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02

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REGULARS

In next months's issue. The electronics in consumer electronics. For instance, have you ever wondered how the infra-red focussing mechanism found in pocket cameras works? We also review developments in fuzzy logic for camcorders, electronic engine management systems for cars, bit stream conversion in hi-fi and the stereo sound in NICAM. Also in the next issue: a new series on FM tuner design by John Linsley Hood.

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Privatising the recession

There is no such thing as recession. It is simply that people decide to postpone purchasing decisions until some time in the future, although they know that they will have to buy eventually.

This applies to both producers and consumers. Just because there is an economic hiccup, it doesn't mean that there isn't a need to replace ageing test equipment, invest in the next generation of computer tools, install a new level of automation on the production line. After all, when customers regain the will to buy the latest in hot technology, an industry must be ready to deliver. If it isn't, the boom—which will occur just as suddenly as any switch to recession—will simply manifest itself as a trade bonanza for foreign competitors who remember that good times surely follow bad.

Labour politicians correctly point to the use of interest rates as the sole instrument of economic control as the cause of our current financial troubles. However, the same political grouping usually overstates the importance of the cost of money which high interest rates imply. This is only a partial truth. The real evil lies in the disproportionate return which cash mountains bring to their holders for doing nothing more than loading their stash onto the money markets.

No independent observer could suggest socialist money management is good for industry or indeed has ever worked. However, what UK electronics company is in a position to pay dividends that even begin to compete with the returns available on the wholesale money market? Essentially, the Bank of England has set up in competition against HiTech plc for investment funds. There is a world of difference between expensive money—which manufacturing companies can simply treat as an added on-cost—and not being able to obtain investment money at any price.

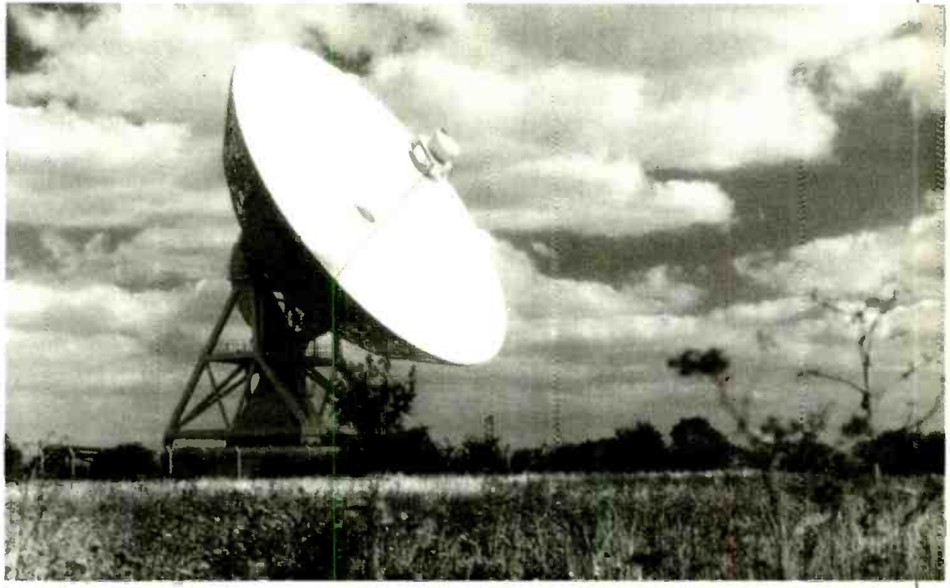
Why on earth should anyone place their money in cash starved industry when there are so many excellent government investments about? The recent electricity sell-off raised £2.6 billion. Oversubscribed 10 times, punters put up £20 billion in a scramble for short term profits. Money is only in short supply for the long term investments, investments of the sort which ensure a healthy infrastructure and a competitive platform from which to deal with our trading partners.

There is only one course of action for a government truly concerned with the wellbeing of industry. It must seek to bring not only our inflation rate to the same level as the rest of the developed world but also the associated interest rate. It must grasp the nettle of higher personal and indirect taxes and underwrite credit lines for manufacturing activity.

In short, it must stop privatising the recession.

Frank Ogden

Wizard new radio telescope



The opening late last year of a new 32m radio telescope near Cambridge marked the completion of a whole network of linked telescopes known as Merlin.

Merlin, Multi-Element Radio-Linked Interferometer Network, is run by the Jodrell Bank University of Manchester research team and now consists of seven linked dishes.

They are linked not just by radio, but by a multiplicity of data links that not only record the received signals but also control the huge dishes so that they all point to the same place in the sky.

Interferometry works on the principle of aperture synthesis, essentially the same way you narrow the pick-up angle of a communications antenna by stacking up the elements. In the case of Merlin, the linked dishes behave, in terms of resolution, as if they were a single dish of 230km diameter. That will allow resolution of celestial objects down to about 0.1arc.s, sharp enough perhaps to see surface detail on some of the largest stars.

0.1arc.s may seem incredibly narrow, but it will only now put radio astronomy on the same footing as optical astronomy where, because of the shorter wavelength of light, a much smaller pickup device can suffice.

In terms of resolution, Merlin will have about the same performance as the Hubble Space Telescope. Advances in technology have meant that Merlin telescopes can be improved in terms of sensitivity as well as resolution. High performance cryogenically cooled (14K) receivers are now being installed on all seven dishes.

Merlin will begin its work looking in detail at some of the crucial events taking place in the far reaches of the Universe; it may reveal more about the quasars.

At the other end of the energy spectrum, Merlin will be using its fine resolution to study the 3K microwave background left behind after the Big Bang that marked the creation of the Universe.

Currently available resolving power shows this to be uniform throughout the Universe, though if variations can be found , they might well point to the existence of "dark matter" - material that may account for most of the mass of the Universe.■

Singing the blues - or reds, or greens or...

If I were to play you a single tone of around l0Hz, I guess you would identify it as a low note and nothing more. On the other hand, if I were to shine a light at you with a wavelength of 750nm, I very much doubt if you'd describe it as light of a low frequency. You would be far more likely to describe it as red.

Why is it then that we perceive sound as a continuum, while the character of light appears to change as its frequency (or wavelength) changes?

This is the sort of (apparently) simple question beloved of children which has no simple answer.

First thoughts are that our ability to see different colours must have something to do with the fact that we have cells in our eyes that are selectively sensitive to different parts of the spectrum. The same, however, is true of the ear which has hair cells with relatively sharp tuning (high Q).

So why do we not hear a note and identify it instantly as A, B or C - just as easily as we identify light as red, green or blue?

The answer is that some of us do, about one in every 2000, in fact. It is an ability known as absolute (or perfect) pitch.

People who have it say that different notes sound qualitatively different, just as colours have a qualitatively different appearance.

Absolute pitch is useful if you are a musician, though by no means as essential as good relative pitch, the ability to compare one note with a reference.

Nat King Cole had absolute pitch; the great pianist Vladimir Horowitz did not. But unless a musician can accurately pitch a G when given a C, his or her career is likely to be somewhat limited.

Fortunately, relative pitch is something that most of us can easily learn. We may not know what a 1:2 frequency jump, an octave, sounds like, but if asked to sing the first two notes of "Somewhere over the Rainbow" most of us would do pretty well. (To be truthful there was some research done about ten years ago at University College, London, showing that about 3% of us are tune/tone deaf. We would fail to spot the mistakes if a familiar melody were played with more than a third of the notes incorrect).

Back, though, to absolute pitch which, according to recent work by the American psychiatrist/jazz musician Joseph Profita, can not be learned. Although some people believe you can acquire absolute pitch, Profita believes the confusion arises because you usually need to be involved in music to discover you have it. Also of course, you must at some stage synchronise your own internal standard to the prevailing musical standard. (A=440Hz has no fundamental significance and was cooked up by a committee as recently as 1939).

What Profita and his co-workers have shown quite convincingly is that absolute pitch can only be acquired by those with a predisposition to acquire it. What is more, by studying dozens of families, he's shown that it is a simple inherited characteristic that is probably carried on a single gene in the body.

The intriguing question is of course why some of us have such a gene. On conventional evolutionary theory it is hard to see what survival value would be conferred by an innate ability to calibrate signal generators.

