 3 by a capacitor to the mid point of R_6. But here that is worse than useless because during crossover BB voltage is not moving. Tying the centre tap of R_6 to BB would actually impede the voltage change taking place at that centre tap. In this type of circuit any current source should be active.

Aural evaluation

Crossover distortion can most easily be heard if the signal is a low frequency sinusoid, say 200Hz, especially if the distortion can be removed at will by switching in an amplified diode. But the real issue is whether it can be heard on programme material of speech and music.

Listening quite carefully to 1V peak speech/music with the circuit of Fig. 1, reveals a quiet irregular hiss, which stops when the signal falls silent.

The hiss is more audible when a solitary male is singing — a low frequency signal can produce more harmonics within the audio band — but is less evident when he is talking. The jumps are at no fixed frequency. With Fig. 3 no crossover distortion at all could be heard.

When Fig. 3 is supplied with programme material, the 0.2mV steps of trace E are still visible via the difference amplifier, bobbing about in an irregular fashion. But can they be heard?

Listening to them in isolation, at a constant repetition rate, at a frequency to which the ear is sensitive (such as 1kHz, with the speaker connected via 100k to a signal generator delivering 2V p-p square wave at this frequency, in a quiet room, then the answer is yes — if one's ear is within one foot of the speaker.

But this test is ridiculously severe. The frequency has been held constant, the genuine signal which always accompanies crossover distortion has been removed, and the ear is unnaturally close to the speaker.

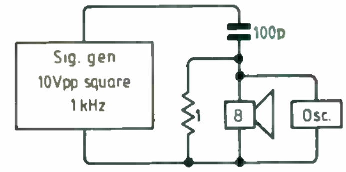


Fig. 6. Audibility test when the 5mA current source replaces R_6. Components chosen by experiment to show just the spikes from trace F of Fig. 2.

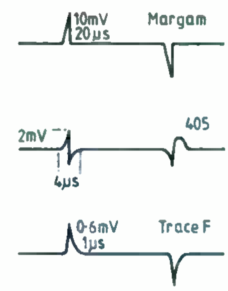


Fig. 7. Crossover distortion. Margam used an output of 6V peak at 2kHz, and Quad 405 output was 1V RMS at 13.2kHz. At crossover these signals have respectively 1.2 and 1.9 times the slew rate of the standard 1V peak 10kHz signal. The above graphs could without criticism be allowed to exceed trace F by those factors.

So for most purposes Fig. 3 might be sufficient. It already includes two improvements in the 100% voltage feedback and reconnected C_3.

If R_6 is replaced by a current source, crossover distortion reduces to two short pulses, (trace F). Pulses of that shape were simulated by the circuit of **Fig. 6.** In a quiet room nothing could be heard, unless a 2in diameter speaker was used, and pressed hard against the ear. Even then the sound was on the lower limit of audibility. No-one would hear such sounds at a normal distance from a speaker, and against the background of genuine programme material.

John Vanderkooy and Stanley Lipshitz displayed the crossover distortion of the Quad 405 current dumping amplifier, by using the filter method[1]. More recently, Eric Margam of Ljubljana has displayed the crossover distortion of a typical class B amplifier, using the subtraction method[2]. Their results are shown in **Fig. 7.** Taking height and duration into account the Quad 405 spikes do 28 times the damage of trace F, and Margam's spikes are 167 times worse. Squaring the amplitudes to compare power would give much more spectacular figures.

R_4 is a menace

Imagine a diode dropped into Fig. 1 between D and E. During crossover F is stationary, and 0.2mV change at A is required to produce the crossover jump at DE. The calculation to that effect appears at first sight unaffected by the presence of R_5-R_4-C_1. In fact Tr_1 acts like a transistor of constant V_{BE} with a resistor of 38Ω in series with its emitter. But R_4 is in series with that 38Ω, and almost doubles the 0.2mV change required to effect the crossover jump. Figure 3 eliminates R_4.

Passage to Fig. 3 meant 100% feedback of the output voltage. Feedback could instead be increased by adding a transistor in the Tr_1-Tr_2 area to increase loop gain. That is difficult, and adds components instead of subtracting them. A third disadvantage is that R_4 would be left in position.

It is now possible to say that during crossover the input impedance found at A in Fig. 3 is low, perhaps 11k (300×38Ω). If further loss of signal at crossover (above 0.2mV) is to be avoided, the output impedance of the preceding class A amplifier should be under 1k.

Summary

The crossover distortion found in Fig. 1 was improved by dropping in a diode, using 100% voltage feedback, reconnecting the 6dB capacitor, and feeding the gain stage from an active current source. The middle two suggestions might seem original. But recent IC power amplifiers do seem to reconnect the 6dB capacitor. They offer to the user just one compensation terminal, with instructions to connect it via a suitable capacitor to the output terminal. That is just what Fig. 3 would require, whereas Fig. 1 requires two points to be brought out for compensation.

In any event, it might appear that the amplified diode has had its day. Without its aid the tolerably quiet distortion audible as trace A has been reduced about 53dB to the level of trace F by a series of changes that requires just one more component. Similar improvements could be expected in expanded versions of Fig. 1. ■

References

1. Vanderkooy, J., and Lipshitz, S.P., *Wireless World*, July 1978, pp. 83-85: see Figures 4c, 5a, 6a.
2. Margam, E. *Electronics and Wireless World*, July 1987, pp. 739-742.

Audio filter eliminates 5kHz whistle on HF

This filter completely eliminates the 5kHz adjacent-channel whistle on short waves.

Reducing the audio or RF bandwidth will have the desired effect, but produces frequency distortion; synchronous detectors can help when there is an interfering channel on one side of the carrier only.

The filter has three sections: low-pass, high-pass and twin-tee notch. The low-pass section is a Sallen and Key filter with deliberately poor damping, so that it boosts the gain at about 3kHz, where the twin-tee would otherwise impose too much attenuation. Overall response is flat to within 6dB from about 200Hz to 3kHz. On the graph, 0dB represents the gain at 500Hz; actual system gain is 3.

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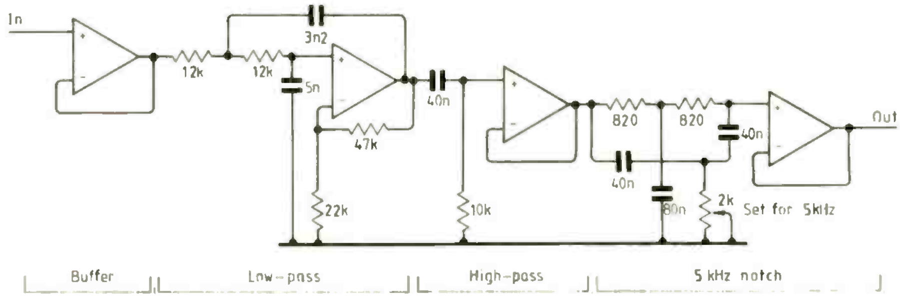
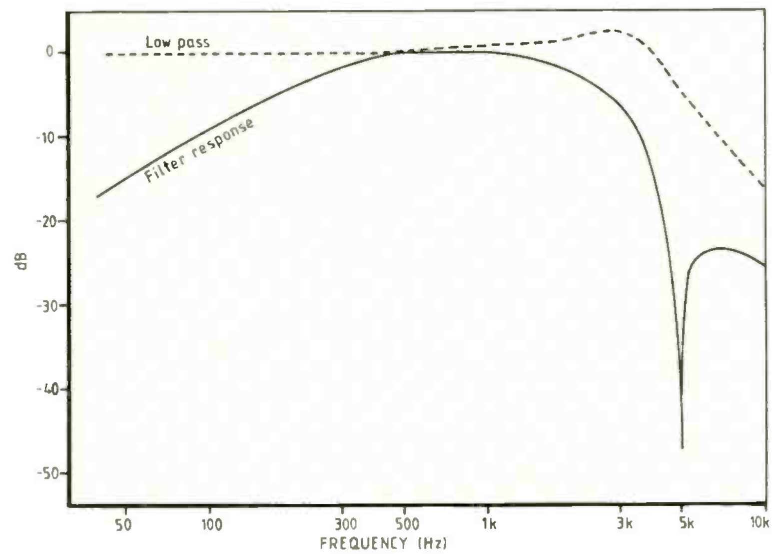
Athens
Georgia
USA





Controllable triangle/square generator

This arrangement affords electronic control of the well known triangular-wave generator in which a capacitor is alternately charged and discharged at constant current

Figure 1 shows the proposed circuit, in which an operational transconductance amplifier (OTA) varies the current into A_1. For an ideal OTA, frequency of oscillation is given by $f_o=g_m(R_2/4R_1C)$, where $g_m=I_B/2V_T$, I_B being the bias current of the OTA and V_T the voltage equivalent of temperature (~25mV at 300K). Substituting, $f_o=I_BR_2/(8V_TR_1C)$.

The macromodel of the OTA's bias current input port shown in **Fig. 2** indicates that $I_B=(V_B+V-V_D)/R_B$, where V_B is the control voltage, so that the frequency of the triangular wave at X and of the square wave obtained at Y are linearly proportional to both control current I_B and control voltage V_B. **Figure 3** shows results obtained using the CA3080 OTA and 741s.

Muhammad Taher Abuelma'atti
Fatheya Abdullah Hassan
University of Bahrain

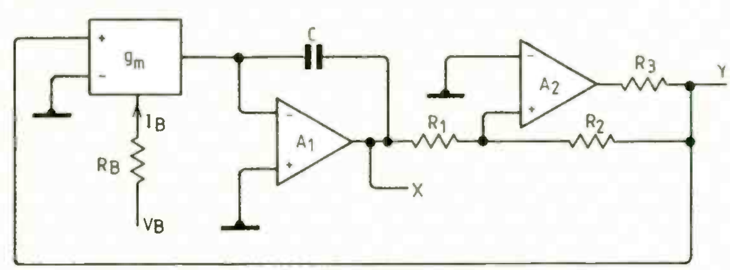


Fig. 1

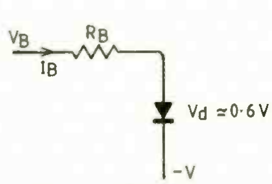
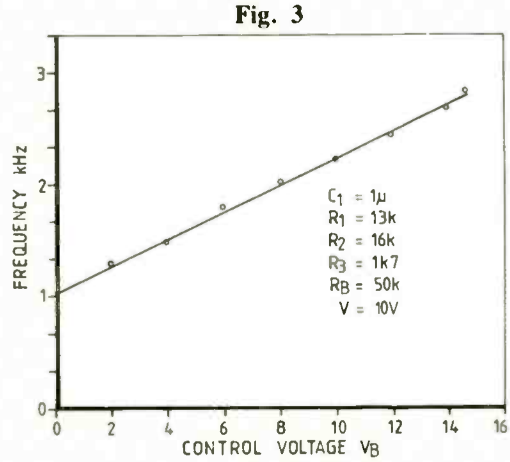


Fig. 2

Fig. 3



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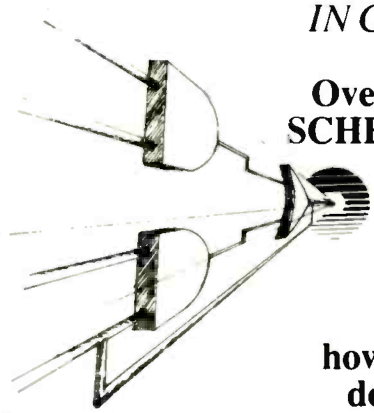

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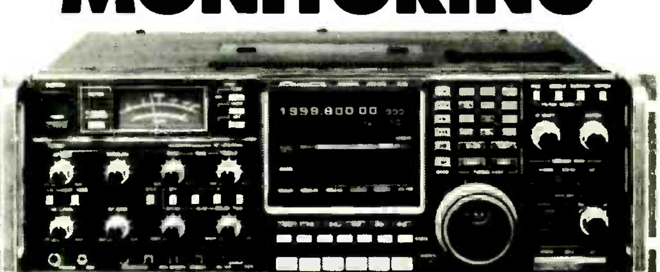

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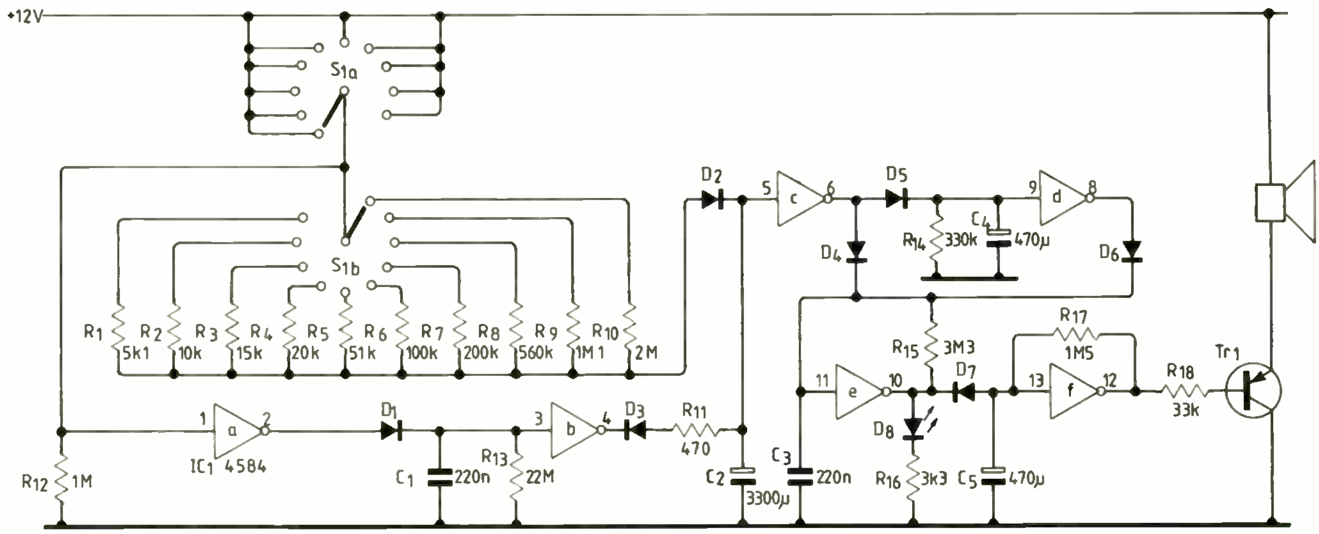
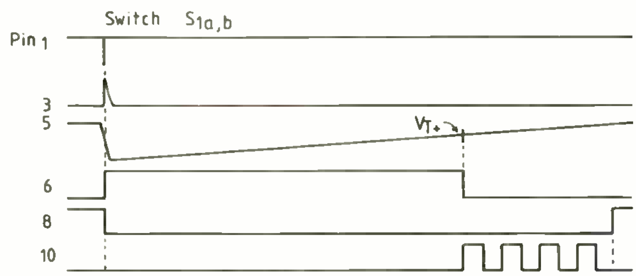


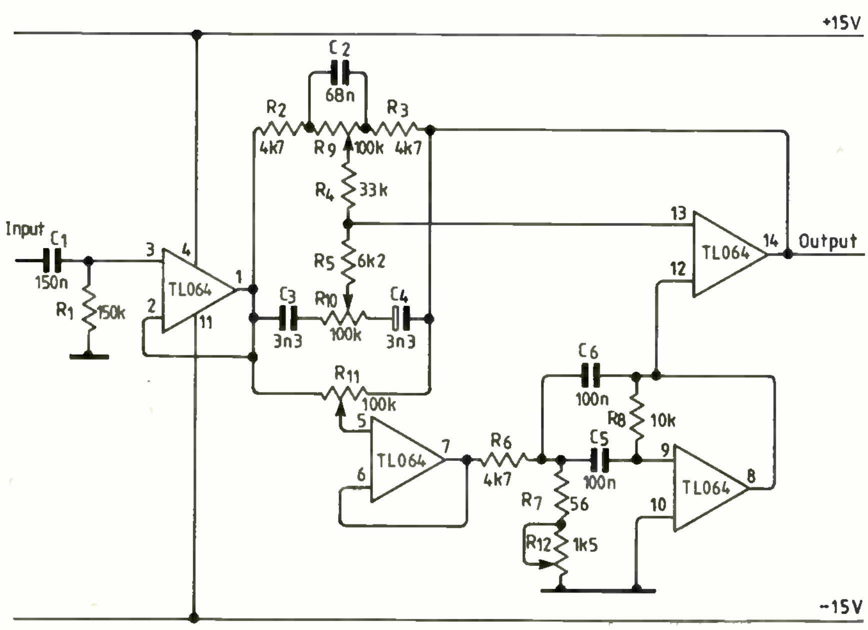


Mid-frequency tone control

Adding a mid-frequency section to an active Baxandall tone control is normally difficult, and the interleaving of poles and zeros does not allow a passive network, particularly one that is adjustable in frequency. Nesting of stages increases noise (and expense).

This circuit provides ±10dB adjustment in the range 450Hz – 2kHz, at a constant -3dB bandwidth of 350Hz. Since P_4 is grounded, digital control of the mid range is possible.

Tony M. Manov
Sofia, Bulgaria



Single-chip alarm

One c-mos Schmitt IC, the CD4584, generates a "beep" delayed by times switchable from 15 seconds to 120 minutes. Alarm audio frequency, period, duration and delay are all changeable.

Resistors R_1-R_{10}, C_2 and IC_c provide the time delay. The capacitor charges through D_2 and the selected resistor but, since R_{12} is large, IC_a input is high and therefore IC_b output also high, so D_3 is reverse biassed. During this time, IC_c output is high, this level setting IC_e output low via D_4 and, via D_5, IC_d output low. The output of IC_f is low, cutting off Tr_1.

As C_2 charges past IC_c trigger point, IC_c output goes low and IC_e, R_{15} and C_3 oscillate with a period of 1s, since D_4 and D_5 are reverse-biassed. When IC_e output is low, Led_1 is off and IC_f input is clamped at zero volts. When IC_e output goes high, Led_1 lights and D_6 is reversed, so that IC_f, R_{17} and C_5 oscillate at 1kHz.

As IC_c output goes low, C_4 discharges through R_{14} and, when the input voltage of IC_d reaches its lower trigger point, IC_d output stops oscillation in IC_e and IC_f.

When break-before-make switch SW_a is moved, the short open-circuit condition is expanded in time by D_1, C_1, R_{13} and IC_b to 5s to discharge C_2.

Yongping Xia
West Virginia University
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USA

Peak/trough detector for noisy signals

This circuit detects the highest and lowest points of a periodic waveform. It copes with noisy signals of varying amplitude and period, and DC offsets, and was originally designed to process biomedical signals from a respiratory sensor.

Amplifiers $IC_{1a,2a}$ in **Fig. 1** form resettable peak and trough detectors, $IC_{1b,2b}$ buffering the output. Hysteresis voltages set by the resistor chain are subtracted $IC_{1c,2c}$, outputs from which are $-(V_p-V_{h+})$ and $-(V_t+V_{h-})$ respectively. The output of comparator IC_{1d} goes positive when $V_{in}<(V_p-V_{h+})$, that of IC_{2d} going positive when $V_{in}>(V_t+V_{h-})$, and the spike produced by this rising edge resets the opposite peak detector.

Figure 2 shows circuit action on a noisy signal. A peak or trough is accepted as such when the input changes from its highest or lowest value by more than the hysteresis voltage, thereby conferring noise immunity. Reset pulses occur when V_p or V_t are stable and can be used to clock subsequent circuitry.

S. Young
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Suffolk

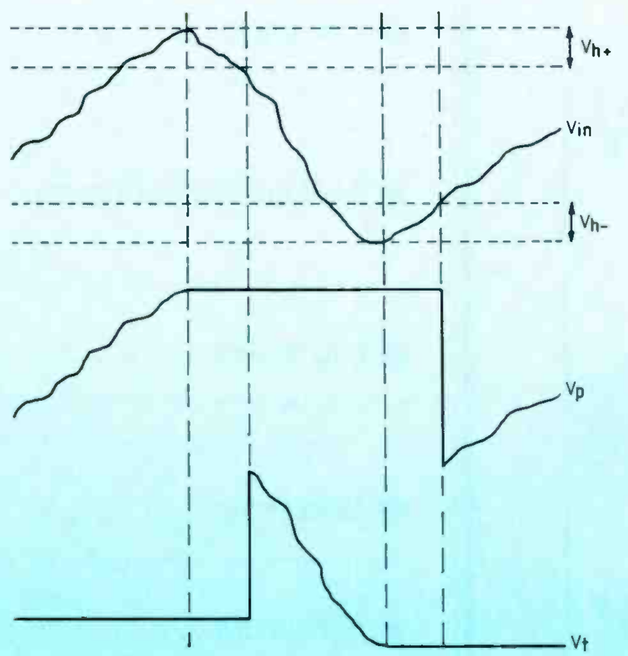
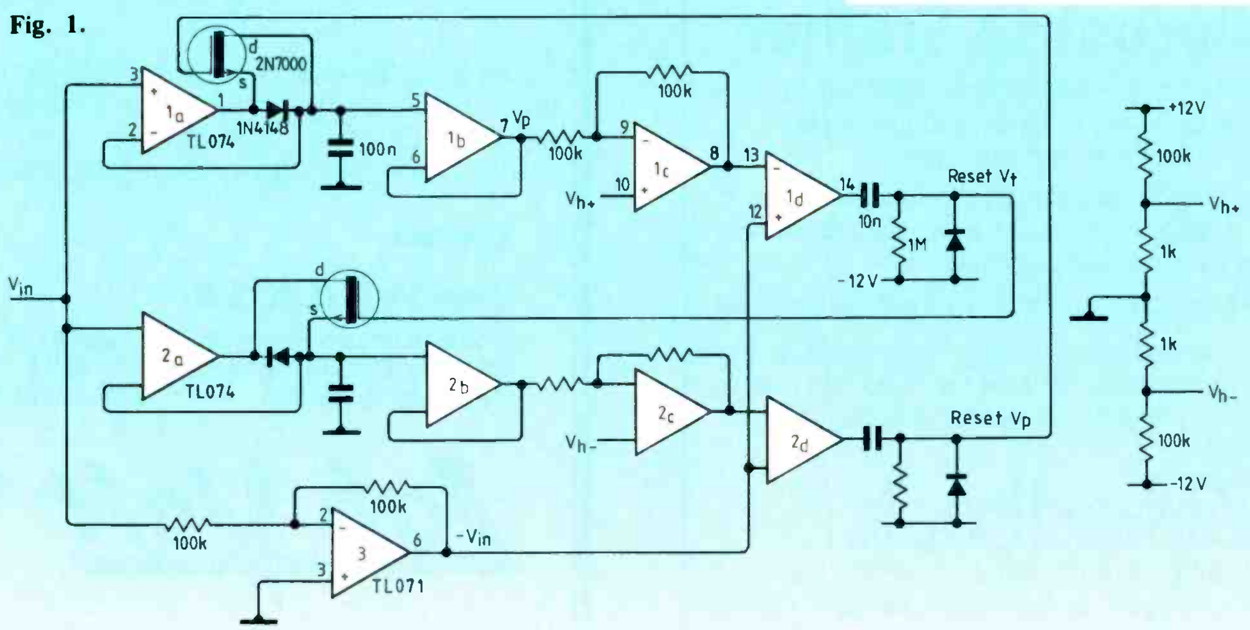


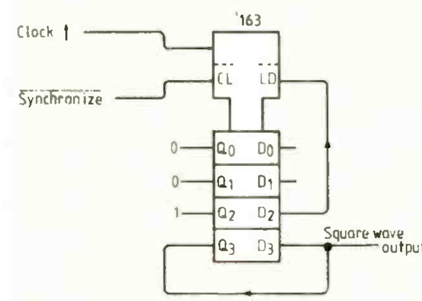
Fig. 2.

Fig. 1.



Symmetrical TTL decade counter

This counter divides the clock frequency by ten, producing a symmetrical output. It is synchronous and may be synchronised using CL, since the normal sequence includes zero.



The configuration can be generalised to allow other moduli. Bit n drives LD which necessarily loads to 1; that and the bits below it form a prescaler, the modulus of which can be varied from 2 to $2^{n-1}+1$. Higher bits are unchanged by the load operation, forming a binary counter.

Rob Kirkby
Woodbridge
Suffolk

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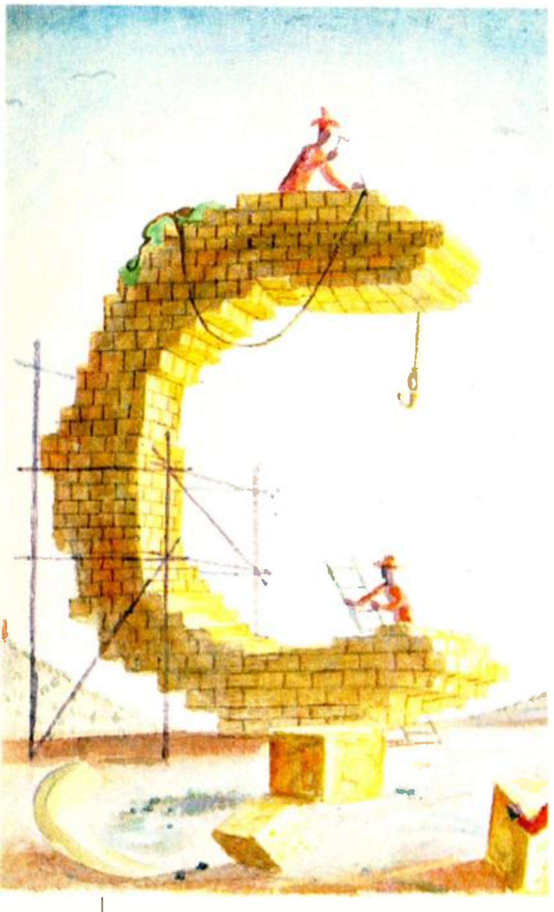
CIRCLE NO. 105 ON REPLY CARD



INTERFACING WITH C

PART 6

After an initial look at digital filtering last month, Howard Hutchings continues with a description of the design process for several types of filter

Interfacing with C

An accompanying set of 49 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 L301, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Credit card orders can be phoned through on 081-661 3614 (mornings only).

To implement the signal-processing characteristics of the analogue first-order, low-pass filter described in Fig. 5.8, re-examine the form of the impulse response h(n). This was simply the sequence 0.5, 0.25, 0.125, 0.0625, truncated after the fourth term for ease of calculation. We propose to use the mathematical models introduced in Part 3 to describe this behaviour more completely. The time-domain model of the impulse response of the filter is

$$h(t)=0.5\delta(t)+0.25\delta(t-T)+0.125\delta(t-2T)+0.0625\delta(t-3T)+\ \ldots$$

To establish the complex frequency-domain model, we must take the Laplace transform of the impulse response:

$$H(s)=0.5+0.25e^{-sT}+0.125e^{-2sT}+0.0625e^{-3sT}+\ \ldots$$

Finally, using the z-transform to model the delayed weighted samples, we can write

$$H(z)=0.5z^{0}+0.25z^{-1}+0.125z^{-2}+0.0625z^{-3}+\ \ldots$$

Recognising that this is an infinite geometric series, we may express H(z) in closed form:

$$H(z)=0.5/(1-0.5z^{-1}).$$

This is simply the transfer function Y(z)/X(z) of the filter in the z-domain.

The relationship between the processed output Y(z) and the input sample X(z) is given by

$$Y(z) = X(z)\ H(z)$$
$$Y(z) = 0.5X(z)/(1-0.5z^{-1}).$$

Cross-multiplying gives the result:

$$Y(z)(1-0.5z^{-1})=0.5X(z).$$

So the recurrence relationship describing the behaviour of the filter is

$$y(n)=0.5x(n)+0.5y(n-1),$$

where x(n) is the current input, y(n) the current output and y(n−1) the previous output. **Figure 5.13** shows the processing operations.

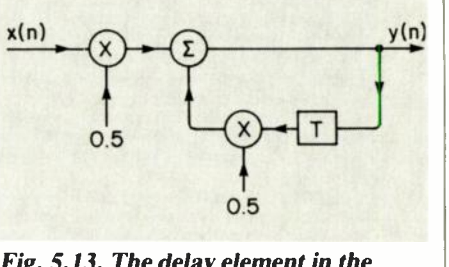


Fig. 5.13. The delay element in the feedback loop retains the weighted processed output y(n) for one sampling interval. It then releases it to the summation element, where it is added to the current weighted input. To produce the processed output y(n)=0.5x(n)+0.5y(n−1)

Recursive software

A computer performs calculations such as these with ease. Realising the filter recursively has the advantage that only a finite number of iterations are necessary to process the signal completely, despite the filter or system being characterised by an infinite impulse response.

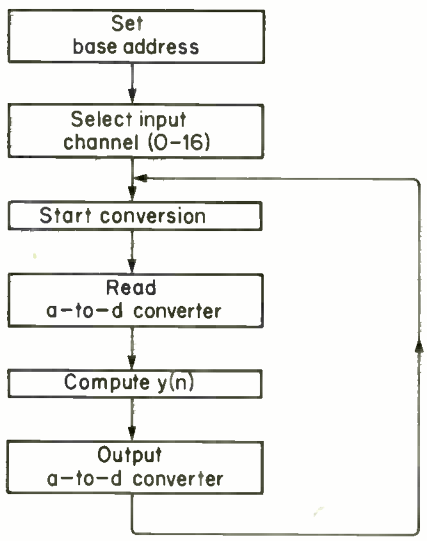


Fig. 5.14. Flow-chart for recursive realisation of low-pass digital filter.

Listing 5.2. Low-pass digital filter.

```
/ ***********************************
*        LOW-PASS DIGITAL FILTER        *
*        y(n) = 0.5x(n) + 0.5y(n-1)     *
*********************************** /
#include<stdio.h>
#include<conio.h>
#define BASE 768
maih()
{
unsigned int contents,output,old_output;
outp(BASE,1);
/* ---------------------------------------
SELECT I/P CHANNEL
--------------------------------------- */
start:outp(BASE + 2,0);
/* ---------------------------------------
START CONVERSION
--------------------------------------- */
contents = inp(BASE + 2);
/* ---------------------------------------
READ I/P PORT
--------------------------------------- */
contents = 0.5 * contents;
output = contents + old_output;
outp(BASE + 4,output);
old_output = 0.5 * output;
/* ---------------------------------------
RECURRENCE RELATIONSHIP
y(n) = 0.5 * x(n) + 0.5 * y(n-1)
--------------------------------------- */
goto start;
}
```

Using Listing 5.2 in conjunction with the signal-processing system shown in Fig. 5.1 produces a real-time low-pass digital filter, which samples every 160μs. **Figure 5.15** shows the effect of processing a square wave of frequency 250Hz.

Comparing the processed output y(n) obtained by recurrence with that obtained by using convolution indicates a certain lack of correlation after the fourth term, these relatively small numerical inconsistencies being due, in this case, to the truncated impulse response. However, this theoretical example serves as a useful illustration, identifying a few of the practical hazards inherent in finite word arithmetic.

When the signal and multiplier coefficients are represented in terms of binary digits, any numerical processing is likely to be subject to error. A principal source of inaccuracy is the integer output of the A-to-D converter, which may be in error by as much as ±0.2% of full-scale for an 8-bit converter. Clearly, 12-bit and 16-bit devices will improve any quantisation error, possibly at the expense of conversion time.

Potentially more hazardous is the inaccurate specification of the coefficients of recursive filters, where rounding errors may result in the system poles moving outside the unit circle, resulting in instability and a badly behaved system. An acceptable approach is to specify multiplier coefficients to four or five decimal figures. Exceeding the dynamic range of the system will result in non-linear processing, a confused output and a collapse of the digital filter.

Poles and zeros

When the current output depends on past output samples in addition to current and past input samples, the filter is termed recursive. A digital filter may be realised in recursive form whenever the transfer function has poles at locations other than the origin of the z-plane. As we have seen, such a filter is characterised by an impulse response that contains an infinite number of terms. The recurrence relationship

$$y(n)=Ax(n)+By(n-1)$$

provides a useful recursive method of implementing a simple low-pass filter. To gain greater insight into the behaviour of the system it is necessary to augment our mathematical toolkit

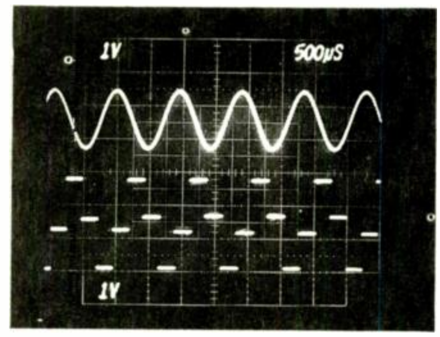


Fig. 5.15. Oscilloscope display of square-wave input to A-to-D at 250Hz and output from D-to-A. Sampling interval 160μs.

and exploit the concept of poles and zeros already hinted at under the guise of transforms.

Z-domain model. The characteristics of a linear digital system may be described in terms of the transfer function H(z). It is a general property of such systems that there are certain values of the complex variable z which make H(z) tend to infinity, and values of z that make H(z) zero. These values are known respectively as the poles and zeros.

Poles and zeros represent critical frequencies where something dramatic happens to the transfer function; as a result of poles and zeros, the function changes as z varies. Unfortunately, I cannot justify this statement without reference to a bookcase of relatively advanced mathematical text books, which is not my intention. However, if you are prepared to accept this in good faith, then what follows will provide a reasonable insight into the frequency response of digital filters.

No real system can have more zeros than poles. To ensure that the system remains stable, the designer must ensure that the poles are located on, or preferably inside, the unit circle. Clearly, the locations of the poles and zeros dictate the behaviour of the system. In an attempt to dispel this fog of mathematical abstraction, consider what we already know. To model time advances or delays it is expedient to use the operator z. Applying the operator to the advertised recurrence relationship, we may write

$$Y(z)=AX(z)+Bz^{-1}Y(z).$$

So the transfer function H(z) can be expressed as

$$H(z)=Y(z)/X(z)=Az/(z-B).$$

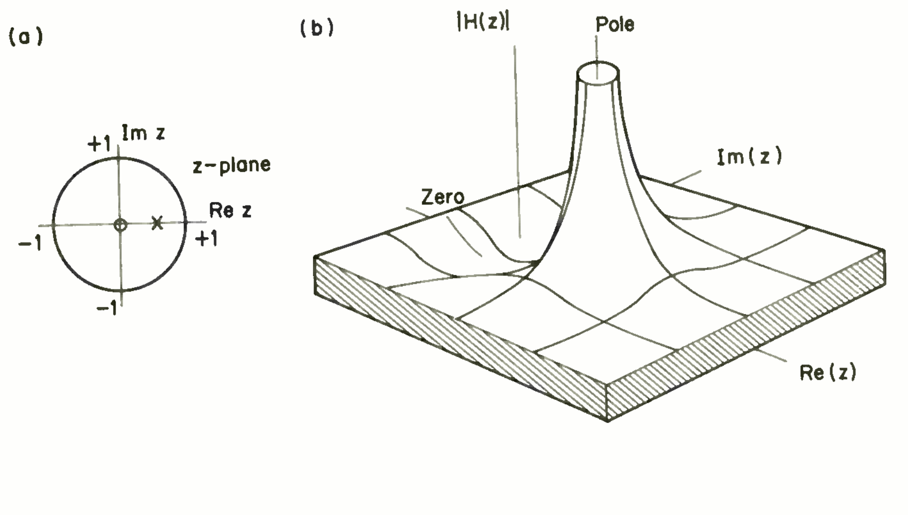


Fig. 5.16. Transfer function $H(z)=Az/(z-B)$ on z-plane (a) and on "rubbersheet" model (b).

By inspection, the system has a single pole at z=B, together with a zero at the origin. Some perception of these rather evocative terms may be gained by plotting the magnitude of H(z), so that it describes a surface. We do not propose to plot all the values, but rather to focus our attention on the value of z which makes H(z) infinite — the pole. Visualise a rubber sheet stretched over the z-plane; when z=B the surface goes shooting off to infinity (imagine a vaulting-pole placed on the plane at this point; the zero located at the origin serves to glue the surface down). An easy-to-understand geometrical illustration is given in **Fig. 5.16**.

Frequency response and operator z. Previous use of the operator z to model time advances or delays placed no restriction on the shape of the time-shifted waveform. The complex variable $s=\alpha+j\omega$ in the expression $z=e^{sT}$ took care of this. In this particular application we are primarily interested in how a digital filter will process sinewaves; we may relax our original definition of s and discard the exponent ′. This means that z may be viewed as a phasor defined by $z=e^{sT}$. The transfer function $H(j\omega)$ represents a complex number and provides a mathematical model of the sinusoidal behaviour of the system.

Viewed as a sinusoidal signal processor the transfer function of the filter may be written as

$$H(j\omega)=(Ae^{j\omega T})1/3(e^{j\omega T}-B),$$

or equivalently, using Euler's rule to express in real and imaginary parts:

$$H(j\omega)=A[\cos(\omega T)+j\sin(\omega T)]/\cos(\omega T)-B+j\sin(\omega T).$$

Describing $H(j\omega)$ as a complex number is simply a succinct method of describing the amplitude and phase characteristics in a single expression. To extract the magnitude of the frequency response we multiply $H(j\omega)$ by $H^*(j\omega)$, its complex conjugate, before taking the square root of the product. For this particular example, the magnitude of the frequency response is given by the expression

$$|H(j\omega)|=A/[\cos(\omega T)-B)^2+\sin^2(\omega T)]^{0.5}$$

The phase response of the filter — or to be precise the argument of $H(j\omega)$, conveniently written as $\mathrm{Arg}[H(j\omega)]$ — is simply the angle of the numerator minus the angle of the denominator.

To use these formulae effectively, pay particular attention to the geometrical meaning of the complex number $z=e^{j\omega T}=\cos\omega T+j\sin\omega T$. Notice that the magnitude is always unity, and the angle ωT depends upon ω (T is simply the reciprocal of the sampling frequency $1/f_s$). So the locus of z will be a unit circle, centred at the origin of the z-plane. Since the highest frequency we can successfully process without aliasing is half the sampling frequency, the range of interest is usually $0<\omega<\pi/T$, which corresponds to a semicircle. **Figure 5.17** shows the magnitude and phase response of the low-pass filter described by the recurrence relationship

$$y(n)=0.5x(n)+0.5y(n-1)$$

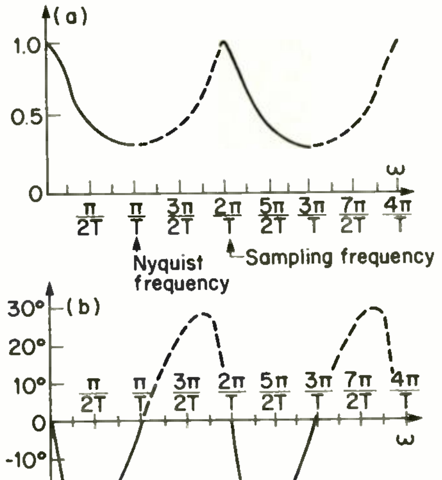


Fig. 5.17. Spectrun of digital filter is repeated version of low-pass response from $\omega=0$ to $2\pi/T$. Aliasing occurs beyond Nyquist frequency.

This example demonstrates how to design a digital filter using z-plane poles and zeros. The performance of the filter may then be determined geometrically, without recourse to analysis using complex numbers. The simplicity of this method makes it particularly attractive, and with practice quickly sketching the amplitude response from the pole-zero pattern becomes routine.

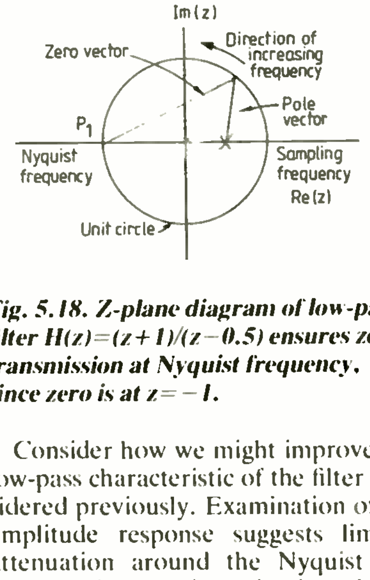
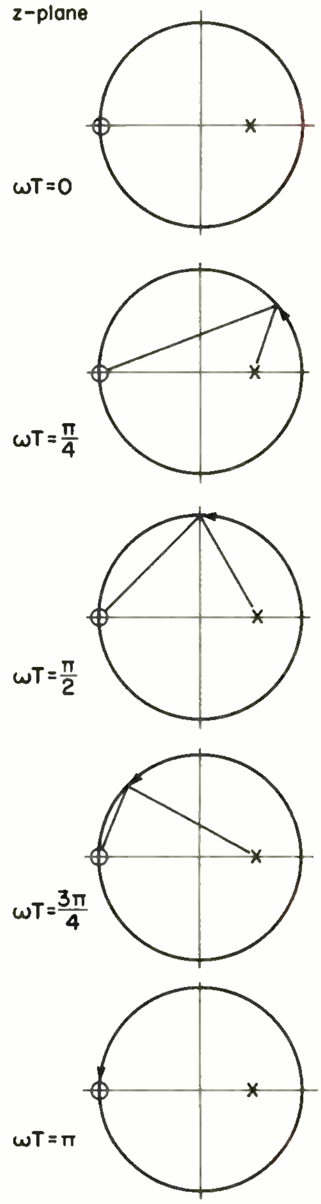


Fig. 5.18. Z-plane diagram of low-pass filter $H(z)=(z+1)/(z-0.5)$ ensures zero transmission at Nyquist frequency, since zero is at $z=-1$.

Consider how we might improve the low-pass characteristic of the filter considered previously. Examination of the amplitude response suggests limited attenuation around the Nyquist frequency. Since our intention is to design a low-pass filter, and the Nyquist frequency is the highest frequency we can successfully process, greater high-frequency attenuation is required. Placing a zero on the circumference of the unit circle located at $z=-1$ guarantees maximum attenuation at this frequency, thereby improving the low-pass characteristic. **Figure 5.18** shows the pole-zero diagram.

To deduce the amplitude of the frequency response geometrically



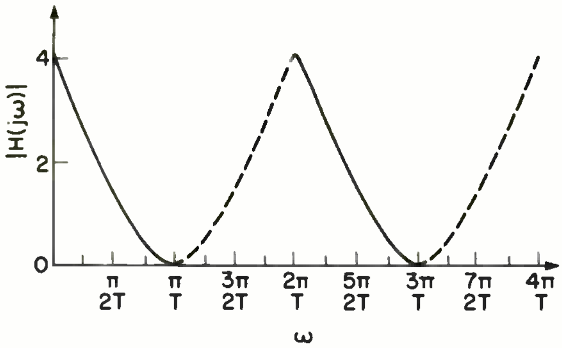


Fig. 5.19. Sketching frequency response from pole/zero diagram.

requires that we calculate $|H(j\omega)|$ or, in plain English, the magnitude of the zero vector divided by the magnitude of the pole vector, for values of frequency from f=0 to the Nyquist frequency ($f=f_s/2$).

The resultant phase response is given by the argument of the zero vector minus the argument of the pole vector. Using these rules we can produce a reasonable amplitude and phase response of the digital filter relatively painlessly. **Figure 5.19** illustrates the process.

To become proficient in this method of predicting the filter's behaviour (i.e. designing in the z-plane) try moving the position of the pole and then the zero. How does the frequency response vary? I hope you found that moving the pole along the negative real axis modified the filter's behaviour, transforming it into a high-pass characteristic. Cascading a low-pass and a high-pass filter would produce band-pass characteristics, although greater selectivity could be obtained by making the poles complex.

Band-pass digital filters

For reasons of simplicity we have deliberately avoided any reference to complex poles. We will now relax this constraint and demonstrate how greater flexibility can be incorporated into filter design, by the inclusion of complex poles. As an illustrative example we propose to design a band-pass filter with characteristics similar to those of a series resonant circuit. In keeping with earlier work, we will identify the transfer function and impulse response before writing a real-time C program. The design will intentionally use simple coefficients with a primitive microprocessor-based system in mind. A careful choice of pole-zero locations ensures simple analysis.

The digital filter will be designed on its own merits. The poles are located at half the Nyquist frequency (i.e. 0.25 times the sampling frequency) where $\omega T=\pi/2$ radians, and at a radius of 0.5.

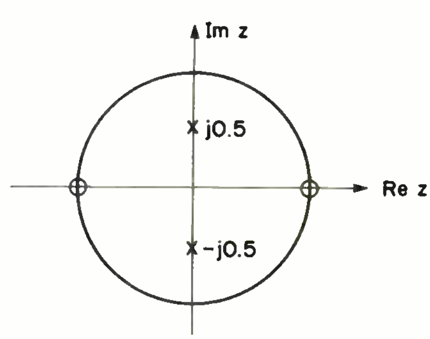


Fig. 5.20. As an example of design with complex poles, the pole/zero diagram has simple coefficients to streamline the arithmetic.

Since the poles are complex, they will be represented as the conjugate pair ±j0.5. This ensures a resonant frequency at a quarter of the sampling frequency. Additionally we choose to suppress the DC component by placing a zero at z=1. The inclusion of a zero at z=−1 ensures complete attenuation of any component at the Nyquist frequency.

Referring to **Fig. 5.20**, we may write the transfer function directly as

H(z)=location of zeros/location of poles

$$=[(z+1)(z-1)]/[(z+j0.5)(z-j0.5)] .$$

Putting H(z)=Y(z)/X(z) we obtain the transfer function in terms of the input and output signals:

$$Y(z)/X(z)=z^2-1/(z^2+0.25).$$

Cross-multiplying gives the result

$$z^2Y(z)+0.25Y(z)=z^2X(z)-X(z).$$

To obtain the recurrence relationship we must convert from transforms to sequences:

$$y(n+2)=x(n+2)-x(n)-0.25y(n).$$

Expressing in terms of the current output:

$$y(n)=x(n)-x(n-2)-0.25y(n-2).$$

The recurrence relationship is implemented in software form by the C program **Listing 5.3**. It is always advisable to dry-run your programs before attempting any real-time testing, complete with A-to-D and D-to-A converters. The program shown is particularly instructive because it incorporates an impulse response test. Unit-sample 1, 0, 0, 0, . . . is input term-by-term from the keyboard and the processed response displayed on the monitor. Contrast this recursive method of obtaining the impulse response with the method of convolution outlined in Part 4. Obviously, recursive methods are suitable for a real-time digital signal processor.

Listing 5.3 Impulse response testing using recurrence.

```
/*************************************
*        SOFTWARE TESTING           *
*        IMPULSE RESPONSE           *
*************************************/
#include<stdio.h>
main()
{
int a,b,k;
```

```
double c,d,e,f;
k = 0;
printf("Input impulse from keyboard\n");
start:scanf("%d",&a);
/*-----------------------------------------
  I/P UNIT IMPULSE
  FROM KEYBOARD
-----------------------------------------*/
d = a - c - 0.25 * f;
printf("Sample No :%d\t",k);
printf("%f\n",d);
k = k + 1;
/*-----------------------------------------
  DIFFERENCE EQUATION
y(n) = x(n) - x(n-2) - 0.25y(n-2)
-----------------------------------------*/
c = b;
b = a;
f = e;
e = d;
goto start;
}
```

Real-time band-pass filter

The required recurrence relationship and software structure has already been successfully tested. Reorganising Listing 5.3 as a real-time band-pass filter in conjunction with the digital processing circuit shown in Fig. 5.1 is straightforward. **Listing 5.4** shows the anatomy of the program, well littered with comments.

Listing 5.4

```
/***********************************
*  BAND-PASS DIGITAL FILTER        *
*  y(n) = x(n) - x(n-2) - 0.25y(n-2) *
***********************************/
#include<stdio.h>
#include<conio.h>
#define BASE 768
main()
{
double a,b,c,d,e,f;
unsigned int y;
outp(BASE,1);
/*-----------------------------------------
SELECT I/P CHANNEL
-----------------------------------------*/
start:outp(BASE + 2,0);
/*-----------------------------------------
START CONVERSION
-----------------------------------------*/
a = 0.00392 * inp(BASE + 2);
/*-----------------------------------------
NORMALISE INPUT
-----------------------------------------*/
d = a - c - 0.25 * f;
y = (unsigned int)(128 + 128 * d);
/*-----------------------------------------
MODIFY THE PROCESSED O/P:OFFSET
BINARY CODING IN D-TO-A
-----------------------------------------*/
outp(BASE + 4,y);
c = b;
b = a;
f = e;
e = d;
/*-----------------------------------------
DIFFERENCE EQUATION
y(n) = x(n) - x(n-2) - 0.25y(n-2)
-----------------------------------------*/
goto start;
}
```

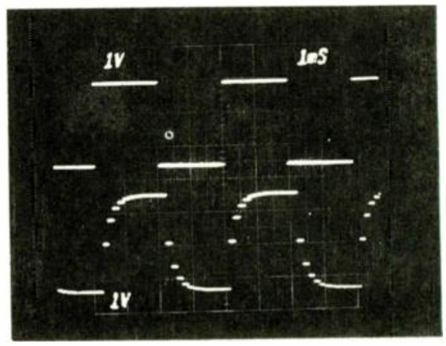


Fig. 5.24. Oscilloscope display of input (1kHz sine wave) and D-to-A output. Sampling interval is 250μs.

Running the program in real time gave a sampling rate of 250μs and a sampling frequency of 4kHz. Since the poles of this system are located at a quarter of the sampling frequency we must expect a maximum output or resonance in the region of 1kHz. **Figure 5.24**, the photograph of the oscilloscope display, identifies the sinusoidal input to the A-to-D converter together with the processed output, which confirms the theory. Applying a square wave of 1000Hz to the linear processor resulted in a sinusoidal output, because all the harmonics apart from the fundamental had been removed, so providing further evidence of the selectivity of this band-pass filter.

Modifying the program to process AC signals using the computer system shown in **Fig. 5.21** requires care, parti-

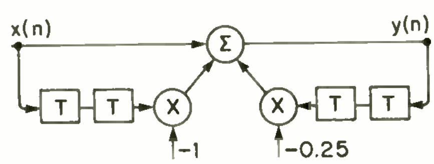


Fig. 5.21. System block diagram of the band-pass filter represented by the recursive relationship $y(n)=x(n)-x(n-2)-0.25y(n-2)$.

cularly if the A-to-D and D-to-A employ offset coding. For example, an 8-bit A-to-D conditioned to accept signals in the range −5V to +5V maps +5V to 255 and −5V to 0, while a similarly conditioned D-to-A maps 255 to +5V, 128 to 0V and 0 to −5V. To avoid the idiosyncracies of this type of coding, an ordered approach is required. In keeping with our earlier work I shall call data captured by the A-to-D "contents" and the data to be processed by the program x(n), where x(n)=(contents/128)−128. Before writing the processed output y(n) to the D-to-A, the following modification is introduced:

output=128*(y(n)+1).

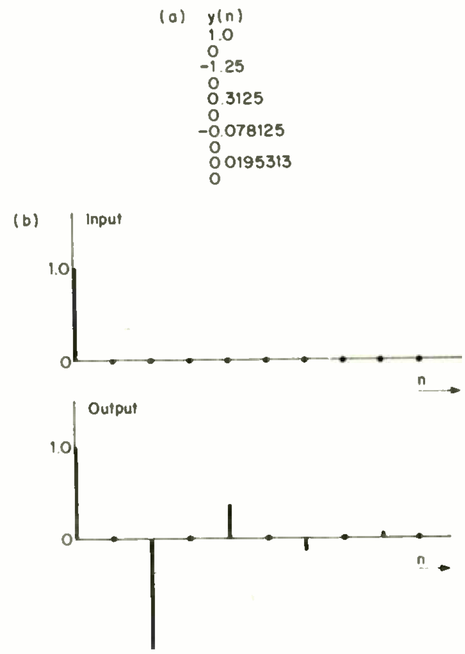


Fig. 5.22. Response from impulse-response test in digital filter design program. Values are at (a) and time-domain transient response (b) oscillates at 0.25 sampling frequency.

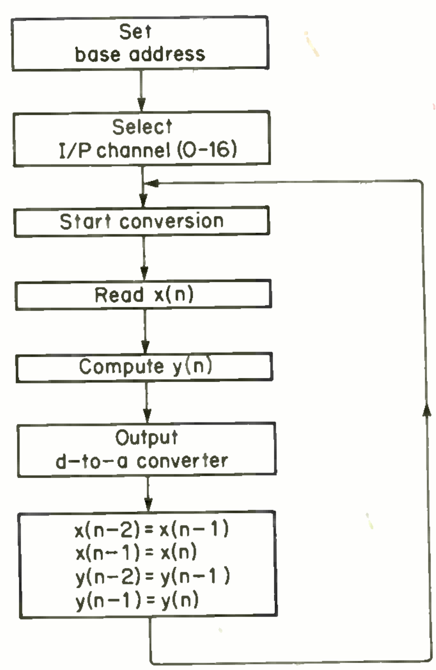


Fig. 5.23. Flow chart for Listing 5.4.

Table 5.1

n	x(n−2)	x(n−1)	x(n)	contents	y(n−2)	y(n−1)	y(n)	output
0	0	0	0.593	204	0	0	0.593	204
1	0	0.593	0	128	0	0.593	0	128
2	0.593	0	0	128	0.593	0	−0.741	33
3	0	0	0	128	0	−0.741	0	128
4	0	0	0	128	−0.741	0	0.185	151.71

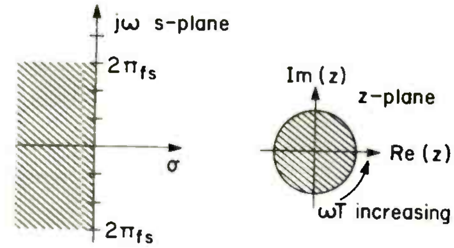


Fig. 5.25. Substituting $z=e^{j\omega t}$ transforms the jω axis of the s-plane onto circumference of unit circle in z-plane.

Table 5.1 is a convenient method of representing the history of the input signal as it is processed by the filter. The amplitude of the input signal was deliberately restricted, in this case to +3V, to avoid generating numbers outside the dynamic range of the D-to-A (0 to 255). If you fail to recognise the significance of this, look again at the synthetically generated impulse response sequence. An input of unity generated an output of −1.25 in the third term of the sequence. Filters with a larger Q-factor would exaggerate this effect, requiring correspondingly greater attenuation in the amplitude of the input signal.

The bilinear transform

The elementary band-pass filter examined previously provided an introductory but limited model of z-plane design methods. The transfer function of the digital filter simply evolved from the locations of the poles and zeros. Rather than restrict the design in this way it may be advantageous to adopt the characteristics of well proven analogue filters such as the Butterworth or Chebychev designs, based on s-plane models.

The bilinear transform is an algebraic method which translates the s-plane characteristics of an analogue transfer function into a unique set of z-plane poles and zeros, from which we may determine the digital transfer function and difference equation. Under the transformation, the coordinates of the s-plane poles and zeros are translated onto the z-plane, preserving the desired amplitude characteristics at the expense of some frequency distortion.

The transform may be written as

$$s=(z-1)/(z+1),$$

which is bilinear in the sense that both the numerator and denominator are linear in z.

Pre-warping. As a prelude to any design, consider the problem of relating the cut-off frequency of the proposed digital filter to the cut-off frequency of the analogue prototype. Remember that s is a complex variable capable of characterizing any waveform; if we restrict our attention to sinusoids the analysis may be simplified by substituting $s=j\omega$, and expressing the bilinear transform as

$$j\omega=(e^{j\omega T}-1)/(e^{j\omega T}+1).$$

Symbolizing the cut-off frequency of the analogue prototype as ω_c and the cut-off frequency of the equivalent digital filter as Ω_c, we can establish the required relationship as follows

$$j\omega_c=\frac{\exp(j\Omega_cT/2)[\exp(j\Omega_cT/2)-\exp(-j\Omega_cT/2)]}{\exp(j\Omega_cT/2)[\exp(j\Omega_cT/2)+\exp(-j\Omega_cT/2)]}$$

$$j\omega_c=\frac{j\,2\sin(\Omega T/2)}{2\cos(\Omega T/2)}$$

$$\omega_c=\frac{\tan(\Omega_cT)}{2}$$

With knowledge of the parameters of the digital filter Ω_c and the sampling interval T, straightforward substitution produces the cut-off frequency of the analogue prototype ω_c, a technique known as pre-warping.

Expressing the transform in its inverse form

$$z=(1-s)/(1+s),$$

and substituting $s=j\omega$, so that

$$z=(1-j\omega)/(1-j\omega)$$

provides a demonstration of how the jω axis in the s-plane is transformed onto the circumference of the unit circle in the z-plane. **Figure 5.25** is the relevant diagram. If you have the time, progressively increase the angular frequency from zero towards infinity, and observe the effects of this mapping. It helps to understand the reality behind the abstraction.

The analogue Butterworth amplitude characteristic is designed to be maximally flat at low frequencies, to roll-off sharply at the cut-off frequency and to fall to zero at very high frequencies. Any digital design should follow the analogue prototype as closely as possible, emulating the flat characteristics in the pass-band, a fall in gain of −3dB at the cut-off frequency, followed by a fall to zero at half the sampling frequency (not infinity as in the case of the analogue filter).

The magnitude-squared expression of an nth-order Butterworth filter is defined by the expression

$$|H(j\omega)|^2=1/[1+(\omega/\omega_o)^{2n}].$$

Normalising the expression by writing $\omega_o=1\text{rad}^{-1}$ leads to a more tractable expression with a −3dB cut-off frequency of 1rad^{-1}. Therefore, we may write the normalised magnitude-squared response of a second order filter as

$$|H(j\omega)|^2=1/(1+\omega^4).$$

The general form of an all-pole second-order filter is given by the transfer function

$$H(s)=1/(as^2+bs+c).$$

To calculate the magnitude-squared function, it is usually easier to evaluate H(s).H(−s) initially, before substituting $s=j\omega$:

$$|H(j\omega)|^2=H(s)\ H(-s),$$

where $s=j\omega$.

$$H(s)\,H(-s)=\frac{1}{(as^2+bs+c)}\ \frac{1}{(as^2-bs+c)}$$

$$=1/[a^2s^4+(b^2-2ac)s^2+c^2].$$

Substituting $s=j\omega$, we obtain the frequency-domain model

$$|H(j\omega)|=1/[a^2\omega^2+(b^2-2ac)\omega^2+c^2].$$

Comparing coefficients with the Butterworth magnitude response, we may write

$$a^2=1$$
$$b^2-2ac=0$$
$$c^2=1.$$

Hence, the second-order normalised Butterworth transfer function is given by

$$H(s)=1/(s^2+1.414s+1).$$

By inspection of the transfer function, we notice that the Q-factor is $1/\sqrt{2}$, which gives the best approximation to an ideal brick-wall response, as shown in **Figure 5.26** for a variety of Q-factors.