Answers may well emerge when scientists get a bit further with the Human Genome Project a massive international project to decode and map mankind's "specification".

Remember though that each one of us is specified by 100 000 genes, which in turn contain some 3000 million chemical subunits.

The task of finding out why you have absolute pitch and I do not may prove harder than landing a man on the moon. ■

Supercomputer shows what blows the solar wind

By means of a mathematical model within an IBM ES/300 3090 supercomputer, Cornell University scientists have taken an important step toward solving one of the strangest of solar puzzles.

Their theoretical model is helping to answer why the solar corona — the tenuous region of gas above the sun's surface — reaches temperatures of millions of degree Celsius when the surface below registers only in the thousands.

Such coronal heating is the energy source of the solar wind, the stream of electrically charged particles that boil away from the corona. The solar wind produces the aurora while explosions in the superhot solar corona can bathe the Earth in high-energy protons, disrupting radio communications and electric power grids and increasing radiation dosage to airline passengers and astronaut.

In a paper delivered at the American Physical Society, Dana Longcope and Ravi Sudan discussed their theoretical model of how immense loops of magnetic fields erupting from the boiling surface of the sun can pump energy into the corona.

Scientists have theorised that the solar corona was somehow heated by Alfven waves in the magnetic field lines of the loops. These waves are lateral oscillations of the magnetic field lines, which are known to arise from the rapid jiggling of the solar surface of hot hydrogen.

The problem for solar physicists, however, was understanding how such Alfven waves were damped in the corona, depositing energy in the tenuous gaseous medium. Such electromagnetic waves had been thought to reverberate along the loop, bouncing from one end to the other without depositing significant energy.

The computer model of Longcope and Sudan shows how the randomly seething surface of the sun can break the emerging magnetic fields into fine, randomly twisted filaments and snarl those filaments, like the intertwined strands of wool yarn.

In previous theoretical work, physicist Philippe Similon, now at Yale University, and Sudan showed how this jumbling of field lines damps the Alfven wave as they reverberate along the line through the corona, causing them to pump energy into the corona, heating it.

According to Sudan, space probes planned for the 1990s by NASA, including the Solar Optical Telescope and the High-Resolution Solar Observatory should provide detailed enough image of the solar surface to help confirm the scientists' theories. ■

Memory molecule

Numerous methods have been proposed for increasing the density of optical storage media. But although it's possible in theory to store a bit of binary data by altering the state of a single molecule, there are several practical obstacles to realising this concept in terms of hardware.

How do you address a molecule; and how do you read its state? Just as difficult up till now has been the question of stability. How can you be sure a molecule will remain in the same configuration, bearing in mind that any practical readout mechanism must be necessary transmit energy to the molecule?

Most molecular storage concepts have so far been based on photochromic compounds, materials that undergo a reversible change in their optical characteristics when irradiated; think of photochromic sunglasses that darken in full sunlight.

There are some five classes of photochromic compounds which undergo a whole range of atomic rearrangements in response to light.

For those with an interest in chemistry, these include trans-cis isomerisation, charge transfer and valence tautomerism. None of these materials has been exploited commercially for their data-storage capability because most are thermally unstable.

The energy of a read-out laser would, more than likely, cause the data to be erased.

A team of Japanese scientists (ZF Liu et al *Nature* 347, 294) have recently found a way of overcoming this using an azobenzene derivative (ABD). This molecule changes from orange to yellow when exposed to UV light and, like others of its kind, will flip back to the original colour when another beam is used to read it.

If, however, the ABD is deposited as a thin film on an electrode then the electrode can be used as a sort of "memory fix" line.

When the electrode is given a charge, the orange molecules stay orange and the yellow ones yellow — even when a laser beam is used to read their state. Conversely, if the electrode is given the

opposite charge, all the molecules will revert to orange, the equivalent of erasing the memory completely. Lin and his colleagues have shown that the film remains reversible after hundreds of write/read/erase cycles.

Reading a colour change from orange to yellow is clearly not the simplest task in practical terms. But if suitable hardware can be developed, such optical memories have the potential to store some 10^8bit/cm^2.

In a comment in the same issue of *Nature* Geoffrey Ashwell of the Cranfield Institute of Technology says that even this is not the limit. The vertical dimension could also be exploited with multi-layer molecular memories sensitive to different parts of the optical spectrum.

If photochromic materials can be developed sensitive only to narrow bands, then it would be possible to make an even denser reversible memory, rather like a colour film.

Liu et al add that if photochromics can be made that respond in the infra-red, then simple write/read devices based on semiconductor lasers would become possible.■

High temperature super conducting transistor

superconducting transistor developed by scientists and engineers at Sandia National Laboratories and the University of Wisconsin, Madison, is currently being used to create a whole new family of electronics which has the potential for integration with existing semiconductor and low-temperature superconductor electronics. Devices based on high-temperature superconducting materials hold promise for higher speeds, reduced noise, low loss and high efficiency for a whole variety of applications in communication and signal processing.

The transistor has been named the superconducting flux flow transistor (SFFT) and Sandia scientists say it is the superconducting analogue of the field effect transistor (fet). It is also claimed to be the first transistor made entirely from the new high-temperature superconducting material. (Passive devices - inductors and some microwave components such as filters and delay lines - have recently been made elsewhere from the new materials and are now commercially available.)

The SFFT consist of parallel weak superconducting link about 10μm long (about a tenth the thickness of a sheet of paper) separating two pieces of superconductor, and a control line to provide a local magnetic field.

Whereas in a conventional fet an output current is controlled by changing an input voltage, in the SFFT output voltage is controlled by changing input current.

This current in the control line (acting like a gate), alters the magnetic fields in the active region of the device. These changes in field modulate the output voltage and hence provide gain. The best results have come with SFFTs made from thin films of the thallium-based family of high-temperature superconducting materials (thallium-calcium-barium-copper-oxygen), which lose all electrical resistance at temperatures up to 125K.

Sandia made the first thallium-based superconducting thin films with high critical current, reported in April 1989.

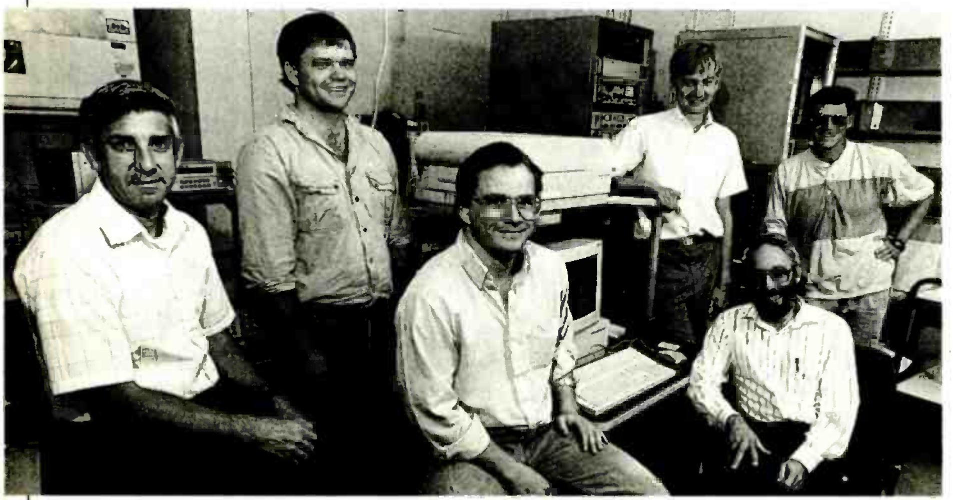
Thallium-based films that have high critical currents can be readily processed to make devices. Very recently, in a collaboration with Julia Phillips of AT&T Bell Laboratories, the same devices have been fabricated in the yttrium-based system, the most widely studied of the new superconducting materials.

Paul Peercy, manager of Sandia's Compound Semiconductor and Device Research Department, says the SFFT and associated circuitry are now being developed together. The team has so far built microwave amplifiers with the SFFT that show significant gain - 10dB at 4Ghz. And the SFFT has been used to make mixers that operate up to 35GHz.