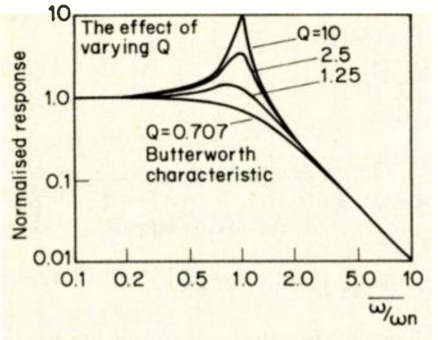


Fig. 5.26. Butterworth filter designed using the bilinear transform. Curve of Q=1/√2 gives best "brick-wall" response.

Design example. Our intention is to design a second-order low-pass filter based on a Butterworth prototype. The digital filter will have a cut-off frequency of 1kHz, together with a sampling frequency of 2.5kHz.

As the complexity of the filter increases, so the time taken to complete the various additions, subtractions and multiplications escalates. Real-time signal processing requires that all the calculations associated with each input sample are completed, before the next one becomes available. Since the software implementation of each design is likely to be unique, it is not possible to be prescriptive. The suggested sampling frequency provides a useful start for second-order Butterworth design exclusively in C.

Pre-warping, we may write the cut-off frequency of the analogue prototype as

$$\omega_c=\tan(\Omega_c T)/2.$$

Substituting for the angular cut-off frequency Ω_c and sampling period T gives the numerical result

$$\omega_c=\tan[(2\pi * 1000)/(2 * 2500]$$
$$=\tan(1.256)$$
$$=3.0777.$$

Hence, we may conclude that the cut-off frequency of the analogue prototype is 3.0777rads^{-1}.

Denormalising, we replace s by s/ω_c in the Butterworth transfer function, modifying the analogue prototype so that

$$H(s)=9.4722/(s^2+4.3518s+9.4722).$$

To obtain the digital transfer function H(z), we apply the bilinear transform, substituting $s=(z-1)/(z+1)$. The transfer function is

$$H(z)=\frac{9.4722}{\left[\dfrac{z-1}{z+1}\right]^2+4.3518\left[\dfrac{z-1}{z+1}\right]+9.4722}$$

$$H(z)=\frac{9.4722(z+1)^2}{(z-1)^2+4.3518(z-1)(z+1)+9.4722(z+1)^2}$$

$$=\frac{9.4722z^2+18.9444z+9.4722}{14.842z^2+16.9444z+6.1204}$$

Converting from transforms to sequences, we obtain the recurrence relationship

$$y(n)=0.6389x(n)+1.2779x(n-1)$$
$$+0.6389x(n-2)-1.1430y(n-1)$$
$$-0.4129y(n-2).$$

Listing 5.5

```
/ ************************************
*   BUTTERWORTH SECOND-ORDER         *
*      DIGITAL FILTER FS = 2.5KHz    *
*   CUT-OFF FREQUENCY = 1000Hz       *
************************************
#include<stdio.h>
#include<conio.h>
#define BASE 768
main()
{
float a,b,c,d,e,f;
/* ---------------------------------
          NOTATION
a = x(n) b = x(n-1) c = x(n-2)
d = y(n) e = y(n-1) f = y(n-2)
---------------------------------- */
unsigned int contents;
outp(BASE,1);
/* --------------------------------
SELECT I/P CHANNEL
---------------------------------- */
for(;;)
{
outp(BASE + 2,0);
/* --------------------------------
START CONVERSION
---------------------------------- */
contents = inp(BASE + 2);
a = 0.00392 * contents;
/* --------------------------------
NORMALISE INPUT
---------------------------------- */
d = 0.6389 * a + 1.2779 * b + 0.6389 * c -
1.1430 * e - 0.4129 * f;
outp(BASE + 4,(int)128 * (1 + d));
/* --------------------------------
WEIGHT AND SCALE: OFFSET BINARY
CODING
---------------------------------- */
c = b;
b = a;
f = e;
e = d;
/* --------------------------------
SHUFFLE DATA
---------------------------------- */
}
}
```

Despite our best efforts the computational efficiency of this program could not achieve a sampling interval better than $400\mu s$. For the purpose of comparison, remember, the straight-wired I/O program, Listing 5.1, provided a benchmark of $25\mu s$.

Software-based multiplication is a thief of time. Disregarding any normalising or off-set coding, the recursive structure of this filter required five multiplications per input sample. No doubt combining assembly language with C offers greater potential for throughput, but at the expense of program complexity and development time. The moral is obvious — if you want it fast, keep it simple. ■

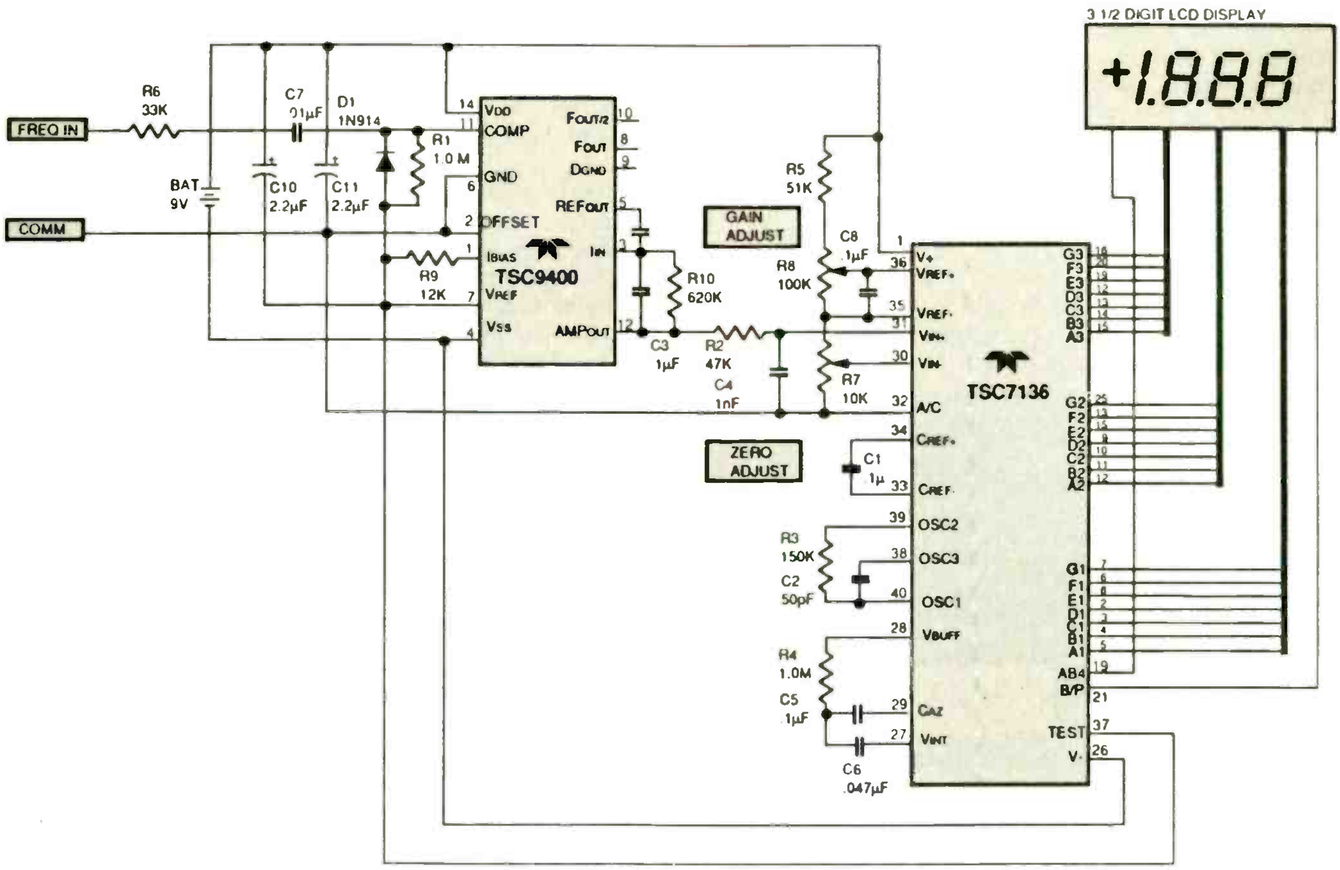
The next part in this series deals with the use of C for finite impulse response filters. The author provides practical programming examples for audio echo and reverberation, effects which are difficult to reproduce in analogue form.

SUPPLEMENT

ELECTRONICS WORLD + WIRELESS WORLD APPLICATIONS

OCTOBER 1990

Simple DFM for 0 to 20kHz



Two chips from Teledyne Semiconductor provide a means of constructing a low-cost digital frequency meter suitable for audio frequencies. Application Note 37 details a battery-powered (single 9V) frequency meter running at three conversions per second, using an oscillator frequency of 48kHz for maximum rejection of stray AC pick up.

The TSC7136 dual-slope analogue-to-digital converter directly drives a 3½ digit non-multiplexed LCD display, so no digital conversion is required. It derives its input from the TSC9400 frequency-to-voltage converter.

Semiconductor Supplies International Ltd, Dawson House, 128-130 Carshalton Road, Sutton, Surrey, SM1 4RS

Ultra-rapid NiCd charger.

There are many portable equipment applications using nickel cadmium batteries in which charging can be a problem. The difficulty becomes apparent when the voltage of the batteries to be charged exceeds that of the charging source, typically a 12V car battery. This note suggests a design for an ultra-fast nickel-cadmium battery charger capable of completely charging eight to 12 batteries at 1.2 to 1.8Ah in 30 to 45 minutes. This is currently possible due to the use by battery manufacturers of new sintered electrode technology which allows rapid charging cycles.

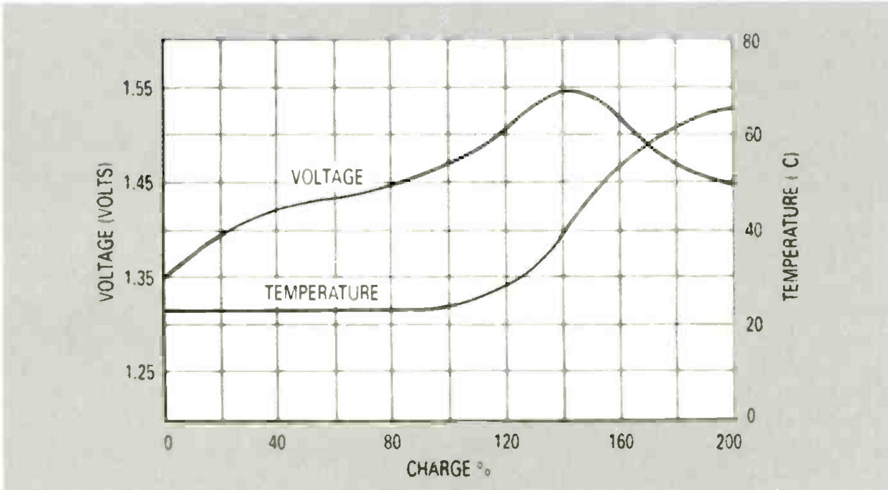


Fig. 1 NiCd battery charging characteristics

Specifications

10 to 14V input voltage; 1 to 3.5A constant output current; 20V maximum output voltage; automatic shut-off; supply reversal protection; full output protection.

A nickel-cadium battery must be charged with a constant current and is completely charged when it receives 140% of rated ampere hour charge. The variation of the battery voltage as a function of the charge depends upon the state of the charge as well as the temperature. When charging is completed, the temperature rises rapidly and, if the battery charger is not shut off, the batteries are destroyed.

This design provides for these requirements by including a constant-current regulator and a switch-mode converter to increase the charging voltage when the voltage of the batteries under charge exceeds 10V. The end-of-charging detection system uses the principle that, when fully charged, the battery temperature increases concomitant with a decrease in battery voltage (see **Fig.1**).

This regulator uses a MTP3055E power mosfet which has a variable operating point for adjustment of the charging current. This current is relatively independent of the drain-source voltage when V_{DS} exceeds 2V.

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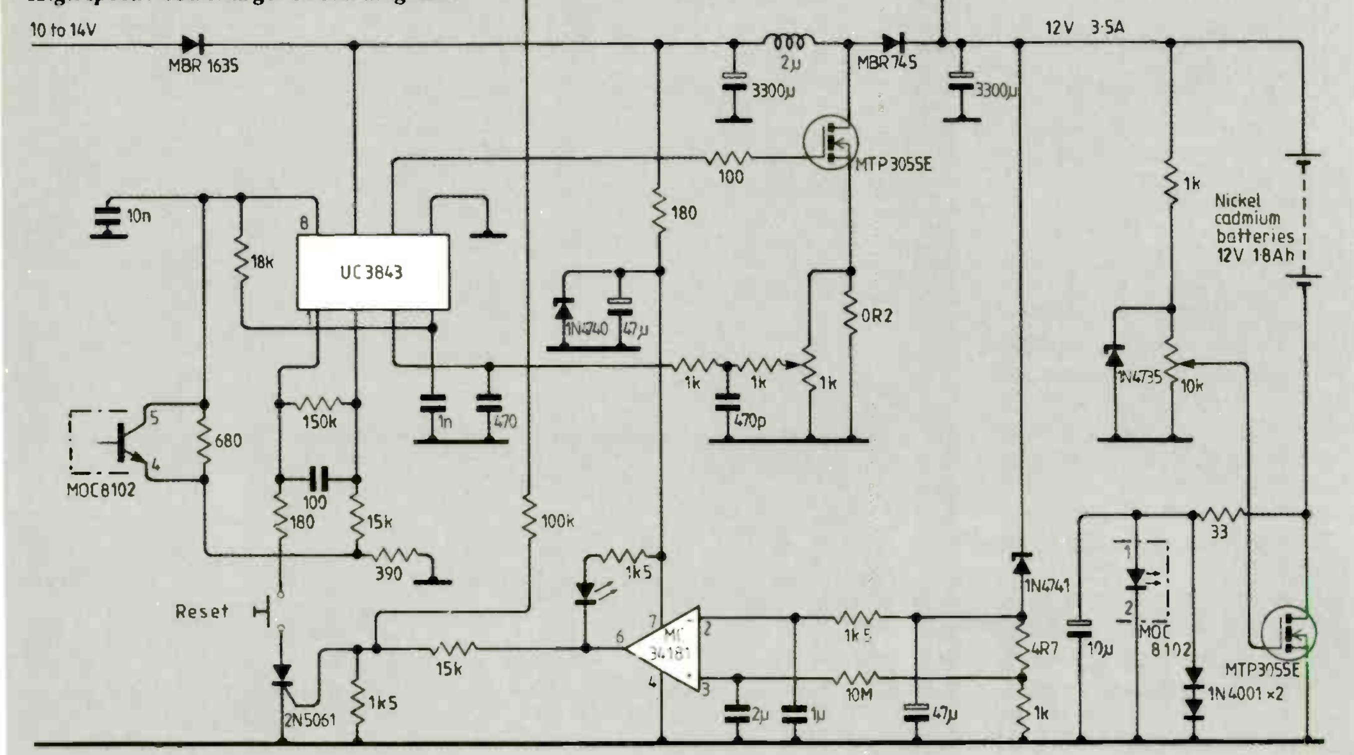
High speed NiCd charger circuit diagram



The converter is used to increase the charging voltage so that the current regulator always has an input of at least 2V. It uses the Motorola UC3843 produced specifically for automotive applications. This chip works in conjunction with a second MTP3055E, a MBR745 Schottky diode and a 25μH inductor. The operating frequency is 100kHz.

A MOC8102 optocoupler monitors the voltage applied to the current regulator and brings this information to the error amplifier of the UC3843. When a decrease in voltage is sensed, the UC3843 reacts to maintain the minimum voltage at the input of the current regulator. This reduces power dissipation in the linear current regulator to a minimum. The output voltage of the switch-mode converter is therefore floating and stays at 2V above the voltage of the batteries to be charged.

If at some instant the batteries to be charged are not connected, the output voltage can exceed 40V. Should this happen, a 2N5061 thyristor, sensitive to overvoltage, immediately turns off the converter.

The combination of the MC34181 operational amplifier and the 2N5061 thyristor provides control of output voltage and automatic shut off at full charge. The MC34181 j-fet op-amp is used as a comparator in the battery charger. Its inverting input is connected to the battery voltage minus the drop provided by the 11V zener diode. The non-inverting input is at a lower voltage due to the 4.7Ω resistor blocking the amplifier in its low-level state. The output from this comparator also drives a led, indicating that charging is taking place.

When the voltage of the batteries under charge decreases (which happens at full charge) the non-inverting input does not have time to vary due to the large 20s time constant. However, the inverting input varies rapidly due to its small time constant, forcing the op-amp to toggle, shutting off the led and turning on the thyristor. The switchmode converter then turns off and charging is completed.

The MBR1635 diode is used to protect the battery charger against polarity inversions. If the output of the charger is short circuited, the output current is still limited but the regulator receives 12V, causing it to heat up. Short-circuits should therefore be avoided or be of short duration.

Derived from Motorola application note EB126

Motorola, Motorola House, 69 Buckingham Street, Aylesbury, Bucks HP20 2NF. Phone 0296 395252. ■

18-bit D to A converter for x8 over-sampling

The PCM61P is an 18-bit, pin compatible replacement for the widely used 16-bit PCM56P. The addition of two extra bits reduces the level of both harmonics and noise in CD audio applications using the PCM56P. The PCM61P includes an internal reference and output op-amp.

The device is capable of 8-times over-sampling (single channel). Manufacturer Burr-Brown says that it meets its specifications without an external output de-glitcher. The device block diagram is shown in **Fig. 1**.

Maximum clock rate

The 16.9MHz stated maximum clock rate for the device is derived by multiplying the standard audio sample rate of 44.1kHz by 16 (for 16x oversampling) multiplied by audio word bit length in use, in this case 24. Thus 44.1kHz x 16 x 24 = 16.9MHz. Note that this clock rate accommodates a 24-bit word length, even though only 18 bits are in actual use.

MSB error adjustment procedure

The MSB error of the PCM61P can be adjusted to make the differential linearity error (DLE) at bipolar zero (BPZ) essentially zero. This is important when the signal output levels are very low, because zero crossing noise (DLE at BPZ) becomes very significant when compared to the small code changes occurring in the LSB portion of the converter. Static adjustment of DLE at BPZ can be made with extra circuitry shown in **Fig. 2**.

Burr-Brown International Ltd, 1 Millfield House, Woodshots Meadow, Watford, Herts WD1 8YX. Phone 0923 33837. ■

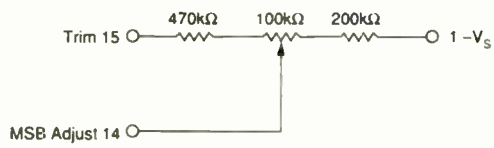
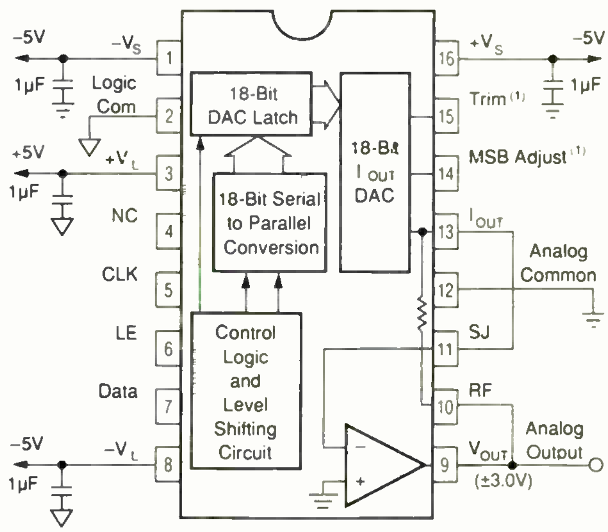


Fig.2

Fig.1



Note: (1) MSB error (Bipolar Zero differential linearity error) can be adjusted to zero using the external circuit shown in Figure 2

High voltage Schottky efficiency

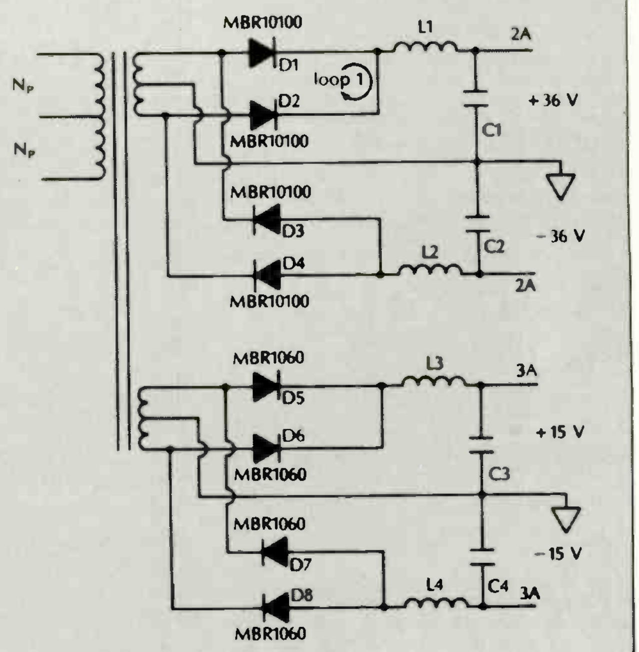
Although the low forward voltage drop of Schottky rectifiers has long been exploited to improve efficiency in converters rated at up to 15 volts, their use in converters in the 15-36 volt region has been limited by the lack of higher voltage devices.

Motorola's application note AR322/D outlines a multi-output converter operating at high frequencies from a preregulated 120V DC supply. Using MBR1060/MBR10100 devices, it provides ± 36V at 2A max and ± 15V at 3A max. If conventional p-n junctions are used as rectifiers in the same output stages, a trade-off between output voltage and efficiency exists.

While p-n-junction devices may be selected which meet the reverse voltage requirements, the forward voltage drop is high over a range of currents and, as a result, so too are the rectifier losses. However, if the peak reverse voltage requirements fall within ratings, Schottky rectifiers can reduce rectifier losses.

In this example, 100V Schottky rectifiers are adequate for the 36V outputs while 60V devices suffice for 15V.

Motorola Ltd, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP. Tel. 0296 395252



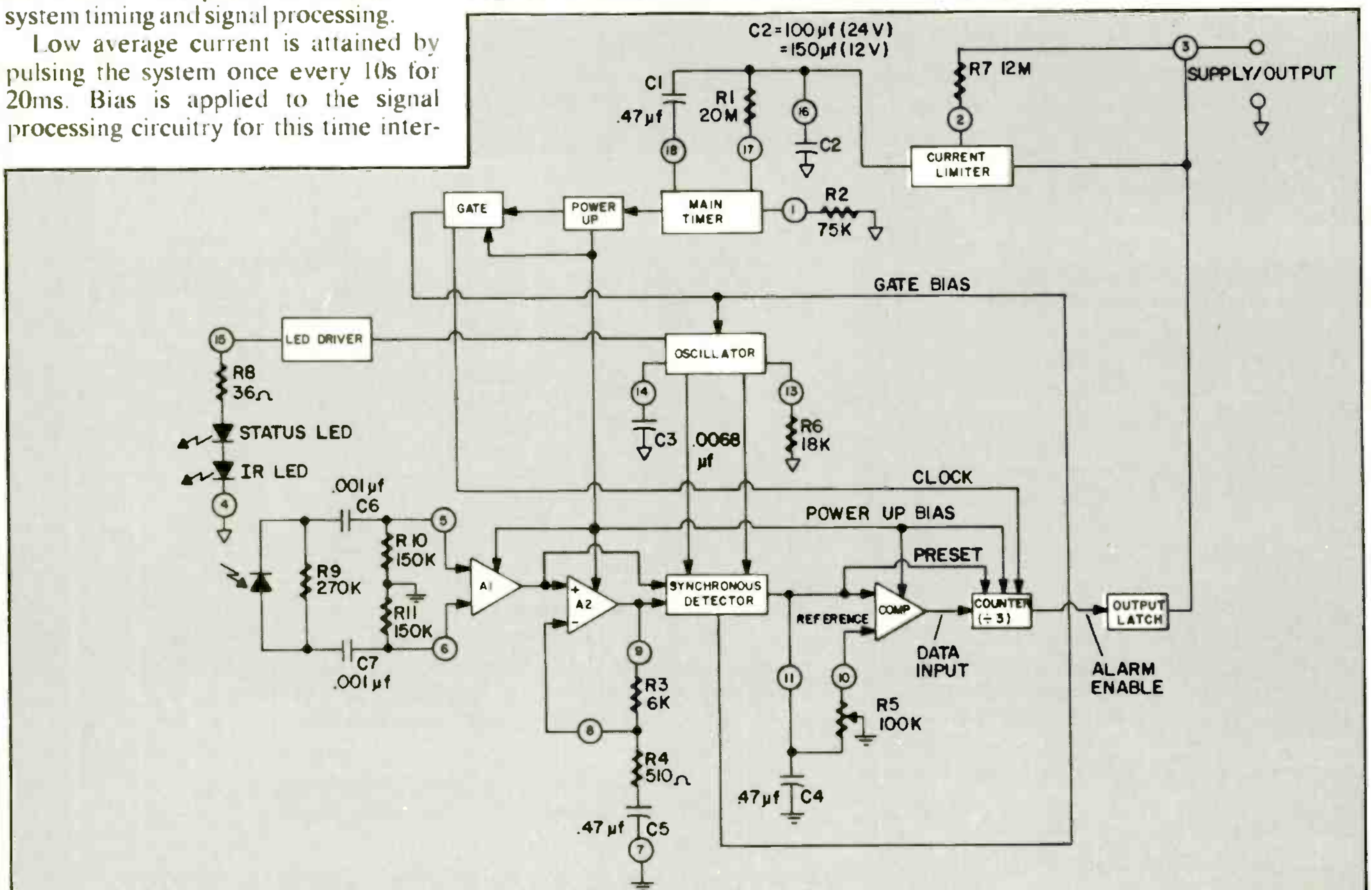
LED smoke detection

A smoke detector based on the CS-235 chip from Cherry Semiconductor uses a pulsed infrared led as the light source and a silicon photodiode as the light detector. The CS-235, along with passive external components, controls the system timing and signal processing.

Low average current is attained by pulsing the system once every 10s for 20ms. Bias is applied to the signal processing circuitry for this time interval. During the second half of the pulse (the last 10ms) the IR led is pulsed and the unit samples for an alarm level smoke condition.

After the first alarm, the sampling rage increases to two seconds. Finally, after three consecutive alarms, the logic drives the output latch to activate the alarm. This latch can sink 100mA maximum and will clamp the V_{cc} pin to 5V.

Clere Electronics Ltd, Kingsclere, Newbury, Berks.

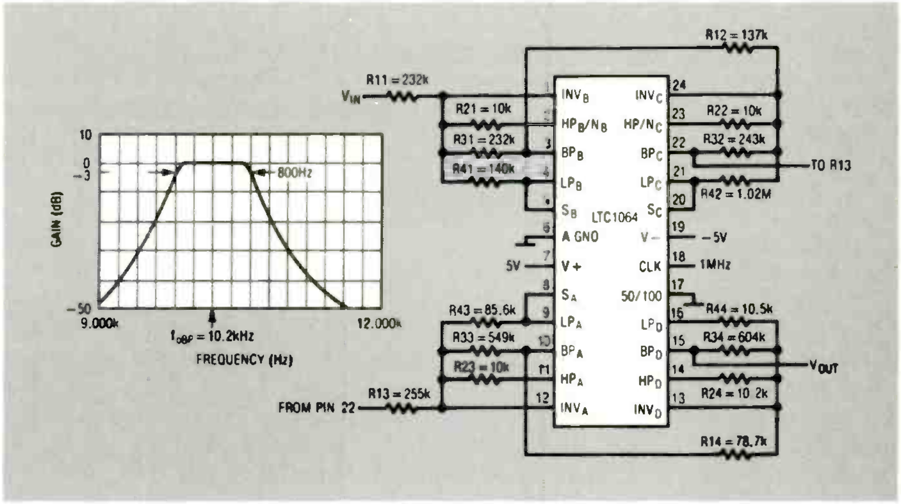


Filter design the easy way

In Application Note 27A from Linear Technology, the emphasis is on simplifying filter design procedure. It discusses two methods of designing bandpass filters from switched-capacitor building blocks – one using traditional non-identical sections and the second involving identical sections.

Design tables are included, one of which Linear Technology claims enables anyone to design Butterworth bandpass filters.

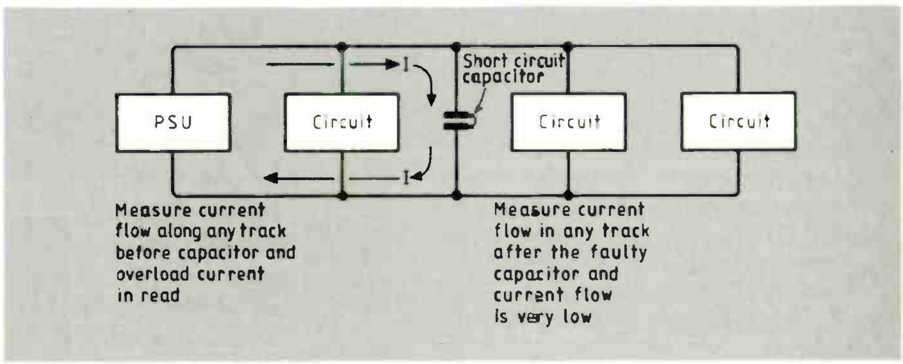
One of three design examples in the note is this eighth-order bandpass filter for 10.2kHz. *Linear Technology, Microcall, Thames Park Road, Thame, Oxfordshire OX9 3XD. Tel. 0844 261939.*



Fault finding with an ammeter

A current meter sensitive enough to measure the resistance of a PCB track is an invaluable fault-finding aid. For example, finding a short-circuited decoupling capacitor on a dense logic board is very time consuming by conventional methods, but with a sensitive current meter finding even a partially-shorted capacitor should take no longer than a few seconds – without track cutting.

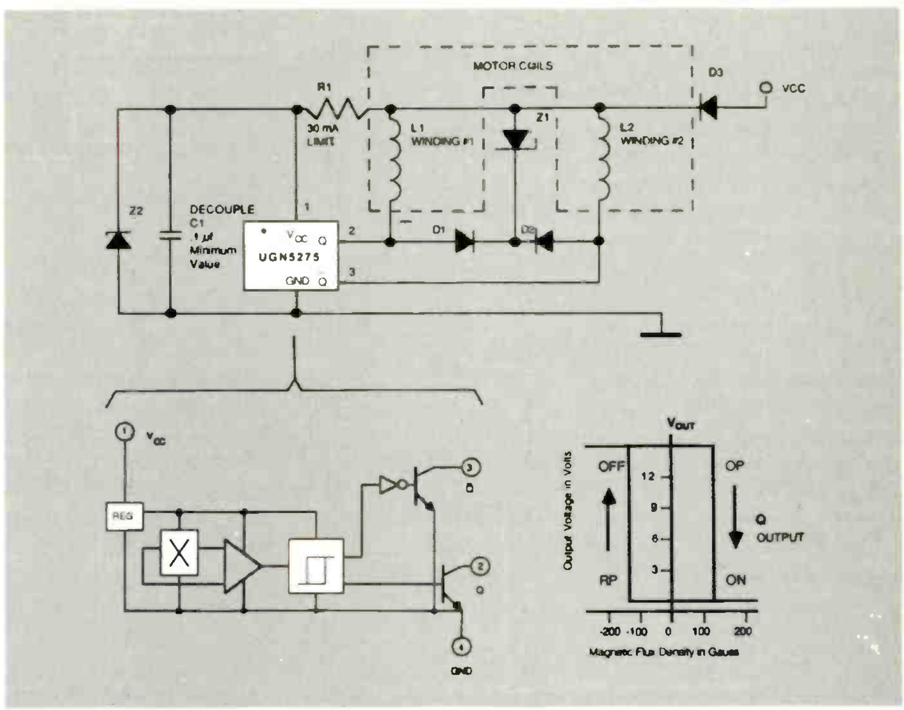
This application relating to the TL101A ammeter is outlined in a note from Transducer Laboratories. Among other uses suggested for the meter are cable-length determination and cable voltage-drop measurement. *Transducer Laboratories, Guildford Road, Farnham, Surrey GU9 9P2. Tel. 0252 733732.*



Power Hall device simplifies brushless motors

Design of small brushless motors is simplified by the availability of power Hall-effect ICs. Sprague's UGN5275/7 latching Hall-effect sensors can sink 300mA continuously and besides power-output transistors include a Hall voltage generator, an op-amp, a Schmitt trigger, and a voltage regulator. As a result, little more than one IC is required for commutation.

This circuit is the only one in the device data sheet, but guidelines for application are given. *Sprague Semiconductors, Balfour House, Churfield Road, Walton-on-Thames, Surrey KT12 2TD. Tel. 0932 253355.*



Compander for radio mics

Wire-less audio systems are finding increasing use in live performances, as well as in communications equipment where mobility is required. Designing such systems presents a difficult challenge; in particular, how to maintain adequate audio performance in view of power supply and current consumption limitations.

To reduce transmission noise, the audio signal is usually compressed at the transmitter and expanded at the receiver by using a telecommunications industry-standard compander IC, which has barely adequate audio performance by professional standards. This article describes a companding system utilising the SSM-2120 dynamic range processor, which offers improvements over the other techniques in terms of noise, distortion and feedthrough.

Transmitters are battery powered, and hence impose severe constraints on supply voltages and current consumption; receivers are often AC powered, so bipolar supplies are more easily accommodated. Since the SSM-2120 requires split supplies, a voltage doubler circuit is necessary for the transmitter, though in some cases this may not be feasible. In this event, however, the SMM-2120 is still useful in the receiver expander circuit to complement any compressed signal, and improve overall system performance.

Compressor and limiter circuits

The design described is intended for ±9V DC battery power and includes a third-order high-pass filter for the elimination of subsonic noise and low-frequency pops that would cause compander overload or mis-tracking.

Figure 1 shows the connection of the SSM-2120 (U_3) VCA_1, rectifier, and control amplifier as a compressor, the VCA being connected in the feedback loop of the preamplifier U_1 to control the gain. The compressor is designed for a 2:1 compression characteristic; if the input rises by 6dB, the output level will only increase by 3dB. The gain compression can therefore be expressed as:

$$= \frac{R_2 . R_4}{R_1 R_3}$$

as long as the rectifier input currents are limited by R_5 and R_6, and the rectifier has a ~10μA reference current.

The SSM-2120 rectifier and VCA have a dynamic range in excess of 100dB, resulting in exceptional tracking of the expander/compressor in the compander system.

Small-signal averaging time for a 10μF integration capacitor is 25ms, while the attack time to within 3dB of the final value is also about 26ms and is almost independent of signal level increases for level changes in excess of +10dB. Decay rate is 3ms/dB. The high-pass filter keeps frequencies below 90Hz from the input of the rectifier, reducing the low-freqency distortion caused by the VCA control circuit.

DC and high-frequency feedback are provided for U_1 without sacrificing bandwidth or stability. Output current from the signal-inverting VCA is summed, along with the microphone signal current, at the virtual-ground non-inverting input of preamplifier SSM-2134, U_1. The 10kΩ resistor at the input of the VCA limits the input current, while the 2200pF, 47Ω network provides frequency compensation for the VCA, keeping it stable. Gain is adjusted for 0dBu with −50dBu applied to the microphone input terminals.

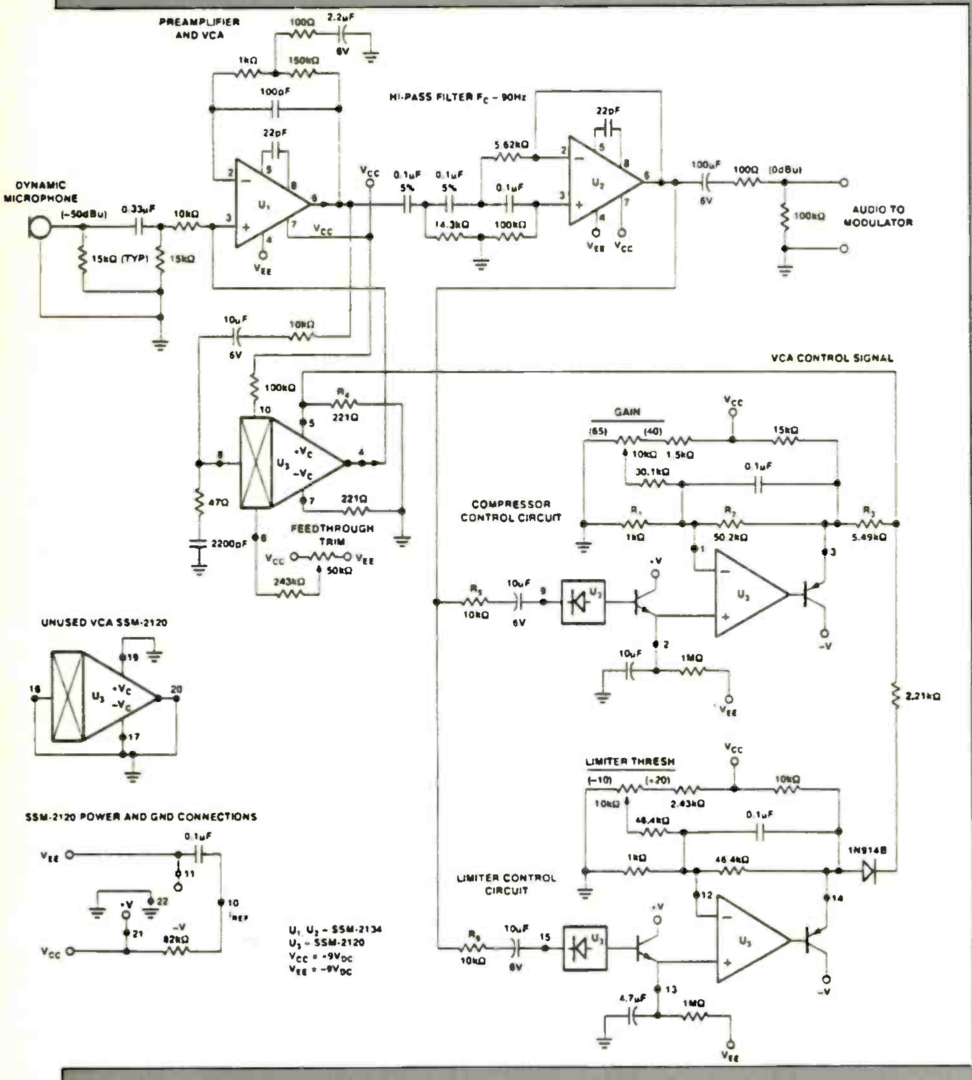


Fig. 1. Compressor-limiter circuit for transmitter. High-quality passive components are recommended.

Compressor/limiter

Input voltage range (0dBu out)	−65dBu to −40dBu
Attack time	26ms
Recovery	3ms/dB
Gain reduction	2:1
Limiter attack time	13ms
Limiter recovery	1.5ms/dB
Limiter gain reduction	4.6:1
Frequency response (90Hz-20kHz)	±0.5dB
S:n ratio at 0dB	100dB
THD+noise	0.05%

Expander

Input voltage range	−10dBu
Attack time	26ms
Recovery	3ms/dB
Gain ratio	1:2
Frequency response (20Hz to 20kHz)	±1dB
S:n ratio	100dB
THD+noise	0.2%

Performance of compander using Precision Monolithics SSM-2120 dynamic range processor

Precision Monolithics is at 90 Park Street, Camberley, Surrey GU15 3NY. Telephone: 0276 692392.

The 100kΩ resistor from V_{cc} to pin 10 of U_3 establishes the operating current for the VCA. To keep power supply current to a minimum, all pins of the unused VCA should be returned to ground. Feedthrough trim is optional and can be used to minimise the VCA control voltage feeding through to the output.

Protection limiter

This uses the second rectifier and control amplifier for separate and independent attack and decay times, along with a steeper gain-reduction slope. A threshold control sets the predetermined gain-limiting point for high input-signal levels. Gain reduction ratio is 4.6:1 and typically the onset of gain limiting should be set to +10dBu at the output.

As in the compressor control circuit, the rectifier input current is limited by R_6 and the rectifier also referred to 10μA. Lower precision capacitors and resistors can be used in this case and, as with the compressor, the attack time is much faster than the decay.

The VCA/preamplifier was designed as a system: the VCA was put in the signal feedback loop of the preamplifier principally to prevent preamplifier overload, while keeping the overall noise low, and minimising component count.

Power consumption

The application circuit requires two power supply voltages, ±9VDC; power consumption of the circuit shown in Fig. 1 is less than 15mA from each supply. The design described will operate properly with good dynamic range as the battery voltage begins to fall below the nominal 9VDC. It is assumed that two 9V batteries would be used, but for the smaller hand-held wireless microphones, a single 9V battery would be sufficient. **Figure 2** depicts a DC-to-DC converter that will supply the -9VDC.

The converter circuit incorporates an astable oscillator running at 25kHz, which is followed by a capacitor-coupled level shifter and rectifier with a filter. An SE/NE555 timer is used in the "output sink" mode for maximum efficiency and longest battery life.

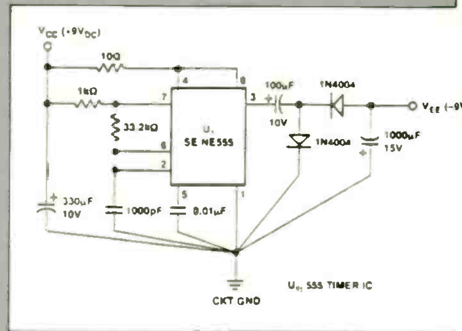


Fig. 2. DC-to-DC converter for ±9V DC at 15mA

Receiver expander circuits

Figure 3 shows the control connection of the SSM-2120 (U_3) VCA, rectifier and control amplifier. The control circuit connection to the VCA produces a 1:2 gain expansion curve: if the input rises by 3dB, the output level will rise 6dB. Gain expansion ratio is:

$$= \frac{R_2 \cdot R_4}{R_1 \cdot R_3}$$

The rectifier input current is again limited by a 10kΩ resistor connected to pin 9 of U_3, and the rectifier is biased at 10μA current though a 1.5MΩ resistor connected to V_{EE}. The SSM-2120 rectifier and VCA each have a 100dB dynamic range, resulting in accurate tracking of the compressor.

Small-signal averaging time, attack time and decay rate are identical to those of the compressor/limiter circuit.

Control-circuit gain values provide a control voltage to the VCA section $+V_c$ control port (U_3, pin 5), which results in a 1:2 signal expansion characteristic. The level control sets the initial overall gain value and is adjustable from −10dB to +20dB.

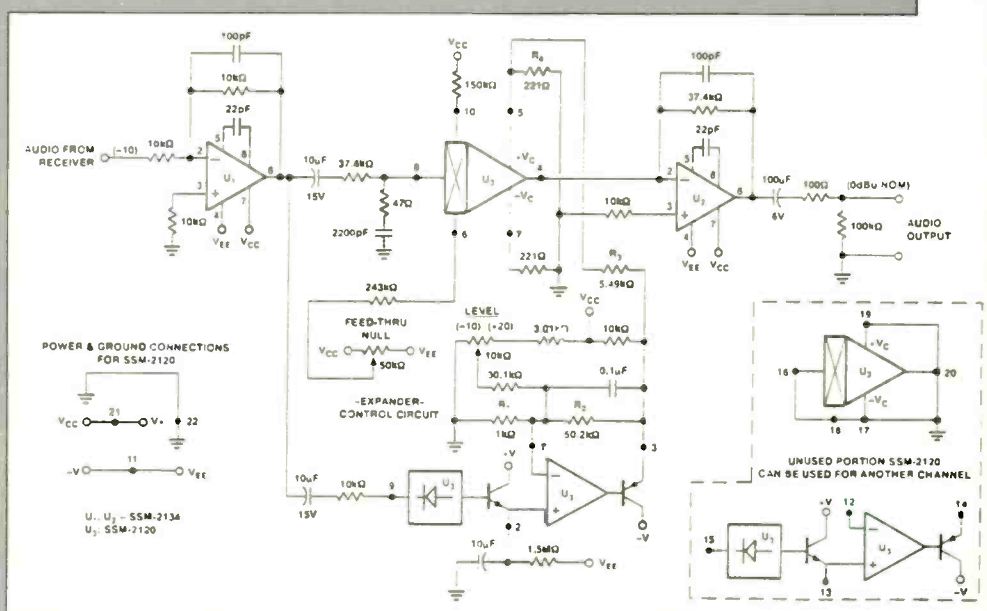
Audio signal source

Input amplifier U_1 acts as a buffer between the input signal source (FM receiver), the expander rectifier/control circuit, and the VCA audio signal input. If the signal-source output impedance is below 100Ω, U_1 can be omitted.

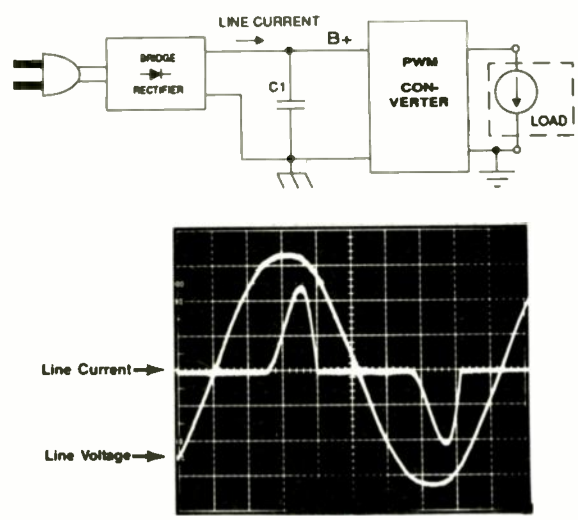
The nominal source signal level should be −10dBu; if signal gain or loss is required, U_1 gain structure should be modified to provide −10dBu to the VCA input-current limiting resistor. The 37.4kΩ resistor ahead of the VCA input limits peak signal currents to avoid VCA distortion.

A 150kΩ resistor to V_{cc} sets the VCA input/output current compliance range and a VCA input shunting capacitor minimises signal distortion and keeps the VCA stable by providing a high-frequency path to ground, the exact value being determined empirically. ■

Fig. 3. Expander circuit for receiver processor.



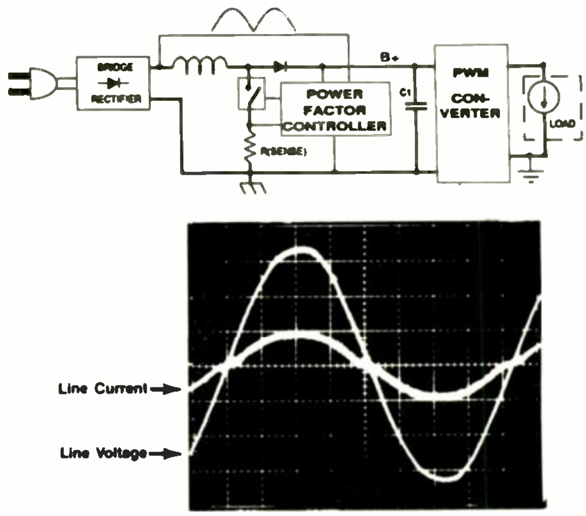
UNCORRECTED SUPPLY



2A/division for Line Current
50V/division for Line Voltage

Line Current is drawn during a short portion of the cycle in a conventional electronic power supply. (Power Factor = .7)

WITH ML4812 POWER FACTOR CORRECTION



2A/division for Line Current
50V/division for Line Voltage

Line Current is sinusoidal in a supply with Micro Linear's ML4812 Power Factor Correction. (Power Factor = .99)

Power-factor problems in switch-mode PSUs

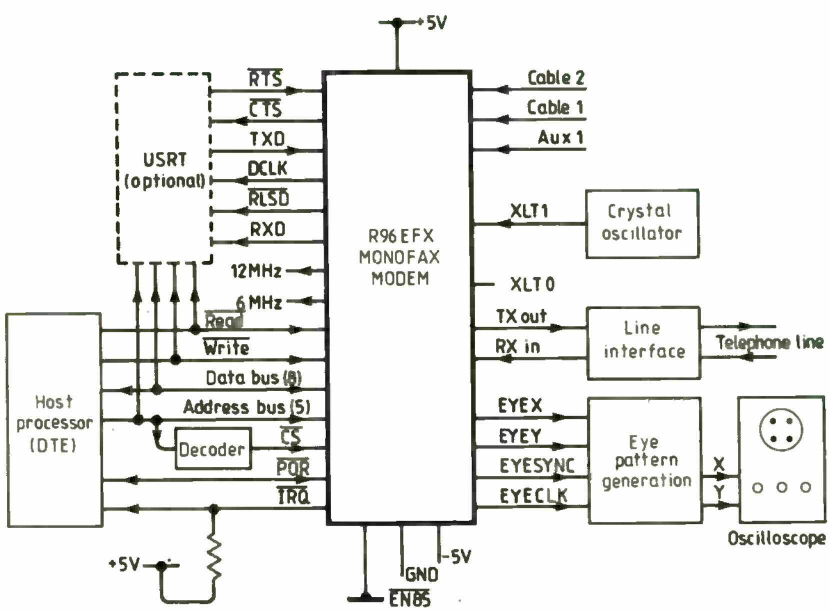
Most switch-mode power supplies have a poor power factor, and as a result draw inordinately high peak currents from the mains supply. In addition, harmonics produced by the current pulses develop substantial amounts of power-line noise and distortion, and since producing the harmonics takes power, efficiency of the supply is reduced.

These effects and a solution in the form of a new power-supply IC are discussed in an application note from Ambar Cascom. The chip – the ML4812 – controls a current-mode boost regulator that preregulates input voltage for a conventional pulse-width-modulated converter. A power factor better than 0.99 is achievable says Ambar. *Ambar Cascom, Rabans Close, Aylesbury, Buckinghamshire HP19 3RS. Tel. 0296 434141.*

Fax facts for modem designers

Communication standards are fine for users but they can cause problems for designers. For those of you considering new fax implementations, RCS Microsystems has produced an information sheet listing and outlining the relevant standards.

Addressess of standard sources are given, together with a list of fax modem products and application notes. *Rockwell, RCS Microsystems, 141 Uxbridge Road, Hampton Hill, Middlesex TW12 1BL. Tel. 01-979 2204.*



Data on this error-detecting fax modem forms part of a designer's information pack. Rockwell's R96EFX is a 9600 bit/s modem IC that conforms to CCITT recommendations V.29, V.27ter, V.21 Ch.2, T.3 and T.4: it covers the binary signalling requirements of T.30 too. Also in the designer's pack is data on other fax modem products and the information sheet mentioned here.

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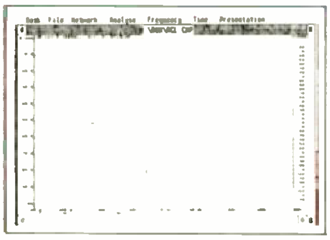

Frequency response of a low pass filter circuit

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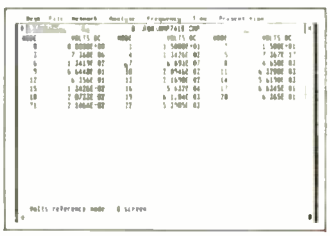
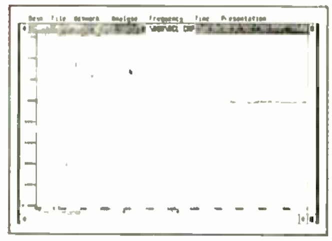
2 DC Quiescent analysis
SPICE•AGE analyses DC voltages in any network and is useful, for example, for setting transistor bias. Non-linear components such as transistors and diodes are catered for. (The disk library of network models contains many commonly-used components – see below). This type of analysis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



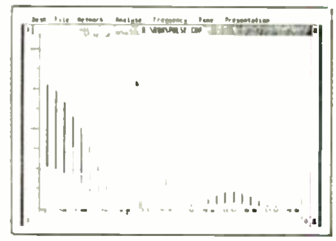
DC conditions within model of 741 circuit



Impulse response of low pass filter (transient analysis)

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

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



Spectrum of rectangular pulse train (Fourier analysis)

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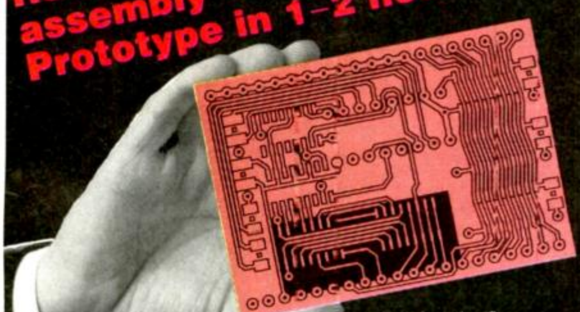

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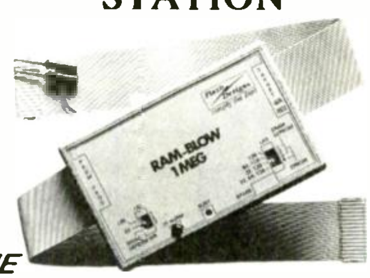

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A-TO-D converter using V-to-F conversion

An attractive method of A-to-D conversion is to use a voltage-to-frequency converter and to count the output frequency which, assuming that the conversion is linear, is proportional to the input voltage and can be scaled to read voltage directly. Although conversion does not compete in speed with other methods, it is accurate and its intrinsic integration permits the virtual elimination of low-frequency interference such as that at 50Hz.

As the application note from Burr-Brown points out, the result of a V-to-F conversion is a serial data stream which is easily handled in multichannel systems and transmitted over long lines with good noise immunity. Optical isolation is feasible and multiplexing is carried out digitally.

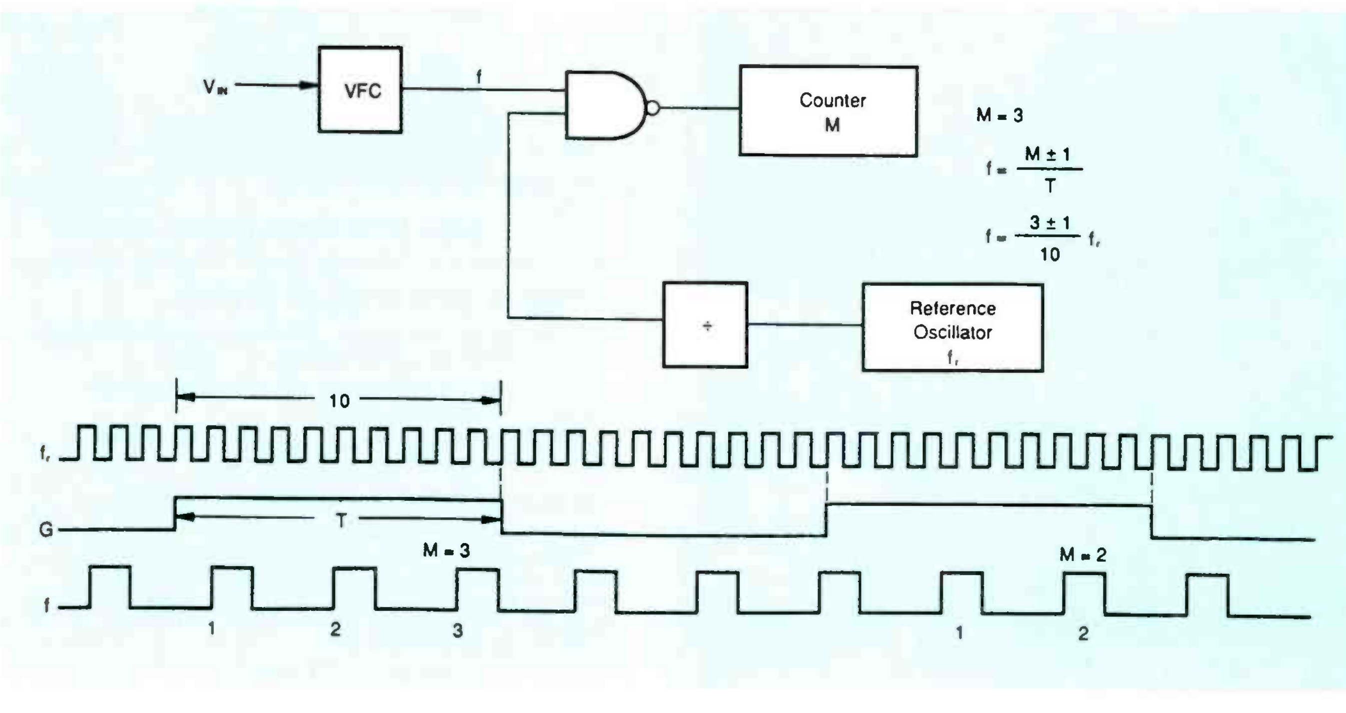
There is, however, one source of inaccuracy, commonly thought to be inherent: the plus-or-minus one count error, illustrated in **Fig. 1**. This shows the usual method of counting, in which the gate period is derived from a stable oscillator which is unrelated in phase to the frequency being counted. Depending on the phase of the gate oscillator in relation to the frequency, the count in this case is either three or two. One solution to the problem is to arrange for a large number of counts during the gate time but, since speed of conversion often dictates a short gate time, the result is a requirement for very high signal frequencies, at which the linearity of V-to-F conversion can be low.

Figure 2 shows a system in which the dilemma is resolved. It is known as the ratiometric technique, in which a large count is obtained to make the one-count error insignificant. N counts of a high-speed clock occur during an exact integer M counts of the V-to-F converter, giving an accurate ratio of the unknown frequency to the frequency reference.

A D-type flip-flop, clocked by the VFC output, produces a gate period which is an exact number of VFC pulses in duration, so that the count in M is not subject to the one-count error. In the same gate period, pulses from the high-frequency oscillator are counted by N; since the gate period and oscillator frequency are unrelated, the one-count error is present, but is relatively small compared to the large count. The result is a ratio (M:N), which is determined by a host processor or microcontroller, together with scaling and offsetting. V-toF conversion is now carried at low frequency, where accuracy is highest.

An example of a system using the technique is shown in **Fig. 3**, in which the VFC110 converts a 0–10V input to a 10–100kHz output by offsetting the

Fig. 1. Potential inaccuracies in counting. Same gate period can give different counts.



VFC input with a reference voltage; the 5V references set a constant input current through R_1 which is added to the signal input current through R_{in}. To avoid a very low VFC frequency causing a long gate period, the offset allows 10kHz (0V) to be counted during the desired gate time.