A number of passive components is being developed for use in combination with the SFFT to form a complete set of high-temperature superconducting electronic circuits. Microwave and millimetre-wave circuitry are among the most promising applications. The SFFT can serve as an interface between conventional, low-temperature superconducting electronics, which usually operate at liquid-helium temperatures of 4K, and semiconductor electronics. Low-temperature superconducting electronics rely on Josephson junctions.

These devices operate at ultra high speeds, but their properties (low output impedance and small voltages) make it difficult to link them directly with semiconductor electronics.

The SFFT, however has resistances that are low at its input and reasonably high at its output, enabling the transistor to serve as an active link or converter between the two. Sandia has carried out successful experiments in which a Josephson junction drives the input of an SFFT and the SFFT drives the gate of a mesfet ■



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

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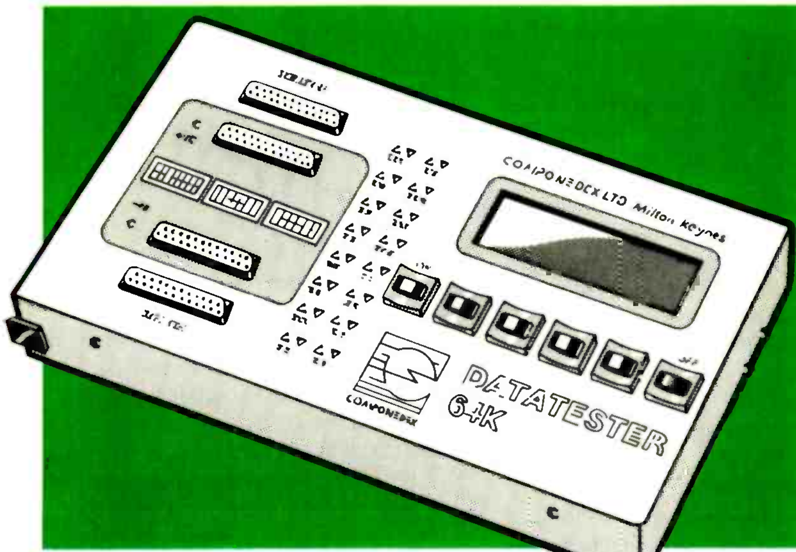

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HDTV still moving despite BSB loss

Many industry pundits hailed last year's merger of Sky and British Satellite Broadcasting as the final nail in the coffin of European high-definition television

But Societe Europeenne des Satellites (SES), which owns and operates BSB's Astra satellite, has announced that it has bought two more satellites, one of which could be used for HDTV broadcasts by spring 1994.

The first of these, Astra 1C, will be launched early in 1993, and will provide backup for the 1A satellite currently broadcasting. It will be switchable to the frequency range below 1A, to provide an extra 16 broadcast channels, while its backup function is not required.

Astra 1D will be used as backup for the 1B satellite, due for launch in February 1991, and for 1C. But it can also be reconfigured to provide the so-called broadcast satellite services channels required for HDTV. Four of the satellite's total of 24 transponders will be used for each broadcast channel, or it could be used to provide even more standard channels.

Back on earth, BSB has been having trouble with the retail outlets which had been selling the old BSB squarial equipment. Told to remove the equipment from their shops' shelves, the retailers pointed out that they were saddled with a large amount of stock, now useless. Writs were threatened, and BSB responded by telling the shops to put the equipment back on display, even though it would be useless within a matter of weeks.

The position of existing BSB subscribers has also been swinging to and fro with the new company first saying that receivers would be replaced free of charge, then changing its mind and offering replacements at a discount; then having a further rethink and going back to the original deal.

Speculation is mounting that there may be an Astra version of the flat-plate array "squarial" antenna in the pipeline. Because of Astra's lower power, this variant would need to be somewhat larger than the original BSB version, but would retain the characteristic shape.

Astra 1C and 1D television and radio satellites are to be built by Hughes Communications International for Societe Europeenne des Satellites of Luxembourg. The satellites are of the HS 601 type with cube-shaped bodies and two, three-panel solar arrays and provide 18 Ku-band 63W channels. Astra 1C is due for launch by an Ariane 4 early in 1993 and 1D is scheduled for 1994.

Optical computer in sight?

Workers at AT&T Bell Laboratories in New Jersey have developed a machine that processes information in the form of light, rather than electrical pulses and see the development as a first step towards an optical computer processing more than 1000 times as much data as conventional machines.

Thirty two $0.5\mu m^2$ optical switches in four arrays are activated by light from laser diodes in interconnecting arrays, the switches having a potential speed of 109 operations per second with a switching energy of 10^{-12} joules. Switches are made of gallium arsenide and aluminium gallium arsenide, each being provided with two mirrors which have controllable reflectivity to infrared radiation.

Connections in the processor are formed by lenses and masks between the arrays, the masks taking the form of glass panes with patterns of transparent and opaque dots. Each optical switch is a Nor gate, the only logic element in the processor, the logic state of each array being determined by the state of devices in the previous one, from which it derives its input. Output and input functions are carried out by optical-fibre or laser beams in free space.

AT&T claim the work to be a "breakthrough" in optical computing, but point out that there is still a great deal to do before such computers can become commercial reality.

£600,000 from Japan to fund UK research

Toshiba has become the latest Japanese semiconductor company to call on UK expertise in its research and development effort.

The company is to set up a £600,000 research centre in Cambridge, close to the university's Cavendish laboratory. Toshiba Cambridge Research Laboratory (TCRC) will be staffed by ten scientists, who will concentrate their efforts in the field of quantum physics.

Although the research is intended for eventual commercialisation, the company is obviously taking a long-term approach. Toshiba's director of technology, Dr Sei-ichi Takayanagi, said that there was no guarantee of any useful results. "Even if we are lucky enough to have results that can be applied, I doubt it will be before the 21st century," he commented.

The centre will be headed by Professor Michael Pepper, Professor of Physics at the University of Cambridge. Prof. Pepper is to continue his research activities at the Cavendish laboratory, and Toshiba hopes for collaboration between the two labs.

TCRC is the company's first R&D facility outside Japan, and will maintain close links with its home based workers. Asked whether other European sites had been vying with Cambridge for the finance, Dr Takayanagi explained that the choice had little to do with location.

Signing the agreement to create the Toshiba Cambridge Research Centre (above) are Dr S Takayanagi, T Fujii and Dr N Shimomura of Toshiba with Professor M Pepper of Cambridge who is also managing director of TCRC.

"Success depends heavily on the capabilities of the researchers, not on their quantity. We cannot plan when and how we will find the right people." Plumping for Cambridge, he explained, was heavily dependent on Prof. Pepper's willingness to participate.

According to Prof. Pepper, the initial stages of research will concentrate on quantum physics and so-called "zero-dimension devices". These structures are so small (in all three dimensions) that their behaviour can only be understood on an atomic or nuclear level—single atoms, for instance impurities in the semiconductor structure, determine how the device acts. These studies will not only be useful in their own right. The electrons associated with very small structures behave more like electromagnetic waves than particles, providing a link to opto-electronics research.

Prof. Pepper pointed out that the relationship between science and technology is not fixed. "Sometimes one leads," he said, "sometimes the other.

Light conversation

British Telecom, in association with GEC Plessey Telecommunications, BICC Cables and Fulcrum Communications, is carrying out what they claim to be the world's most advanced trials of optical-fibre local telephone networks, in Bishop's Stortford. Telephone traffic, television and text are sent to homes and businesses, television viewers having a choice of 18 channels, including satellite and cable television, as well as the broadcast programmes — all free during the two-year period of the trials.

The trials are intended to demonstrate the feasibility of the networks developed by BT, which started trials of such systems in 1987. Tim Pickup of Fulcrum says: "At present, it is expensive to run fibre to every house in a street, so the purpose of the trials is to test various types of network to find the most cost-effective system. This will allow British Telecom to secure the maximum return on the massive investment needed to replace its existing copper-pair local loop networks with fibre".

Both "tree-and-branch" passive and "broadband integrated star" active systems are under assessment. In the former, inert fibre splitters pick off services to each customer on the network, while the latter contains provides services selected by the customer by keypad from a broadband access point.

Blumlein biography mystery

Our story about the mystery of the missing biography of inventor Alan Blumlein (*Electronics World + Wireless World*, November 1990) has opened a can of worms.

Several people have wondered whether the Institution of Electrical Engineers can do something to ensure that a biography of Blumlein is published. The IEE confirms that Francis Thomson, the man who for 18 years has been collecting information on Blumlein's life but who has not yet produced his promised biography, *is* a member. And the Institution is "concerned that there is no biography of Alan Blumlein". The IEE says it would also be "concerned" if documents needed for a full biography were not available to an author.

But, says the IEE, "it is difficult to exert other than moral pressure where records are held by a private individual".

Meanwhile we have learned that Francis Thomson has been building up a store of other material as well.

In short, it seems that the best way to bury someone's memory is to get in first with a public call for all available biographical material, and then keep on saying you are writing a biography. In 1979 Thomson wrote to the inventors of the heart and lung machine, saying that he expected soon to finish his biography of Blumlein and would then like to have a go at writing their story. Perhaps wisely, they did not bite.

This was the year before Thomson appealed (again as Blumlein's biographer, and in the January 1980 edition of *Wireless World*) for "papers, notes, photographs etc." from anyone who knew SG Brown FRS. Sidney George Brown, who died not long after Blumlein, had patents on ground-breaking technology such as the gyrocompass and audio headphones. Thomson said he was writing Brown's biography.

Ten years later, there is still no biography of Blumlein or Brown. But Thomson is still collecting material on completely new topics. The Spring 1990 newsletter of the Special Forces Club carries an appeal from Thomson for memories, photographs and names and addresses of anyone who was at Gorhambury House, St Albans, during the war.

"I have been asked to compile an exhaustive record of SOE and War Office use of this stately home", he assures SFC members. As with the original calls for material on Blumlein in 1972, Thomson creates a sense of urgency with a tight deadline for contributions, "June 30, 1990 if you can manage it". As an example, Thompson says he is interested in people from Occupied Europe who were staying at Gorhambury.

As one concerned party notes, Thomson's entry in the current edition of Who's Who makes no mention of Blumlein or Brown and as Thomson has not published anything since "Tapestry: Mirror of History," in 1979, following "History of Tapestry" (2nd edition) by WG Thomson, edited with ES Thomson in 1973, it does not seem likely that biographies of AD Blumlein and SG Brown and a history of Gorhambury will shortly appear.

All this raises the question: how many other biographical enterprises does FP Thomson have in hand?

SOI chip production heralds superfast transistors

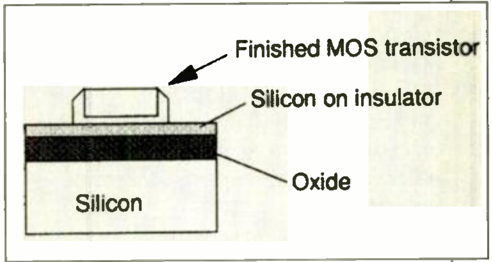
Transistors running three times faster than conventional devices may soon see the light of day as a result of development by IBM of a production technique for manufacturing "silicon-on-insulator" (SOI) materials.

The transistors are c-mos-type electronic devices, and IBM researchers at the company's TJ Watson Research Center in New York state say their performance indicates the long range promise of silicon-on-insulator devices to speed operation and decrease errors in circuits.

Computer scientists have long known that SOI offers advantages over pure silicon for building computer circuits. By putting silicon over a material that does not conduct charge, chip designers can reduce leakage of current from the semiconductor and speed chip operation. SOI also protects tiny computer circuits from "soft errors" caused by exposure to external radiation sources such as cosmic rays.

Despite the appealing properties of SOI, the material has proven difficult to produce. Different properties of semiconductors and insulators have created a mismatch that has held back the growing of defect-free, ultra-thin layers of silicon on top of an insulator.

But IBM researchers have found a way to coax silicon to grow on an insulator that results in material virtually defect-free and comparable in quality to pure silicon.

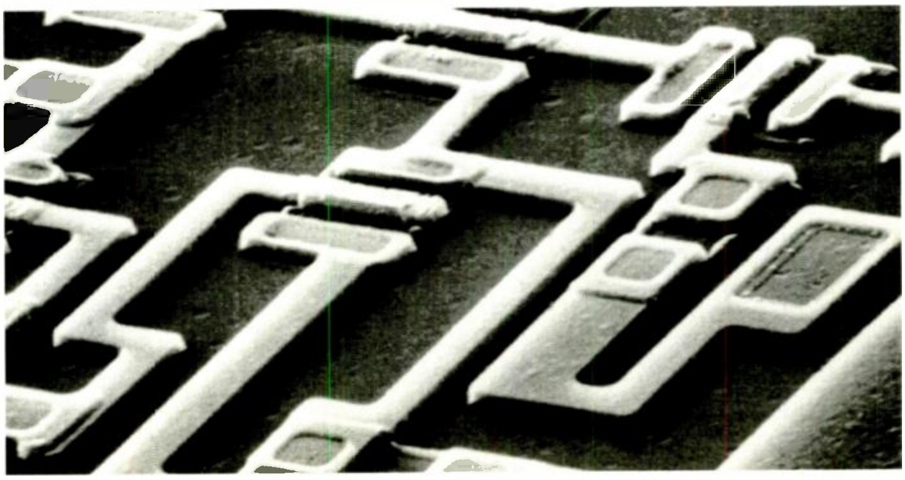


To grow the thin films of silicon-on-insulator, the scientists start with a silicon wafer base, then grow oxide on top by heating the wafer in an 980°C furnace in the presence of oxygen — the layer of silicon dioxide is the insulator.

Tiny lines are then opened in the oxide, exposing the silicon underneath, and a silicon-containing chlorine gas is passed over the wafer to deposit silicon in a process called selective silicon epitaxy. Silicon grows in "blobs" along and on top of the lines. The blobs of silicon can then be thinned down to the desired thickness of one-tenth of a micron.

In a demonstration of the SOI c-mos transistors, the devices clocked a switching speed of 33 picoseconds. That is three times faster than comparable, half-micron c-mos transistors built of pure silicon.

Now that the IBM process has shown the fabrication of good quality silicon-on-insulator to be feasible, the company hopes to develop transistors with improved characteristics.



Fast, faster, fastest: IBM is claiming world speed records for circuitry used in mainframe computers. The standard ECL circuit (pictured) with IBM-developed bipolar silicon and silicon-germanium NPN transistors will switch at less than 25ps.

Lab windows package can exploit 16Mbyte

LabWindows PC-based test and measurement system has been upgraded by manufacturer National Instruments.

Labwindows 2.0 includes support for extended and virtual memory, so giving programs access to up to 16Mbyte of memory.