Counting is carried out by the 8254, which contains three counters and interfaces to many microprocessor types. Counter C2 acts as a programmed divider to the 3.58MHz clock to produce the gate signal G of 16.66ms in Fig. 2 at the output of FF1. Flip-flop 2 synchronises G to an integer number of VFC pulses to produce SG in Fig. 2. Counter C0 is M and counter C1 is N.

A gate period of 16.66ms results from the need to integrate over one cycle of mains frequency (this is an American design, intended for 60Hz working). The frequency response of a VFC is comb-like, with deep nulls appearing at multiples of 1/T, where T is the gate period.

Using this circuit, speed of conversion is about 30 times faster than in the traditional method.

Burr-Brown International Ltd, 1 Millfield House, Woodshots Meadow, Watford, Hertfordshire WD1 8YX. Telephone: 0923 33837.

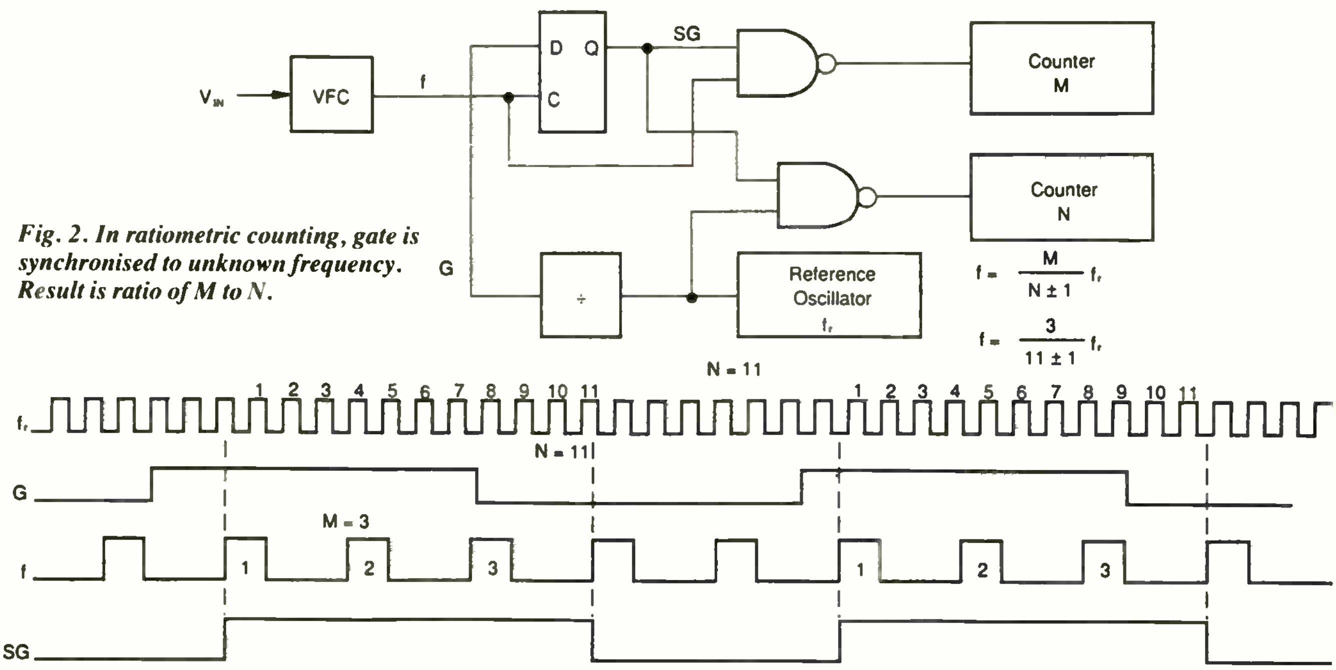
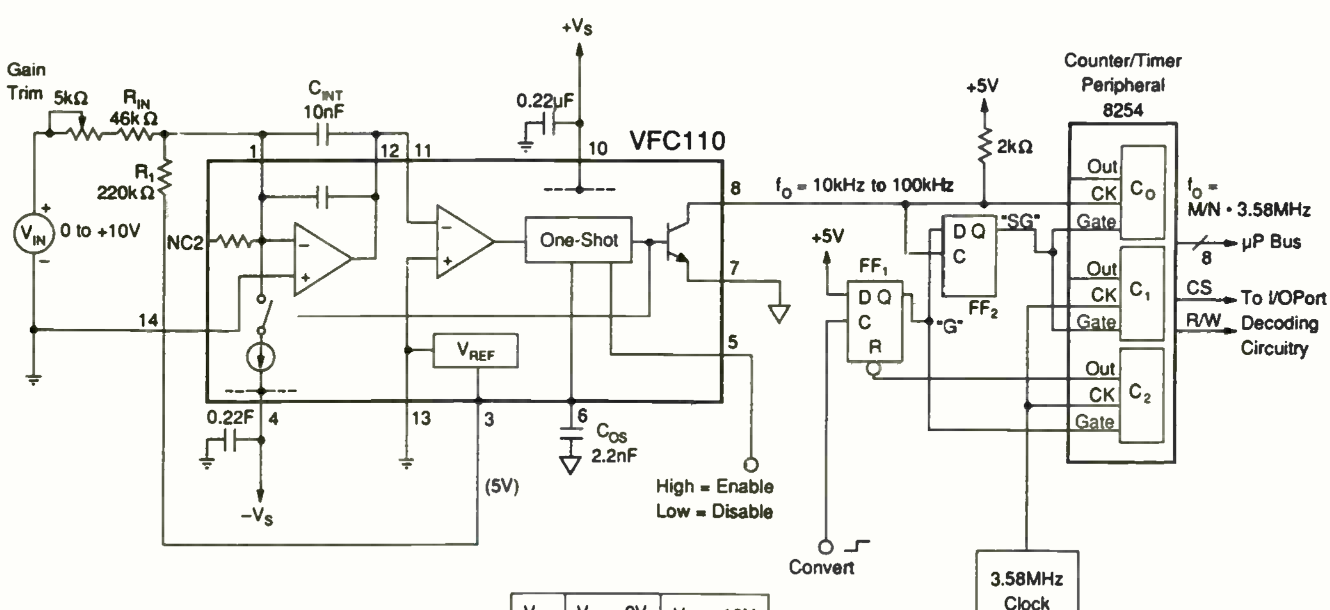


Fig. 2. In ratiometric counting, gate is synchronised to unknown frequency. Result is ratio of M to N.



V_{IN}	V_{IN} = 0V	V_{IN} = 10V
f_O	10kHz	100kHz
M	≈167	≈1667
N	≈59700	≈59700

Fig. 3. Practical VFC analogue-to-digital converter.

Balanced-input, high-level amplifier

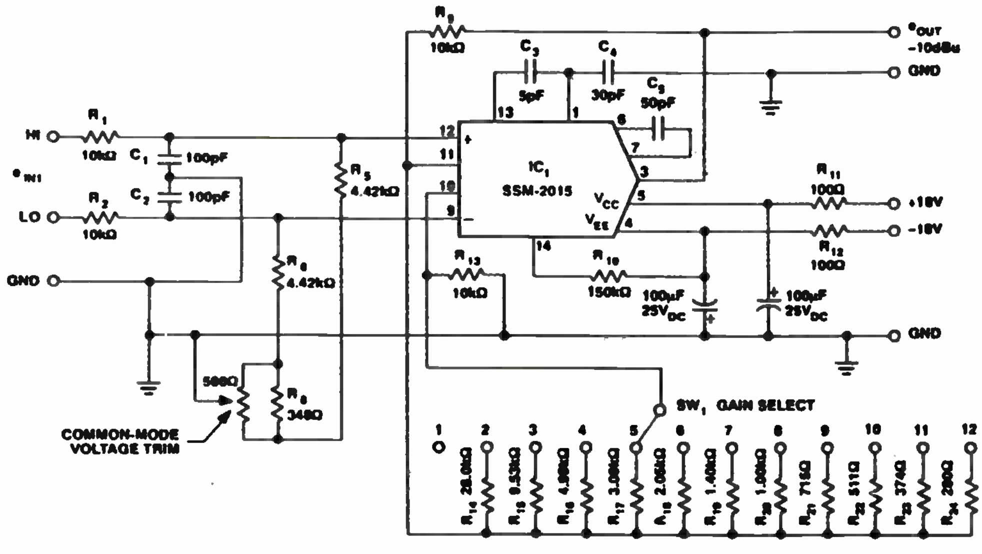
The amplifier shown in the diagram provides adjustable gain and accepts audio signals from −27.5dBu to +0dBu with more than 30dB of "headroom" and a common-mode voltage of 340 Vpk-pk. Common-mode noise rejection is greater than 100dB at 1kHz and equivalent input noise is −124dBu. Gain is adjustable in 2.5dB steps and worst-case THD is less than 0.008%; intermodulation distortion less than 0.015%.

A true differential-input IC amplifier, the SSM-2015 from PMI uses two identical low-noise bipolar transistors, with access to the emitters for gain adjustment. Switched resistors (R_{14} – R_{24}) set the gain according to the expression $G=3.5+(20\times10^3/R_G)$ for R_9 and R_{13} of 10kΩ.

This use of emitter feedback results in minimum noise and maximum CMRR, while retaining a high input impedance, and complementary bipolar transistors at the output produce a slew rate of 6V/μs with the capability of driving a 2kΩ unbalanced load. Direct coupling can be used, but if normal-mode input direct voltages are expected here, AC coupling may be needed for the following stage.

An RC filter at the input limits input voltage slew rate and reduces interface transient intermodulation distortion; it has little effect on phase response in the pass-band 20Hz to 20kHz. Capacitors C_1 and C_2 should be matched to preserve high-frequency common-mode performance.

Bourns Electronics Ltd, 90 Park Street, Camberley, Surrey GU15 3NY. Telephone: 0276 692392.

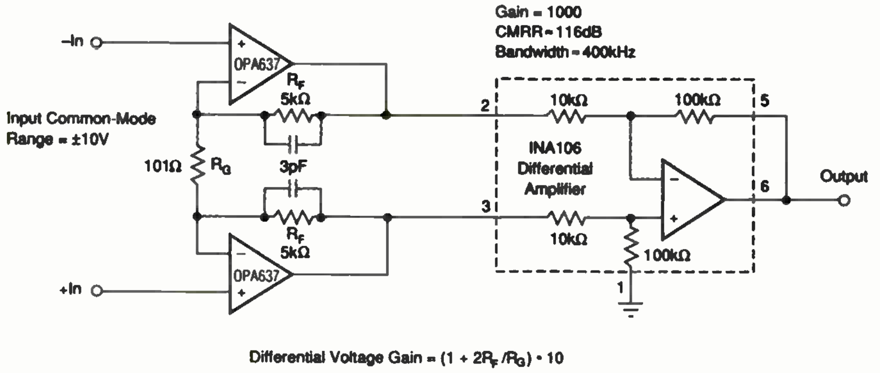


High-speed, high-gain instrumentation amplifier

Burr-Brown's OAP637 is a high-speed, low-noise op-amp which operates well from high source-impedances and which is fabricated in a complementary n-p-n/p-n-p process. Gain-bandwidth product is 80MHz and noise at 10kHz is 4.5nV/√Hz. Voltage offset is 100μV maximum, drift is 0.8μV/°C maximum and bias current 5pA. For driving long lines or capacitive loads, typical output current is 45mA at ±10V. It may be used as an inverting amplifier with a gain more than four or in a non-inverting form at a gain over five, which means that feedback capacitors can cause instability, since HF gain could fall to unity.

The circuit shown is a differential instrumentation amplifier with a gain of 1000, using a INA106 output stage with a gain of 10. The makers suggest that, as well as ordinary precautions in board layout, pin 8 (TO-99 package) should be connected to an AC ground for lowest pickup of external fields, although DC ground or a positive or negative rail would also serve. For lowest possible input bias current, the case (pin 8) could be connected to a circuit board guard pattern around pins 2 and 3.

Burr-Brown International Ltd, 1 Millfield House, Woodshots Meadow, Watford, Hertfordshire WD1 8YX. Telephone: 0923 33837. ■



Differential Voltage Gain = (1 + 2RF/RG) • 10

A mass of protests

As a postscript to my letter (*EW+ WW*, December, 1989 p.1208) drawing attention to a controversial article in an American journal questioning relativistic mass and $E=mc^2$, I thought readers would like to know how that controversy is developing in that journal's own letters column.

What started it all off was the view of Lev Okrun in the June 1989 issue of *Physics Today*, a magazine of the American Institute of Physics that "The famous formula $E=mc^2$ has to be taken with a large grain of salt".

Now *Physics Today* (May 1990) has published readers responses.

W Rindler of Texas University does not dispute Okun's conclusion but he is ". . . disturbed by the harm that Lev Okun's earnest tirade. . . might do to the teaching of relativity."

P Murugesan of Stetson University writes ". . . students are taught that as the velocity of an object of 'rest mass' m_0 gets close to velocity of light (c), its mass become extremely large. If v=c then the mass becomes infinite. The same students are also told that particles in cosmic rays could have velocities greater than 0.9c without any change in their masses!. . . It is about time we eliminated such contradictory and confusing statements from our textbooks"

C Sauter asks: ". . . Why is it that the academic system has been able to pass along information like this for so long? . . . Does mass truly depend on velocity?"

Lev Okun replies: "There is only one mass, the Newtonian mass m, which does not vary with velocity. . . I don't think we should try to banish $E=mc^2$ from T-shirts, badges and stamps. But in the textbooks it should appear only as an example of a historical artefact, with an explanation of its archaic origin".

John Ferguson
Camberley
Surrey

Cheque on science

Harrowell is wrong in his letter (*EW+ WW*, May, 1990 p.426) in ignoring the controlling behavioural model in scientific suppression, which is Power. (This was de Gracia's conclusion in "The Velikovsky Affair", Ed de Gracia.)

Harrowell seems to think that the guiding light is still Search after Truth; an indulgence that today's salaried, mortgaged scientists eschew.

A tiny fringe of scientists (Hillman, Theocharis, Walton, Mike Gibson) still keep to the nineteenth century, amateur ideals, but scientific advance is a thing of the past. The vandals are in control. Read Professor Paul Davies in the Guardian.

Ivor Catt
St Albans.

Gyroscopes, Sagnac and relativity

While John Nuttall's article "Optical fibre gyroscopes" (*EW+ WW*, July, 1990 pp.608-611), was interesting and informative, he makes the contentious statement that the Sagnac effect can properly be explained only in terms of General Relativity. Surely it appears completely to contravene the principles of General Relativity and indeed provides a powerful argument in refutation of Einstein's postulates?.

M E T Hewlett
Midhurst
West Sussex

I would like to respond to some of the incorrect and misleading comments contained in John Nuttall's article "Optical-fibre gyroscopes" *(EW + WW*, July, 1990 pp. 608-611) particularly concerning the Sagnac effect.

It is not unreasonable to suppose that Sagnac's 1913 paper "Experimental Proof of Reality of the Ether" was specifically responding to the alleged superfluousness of the ether put forward by Einstein in 1905, and to its alleged non-existence suggested by others.

Sagnac's paper makes it clear that he conceived the optical-gyro effect on the basis of the ether, and performed the experiment with the declared objective of demonstrating its reality.

But the first response from the relativists was not until several years later, in 1921, and as far as I know Einstein never uttered a word on this topic.

Yet relativists today have the effrontery to claim that the Sagnac effect can properly be explained only in terms of relativity. This and their various claims that relativity is supported by experiment, or that it has generated practical applications (e.g. nuclear power and atomic clocks) are simply bogus and must be exposed as such.

In sustaining the phoney explanations and absurd claims, many true but inconvenient facts are either quietly suppressed or suitably distorted, and history is disgracefully re-written in a fashion that Stalin would envy.

Our only hope is that a scientific glasnost will defeat this stagnation.

Theo Theocharis
London

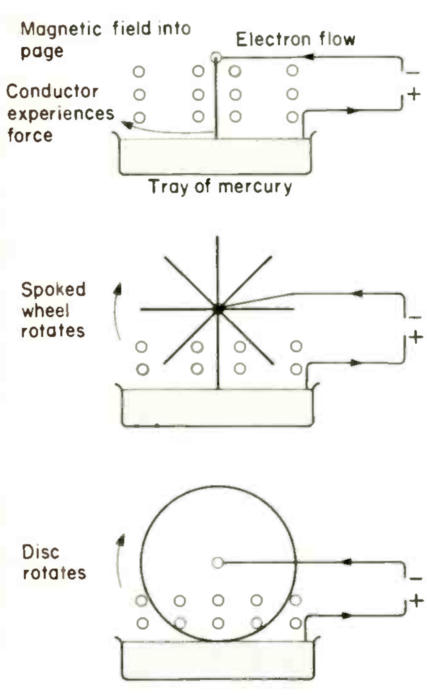
I would like to comment on John Nuttall's article (*EW+WW* July 1990), the Sagnac effect has never been adequately explained by General Relativity. At best the argument is based on an hypothesis linked with a non-rotating inertial frame, just as Special Relativity argues that light speed is constant relative to any observer if measured in a non-accelerated (non-rotating) system.

Gravitation does affect the speed of light in vacuo — light rays bend around the stars — to disprove Special Relativity, were it not for Einstein dodging away from the problem by arguing equivalence between acceleration and gravitation and somehow bringing accelerated

Torque talk

May I offer some input into the alpha-torque correspondence which has been appearing in your letters pages.

It has been suggested that electrons in solid copper move independently of the crystal lattice. But I think there may be a mechanism for an interaction.



Consider a conducting rod hanging from a pivot at its upper point and touching a bath of mercury at its other end. With a circuit producing electron flow down the rod, into the bath, and a magnetic field flowing perpendicular to it, electrons in the conductor will be forced to the left. As they cannot leave the surface, the whole conductor will be forced to the left. If the single conductor is replaced by a spoked wheel, then it will rotate — each spoke experiencing a force to the left as it makes contact with the mercury. The current can only flow radially.

If the spoked wheel is replaced by a solid copper disc, current is no longer constrained to flow along a radial path — the conduction electrons are free to move in circular paths. So the conduction electrons could be expected to move in a curved path from centre to point of contact with the mercury, leaving the lattice alone. However, the disc will rotate just as the spoked wheel did, seeming to indicate that as the electrons flow and are deflected to the left, they somehow drag the lattice to the left also.

Peter F Vaughan
Lynton
North Devon

motion into a uniformly moving field system.

The same dodge is applied, less convincingly, to the Sagnac interferometer. If it rotates it is not in non-accelerated motion and, as relativists cannot abide experimental evidence that rotation can be detected as if light speed were referenced on an ether, they side-track on the assumption that the mysteries of General Relativity must hold the key.

Modern physicists following the relativity route tend to adopt Langevin's argument *(C.R. Acad. Sc., 173*, 831 (1921)), which renders the Sagnac experiment consistent with the behaviour of the Foucault pendulum or the inertial space property of the mechanical gyroscope.

If there is an argument based on General Relativity and its incredible mathematics then, should any relativist respond to put the case, I ask that no defence for Einstein should be offered unless the following question can be answered.

Assume that one day space technology is such that John Nuttall's optical fibre gyroscope could have its terminals on Earth but its loop wound around the orbit followed by the Earth in its motion round the sun, so that the whole gyroscope structure rotates once a year. Would it be possible to detect that 30km/s motion by light speed measurement within that optical fibre?

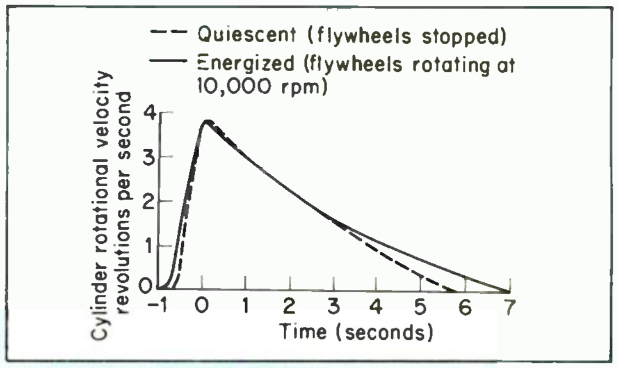
If yes, then the basis of Special Relativity is destroyed because it relies on the Michelson-Morley null test aimed at that very objective.

If no, then, inasmuch as the device described in the July 1990 issue of *EW+WW* does function to detect rotation in laboratory devices, where does Relativity point to the radius of transition between what works and what does not work?

It is quite obvious that Einstein's theory fails and that relativists have buried their heads in the sand, hoping to avoid the implications deriving from technological progress on light speed measurement.

Harold Aspden
Department of Electrical Engineering
University of Southampton

Swings and gyros



In an age when precision of mechanical measurements has reached fractions of the wavelength of light it is surprising that Dr H R Harrison (Letters, *EW+WW*, July, p. 603) would rely on observation of a toy gyroscope swinging on the end of a string to measure an effect which could profoundly affect fundamental physics.

A proper experiment to measure the period of a pendulum with a rotating bob would consist of two gyroscopes counter-rotating, co-planar and with axles parallel, mounted in a cylinder suspended on bearings and swinging on a platform pendulum, so there could be no possibility of any precessionally engendered torques affecting the period of the pendulum. The changes in the period of the pendulum thus observed are of the order of parts in 10^5. Clearly this would not be observable to the naked eye.

In 1974 Dr Eric Laithwaite, former professor of heavy electrical engineering at London Imperial College of Science and Technology demonstrated a prototype antigravity machine which lost 20% of its weight when energised. The understanding of this machine has been incorporated in an apparatus developed by Scottish inventor Sandy Kidd. Dr Harold Aspden, Senior Research Fellow at Southampton University witnessed operation of this device. Kidd is now living in Australia where it is reported this device can hover and lift seven times its own weight.

Antigravity devices of this type can be described in terms of a variable inertia principle coupled with an oscillatory motion which I have demonstrated with a precessing gyroscope — two 30-pound, 11-in diameter flywheels rotating in opposite directions — by weighing the gyroscope. Of course an experiment performed in air can be questioned on many counts, but I have verified this with a fully enclosed gyroscope protected from the air.

One can construct a balance using a 1m piece of light wooden rod and balancing a "toy" gyroscope against an equivalent inert mass. Spin the gyroscope and hang it on a string by the end of one of its axles and release the apparatus, allowing the gyroscope to precess. Careful observation will show the balance tilting upward on the gyroscope end.

It would be fatal for society to limit knowledge of dynamics and rotating motion to "classical mechanics". I suggest that Dr Harrison apply the measurement precision of the late 20th century to the understanding of rotation.

Before one can comment on an experiment one must *exactly* repeat it. In the Alex Jones experiment (*EW+WW*, April, 1990 p.332), the apparatus was mounted on steel ball bearings so there was *no constraint*, as opposed to Harrison's set up. Because gyroscopic forces are exerted against space itself, the Harrison experiment yielded a reaction force.

I can only submit that understanding of the gyroscope is dependent on the absolute rotation of the rotating wheel in relation to a stationary ether.

Bruce DePalma
President, DEC
California

FNDR geometry

Ian Hickman's voltage vector diagram for a frequency-dependent negative resistance (FNDR) filter (*EW+WW*, July pp. 584-587) is highly reminiscent of the construction of a hyperbola using a rod and a piece of string. Similarly, the current vectors represent the mensuration of triangles. Could it be that negative resistance circuit design is a matter of simple geometry? And is an FNDR really an analogue circuit if the voltage across a "supercapacitor" falls at twice the rate as that across a normal capacitor; is this the configuration of a superconductor?

Many such effects have been reported for biological systems — perhaps it is possible for electronics too.

B E P Clement
Crickhowell
Powys

Risky business

I was serious when I asked (Letters, *EW+WW*, June, 1990 p.526) what were the chances of acquiring acute myeloid leukemia. I was a radio station engineer for 20 years, lived under a 7500 volt feeder for 15 years and am still an amateur radio operator.

My concern is that we have a multiplicity of warnings worded "double your chances" of a certain disease, only to find that the original risks were more than a million to one. In at least one case recently, avoiding the danger warned about led to an increased risk of a much more common ailment. For that reason, I suspect any warning which does not give at least some idea of what the chances really are.

Joel S Look
Pawtucket
USA

ACTIVE

A-to-D and D-to-A converters

Dual 18-bit audio D-to-A. The PCM1700P claims to be the first monolithic, dual 18-bit D-to-A converter for high-performance digital audio with a maximum conversion rate of 768kHz. Multiple over-sampling, low noise and distortion figures better than 92dB THD+noise are promised. Serial input data in BTC format produces co-phase, glitch-free audio outputs of either ±3V or ±670μA. Current output is trimmed to an absolute ±2% tolerance. Burr-Brown Ltd, 0923 33837.

Three-channel converter. Sony's CX20206 8-bit high-speed D-to-A converter for video band use offers separate R, G and B channels, maximum conversion speed of 35Msamples/s, and differential linearity error of ±½LSB. Input is at TTL levels and full-scale output is typically 1Vp-p. The 42-pin SDIP package, 5V supply, typically consumes 360mW. Volume price £15. Hakuto International (UK) Ltd, 0992 769090.

Four-channel D-to-A board. The ADC-40 analogue output board for PC control applications has four output channels for control signals, as voltages: ±5V, ±10V, 0-10V, 0-5V or control loop 420mA. Each channel is configured independently with fast D-to-A conversion of output (up to throughput 30,000 samples/sec). On-board DIP switches select base address. Simple call statements program the board. Instrumatic, 0628 476741.

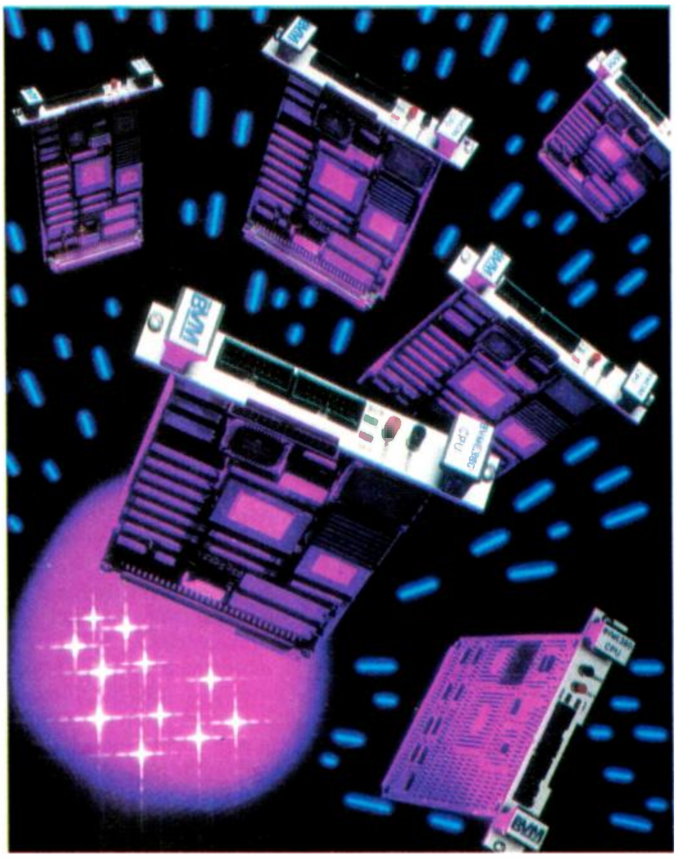
Video D-to-As. The SC11471 and 478 are triple 6/8-bit Brooktree architecture video D-to-As fully PS/2 compatible with 256-location colour palettes and 15-level overlay palettes. Colour palette ram is programmable through a microprocessor bus interface operating asynchronously from the video data bus. Pixel mask register and sync generation is on all three channels. Outputs can directly drive dual-terminated 75Ω lines to RS343A levels. Sierra Semiconductor Ltd, 0793 618492.

Discrete active devices

RFI-immunity junction fet. By integrating two resistors and two mos capacitors on a single chip, the BFR200 adds a low-pass filter to the input stages of sensitive equipment, suppressing RFI signals in the 450 to 900MHz cellular radio range. Philips Components, 010 31 40 72 43 24.

Linear integrated circuits

Linear semi-custom IC. The CS5200 linear bi-polar semi-custom integrated circuit for operation on a 1GHz process provides up to 25% greater packing density than other arrays in the Genesis family. Single-layer metal interconnects provide low-cost solutions, for higher-density, two-layers can be provided. 226 small n-p-n, eight medium current (100mA) n-p-n, 130 lateral p-np, and 22 substrate pnp transistors are on chip. Clere Electronics Ltd, 0635 298574.



BVM's 68030 multiprocessor system, the BVME380.

Darlington amp range. Eleven silicon-monolithic Darlington amplifiers, the HPMA-02XX/03XX/04XX/20XX/21XX series, come in two types of microplastic packages: the 85 – straight microstrip leads; 86 – bent leads for surface mounting. 21XX is also available in the SOT-143 package. The amplifiers act as flexible 50Ω building blocks. The 2185/86 offers highest gain at 18dB typical at 1GHz, the 0485/86 is top power handler with 12.5dBm typical output at 1dB gain compression. Hewlett-Packard Ltd, 0344 369369.

Fast-settling amplifier. The Elantec EL2029 monolithic amplifier aims for fast clean settling with millivolt accuracy; 0.01% from a 10V step in 200ns, with no thermal tail, input slew or overload penalties. It has low bias currents and large voltage gain, internally compensated for closed loop gains of five or more. Inputs handled up to 10V differential overload. Slew rate is typically 900V/μs, full power bandwidth is 5MHz. Output can drive up to 75mA, is current limited and can drive capacitive loads of up to 100pF. METL, 0844 278781.