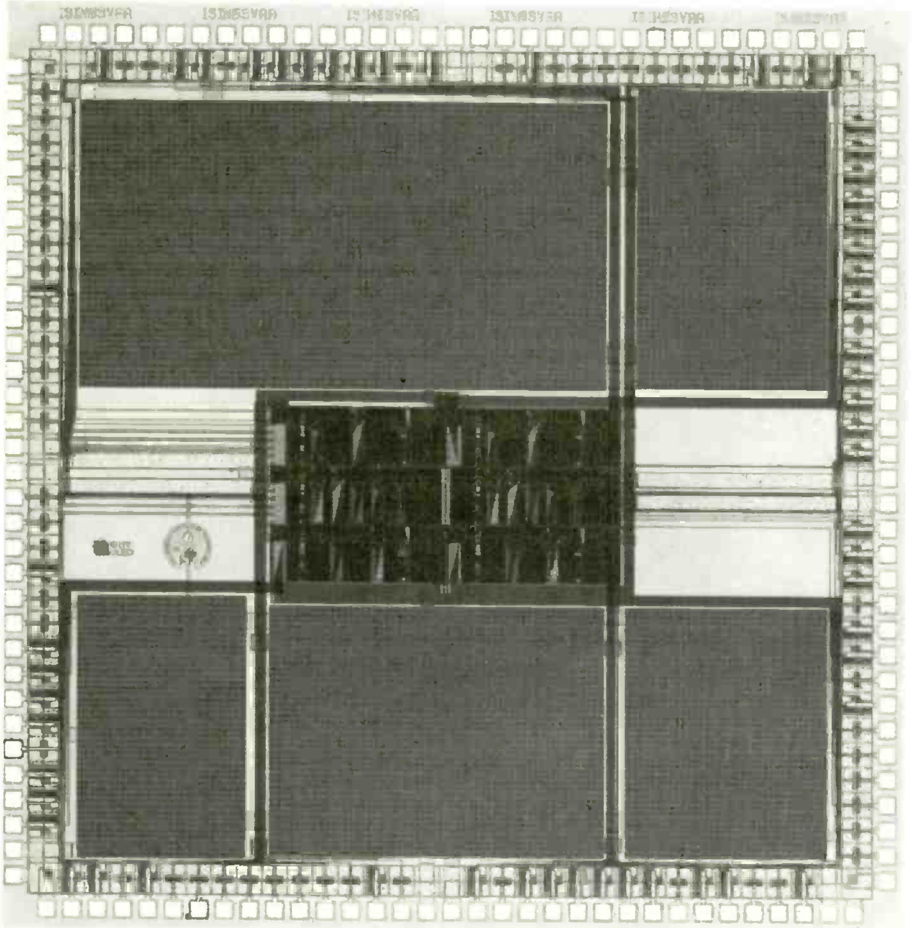
The expansion has in turn allowed the addition of a graphical user interface library (GUIL), which includes full colour graphs, strip charts and I/O controls. Command bars, pull-down menus and pop-up dialogue boxes can all be created via a graphics editor, eliminating the need to write code.

For those needing to produce their own code, the package can now use externally generated C libraries and objects as if they were standard LabW indows libraries. So programs can use more complex plug-in hardware — for instance boards which require DMA or interrupt handling.

National has also expanded its GPIB and plug-in instrument libraries, and added a VXI library, which can be used either in conjunction with add-in VXI controllers, or with the MXI system.

To go along with the new software is a whole collection of new instruments, including four low cost PC plug-ins — one analogue, two digital and one event counter/digital waveform generator.

For ATs, a multichannel analogue board working at 200ksamples/s is now available and, in case Macintosh users feel left out, there is a an IEEE-488.2 compatible controller card which offers



The "most powerful computer in the world", is to be installed at the California Institute of Technology. Touchstrone Delta, an advance on Intel's iPSC/860 supercomputer, has 528 numberic processors to provide a peak speed of 32Gflops. Delta's mesh-routing chip, 4.5mm², (above) is the message packet "traffic controller".

Operating system co-operation speeds up transputer change

Transputer development will be made easier and code written for other processors able to run on transputer systems following the announcement that Ready Systems is to port its

VRTX32 real-time operating system to Inmos's transputer. VRTX is in fact a "real time kernel", providing the most basic of operating system functions. It is designed for multi-tasking systems, and so includes facilities such as inter-task communication and synchronisation, clock management and interrupt servicing.

The two companies have been collaborating for some time, although the formal announcement of the tie-up did not come until late last year, and the transputer VRTX will not be available until the second half of 1991.

In the meantime, according to Inmos, Ready has, among other things, been collaborating on the design of its next generation processor, codenamed H1, which is due for release early this year.

The software house has a long history in real-time systems, which have not only to work quickly, but in a predictable way—even when unpredictable real-world events intervene. The processor itself will be a "superset" of the existing T-type chips, allowing current code to be run without being recompiled.

Inmos is pushing the idea of "application specific microprocessors"—devices designed as, for instance, graphics accelerators, or communications processors. The tie-up with Ready is part of its push to make multiprocessing easier for the user, particularly in embedded control applications.

The company now has debuggers, configurers, and profilers, to go along with programming languages including C++ and Fortran. Ian Pearson, the company's technical director, says that development also includes work on parallel processing algorithms, and formal proofs. The mathematics, he says, should eventually provide ways of making parallel processing much easier to implement.

Andy Gothard

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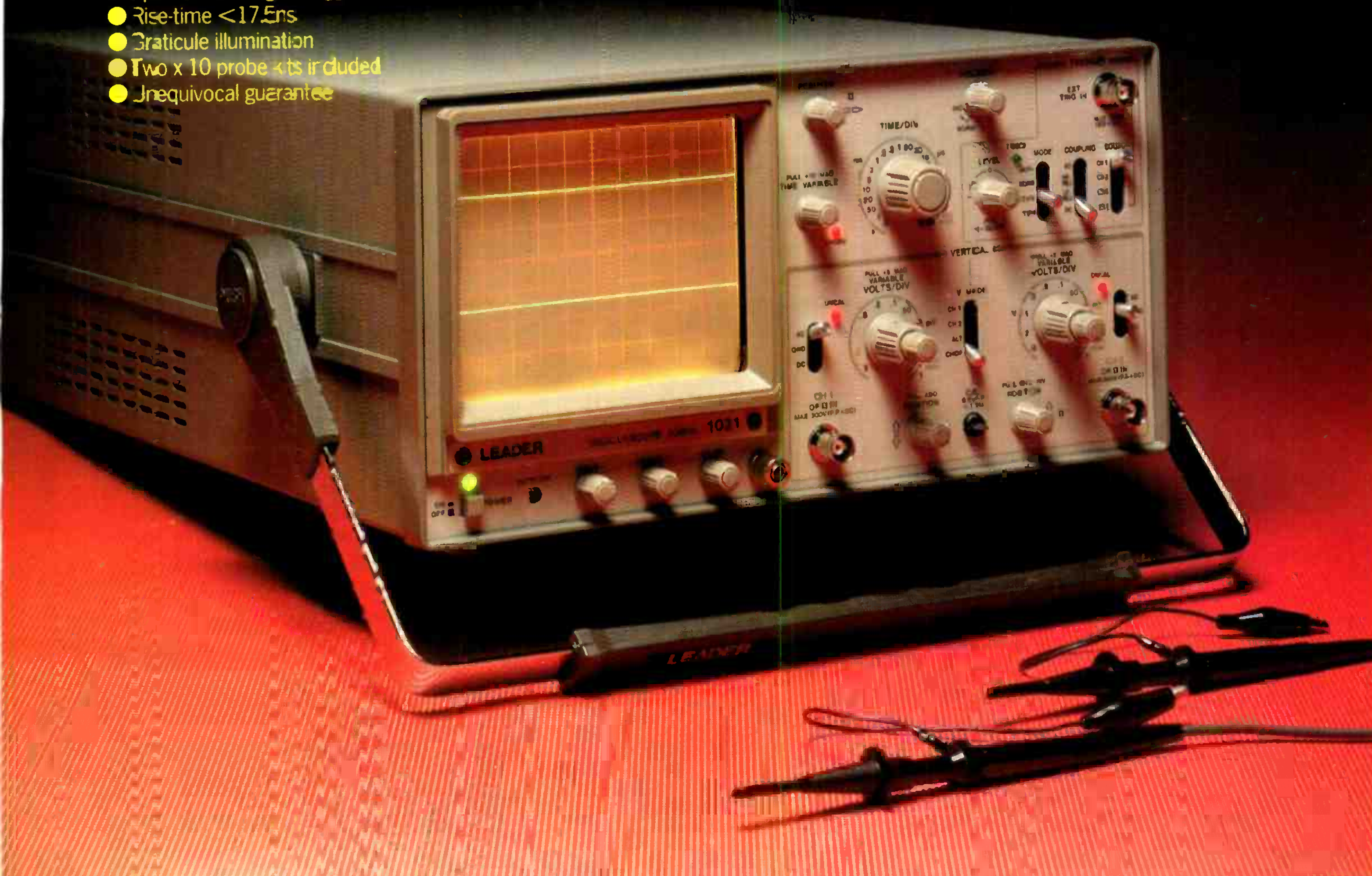

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80386S	16	20	8	-	2/6/-	£ 290	£ 340	£ 400	£ 510	£676	£925	£1105	£1220	£1310	
80386S	20	26	8	-	2/6/-	£ 350	£ 400	£ 460	£ 570	£737	£987	£1166	£1280	£1370	
80386	20	28	16	-	2/6/-	£ 435	£ 485	£ 545	£ 655	£800	£1050	£1230	£1345	£1435	£2100
80386	25	34	16	-	2/6/-	£ 485	£ 535	£ 595	£ 705	£850	£1100	£1280	£1395	£1485	£2150
80386	25	43	16	64K	2/5/1	£ 620	£ 670	£ 730	£ 840	£970	£1220	£1400	£1515	£1600	£2270
80386	33	56	16	64K	2/5/1	£ 765	£ 815	£ 875	£ 985	£1120	£1370	£1550	£1665	£1750	£2420
80486	25	114	32	option	2/5/1	£1665	£1715	£1775	£1885	£1995	£2245	£2425	£2540	£2625	£3290
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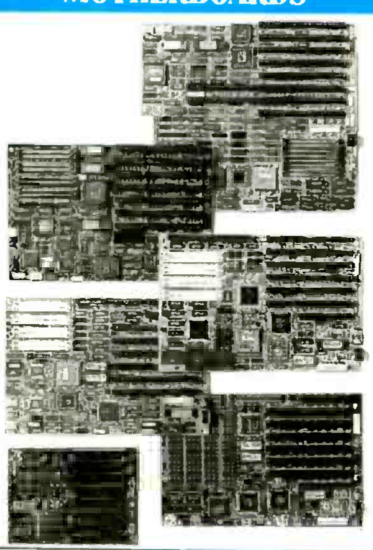

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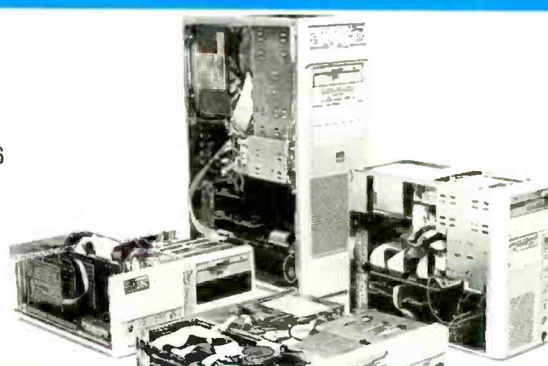

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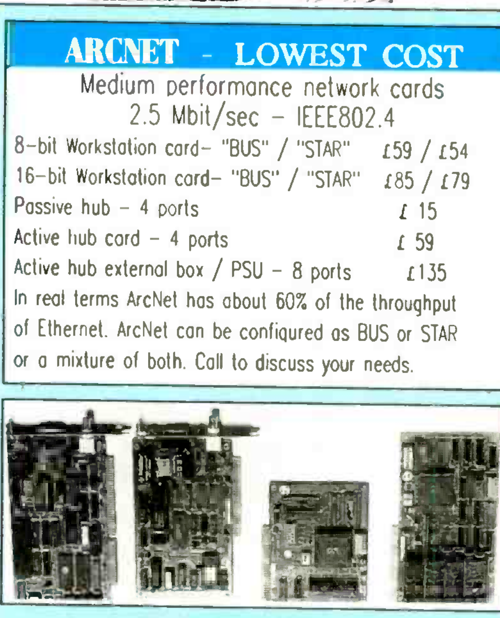

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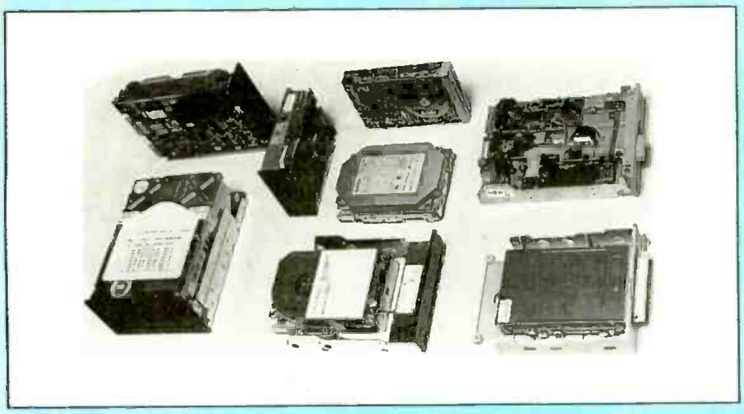
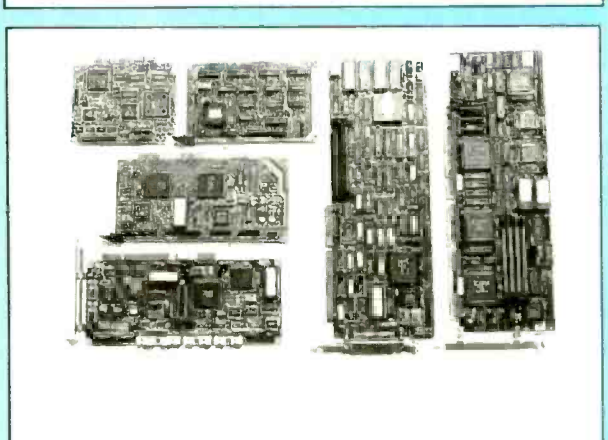
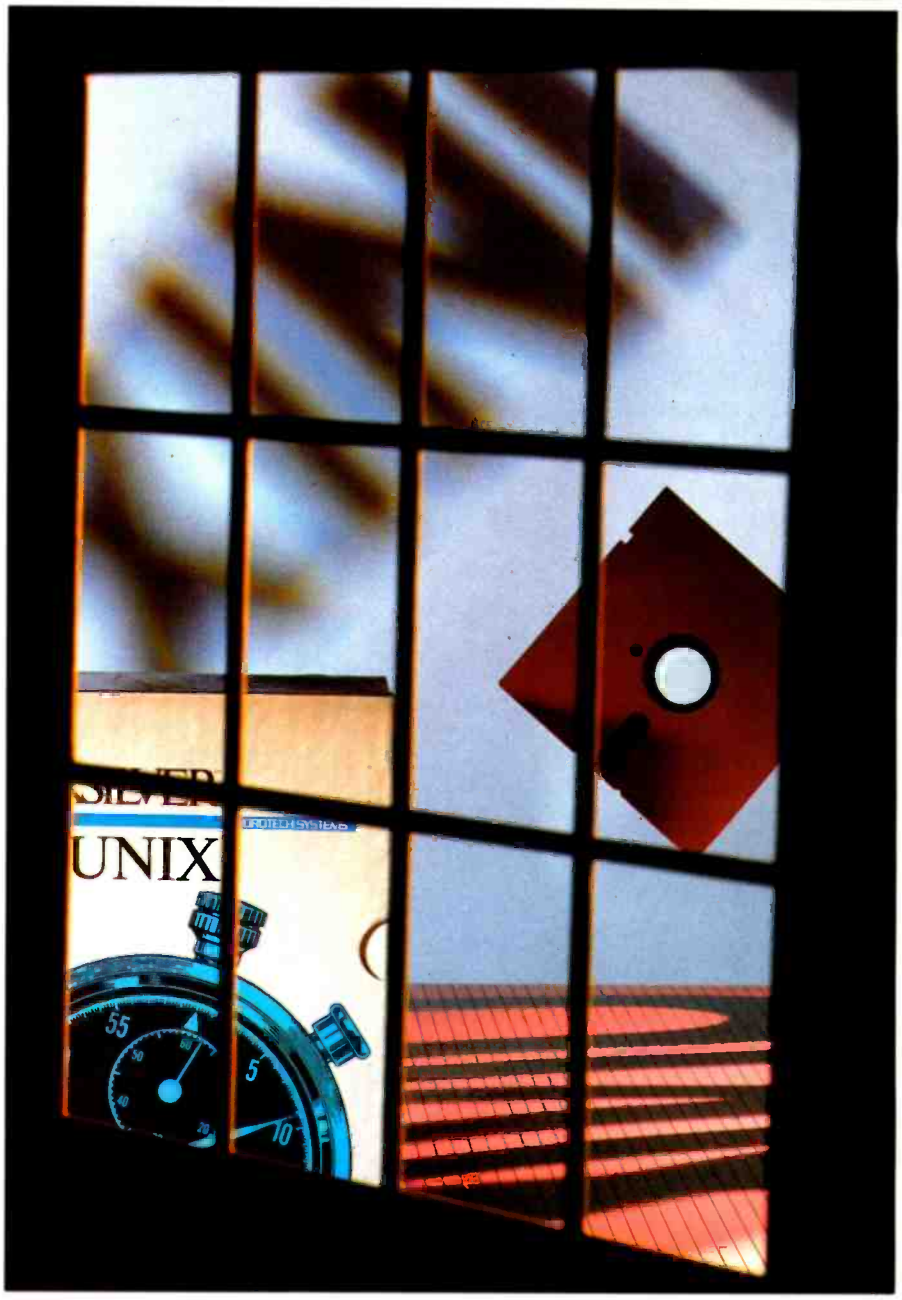






The mainframe computer world is under siege from desktop workstations running the Unix operating system. The corporate dinosaurs which live there face the choice of evolution or extinction says Jack Schofield.