Chopper-stabilised amplifier. Linear Technology's LTC1100 chopper-stabilised instrumentation amp has an offset voltage of 10μV, drift of 100nv/°C and a bias of 50pA. Gain linearity is 8ppm with a drift of 4ppm/°C. Output typically swings to within 300mV of the supply rails, with a 10k load. Voltage noise is 2μVp-p and CMRR is 104dB minimum. Micro Call Ltd, 0844 261939.

High-speed op-amp. The OP-160 will drive large capacitive loads without oscillation. It upgrades AD846, AD844 and EL2020 applications and conforms to the industry standard single op-amp pinout, available from stock in an 8-pin Cerdip and 8-pin plastic package. Precision Monolithics Inc, 0101 408 727 9222.

Monolithic wideband amplifier. The Si582 is a low-gain op-amp with a −3dB bandwidth of 180MHz. Current-mode feedback offers a transparent, high-performance alternative to conventional amplifiers. It also features low poser dissipation (typically 150mW), fast settling (0.05% in 12ns), and minimal signal degradation. Distortion is typically −60dBc at 20MHz, and gain flatness is within 0.4dB from DC to 50MHz. Siliconix Ltd, 0635 30905.

Memory chips

On-chip eprom. NEC's uP75P116 4-bit single-chip microcomputer is identical to its sister mask-rom version but with field programmable rom. Advantages of on-chip eprom include elimination of minimum order quantities and delivery delays associated with mask-rom devices. NEC Electronics (UK) Ltd, 0908 691133.

Microprocessors and controllers

Multi-processor 68030 systems. The BVME380 features a 68030 CPU with up to 4Mbyte of dram and a data and instruction cache. Bi-directional interrupts and on-board mailboxes provide data and control mechanisms. Up to seven CPUs are available, each running its own copy of OS-9 and communicating using the networking file manager. CPUs can access any I/O device, including disc storage. BVM Ltd, 0703 270770.

Single-chip controller. The 82C710 has a serial port, a bi-directional parallel port, PS/2 drives and a floppy disk controller. 24mA drive buffers eliminate external buffers. A uPD765 basis ensures compatibility with IBM Bios. An analogue data separator gives transfer rates up to 1Mbyte/s. 48mA floppy drive interface buffers are included. Two floppy drives can be directly supported. Katakana Ltd, 0628 75641.

IEEE 488 controller. The PATC process controller is of solid design and offers complete measurement solutions. Components are a CPU 80286/12MHz, 14in colour monitor, VGA graphics adapter, 40Mbyte hard disk, 1Mbyte ram, extended or expanded memory and more. Main memory can expand to 8Mbytes. Rohde & Schwarz UK Ltd, 0252 811377.

Optical devices

High-sensitivity coupler. A single-channel optically coupled isolator, the IS204, has a current transfer ratio of 100% at 1MA and a high DC breakdown voltage ±5000V. Packed in a 6-pin DIL plastic package, it offers a ratio of 400% at a forward current of 10mA, and will operate at −55°C to 100°C, using a gallium arsenide infrared emitting diode. Maximum ratings are 60mA forward, 6V reverse, 3A peak forward current, and a dissipation of 100mW. Milgray Distribution Ltd, 0788 543550.

Optoelectronic rotary pulse emitters. The Zivy ZR series incorporates four optoelectronic rotary pulse emitters designed for rough handling and electrical interference. A rotating slotted disc triggers the count or enables determination of direction of rotation (discriminator) and/or pulse multiplication. Each incorporates an amplifier and pulse shaper. Swissinco, 081 965 9505.

Programmable controllers

Remote relay control. The Isoplex 50 controls up to 16 relays via its RS232 interface and will mount on a standard DIN rail. Data integrity is boosted with checksum, message tagging and parity checking. Output relays are disabled during a fault. Baud rate is DIL switch selectable with odd, even or ignore parity on receive. Klippon Micro-Systems Ltd, 0732 460066.

Programmable logic array

Field-programmable gate arrays. The ATT3000 FPGA family, 0.9μm cmos technology, has maximum flip-flop toggle frequency of 140MHz with frequencies typically 50% maximum. Packages are PLCC, PPGA, CPGA, and PQFP, with 68 to 175 leads, 2000 to 9000 gates, and 64 to 144 inputs/outputs. AT&T (UK) Ltd, 0344 487111.

5ns PLDs. Five-nanosecond TTL-compatible devices, with standard packaging and corner power and ground pins, are being offered as drop-in replacements for 7ns PLDs, with industry standard 20- and 24-pin pal functions. 21% improvement in noise characteristics is promised. The 5ns PLDs are said to generate less noise than any 7 or 10ns device. Texas Instruments Ltd, 0234 270111.

Extended software cell. The TSC500 offers 25,000 gates and compiler memory allowing building of a flexible memory structure. Specific memory can be compiled and unique data sheet and models generated. The compile memory can generate sram up to 32,768 bits, clocked ram up to 65,536 bits and rom up to 262,144 bits. Texas Instruments, 0234 223252.

Power semiconductors

Power mosfets. The SMP7N60 and SMP4N60 in the TO 220 package are low on-resistance 600V power mosfets for high-voltage supplies and electronic ballasts. SMP7N60's (7A) 1.1Ω on-resistance and SMP4N60's (4A) on-resistance rating of 2Ω means cooler running greater reliability and smaller heat-sinks. Siliconix Ltd, 0635 30905.

PASSIVE

Passive components

SM inductors. Delevan series 1010, 1210, and 1818 compact inductors is designed for high-density surface-mount applications and is available in standard EIA package sizes. Reliability is increased with "J" terminations. Suitable for all soldering processes. Inductances from 0.010μH to 150μH. STC Mercator, 0493 844911.

High quality air coils. A series of microwave coils, providing precise inductance values, in materials such as gold, silver and copper, may be configured as spaced, coated or tinned, and alloy metal. The series offers multi octave performance, high "Q", low loss, controlled self resonance and mechanical stability. Teknis Ltd, 0344 780022.

PCB power transformers. Encapsulated light, small, high efficiency PCB toroidal power transformers, with power ratings from 15VA to 120VA, and two primary windings of 120V for series or parallel connection. Maximum operating temperature is 42°C; weight varies between 0.42Kg and 1.9Kg. All in thermally conductive resin within a nylon enclosure. Secondary voltages at each power rating are values frequently found in electronic circuit applications. Toroid Technology Ltd, 081 689 8002.

Connectors and cabling

Zip sockets for zigzag ICs. Augat's zip sockets for zigzag contact configuration ICs, have high-reliability gas-tight contact and protected entry for accurate alignment. Sockets are stackable end-to-end and side-to-side with tapered leads to allow easy insertion into a PCB. Insertion/extraction tool can be supplied. STC Electronic Services, 0279 626777.

Filters

Smaller bandpass filter. The DFC3R866P004 3-pole filter – 50% smaller than many current types with a resonator cavity width of 4mm and overall dimensions of 4.5 x 14.0 x 11.0mm – has a bandwidth of ±2MHz around a centre frequency of 866MHz. Maximum ripple is 0.5dB, VSWR is 2.0 and maximum insertion loss is 5dB, achieved through high-Q dielectric resonators. Surface mount versions will be available. Murata Electronics (UK) Ltd, 0252 811666.

Hardware

Waterproof housings. Polynorm ABS and polycarbonate waterproof boxes, manufactured by Rose and Rose of West Germany are obtainable in 18 sizes, from 80 x 80 x 60mm to 160 x 240 x 90mm. Halogen-free, both types are VO-self extinguishing, suitable for severe environments. Radiation Components Ltd, 081 891 1221.

Instrumentation

1-3GHz frequency counters. High speed R5361/5362 series of frequency counters span 0.2MHz to 1GHz (R5361) or 3GHz (R5362). An expanding/reciprocal system ensures fast frequency measurements at high resolution. The R5361 can measure 100MHz at 1Hz in 256ms, and the R5362, 1500MHz at 1Hz in about 1.7s. Both are TR1644 compatible with the calculation unit which evaluates, deviations and scaling of results. Advantest UK Ltd, 081 336 1606.

Programmable counter. Model 50 five-digit programmable counter and time-interval generator digital-panel-meter transforms frequency and rate inputs into engineering units. Time base can be jumper-programmed to read in any units of measure. Its seven segment, 0.56in LED display is crystal controlled (0.01% accuracy) with a programmable rate indicator and variable time interval generator. Three inputs can be accepted: +2.5 to 15V negative transition; and 10mV RMS to 20V RMS. Amplicon Liveline Ltd, 0273 570220.

Digital thermometer. The Therma 2 operates at −49.9 to +199.99°C with a 0.1°C resolution and repeatability. Accuracy is ±0.4%. £65.00 for instrument and probe. ETI Ltd, 0903 202151.

Logic comparator. Faster trouble-shooting of digital ICs while still in circuit is the aim of Bugtrap logic comparators. Two models, for TTL or cmos, compare the IC under test with a reference in the zero-insertion force socket. Any discrepancies will light an LED showing the faulty nodes(s), latching to capture intermittent faults. Emerson Electronic Equipment, 06285 28944.

Microwave synthesiser. The Systron Donner 1730B provides +10dBm of levelled output power from 0.01 to 26.5GHz and (+8dBm with step attenuator). Maximum output of +15dBm simplifies compression testing of components. Minimum of −100dBm eases testing of sensitive receivers. The internal direct digital synthesiser (DDS) allows phase to be adjusted: 0.1Hz resolution allows variation as slowly as 30°/s. Fieldtech Heathrow Ltd, 081 897 6446.

Intelligent panel meter. The DPM-24/MF is a 40 000-count instrument with a user-selectable display from −19999 to +99999, and some alphanumerics for menu programming. It has a built-in Ato-D unit and microcontroller. Universal power supply accepts 24-48V DC and 24-240V AC without tap changers or selector switches. ITT Instruments, 0753 511799.

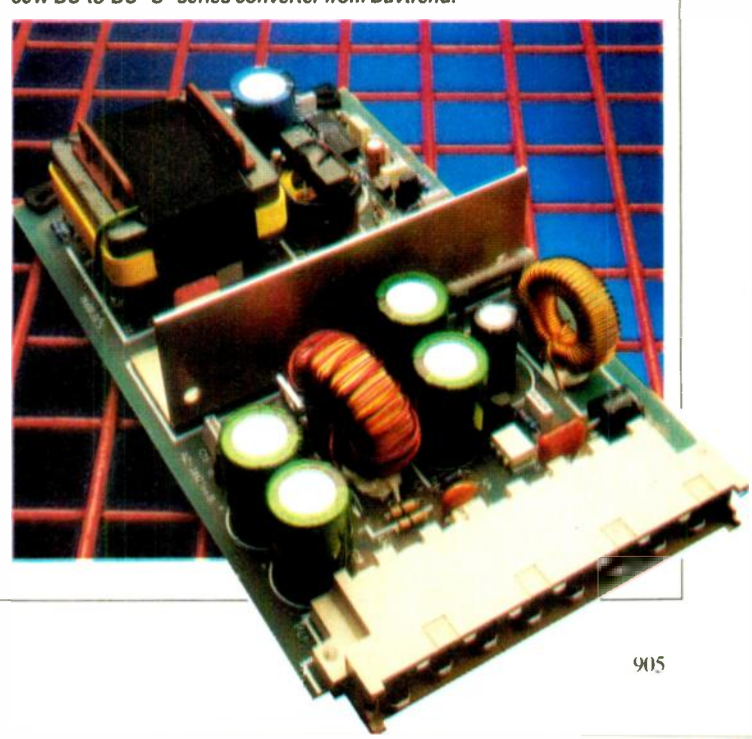
Multi-channel monitor. Real-time performance is promised with AT Codas and MCA Codas, compatible with AT and Micro Channel bus architectures. They support VGA monitors, and contain on-board A-to-D and D-to-A converters. 16 fast-changing analogue waveforms can be continuously monitored and recorded. While displaying waveforms, data can be recorded to disk. 50kHz maximum throughput rate. Keithley Instruments Ltd, 0734 575666.

First GSM test system. The first mobile radio test system for the Pan-European digital cellular radio (GSM) network, the 6151 GSM MS, is based on VXI-bus technology. Six plug-in modules housed in a C-size VXI chassis form a complete signalling and RF test system. A PC controller provides the user interface, Racal Instruments Ltd, 0734 782158.

Precision multimeter. Schlumberger's 7171 multimeter's two integral micro-processors replace a separate computer and test gear. Ultra-low-noise circuits operate at 100nV sensitivity on DC, 1μV on AC, and down to 1Ω using four-wire resistance. A pulse-width A-to-D converter helps provide high linearity and a basic accuracy of 0.002%. Eight programmes can be controlled from the front panel or its IEEE and RS232 interfaces. STC Instrument Services, 0279 641641.

PC-based digital oscilloscope. The B3160 digital oscilloscope for automatic measuring has two input channels with a bandwidth of 100MHz and a resolution of eight bits, and may be used to store and display repetitive signals. Sampling rates are 50μs to 50ms in three modes: real-time (low-frequency inputs), random sampling (higher-frequency and periodic signals) and tolerance band (check against limits). Siemens plc, 0932 752323.

60W DC-to-DC "S" series converter from Davtrend.



AC-measuring digital panel meter. The AC-powered UM-35AC 3 1/2 digit panel meter for power-line voltages is single-ended with provision to offset the zero of the reading being displayed. Two ranges are 199.9VAC and 500VAC with multi-turn, infinitely adjustable Span potentiometer and "Hold" of displayed reading. Screw terminal or PCB edge connector inputs. £35. Texmate Ltd, 0481 53131.

Programmable digital storage. The DSA 524 will convert oscilloscopes into digital storage oscilloscopes, linkable to a PC. Control of front panel status and bi-directional transfer of waveform data are provided by serial or optional IEEE 488 interfaces. Connection to 'scope is via a single BNC cable and to PC through the serial port. Special interface cards not required. Thurlby-Thandar Ltd, 0480 412451.

Interfaces

336-line I/O card. A full-length TTL I/O card, PC/AT compatible, uses seven 82C255 devices (two 8255s in a single 64-pin "shrink DIL" package) to provide 336 programmable lines using one PC slot. 8255 programming modes are supported. Cmos based. Selectable addresses allow two cards to provide 672 lines. 8253 counter/timer included. £299. Fairchild Ltd, 042121 6527.

Compact amplifier module. The S7DC amplifier is DC-operated, accepting ±10 to 18V or 20 to 36V. It will excite a remote transducer over an adjustable 3 to 10V. Full transducer signal conditioning of zero and scale. Output is available as ±5, ±10V full scale or 4-20 mA over a frequency bandwidth of 0 to 100Hz. RDP Electronics Ltd, 0902 57512.

PC bus interface. The SYN-NCM5 board is a PC bus interface for Topaz local area network systems, allowing PCs to integrate into the distributed system on the Topaz network. It plugs into the expansion bus, short slots, and allows the PC processor to access all on-board devices while occupying 32 bytes of system I/O space. Integral Manchester Encoded RS485/RS422 interface. Syntel Microsystems, 0484 519363.

Power supplies

UPS for PCs. The MP5's 500VA output could drive two PCs, a printer, a small cad station or call-connect telephone exchange and a small fax machine. 230V 50Hz input outputs 230V at 50Hz from two 13A sockets. Sine wave output has less than 3% THD with a resistive load and a load crest ratio of 3:1. Noise at 1m is 40dBA. 44.5 x 14.3 x 19cm, 13kg. £600. Avel-Lindberg Ltd, 0708 853444.

Single/triple output converters. Bulgin Power's DC40F Eurocard (100 x 160 x 30mm) DC-DC converters, single and triple outputs, are designed for nominal 24V (20-30V DC) or 48V (40-60V DC) applications. Models span 5V, 12V, 24V and 48V outputs and triple output units feature 5V with two 12V auxiliaries (fully floating). Eurocard screw terminals, chassis-mounted screw terminals, or chassis-mounted screw terminals with cover. Cirkit Distribution Ltd, 0992 444111.

Universal power supply. The six single-output models in the EWS range, 25 to 1500W, offer high specification relative to cost, universal inputs for all input voltages in the lower output models, and auto-selector on high input. Common supply for all products. Meets UL, CSA and VDE. Coutant-Lambda Electronics Ltd 0271 863781.

Converter for telecoms. The "S" series DC to DC converter, BTR 2511 approved 3U Eurocard or TEP 1E format, offers 60W over three outputs; 5V and ±12 or ±15V. Others can be provided. It will operate from nominal 12 to 50V. One output can offer switch-on surge capability of 40W peak for 50ms. Less than 3W required at no load, switching frequency 80kHz, nominal efficiency of 80%. Davtrend Ltd, 0705 372004.

Programmable voltage reference. The LT1431 programmable voltage reference produces a stable 5V reference. With two external resistors it can be programmed to any reference between 2.5V and 36V. Guaranteed initial voltage tolerance of 0.4% and temperature stability of 0.3%. On-chip divider resistors allow configuration as a 5V shunt regulator with 1% initial voltage. Linear Technology (UK) Ltd, 0932 765688.

On-line UPS. Pioneer's On-Line UPSs are PWMs providing a stable and interference-free source of power. Three tower units — 1kVA, 3kVA and 5kVA – have static bypass protection connecting mains input through to load after a fault or overload. Standard equipment includes battery status indication and voltage-free contact outputs for remote status. Quadshield Ltd, 0908 222050.

Radio communications products

Broadband circulator. Type 2722 162 05991 is not limited to a preset frequency or frequency range, needing no tuning by the customer. It simplifies tuning of the final transistor amplifier stages, decoupling the transistorised drivers from the final valve output stage of the transmitter, thus protecting transistors from power reflected from valves. Output 50W, insertion loss 0.8dB VSWR 1.3, and isolation better than 18dB across temperature range of −10 to +50°C. Philips Components, 010 31 40 72 43 24.

Transducers and sensors

Multilayer ceramic actuator. Electrostrictive actuators for precision displacement monitoring based on multilayer ceramic technology. Advantages over piezoelectric and magnetostrictive counterparts are said to be repeatability of movement and cost. AVX Ltd, 0252 336868.

COMPUTER

Data communications products

Datacom card for IBMs. The Radacs RLC-100 radio data link controller is a 3/4-length PC/XT/AT card enabling communication with many outstations. It operates the AX.25 packet radio protocol using TheNode driver software running under dos and supports four separate radio channels. Software remains in background. CMT Ltd, 0908 690690.

Message-processing software. The RF-6500 uses an adaptive ARQ protocol with forward-error checking (FEC) for accuracy at rates up to 2400bps in poor conditions. FED coding adjusts dynamically to match quality. When transmission errors increase, it switches to more powerful FEC. As conditions improve, less powerful FEC maximises throughput. Error-free delivery shown with rates as high as one error in every five bits. Harris Corporation, 0101 (716) 244 5830.

Development and evaluation

M50734 designers' board. The M50734 designers' board, based on the M50734SP extended microprocessor, can evaluate and initial design all 740 series. It can connect to the target via I/O interfaces. Software loaded from the host system can be debugged. Board includes microprocessor, 8k of ram with battery back-up and 16k eprom containing the monitor programme, reset circuit and watchdog timer. RCS Microsystems Ltd, 081 979 2204.

Mass storage devices

Dat storage for PCs. Digital audio tape (dat) technology is used in the QA-600 large-capacity tape backup system: 600Mbyte of storage in a compact package. The system combines an intelligent controller with the Systos operating system, and is the first dat offering to fit the standard PC AT-style chassis. HTEC Legend Ltd, 0703 581555.

Computer peripherals

SCSI-interface disk drives. The FD235 3.5in intelligent drive has 2Mbyte or 4Mbyte storage capacity using barium ferrite-coated extra density disks. 105 x 42 x 162mm, weight 500g. Operating from +5V DC supply, maximum consumption is 1.75 to 2.0W, standby 0.35 to 0.4W. FD55 5.25in version has 1.6Mbyte capacity, 146 x 43.8 x 203mm. Multi-format capabilities ensure compatibility with other standards from 250k upwards. +12 or +50V DC, power consumption 4.4W operating, or 1.4W standby. Data Peripherals (UK) Ltd, 0785 57050.

Software

Icon-driven data acquisition. Easytest data acquisition and analysis software, PC-compatible, integrates analogue and digital acquisition and control, analysis, and flexible graphics. Easy-to-use icon interface. A powerful sequencer automates for high productivity. Utilities for common needs are built in. Data acquired at rates up to 110 000 samples per second (65,000 samples/s direct to disk). Keithley Instrument Ltd, 0734 575666.

PCB cad for PCs. Pads-2000 claims to be the most powerful PCB PC cad system available. Running on 80386 and 80486 machines in virtual memory it overcomes the limits of MS-Dos and is thought to be the first 32-bit PCB cad system for the PC. Layouts up to 4000 ICs, its resolution allows users to define features to an accuracy of 0.000001in or 0.001mm. Lloyd Doyle Ltd, 0932 245000.

Real-time operating system. The

Data acquisition and analysis software. Easytest by Keithley.

OS-9000, optimised for I/O intensive applications, supports file sharing, secure archival procedures and multi-node transparent networking. Its I/O Manager co-ordinates all data transfers. Hardware-dependent and independent modules are isolated, simplifying installation and minimising memory requirements. Networking capabilities allow the OS-9000 to act as a real-time front end. Microware Systems (UK) Ltd, 0489 886699.

Spice amplifiers. Instrumentation amplifier and low-noise amplifier Spice models OP-177 and OP-77 op-amps are said to be the first to perform complete noise analysis simulations, simulating broadband noise and 1/f noise for voltage and current noise. Precision Monolithics Inc, 0101 408 727 9222.

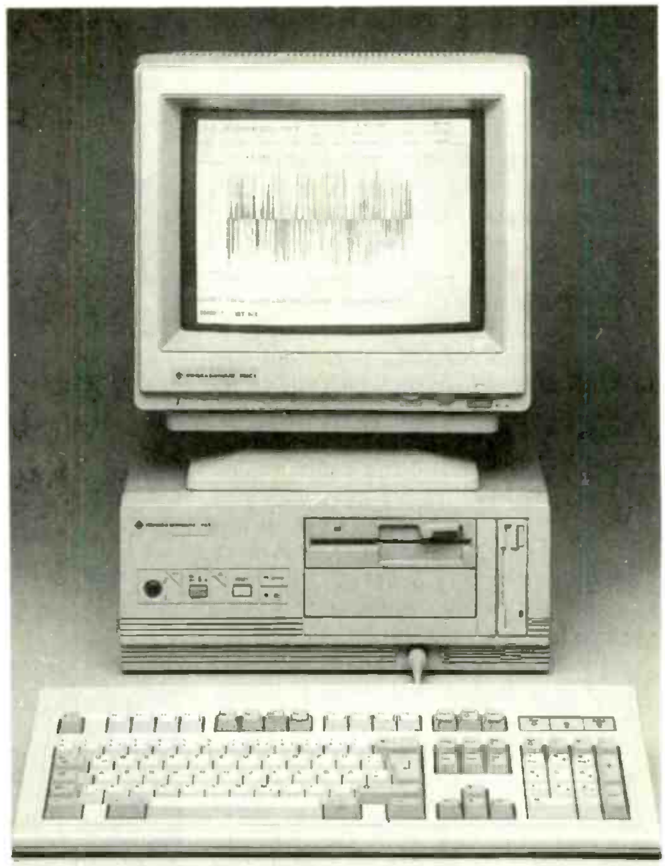
Computer board level products

Output card safety. All outputs on the DOP-24 digital output card set to either "on" or "off" after switch-on or power failure should ensure safer machinery. 24 opto-isolated Darlington drivers allow voltages up to 24V at 400mA to control relays and solenoids. Base address can be set and several cards can fit into a PC. Signals terminate on a 50-way connector. £195.00 with documentaion and example programmes. Blue Chip Technology, 0244 520222.

IEEE-488.2. The NAT4882 C-mos 68-pin plastic leaded chip carrier increases performance of GPIB controller chips NEC 7210 and TI 9914, maintaining compatibility with both. Its enhanced command set reduces software driver overhead and code size. It has both 7210 and 9914 compatibility modes. National Instruments, 0635 523545.

Computer systems

Unix workstations. R200 Unix workstations are based on the ARM 3 second-generation high-speed risc processor with embedded cache, delivering 10+Mips for less than £5,000. 8Mbyte ram expandable to 16Mbyte. 100Mbyte (formatted) fast-access internal SCSI hard disk. The diskless R2 provides 4Mbyte of ram as standard, expandable up to 8Mbyte. Both have a 4Kbyte embedded cache. Acorn Computers Ltd, 0223 24520.



Process controller by Rohde & Schwarz, the PATC.

PIONEERS

46 W.H. Eccles 1875–1966 The first physicist of wireless

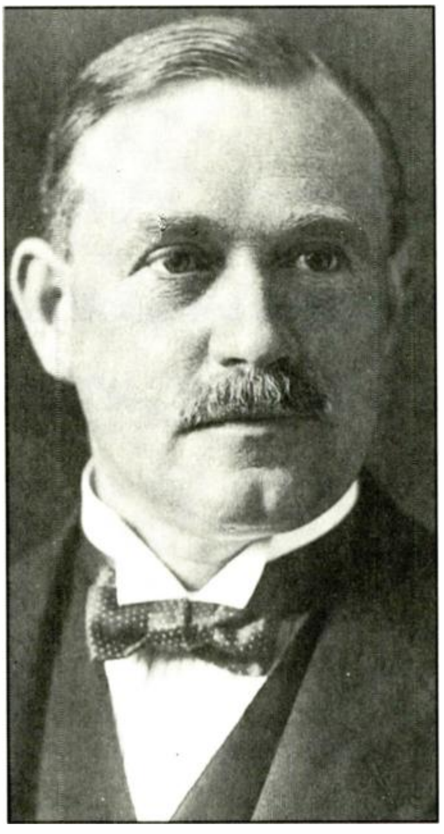
These days, the name Eccles brings to mind the widely used Eccles-Jordan multivibrator or flip-flop circuit — trigger relay, as they called it in 1919. So it is a little surprising that in a 1965 *Wireless World* article which commemorated Eccles's 90th birthday and in an obituary published in the journal *Nature*, no mention was made of the Eccles-Jordan circuit. So notable were his other contributions, mostly to the science of wireless, that there was no room for the circuit which still bears his name.

That name was one to conjure with in the first quarter of this century, said *Wireless World*, "in the more elevated radio-technical circles."[1] His most significant work, it added, "was on a subject at the very heart of our affairs — on radio wave propagation." This referred to his early explanation of the origin of the Heaviside layer. His other contributions included those to short-wave radio, radio broadcasting, the study of coherers, and the proposal of what became the standard names for valves: diode, triode, etc. *Wireless World*, the article said, could "blush with shame" for having stigmatised this proposal as "too academic".

William Henry Eccles was born near Ulverston, near Barrow-in-Furness, on the 23rd August 1875, the son of Charles Eccles, a blacksmith and later an engineer, and his wife Annabella. He died aged 90 on the 29th April 1966.

"Because of many small illnesses in childhood his early education was largely at home," Eccles later wrote about himself[2]. His father taught him about thermodynamics and steam engines, and structural steelwork, which came in useful years later when he came to erect steel radio masts. A more conventional education at a private school won him a national scholarship to the Royal College of Science (now Imperial College) at South Kensington, London, where he graduated in 1898 with a first-class honours degree in physics. Although he once described metallurgy as his first love, his skill as a physicist was to lead to his being regarded by many as the first wireless physicist.

For a short time, he worked as a demonstrator at the college and attended some City and Guilds lectures on electrical engineering. These electrical lectures introduced him to radio telegraphy right at the start of the wireless age. In 1899 he joined the select band of assistants to Guglielmo Marconi.



He stayed with Marconi for less than two years, designing and building oscillation transformers, or "jiggers" as they were called, and he "lent a hand", to use his own words, with the design of the towers for the famous transatlantic transmissions from Poldhu in Cornwall. Much of his time, however, was spent at Poole in Dorset at the Haven Hotel, where Marconi had set up an experimental radio station. It was there that numerous demonstrations were given to potential customers.

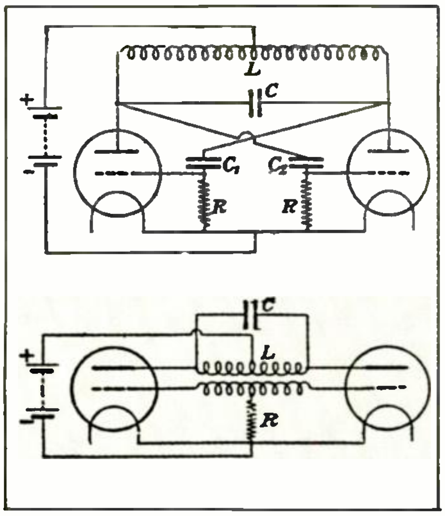
After leaving Marconi, Eccles spent a short time with a firm making AC machines before becoming the head of the Department of Mathematics and Physics at the South Western Polytechnic, Chelsea, in about 1904. This was his entry into a career in higher education which was to last until his retirement. In 1910, he was promoted to Reader in "Graphic Statics" (structural engineering design) at University College, London, where he also lectured on the theory of machines and the theory of structures.

He moved again in 1916, this time to the City and Guilds College, Finsbury, as Professor of Applied Physics and Electrical Engineering. At the age of 51, after a severe illness, he retired to become a private consultant. He was still being consulted when he was in his eighties.

Radio research

His first research into radio was to make some scientific sense out of the behaviour of coherers, those enigmatic radio detectors used in the first years of radio telegraphy. His success earned him a Doctor of Science degree from the University of London in 1901. This study of coherers was extended into a comprehensive study of crystal detectors and from there into all technical aspects of wireless. As the Dictionary of National Biography puts it, "Eccles was in close contact with nearly every aspect of the subject, as research worker, member of advisory committees, president of learned societies, writer of articles and textbooks, patentee and expert witness. For many years he was the leading (and almost the only) independent physicist working in the field of radio science.[3]"

One spin-off from his crystal-diode research was the crystal oscillator. In about 1909/10, he discovered ways of making crystal detector circuits oscillate and suggested that "under certain conditions a rectifying detector could become a generator of oscillations and conversely a generator of oscillations could be used as a rectifier." One



1. Circuits from a one-page report, "A Method of Using Two Triode Valves in Parallel for Generating Oscillations," **The Electrician,** ***19th September 1919. Starting with a single-triode oscillator, Eccles and Jordan explained how two triodes could be used to produce oscillations with their anode circuits connected directly, inductively, resistively or capacitively.***

writer has over-enthusiastically suggested that Eccles could therefore be regarded as the grandfather of the transistor. In fact, Eccles had discovered that a contact between two pieces of galena could produce a negative resistance and that, as with electric arcs, this could generate oscillations. He did not have a prototype transistor, but he may have had a very early tunnel diode.

When the triode began to gain wider use, just before WW1, Eccles was soon studying its applications. It is said that he was one of the first to represent its action algebraically in terms of the self- and mutual-conductances of its electrodes (1919/20) and he used the triode in a variety of circuits[2]. It was during this work that the Eccles/Jordan multivibrator was invented. Several circuit configurations seem to have been studied "for obtaining various types of continuously acting relay," and patents were taken out by the Admiralty in 1918. This would imply that the work was performed under Admiralty contracts during the war. Because of his Quaker beliefs, it is said, Eccles was himself reluctant to patent his inventions.

Eccles and Jordan did other fascinating work for the Admiralty. In unpublished memoirs, Eccles recalled the use of a triode to sustain the vibrations of a tuning fork. This work, published in 1919, began in 1914. The aim was to use the harmonics of a vibrating tuning fork to evade a Telefunken patent which "covered all forms of back-coupled triode circuit and dominated the future of radio" — an interesting nicety, considering the patent was held by a foe. The result was "a generator of remarkable constancy," which when "combined with a phonic motor" gave a "precision clock." This precision clock was then combined with a known method of picture transmission to give, in 1918, "a secret method for the transmission of naval signals.[2]"

Another Eccles-Jordan idea was to connect two triode oscillators to produce wavelengths as short as seven metres using ordinary receiving triodes. "The apparatus was invented in 1916 at the request of the War Office and the patent was later bought by the Marconi Company and used in their short-wave beam stations," wrote Eccles[2]. A separate account refers to a 60MHz short-wave transmitter designed by Eccles in 1915 and tested by the French Army for short-distance work. The signals were picked up in Syria and may have been the first indication of the long-distance possibilities of short-wave radio.

Bending round the Earth

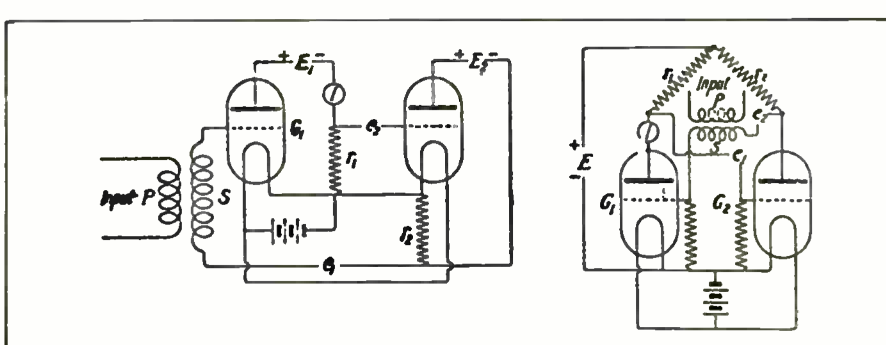
Eccles's "most significant work" was his attempted explanation of how radio waves may be reflected by a conducting layer in the upper atmosphere and so travel round the curvature of the earth. This had been independently suggested in 1902 by Oliver Heaviside and by A.E. Kennelly following Marconi's success in signalling across the Atlantic. Eccles is credited with the first serious attempt to explain how this reflection may occur.

In 1912, he presented a paper to the Royal Society in London "On the diurnal variations of the electric waves occurring in nature, and on the propagation of electric waves round the bend of the Earth." Before trying to obtain an explanation of the events, he first needed to obtain reliable experimental data, which was not easy. He turned to naturally occurring atmospherics or "strays" as they were then called and, with the help of a colleague, "strays" were recorded at London and Newcastle. Many were discovered to occur simultaneously and to have similar relative strengths. He concluded that they originated several thousand kilometres away. Also, he pointed out that "strays" were generally weaker and fewer during the day than the night, and that there was usually a lull just before dawn.

Eccles commented, "The result is so completely inexplicable by the ordinary conception of the propagation of electric waves through the atmosphere that we are compelled by its refusal to fit into the accepted scheme of things to attempt an extension of that scheme.[2]" He then expanded the Heaviside/Kennelly concept and calculated many of the necessary parameters. He assumed air, ionised by sunlight, to be the agent responsible for "bending" the waves around the Earth's curvature.

Eccles' detailed theory sparked considerable controversy. Though incomplete and, in places, a little confused it became widely accepted, especially after supporting evidence was obtained during a partial solar eclipse. It provided the basis for the later fuller theory put forward by Edward Appleton and others.

Soon after this period came the First World War. As one of the few people with a sound scientific knowledge of



2. Circuits from the **Radio Review*****, December 1919, showing a "trigger relay" or triggered bistable. A pulsed input to triode one would switch it on, causing triode 2 to switch off. The circuit was then stable until reset. The reset method suggested was "to interrupt for an instant the linkage between the tubes, or to stop the operations of one or both of the tubes, as, for instance, by dimming its filament."***

wireless, Eccles was called upon to serve his country as an adviser to all the military branches and was honorary secretary to the Conjoint Board of Scientific Societies. After the war he continued to serve in areas of public and political concern related to the rapid expansion of radio. These included Imperial communications, public broadcasting, and the relative functions of government, industry and amateurs.

Shakespeare

In 1924, at nearly 50, he married his secretary, Nellie Florence, nearly 20 years his junior; they had no children. Throughout his life, he is said to have enjoyed music, especially Beethoven, and he loved Shakespeare. Hardly a day went by, so it was said, when he did not quote from Shakespeare. He preferred walking, riding, swimming and sailing to organised sports and "kept a small sailing boat in the Thames estuary for use in summer and a horse near town for winter.[2]" Once he was ordered to take up golf for medical reasons, a doctor's order that many men would pay to receive. Eccles grew bored with the "waste of time" and "gave his clubs away within a month or two.[2]"

He served as president of many societies, including the Institution of Electrical Engineers, the Institute of Physics and the Radio Society of Great Britain. He was even on the committee that set up the forerunner of the RSGB in 1913, the Wireless Society of London. He wrote three books: two of the earliest authoritative texts on wireless and a popular treatment published in 1933. That he is now remembered almost entirely for having his name attached to half of a simple but popular circuit really does not do justice to a man of vision and perception who helped to steer radio through its early years.

Publications by Eccles and Jordan

"A method of using two triode valves in parallel for generating oscillations," *Electrician*, Vol. 83, 299, 1919.

"A small direct current motor using thermionic tubes instead of sliding contacts," *Electrician*, Vol. 82, 670, 1919.

"Sustaining the vibration of a tuning fork by a triode valve," *Electrician*, Vol. 82, 704, 1919.

"A trigger relay utilizing three electrode thermionic vacuum tubes," *Electrician*, Vol. 83, 298, 1919, and *The Radio Review*, 143, December 1919.

"A method of amplifying electrical variations of low frequency," *Electrician*, Vol. 85, 176, 1920.

References

1. H.F. Smith, "The Indefatigable Dr Eccles," *Wireless World*, September 1965, p. 436.
2. "William Henry Eccles, 1875–1966," Biographical Memoirs of the Royal Society, Vol. 17, November 1971.
3. "Eccles, William Henry," Dictionary of National Biography, 1961–1970, p.322.

F.W. Jordan

Biographical information about F.W. Jordan has proved elusive. As the police might say, any information which would assist our enquiries would be gratefully received. ■

Peel on a PC without pain

Gould's Peel development kit can produce complete custom logic devices on a PC. Is it difficult to use? No, says Stephen Franks, at least not when you know how

The Gould Peel development kit sets out to be a complete "personal PLD workstation", and certainly contains all that is needed to perform this function. Only Peel devices can be programmed (although other types can be read), so the hardware is kept simple and therefore inexpensive.

However, that does mean the user is limited to one type of device, whereas a dedicated PAL programmer (or add-on to an eprom programmer) will allow the selection of the best type of chip for the job. Even among EPLDs, not all types are interchangeable.

But anyone with a knowledge of fusible-link pals will be able to benefit immediately from the Peel kit, which is roughly comparable in price and performance to others on the market. The kit can also be made use of with little or no knowledge of pals, but be prepared to work hard while learning about the use of programmable logic: the data sheets are very comprehensive and with some effort can provide all the information required.

Easy installation

Installing the programmer could not have been made easier. The card does not have any jumpers or switches to set, and simply plugs into any free slot in the PC. It only uses I/O addresses 258H and 259H, so is unlikely to conflict with anything else, but the addresses cannot be changed if there is a clash.

The ribbon cable is a little short (presumably dictated by the speed and number of connections), so that it can only comfortably be used with desktop PCs.

Software is equally simple to install. A self-install program creates a Peel subdirectory, copies in the files, and asks a few questions to configure the program. These settings, plus several others, can be changed at any time using menu selections.

There should be no need to alter the CONFIG.SYS or AUTOEXEC.BAT files. Hard drives must be C:, D: or E:, but it is a simple matter to copy files if you wish to use a drive letter greater than this.

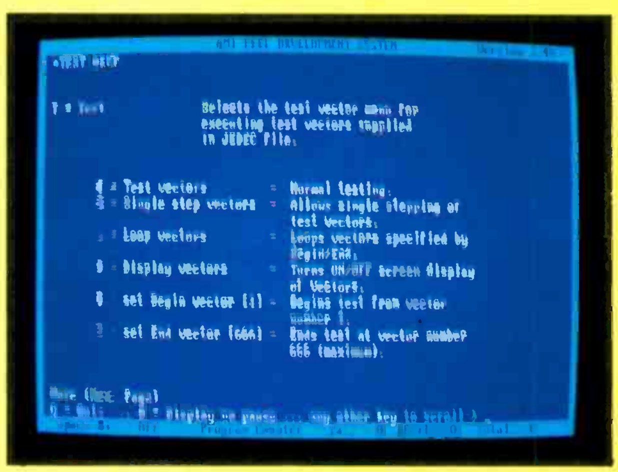
One word of warning: unless you want your colleagues to think you are playing games, turn the sound off. Various noises accompany different actions, and unless your PC is equipped with a volume control you may get accusing stares from all around.

Anti-static measures are necessary. Neither the main manual nor the data sheets mention this, although both the PC card and the sample chips arrive in conductive packing.

Friendly software

The software is extremely easy to use. I found I could use all the features of the system without recourse to the manual. The various functions are grouped into device-related tasks, Jedec file-related tasks, and general utilities.

The Peel editor will be familiar to WordStar users.

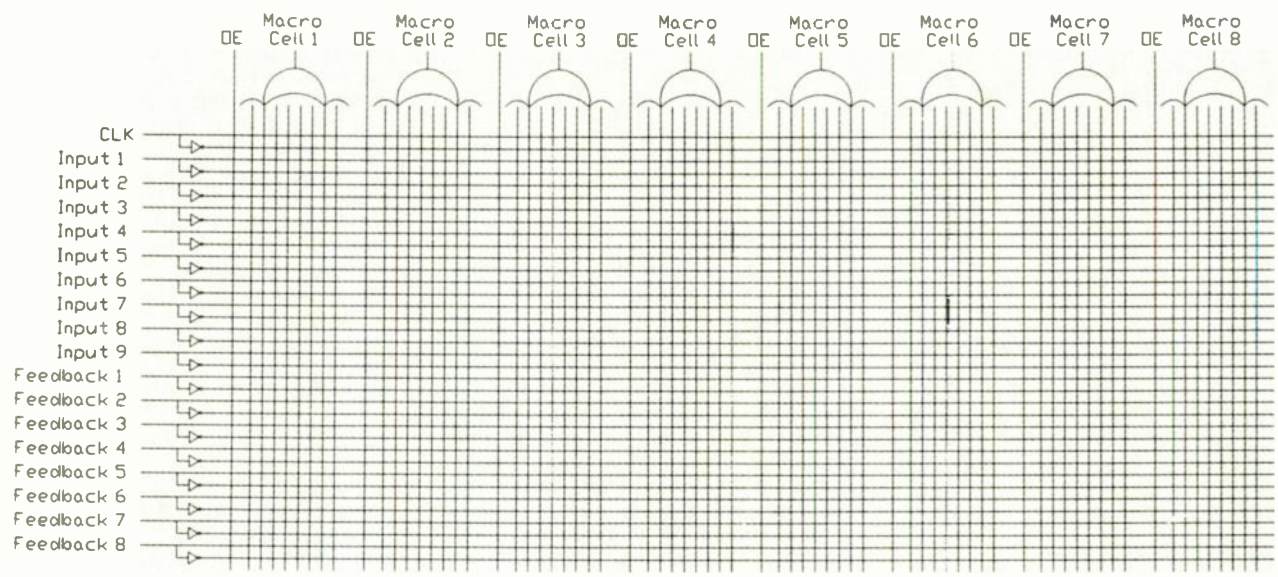


Help screens make software easy to use.

Device tasks: Device tasks are as expected: program device from memory, read device into memory, verify device with memory, and test device. There is a separate utilities menu that contains lesser-used facilities such as setting the security bit, or erasing the entire device.

The program function automatically erases the chip first, and the complete erase-program-verify takes only a few seconds. The "read chip" option can cope with a wide range of devices, so that it is possible to take an existing pal and copy the logic onto a Peel chip.

The test function can be used in several modes. Apart from simply applying the test vectors and indicating the results, vectors can be applied repeatedly (but note that connection to an oscilloscope or logic analyser requires an isolated ground). There is also a single-step mode, and the ability to capture all outputs from the chip,



'AND' Matrix

EEPLDs

Electrically erasable programmable logic devices (EEPLDs) marry fusible-link pals with electrically erasable prom technology, to provide a reprogrammable chip set that is pin-compatible with all the common pal range. Several manufacturers offer eeplds, and the technology has matured sufficiently for there to be second-source agreements.

Gould's Peel chip set is one of these families of EEPLDs. Each of the Peel devices can emulate several common pals, and can also offer extra configurations not available in the fusible-link chips. Despite being constructed in c-mos, the propagation delays are low enough for most applications, and the 18CV8 is available in 25ns and 15ns versions.

While there are many members of the family, the Peel 18CV8 is one of the more popular devices. It has nine general-purpose inputs, a clock input, and eight "macro cells", each driving a bidirectional I/O pin. Each macro cell can be individually assigned one of 12 configurations, compared to four available with a standard pal.

Inputs to the macro cells are programmed to be a logical function of any of the input, clock, and feedback terms. The logical function required should be expressed as a "sum of products" (with a maximum of eight products), so that the matrix can be programmed as required. More advanced programming software can rearrange the Boolean equations for you if required.

Because of the latches in the macro cells, it is impossible to discover how a device has been programmed simply by applying inputs and observing the outputs. As part of the programming function, chips can be read to verify that they have programmed correctly, but once this is done the read function can be disabled. This prevents copying, but does not prevent the device from being erased completely so that it can be used again.

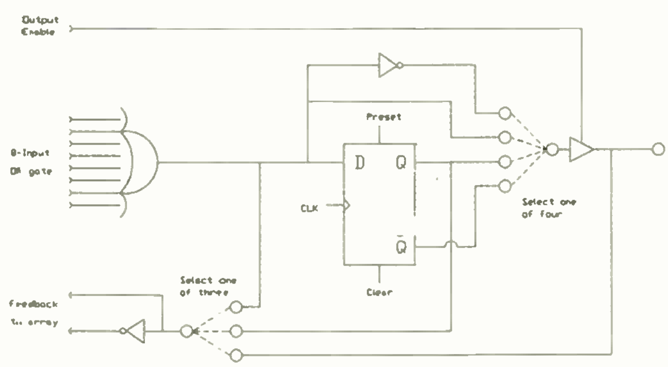
There is more to programming these devices than eproms. You cannot express the desired function as a simple list of 1s and 0s, and so the Jedec file standard was created to unify the description of the links to be made (or fusible links blown).

Normally you do not access such a file directly (although they are readable text files), but they are interchangeable between almost all logic programmers, and are the output files of logic "assemblers" or "compilers", which can be bought separately.

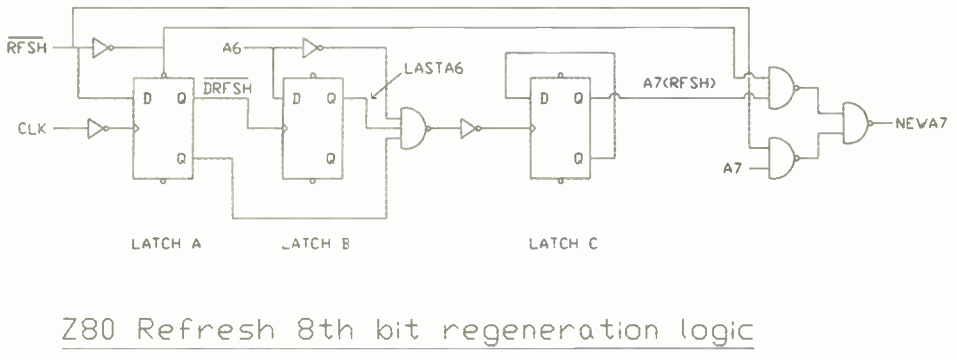
The Jedec file not only contains programming information, but can also incorporate test vectors, which can be used to test the programmed chip. These consist of a sequence of inputs — 0, 1, clock or don't care — and the expected outputs — 0, 1, high impedance or don't care.

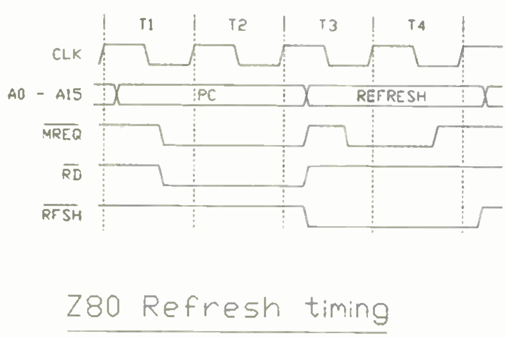
Most programmers can also apply the vectors to a simulation of the design based on the Boolean equations, so you can be sure that a correctly programmed chip will pass the test.

Another common programmer feature is "fault grading", a measure of how well vectors will perform, expressed as a percentage of the faults they will discover, compared to all possible faults.



Macro Cell





Z80 refresh circuit and timing.

Test design

To test the development kit, I used a piece of logic I have implemented in a number of real designs, and fitted it into (part of) an 18CV8 chip. The circuit shows logic that overcomes a drawback of the Z80 processor when driving dynamic memory. The Z80 generates refresh cycles, but only provides a 7-bit refresh counter, while most dram chips require 8 bits. The circuit generates the eighth bit, and gates it with the appropriate Z80 address bit to make it appear as if the Z80 had produced it. The circuit as drawn can be simplified, although the method depends on what spare gates are available from other functions.

Briefly, the circuit works as follows. Latch A controls the timing, and ensures the circuit only works during refresh cycles. Latch B holds the state of A6 from the previous refresh cycle, and latch C is toggled only if A6 is currently '0', but was '1' in the last refresh cycle. Thus latch C behaves as if it were the next most significant bit of the Z80's refresh counter.

To program (part of) a pal to do the same job, consider the circuit as a state machine. The action of latch A needs modifying slightly because there is no asynchronous preset available. It would be possible to use the asynchronous clear, but this line feeds all latches, and might upset another function of the chip.

Instead, the latch is only kept low for one clock cycle, and then allowed back high. The effect on output is to allow A7 to change slightly earlier than the other address lines during a refresh cycle, but this is unimportant when using drams.

So latch A, normally high, must go low on the next clock edge after $\overline{\text{RFSH}}$ goes low, and must go high one clock cycle later. The input to latch A is:

($\overline{\text{RFSH}}$ OR !DRFSH).

For latch B, remember that the clock input drives all the latches in the chip. Whenever latch A is high, the output of latch B must remain unchanged, written:

($\overline{\text{DRFSH}}$ & LASTA6)

even those given as "don't care".

Jedec file tasks: Jedec file tasks allow Jedec files to be read, written and displayed. There are also options for translating the file for another device, calculating the checksum, and transmitting or receiving files. No explanation is given of the format used for transmission, which might be plain text or some proprietary protocol that will only work between two machines running Peel software.

General utility tasks

The editor: A WordStar-compatible editor comes with the package and, despite being free, contains many sophisticated functions, such as a split-screen option to allow two windows into the file being edited. The editor accepts WordStar commands, or can be used with a menu accessed with F10.

The only flaw in the editor is that block operations will handle only whole lines of text, so it is impossible to move, copy or delete a block containing part of a line. This is particularly noticeable when entering test vectors which, by their very nature, contain much repetition. This apart, the editor is more than good enough.

Apeel assembler: The development kit has many functions, but it is the Apeel assembler on which most users will concentrate, allowing the logical function required of the pal to be entered in readable form. The assembler can then create a Jedec file to program the device.

Its basis is Abel and, although simple in comparison, is perfectly adequate. Its simplicity could even be an advantage, because designs can be optimised by considering how the equations map onto the device. However, a complex design could be speeded up by using Abel or similar.

Apart from assembling the source file, the assembler allows design simulation. Test vectors must be included in the source file, supplying input sequences and the expected outputs.

A set of test vectors need not test the entire device, and it is possible to include multiple sets to check each part of the design in turn. "Don't care" and high-impedance states are fully supported.

Provided you have tested the design, you are offered the option of "grading" your test vectors — calculating the percentage of faults that your vectors will discover, compared to the theoretical maximum.

Often it is difficult to devise vectors that can test for all possible faults, and the software provides comments on

"Ready to program" menu.

```
TITLE 'Z80 Refresh bit 8 generator
DESIGNER: sf
DATE: 27/3/90'

Z80RFSH DEVICE PEEL18CV8

"DESCRIPTION
"                      PEEL18CV8
"                      ___  ___
"                     |   \/   |
"            CLK  ( 1       20 )  Vcc
"          RFSH\  ( 2       19 )  DRFSH\
"         BUSAK\  ( 3       18 )  LASTA6
"             A7  ( 4       17 )  A7RFSH
"             A6  ( 5       16 )  NEWA7
"                 ( 6       15 )
"                 ( 7       14 )
"                 ( 8       13 )
"                 ( 9       12 )
"            Gnd  (10       11 )
"                 |____________|


"PIN ASSIGNMENTS

 CLK      pin 1
 RFSH\    pin 2
 BUSAK\   pin 3
 A7       pin 4
 A6       pin 5

 DRFSH    pin 19 = pos reg feed_reg
 LASTA6   pin 18 = pos reg feed_reg
 A7RFSH   pin 17 = pos reg feed_reg
 NEWA7    pin 16 = pos com feed_or

EQUATIONS

 DRFSH\  :=  RFSH\ # !DRFSH\
 LASTA6  :=  (!DRFSH\ & A6) # (DRFSH\ & LASTA6)
 A7RFSH  :=  (!DRFSH\ & !A6 & LASTA6 & !A7RFSH) #
             (!LASTA6 & A7RFSH) # (DRFSH\ & A7RFSH) #
             (A6 & A7RFSH)
 NEWA7    =  (A7 & RFSH\) # (!RFSH\ & A7RFSH)
 Enable NEWA7 = BUSAK\

TEST_VECTORS

([CLK, RFSH\, A6, A7, BUSAK\] -> [DRFSH\, LASTA6, A7RFSH, NEWA7])
 [C,   1,     0,  0,  0     ] -> [X,     X,      X,      Z]
 [C,   0,     0,  X,  1     ] -> [L,     X,      L,      L]
 [C,   0,     0,  X,  1     ] -> [H,     L,      L,      L]
 [C,   1,     X,  X,  1     ] -> [H,     L,      L,      X]
 [C,   0,     1,  X,  1     ] -> [L,     L,      L,      L]
 [C,   0,     1,  X,  1     ] -> [H,     H,      L,      L]
 [C,   1,     X,  X,  1     ] -> [H,     H,      L,      X]
 [C,   0,     1,  X,  1     ] -> [L,     H,      L,      L]
 [C,   0,     1,  X,  1     ] -> [H,     H,      L,      L]
 [C,   1,     X,  X,  1     ] -> [H,     H,      L,      X]
 [C,   0,     0,  X,  1     ] -> [L,     H,      L,      L]
 [C,   0,     0,  X,  1     ] -> [H,     L,      H,      H]
 [C,   1,     X,  X,  1     ] -> [H,     L,      H,      X]
 [C,   0,     1,  X,  1     ] -> [L,     L,      H,      H]
 [C,   0,     1,  X,  1     ] -> [H,     H,      H,      H]
 [C,   1,     X,  X,  1     ] -> [H,     H,      H,      X]
 [C,   0,     0,  X,  1     ] -> [L,     H,      H,      H]
 [C,   0,     0,  X,  1     ] -> [H,     L,      L,      L]
 [C,   1,     X,  X,  1     ] -> [H,     L,      L,      X]
 [C,   1,     X,  0,  1     ] -> [H,     L,      L,      L]
 [C,   1,     X,  1,  1     ] -> [H,     L,      L,      H]
 [C,   0,     0,  X,  1     ] -> [L,     L,      L,      L]
 [C,   0,     0,  X,  1     ] -> [H,     L,      L,      L]
 [C,   0,     0,  X,  1     ] -> [L,     L,      L,      L]
 [C,   0,     0,  X,  1     ] -> [H,     L,      L,      L]

END Z80RFSH;
```

When latch A is low, latch B must be set to the current value of A6. Its equation is:

($\overline{\text{DRFSH}}$ & LASTA6) OR (!$\overline{\text{DRFSH}}$ & A6).

Similarly, latch C must toggle only if A6 is high, last A6 was low, and DRFSH is low; in all other cases it must remain the same. After a bit of manipulation, this becomes:

(!$\overline{\text{DRFSH}}$ & !A6 & LASTA6 & !A7RFSH) OR (!LASTA6 & A7RFSH) OR ($\overline{\text{DRFSH}}$ & A7RFSH) OR (A6 & A7RFSH).

Finally, the result needs to be gated with the real A7. The modified A7 must follow the Z80's A7 pin unless $\overline{\text{RFSH}}$ is low, when it must be forced to be A7RFSH, written:

(A7 & $\overline{\text{RFSH}}$) OR (!$\overline{\text{RFSH}}$ & A7RFSH)

As an added bonus this output can also be set to a high-impedance state whenever the Z80's address lines do the same, by use of the $\overline{\text{BUSAK}}$ signal, although this ties up another input pin of the pal for a feature that might not be needed.

These equations may now be put in a text file along with other information such as the device type, macro cell configuration, pin assignments, etc.

The pal still has plenty of room for additional logic to be implemented, and in this case it would be sensible to use it to generate $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ for the drams, plus any other memory-related signals. It could, however, be used to construct completely unrelated logic.

how well you do. Less than 50% is "Poor"; above 50% is "OK"; and 100% gets a small fanfare, a flashy screen, and the comment "Excellent!". Both simulation and fault grading are noticeably speeded up when using a faster processor.

Other aspects

"VT" terminal emulation is provided, along with access to the DOS command line without leaving Peel. Both work, but it is hard to see why they are included. The terminal emulation is not configurable, apart from the serial line parameters such as baud rate, and a separate file utilities menu allows copying, renaming and deleting of files.

The software has been around for a few years, and as you would expect there are no major bugs. But surprisingly, I did find a couple of minor ones — perhaps no-one has bothered to report them as neither is at all significant.

The first is that at the end of the program the user is requested to remove the chip from the socket and press any key. But the key pressed is not removed from the keyboard buffer, so that DOS finds the keystroke and uses it as the first character of the next command.

The other problem is that the "total time taken" figure given after the assembler is run is not explained by the manual and the values produced varied apparently randomly from a few seconds to several hours.

Using the system

To test the system, I used a circuit fragment that I have used in TTL form in several designs (see "Test design"). Logical equations were constructed and entered using the built-in editor.

The only problem encountered was due to the block instructions, as described earlier. I am familiar with WordStar key sequences, and I completed several block operations before I noticed that the effects on screen were not what I had intended.

Once entered, however, the design was easy to assemble and test.

I introduced a number of common errors into the source file, and they generated reasonable error messages. However, one unintentional error did not produce any message, but merely caused the fault grading to report 0% coverage. This turned out to be as a result of my entering expected outputs as 1s and 0s. Rather illogically the system requires 0 and 1 for inputs, and L and H for outputs.

Documentation

Data sheets for the Peel device range, and a manual describing the software, accompany the kit. The manual is well-produced, ring-bound, with tabs to help find any given chapter, but it is so poorly laid out that it can be frustrating to use. For example the entire description of the terminal emulation consists of:

Z=VT emulation. Allows video terminal emulation to be performed.