NOTHING BUT UNIX

Most computer users are now wondering whether or not to buy a Unix system. Some have to make a choice between Unix and OS/2 on PCs. Some have to make a choice between Unix-based file servers and proprietary network operating systems. There is a battle between Unix and a wide range of minicomputer operating systems such as DEC's VMS, IBM's OS/400 and Prime's Primos.

Meanwhile most workstations, mini-supercomputers and supercomputers are already being sold with Unix, or Unix look-alikes such as Idris, Coherent and Helios. And some operating systems which aren't Unix are being taught how to put on a Unix face. Even OS/2 is undergoing a rewrite in C to try to compete with Unix on the desktop.

In sum, Unix is taking over. But because computer users tend to have a narrow field of vision, few have realised how far Unix has spread. It is the only operating system supported by virtually every firm from Atari to Cray Research. Its range is unmatched.

In the 1980s, DEC quintupled in size by selling the idea of using one operating system, VAX/VMS, all the way from the desktop workstation to the mainframe-powered VAXcluster in the corporate data centre. Unix goes further: from home and school users with Acorn Archimedes workstations to national supercomputing centres with Crays (UniCOS is Unix too).

Unix has often been touted as the way to avoid getting trapped in a proprietary environment. If your proprietary supplier overcharges, provides poor services, fails to provide an upgrade path or goes bust, there may be nothing you can do about it. With Unix, you can move your programs and data to another brand of hardware.

This portability means you can move from (say) one mini to another. But it also means that Unix provides scalability—you can move your programs and data from a smaller machine to a larger one, and the price range for Unix runs from $3000 to over $30 million.

Compare this with the 'portability' promised by IBM's Systems Application Architecture (SAA). Is anyone really going to move an application developed in C on a single-user PC running OS/2 to an AS/400 minicomputer optimised for RPG? Would anyone willingly rewrite an RPG program in Cobol for an ES/3090 mainframe running MVS, VM or VSE? Although SAA promises that the main software products will be offered on all three platforms, this makes little sense when you think about how it would work in a production environment. Indeed IBM has stopped stressing portability as a major SAA benefit: This isn't a surprise. SAA may make sense if you've already got the machines, but it's an absurd reason to buy them.

IBM needs SAA because it has applied Occam's razor to its lineup of operating systems. It is expensive to support 17 at least 17 different operating systems.

Worse, most firms have equipment from more than one vendor. As well as several incompatible IBM operating sysytems, they may have incompatible operating systems from other suppliers too. Just how many operating systems is it sensible to support? Users need to apply occam's razor themselves.

The European Commission is one large user that has done so. It had four different makes of mainframe—including ICI, Bull and Amdahl—and four incompatible mainframe operating systems. It is now moving everything to Unix. Any firm with several incompatible types of mini-computer or workstation could make the same decision.

It's not just that it's the sensible thing to do, it's the only thing to do. After all, what do Bull, Data General, DEC, IBM, ICL, NCR, Olivetti, Prime, Siemens-Nixdorf, Stratus, Tandem, Wang and the rest have in common? Only one of them supports Primos. Only one of them supports Guardian. Only one supports OS/400. But they all support Unix.

Given that nearly every firm will have to support Unix on some system or other at some level, why not use it on all the systems where it is appropriate and useful? With 75% of the computer industry now backing Unix, the number of such systems will explode over the next decade. This cannot be said of any proprietary operating system.

Since Unix is a portable operating system, different suppliers run it on different processors. Program source code may be portable, but the binary (compiled) code must be different for each CPU. This means you can't stick a disk in a drive and expect it to work, as with PC-compatibles. Sun, for example, needs three different binaries for workstations with Motorola, Intel and Sparc processors; IBM will need three versions of AIX to run on its Intel-

"It's not just that it's the sensible thing to do, it's the only thing to do..."

based PC-compatibles, its RS/6000 systems and for AIX/370, hosted under VM on its mainframes.

In the future, computers at all power levels will be able to run the same binary code, thanks to the ABIs (applications binary interfaces) developed for the leading microprocessors. These include the Intel 80x86, Motorola's 680x0 and 88000, the Mips Risc range and Sun's Sparc.

Microprocessors increase in power by roughly two orders of magnitude every decade. No matter how powerful a microprocessor may be, there is always a way to double the power of a computer: use two chips, or use 10 chips, or ... how many can you afford?

Using multiple microprocessors is not quite as easy as that. However, there are numerous firms with viable Unix-based products—Pyramid, Encore, NCR and Solbourne are examples. Further, there is a company which has a proven Unix system built using standard Intel processors. The system beats almost everything in industry-standard benchmarks. And it has a track record in the commercial world, having been re-badged and sold by the likes of Siemens, Unisys, MAI Apricot and Prime. Its name is Sequent.

The interesting thing about Sequent is that its Dynix multiprocessing system has just been adopted by the Unix International group. It will now be used in the enhanced security, multiprocessing Unix System V Release 4 ES/MP. Sequent's partners in this project are AT&T Computer Systems, Fujitsu, ICL, Intel, Motorola and Pyramid. It will clearly become a standard, and probably the dominant standard for multiprocessing.

Given, say, 40 microprocessors rated at 20mips each, you can build quite a powerful Unix system. The rapid progress of 'drive arrays' built using multiple small hard disks—which will this year become good enough for use on IBM-style mainframes— will solve any storage problem. With the adoption of standard high-speed fibre optics for communications channels—remember, FDDI already offers 100Mbit/s—then input/output will not be a problem. And given that all these technologies are widely supported and extremely cheap, it should be obvious that the current style of mainframe is a dinosaur.

Several of today's mainframe suppliers are capable of adding up and have already realised this. IBM, for example, has started to let its back room boys talk about mainframe 'SysPlexes' where the real work is done by arrays of multiple risc processors. But, strangely, only one mainframe supplier has so far proclaimed the future—NCR.

On September 18, NCR made what it called "the most significant product offering in its 106 year history." It announced the System 3000, with seven levels of machine from laptop-sized PCs to 100,000mips mainframes. Every system (bar the smallest) will run Unix. Every system will be based on Intel microprocessors. Every system will be compatible at the binary level; although NCR has only introduced a couple of the machines, it is already claimed to have 35,000 software packages for them. What Sequent did as a small, start-up company NCR will do with the marketing muscle of a $6 billion corporation. Several dozen rivals will not be far behind.