Since the first part appears on the screen anyway, the explanation leaves a lot to be desired. No explanation is given of why you might want the facility, which terminals can be emulated, or how to set up the emulation.

Similarly, the section on the Apeel assembler describes what buttons to press to perform simulation and fault grading, but not why these might be useful, or more importantly what to do if an error occurs.

Not only are the error messages not collected together for ease of reference, many are not described at all. If the messages were self-explanatory, this might be acceptable, but many of them are not easy to interpret. One of the faults not covered by my test vectors was described as:

Fault SA0 prod 1 input pin 2, RFSH output pin 16, NEWA7.

Given time, enthusiasm, and a knowledge of formal logic design, the message can be deciphered, but it really should be explained in the manual.

To complete the complaints, there is no index. No matter how well laid out a manual is, the absence of an index makes it much harder to use. Given the effort that has obviously gone into the writing, it is very surprising that an index has been deemed unnecessary.

So the kit is not for the faint-hearted as the manuals do assume knowledge of the subject. If you are unfamiliar with the use of these devices, you may find it advisable to locate a good introductory course to supplement the material provided with the programmer.

This is a shame because Peel devices would be an excellent introduction to programmable logic, and if the manual were rewritten with this in mind it would become useful to many more people. ■

Supplier:

The Peel development kit is made by Gould Inc Semiconductor Division, and is distributed in the UK by AMS Ltd, Exfinco House, Sanford Street, Swindon, Wiltshire SN1 1QQ. Telephone: 0252 341500.

Cost of the system is £602 + VAT, but users who can commit to volume orders for Peel chips will be able to negotiate a discount on the development system.

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CIRCLE NO. 145 ON REPLY CARD

Programmable RF attenuator

This digitally controlled RF attenuator uses PIN diodes as tracking resistive elements in a pi network, bias currents being controlled by computer. Its attenuation range is 3-30dB. By Seamus Laverty, Noel Evans and Brian Hylands.

Seamus Laverty and Noel Evans are at the University of Ulster and Brian Hylands is with Short Brothers.

In many instances, the cost of commercial attenuators cannot be justified and their compatibility with specific equipment is often restricted. This attenuator is intended for use in the computer-controlled adjustment of frequencies in the bands 30-50MHz and 130-175MHz, providing about 3-30dB of attenuation to a resolution of 1dB from an input of −20dBm. Its characteristic impedance is 50Ω.

This design is based on the standard pi-network[1] with PIN diodes as the active elements and is controlled by an H-P 85 computer via the GPIO bus. In essence, the design consists of an RF module, control circuitry and computer interface, together with the software. An improvement would be the adoption of a standard interface protocol such as that for the IEEE 488 bus.

RF circuitry

Bridged-tee and pi attenuators are both able to give variable and matched attenuation over wide band of frequencies. Bridged-tee circuits need one less active element, but we chose the pi network in this design for its higher maximum attenuation[2].

Analysing the equivalent circuit of a pi network between two impedance-matched stages, as in **Fig. 1**, gives the two basic design equations.

$$R_p = Z_o(1+G)/(1-G)$$
$$R_s = \tfrac{1}{2}Z_o(1/G - G)$$

where G is the ratio of the attenuator output voltage E_2 to its input voltage E_1.

PIN diode. The important thing about a PIN diode is its behaviour as an almost pure resistance at RF. By applying a direct bias current, one can vary the resistance from around 1Ω to 10kΩ, which makes the device ideal as the controllable element in an RF attenuator.

Conductance of a diode is proportional to its stored charge Q(t), which in turn is related to the diode current I(t) by

$$I(t) = \frac{dQ(t)}{dt} + \frac{Q(t)}{\tau}$$

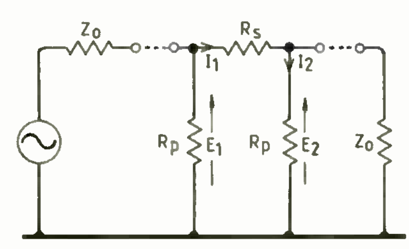


Fig. 1. Pi network connecting two impedance-matched stages

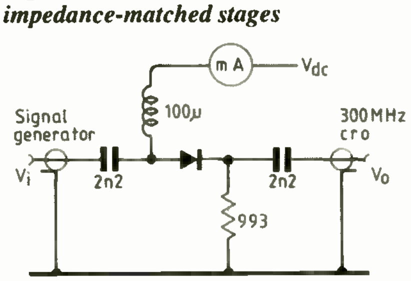


Fig. 2. Circuit to measure PIN diode dynamic resistance as a function of bias current

where τ is the recombination lifetime of the carriers. Frequency dependence is given by

$$\frac{Q(j\omega)}{I(j\omega)} = \frac{\tau}{1 + jf/f_o}$$

where $f_o = 2\pi\tau$.

H-P5082-3080 PIN diodes used in the attenuator have a recombination time of 1300ns, which gives a break frequency of 125kHz and ensures a linear resistance over the required frequency range. We investigated the variation of diode dynamic resistance with bias current using the circuit of **Fig. 2**, which shows that the individual relationships of resistance against current in milliamps can be modelled by

$$R = 22.5I^{-0.83} \qquad (1)$$

So, by replacing three resistors in the pi network by PIN diodes and biasing them with direct current to vary their RF resistance, a variable attenuator is obtained. Equation (1) provides the values of the series and parallel resistances.

Figure 4 shows a large variation in series and parallel bias currents, which highlights the problems of digital control. Since the pi network is symmetrical, the selection of matched diode

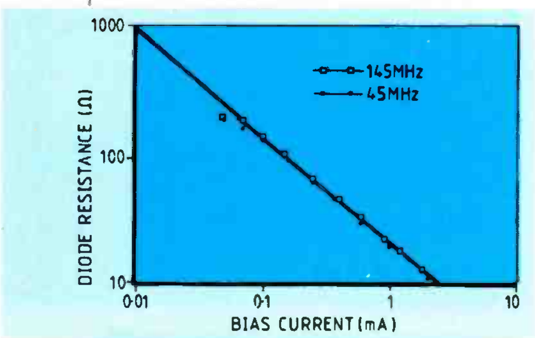


Fig. 3. Variation of diode dynamic resistance with bias current

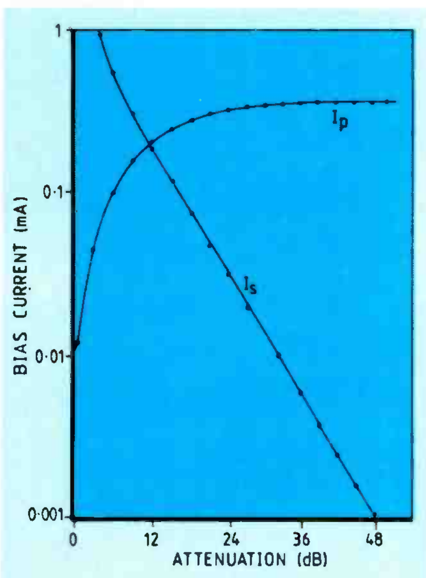


Fig. 4. Series and parallel bias currents to obtain required attenuation

pairs allows one current source to control both parallel diodes.

Digital-to-analogue control

An 8bit D-to-A converter offers satisfactory resolution and range; we used the DAC0800 to provide I_p, which ranges from 12μA to 354μA. Series-current source I_s must operate over the range 13.7μA to 15.15mA with a minimum resolution of 2μA. Limiting the maximum insertion loss to 30dB allows I_s in Fig. 3 to be approximated by the logarithmic law exhibited by companding D-to-A converters used in PCM systems, such as the Precision Monolithics DAC-88 chosen for this design. The transfer characteristic is an eight-chord, piecewise-linear approximation to the Bell System μ255 law[3]. With a maximum output current I_c set to 2mA,

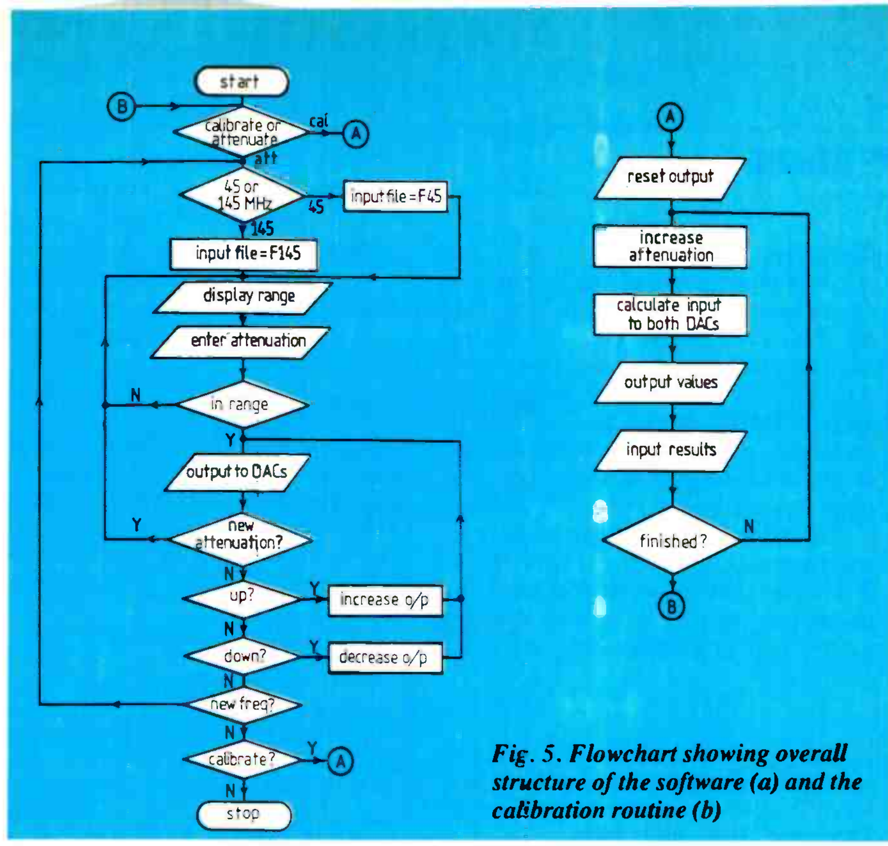


Fig. 5. Flowchart showing overall structure of the software (a) and the calibration routine (b)

the control current I_c for a given digital input is

$$I_c=(2/8031)[2^C(S+17)-16.5]\ I_s(\max) \qquad (2)$$

where C = chord number (0-7) and S = step number (0-15). Output current covered the required range with a resolution of 0.4μA. 74LS241 stages configured for open-collector input buffer the digital input to the D-to-A converter.

Computer control and interface

The GPIO interface of the H-P85 computer provides two 8bit, low-power, bidirectional ports (A and B) and two 8bit, output-only ports (C and D); each port uses a two-wire handshake for I/O data and each can be operated in byte mode. An I/O rom and the interface configured for output ports C and D give explicit access to the A-to-D drives.

There are two sections to the software: an "absolute" calibration routine and the main routine for setting attenuation. **Figure 5** shows the structure of the program.

Calibration is carried out by simply outputting the full range of currents to the attenuator, ensuring that the impedance Z_o is kept at 50Ω and reading in to file the attenuation obtained. When an attenuation is needed at a particular frequency during the main routine, the nearest attenuation in the appropriate file is used. To reduce computation, the output is focused on the series current supply (7bit) rather than the shunt supply (8bit). Earlier equations provide the relationship between series and shunt currents:

$$I_p=\frac{1}{I_s}\left[\frac{Z_0^2+Z_0(Z_0^2+k^2I_s^{2x})^{1/2}}{k^2}\right]^{1/x}$$

where K = 22.5 and x = −0.83, as seen in equation (1); the series current is given by equation (2). Input to the parallel current source to obtain this output is

$$\text{Input}=\frac{255.I_p}{0.354}$$

Hardware

The complete attenuator is built as a "piggy-back" arrangement, with the RF pi network mounted on the control-current module, in separate boxes.

RF module. As has been mentioned, the symmetrical arrangement of the net work means that only one current source is needed to supply both parallel diodes, as shown in **Fig. 6**.

DC blocking capacitors were chosen to have low impedance over the range of frequencies and inductors to present a high impedance in the frequency range; their self-resonant frequency at 14MHz is outside the VHF band.

Control current module. This circuit is shown in **Fig. 7**. No special precautions are needed, apart from its mounting in a separate die-cast box and the use of 10nF feedthrough capacitors to the pi network.

Results

Figure 8 shows the range of attenuation at spot frequencies of 45MHz and 145MHz against input to the series-current D-toA converter. Across each of the two bands 30-50MHz and 130-175MHz, the response is almost flat. The test signal was kept at −20dBm throughout the test.

Throughout most of the range, the attenuation at 145MHz is slightly greater than that at 45MHz, due to the increased reactance of the capacitors. At 145MHz, however, it tails off at about 28MHz, while that at 45MHz continues to increase, an effect that we attribute to parasitic coupling between input and output ports.

The attenuator fulfilled its design requirements, producing ranges of 3.7-29dB over the high band and 3.1-32dB in the low band at an accuracy better than 0.3dB in both cases.

References

1. Lepoff, J.H. PIN diode uses and limitations. Proceedings of the RF Technology Exposition, 1986, pp.187-195.
2. Long, N.R.W. PIN diode attenuators and vector modulators at intermediate frequencies. *Ibid*, pp.355-363.
3. Owen, F.F.E. PCM and digital transmission systems. Texas Instruments Electronics Series, McGraw-Hill, p.63, 1982. ■

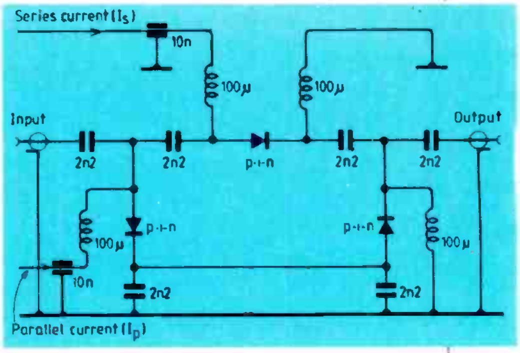


Fig. 6. PIN diode pi attenuator with blocking capacitors and isolating inductors. Both parallel diodes controlled by one current source

The authors thank Standard Telephones and Cables (Northern Ireland) Ltd and the Department of Electrical and Electronic Engineering of the University of Ulster for their support and permission to publish this work.

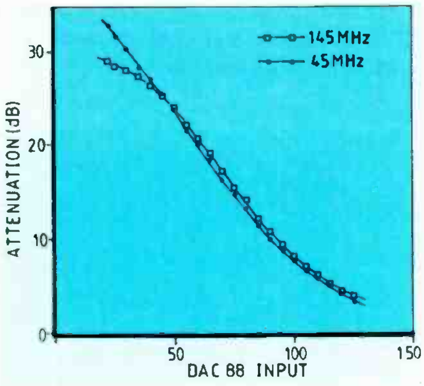


Fig. 8. Spot-frequency results: attenuation against decimal input to the series D-to-A converter

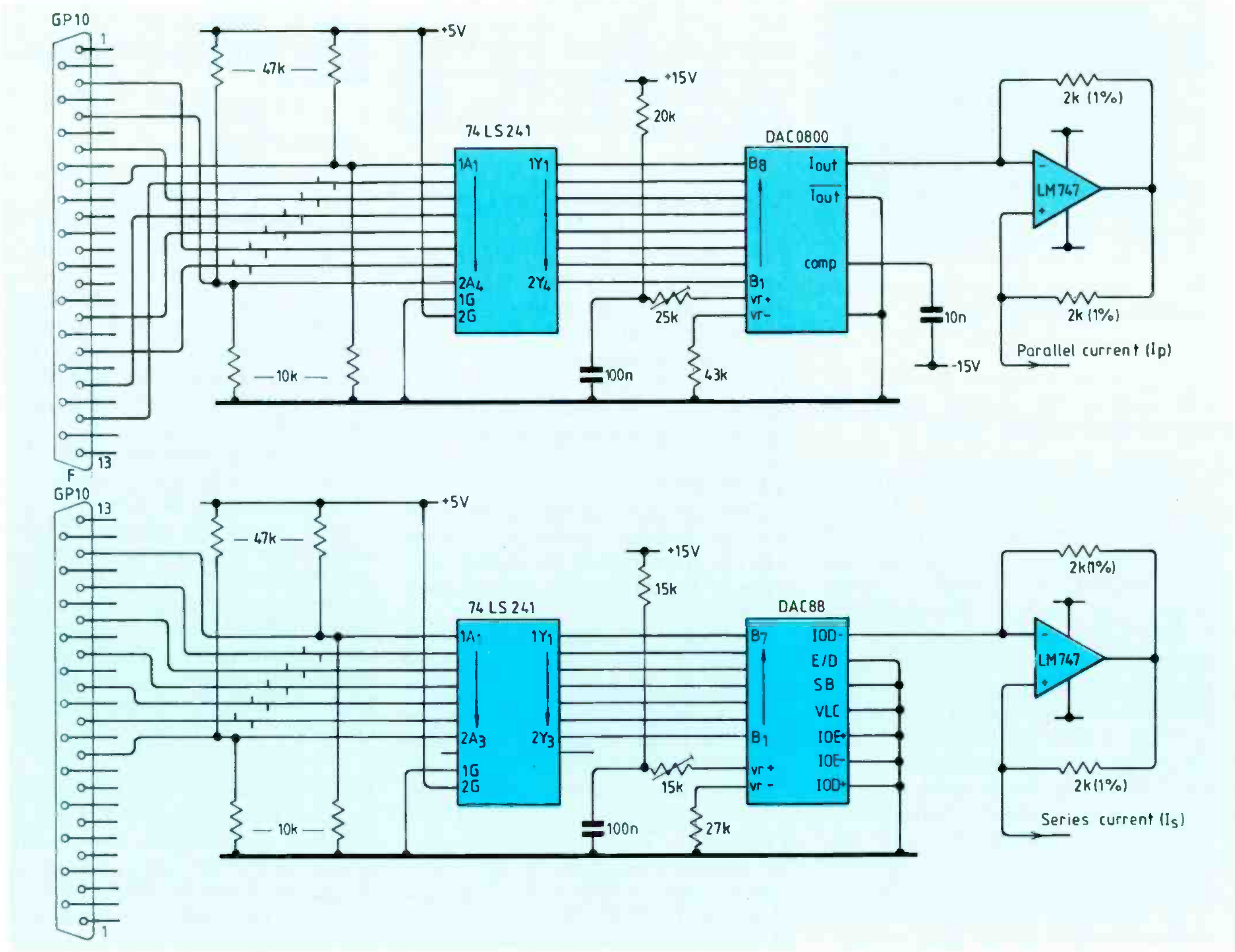


Fig. 7. Current-control circuit generating I_s and I_p from GPIO bus signals

HDTV with a better kind of PAL?

Although MAC is demonstrably superior, it has its operational problems. There is a lot of mileage left in the PAL system of television and Pat Hawker reports on work to improve it, including a method of widescreen transmission

Although BSB did not fulfil its promise to transmit wide-screen (16:9 aspect ratio) pictures on its film channel from the start of service — apparently having found that enhanced-MAC presented rather more operational problems than had been anticipated — the 4:3 D-MAC transmissions have underlined the cleaner pictures, with less triangular FM noise in the colours and the absence of cross-colour effects when received without the use of a PAL UHF modulator, that stems from the use of time-multiplexed component video, and the improved digital stereo sound.

Nevertheless, one still wonders how many viewers are, in practice, dissatisfied with the technical quality of the conventional 625-line PAL pictures of terrestrial TV; at least when this comes from good-quality electronic cameras under good lighting conditions. Established European broadcasters, though well aware of the artefacts inherent in Systems G and I PAL, broadcast in 7MHz (VHF) and 8MHz (UHF) channels, still believe that terrestrial TV will remain the cornerstone of TV broadcasting at least into the 21st century. Furthermore there is growing evidence that 625-line PAL could be further improved, and possibly expanded to the wide-screen picture format, by means of new technology.

In West Germany, an ARD/ZDF "PAL Strategy Group" has been investigating the possibility of introducing improvements to existing terrestrial services without impairing reception on existing receivers. The Group is also taking into account the future requirement to produce programmes suitable for transmission either terrestrially or via an HDTV satellite service, recognizing that, even for an HD-MAC service, some 70% of production, primarily in the form of "short-duration" programmes, will need for economic reasons to be produced in the 625/50 standard.

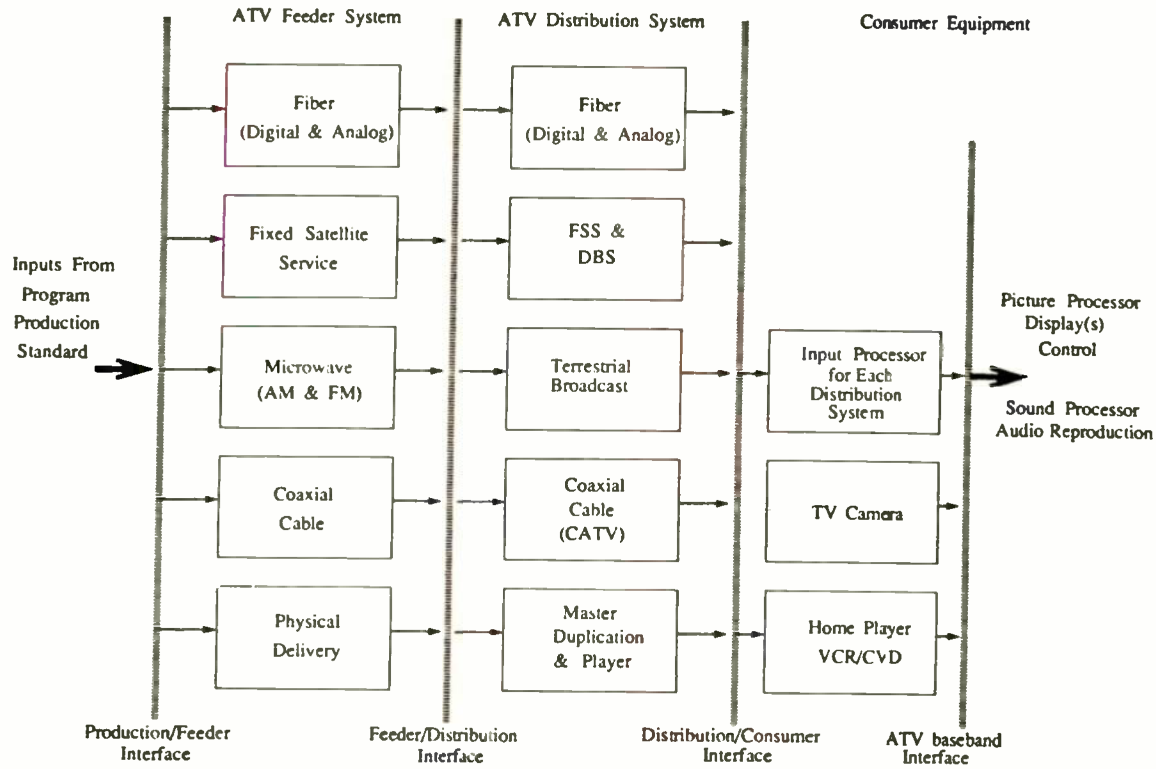
The German engineers, drawing in part on BBC work, have studied two possible methods of using PAL techniques that eliminate cross-effects and, in doing this, recover the full horizontal definition of the source signal (normally partially notched out around the colour sub-carrier). The systems are I-PAL (Improved-PAL) developed by the German Institut fuer Rundfunktechnik (IRT); and Q-PAL (Quality-PAL) based on theoretical studies by the BBC and further developed and implemented at the University of Dortmund. As described by Dr Albrecht Ziemer and Eckhard Matzel of ZDF in *EBU Review — Technical* (February/April 1990), it is also possible to combine some of the quality improvements possible with I-PAL or Q-PAL with an aspect ratio of 16:9 to provide a possible new widescreen terrestrial standard.

This system they designate "PALplus" and it is claimed that, with this system, it would be possible to transmit in terrestrial channels a 16:9 picture which, although wider, would have much the same resolution (lines per unit of width) as a conventional 4:3 PAL picture and would be free of cross-effects. Furthermore they stress that PALplus is downward-compatible; in other words, it could be reproduced by existing PAL receivers with a quality equivalent to that from conventional PAL signals. New PALplus receivers would similarly be capable of receiving conventional PAL signals, giving conventional-quality pictures while providing improved quality widescreen pictures from PALplus signals. They consider that PALplus could thus be introduced gradually, but there would need soon to be a consensus among the major PAL broadcasters to adopt a PALplus standard.

With I-PAL, full bandwidth (5MHz) luminance signals are transmitted in line x, with line x+1 carrying only low-frequency luminance (to about 3MHz) transmitted in frequency multiplex with the quadrature-modulated chrominance subcarrier. A normal PAL burst, with its phase change, is transmitted in every line. Disadvantages are that both diagonal and vertical resolution of the chrominance signal is reduced, requiring conventional PAL sets to be adjusted. Tests in Germany in 1988 showed that differential phase errors occur which can lead to unacceptable hue errors with I-PAL decoding. However, the I-PAL approach can be modified and phase-error compensation is possible (I-PAL-M).

With Q-PAL there is no requirement for a notch filter at the studio output, so that full horizontal resolution of the luminance signal is obtained. A multidimensional filtering technology is used in the transmitter and receiver to create a true three-dimensional frequency multiplex between the luminance and chrominance, permitting disturbance-free separation of the two signal components. Modulation and signal transmission is similar to conventional PAL, maintaining full downward compatibility (in fact Q-PAL improves the quality of PAL receiver pictures by the reduction of low-frequency cross-colour disturbances). The quality of PAL pictures on Q-PAL receivers is also improved by the elimination of the high-frequency cross-colour disturbances by post-filtering. Q-PAL thus lends itself to progressive step-by-step introduction.

Ziemer and Matzel believe that viewers would consider as particularly striking a change in aspect ratio from



the present 4:3 to 16:9. They write: "It is clear that existing PAL receivers must be capable of reproducing modified-format images at least in the manner customarily adopted (in Germany) for the reproduction of wide-screen films." That is the "letter-box" presentation with black bands above and below the image, reducing the number of lines in the vertical definition. Conventional PAL receivers have no means of modifying the deflection geometry. For the letterbox solution, IRT is currently developing a method where every fourth line (counted spatially) of the 575 active lines is removed and the remaining 431 lines pushed together. The picture is thus reduced to three-quarters of its original height, corresponding precisely to a change to 16:9 aspect ratio. Then 72 of the missing lines are inserted in each of the spaces which become empty at the top and bottom borders of the picture. An "intelligent" 16:9 receiver would restore the picture to its original state, but in 16:9 format.

Transmission of such a modified signal in the 7MHz channels used in Europe on VHF still presents problems. Attempts are being made to transmit the "border" signals in the range between black level and one-half of the synchronization pulse level, i.e. in the "blacker-than-black" range, and thus invisible to viewers with 4:3 sets. This technique, however, requires further subjective tests to determine whether such signals have any negative effect on overall picture quality; by now field tests should have been completed.

Fig. 1. Production, delivery systems and display of ATV predicted by Rzeszewski in the US.

In *Proc IEEE* (May 1990) Theodore Rzeszewski of AT&T Bell Laboratories provides an in-depth (16-page) "Technical Assessment of Advanced Television (ATV)". He categorises ATV in three main groups: High-definition TV (HDTV); Enhanced Definition or Extended Quality TV (EDTV/EQTV); and Improved Definition TV (IDTV) and the requirement of any new system to provide a significant improvement in quality compared with 525-line NTSC. For eventual delivery to the home of the highest quality pictures he sees a future of fibre-based networks and pre-recorded material for home (tape and disc) players rather than broadcast distribution. He believes that such factors as relative costs, ease of acceptance, quality differences and how much improvement over NTSC "is enough" will prove decisive in selecting one system rather than another: "HDTV could have a significant market share in the late 1990s but if EDTV or IDTV succeed sooner, then an HDTV volume market may not come until after the year 2000. He places the time window for IDTV between 1990 and 1994 and EDTV/EQTV between 1990 and 1997 with "some form of ATV introduced to the consumer soon.

"In other words, the question is no longer if ATV will come but rather, when and how many versions will be introduced, and be successful." He notes that, in connection with optical-fibre networks, some people predict that it will take until the year 2000 for fibre POTs (Plain Old Telephone service) to be less costly than copper, but that others predict that an integrated services approach should be economical long before that, perhaps in the mid-1990s; "Further, a mostly fibre network approach to CATV has been estimated to break-even with copper costs before 1993." **See Fig. 1.** ■

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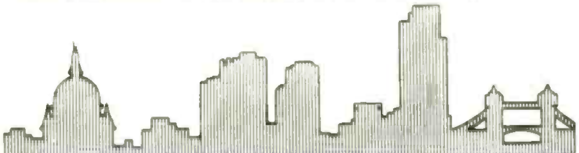

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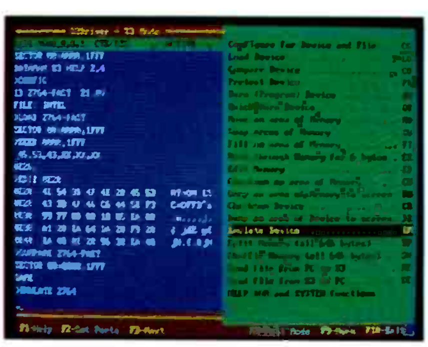

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