Historically, many industries have gone through turning points where leading suppliers failed to see what was going on until their customers disappeared. The railway barons, for example, failed to see the threat of the motor car, the great steamship owners didn't extrapolate to the jumbo Jet. We are at such a point now—and since this is the computer industry, the change will take 10 years instead of 40. Just don't say you weren't warned. ■

Jack Schofield is editor of Computer Guardiani

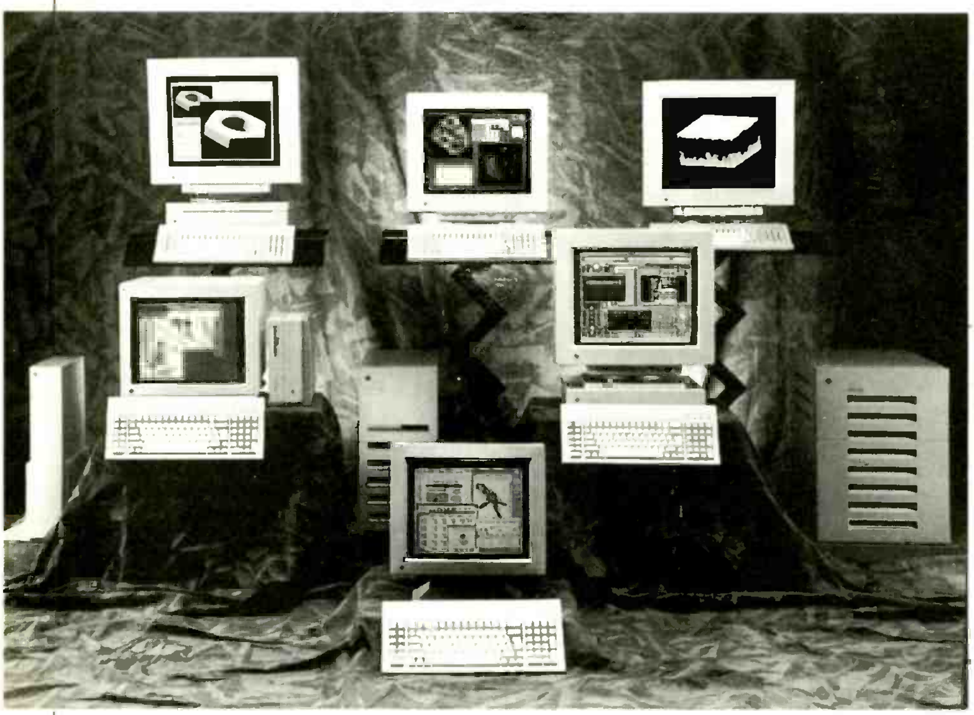
Cost-effective, powerful, expensive, complicated? Steve Rogerson finds out whether Unix and Dos can learn to live with each other.

Dos/Unix - the price of change

Deciding to move from dos to Unix is not easy. But the decision is made harder by common half-truths surrounding Unix, particularly concerning price.

Companies frequently justify their decision to stay with dos on the premise that costs of a Unix system are so high as to be restrictive; in fact a bottom-end Unix workstation can be bought for less than a top-end 486 PC and has a higher performance.

Where cost definitely does affect adoption of Unix is software which is generally expensive. But even here all predictions are that the difference with dos will whither away within two years at the most. There is also quite a lot of free Unix software milling about.



Sun Sparcstation family: Clockwise from the centre are SLC, IPC, 2GT, 330, 470VX and 2 models.

Cheaper workstations

Sun Sparcstation is the leading Unix engine. But the key to cheaper workstation price is that Sun has opened up its architecture. Now Sun clones from Japan are coming onto the market and soon even cheaper models will arrive from Taiwan.

One of the established makers of machines is the US-Japanese alliance of Matsushita and Solbourne. For £3000 you can get a monochrome 12Mips Unix station and in a short time models are predicted to be available at around £1000 cheaper.

Steve Scrace from Solbourne explains that Sun's acceptance of clones has clearly had an effect.

"Sparc has about 60% of the risc market. There are at least five or six companies planning Sparc machines in the next few months and there are even Sparc laptops around."

Ray Whalley of ARS Microsystems points out that from a pure hardware point of view, for cae use in medium to small companies, even the Sun itself has a distinct price advantage. He says it is giving the 486 a run for its money ."and now that clones are about you don't have to put all your eggs in one basket. Solbourne for example is a very competent machine."

There seems general agreement that workstations are a little dearer than PCs. But they are coming down in price and there is a merger between the high-end PC and the low end workstation.

Even so John Coom from Sun admits there is still a problem with users' conception of price.

He insists the cost barrier has been dismantled, but a psychological barrier remains. "People perceive Unix as more expensive. Yet systems start at around £3500, and you can get a good system for that. Compared with the equivalent PC, it is cheaper" he says.

Software cartel?

There is simply no justification for the massive differences between the prices of dos and Unix programs.

One explanation for the discrepancy is that most of the software is produced by a small number of companies - a situation beloved of cartel operators. Companies know that at present people will pay more for Unix software, so why drop the price?

But this arrangement is likely to be broken open in the next two years as smaller software firms enter the scene.

ARS agrees that the drawback to Unix is cost of software and that on this basis, dos currently wins, though is likely to change quickly. But it won't be the "fat cats of the cae software industry" that will be the leaders in this respect, says Whalley. "It'll be the innovative and dedicated cae suppliers that will start the ball rolling".

The price difference has obviously had a drag on Unix, with potential users reluctant to purchase until the price of software reduces. However during the next year prices should start falling with the launch of new software products.

But Whalley says that judging by the number of calls ARS receives on the subject, there is already quite a flow of people moving over to Unix.

"They want the schematic capture tools that are available; they are buying the machines and then looking for the software which they find is very expensive", he says.

Companies like ARS are doing their bit to help users make the transition a little less painful. For example ARS sells the PSpice circuit analysis and circuit synthesis packages and for users wanting to migrate from dos (extended or not) to Sun Unix, the company offers 100% off the price the user paid for the dos version against the Unix version.

Francis Griffith from National Instruments agrees that software for simulation is really expensive, though it is very powerful. "You wouldn't pay £40 000 for software on dos; the software though is really high performance", he says.

Meanwhile, companies are working towards levelling out software costs.

Coom from Sun agrees that in general Unix software is still dearer: "But at the low end the difference is small and getting smaller. As the volume of work-stations rises, software costs will come down."

"There is a merger between the high end PC and the low end workstation."

"The fat cats of the cae software industry won't be the leaders, it will be the innovative and dedicated cae suppliers that will start the ball rolling."

Multi-users

One of the big disadvantages of dos is limited memory, and lack of a true multitasking operating system. It is also difficult for it to be a multiuser system; with cad you need a sensible networking system and dos was never designed for that.

"Dos is single user, single tasking built on technology available ten years ago", says Coom. "Unix can be run on virtually any platform and takes advantage of the risc line. dos is locked into the Intel instruction set and will always perform best in that environment. Things like networking are all built in with Unix."

Unix also has a better security system with restricted access and passwords. Straight dos has no passwords even though the packages that run on dos do have password systems.

Memory is not limited on Unix as it is on dos, so when writing software the user does not need to be aware of the memory size in advance.

Dos still appropriate

But for some applications dos is ideal, and Scrace says that if you are running a single user task using one application then dos is a fair choice.

John Wilburn at JAV Electronics supports this view and says for his firm, coping with draughting, PCB layout and general two-dimensional work, the dos-base meets their needs.

He accepts that Unix has greater capabilities than dos but that it has been "bloody expensive" and ruled itself out of a lot of markets.

"As an engineer you are normally working on your own so you don't need the system to be multiuser", he says. "We use a resource sharer network with no file server. This is a better approach than having an expensive file server with low cost terminals because you can't afford better ones."

John Hicks of Amplicon has a similar view: "All our systems are dos based and the people who come to us have usually decided they want dos. We see, again and again, people going to dos on cost, cost, cost all the time. Dos is more economic, though Unix is much more powerful".

It may be this assessment which will stop Unix from taking over completely. In any case not everyone wants to move away from dos or needs the extra facilities.

Coom recognises that it is a big decision to move out of dos if you have invested a lot in it. In his opinion if all you are doing is running a simple dos based programme then you should stick with dos.

But he is clear that if you want multitasking, networking and good graphics then you must move to Unix.

Esoteric language

The traditional anti-Unix brigade points to its rather esoteric command language as a drawback, but this is really no longer applicable.

Sun machines have Open Windows which is an icon-based system that is easy to use and makes the transition from dos to Unix much more straightforward.

Unfortunately for dos early versions of Windows were pretty much a disaster. Whalley reminds us: "Windows 1 and 2 under dos were virtually unusable and this has no doubt had a negative effect on software authors migrating to Windows 3, which is quite usable. "

Windows 3 does seem to have brought a slight turnaround in allowing applications to run at the same time, though it is still only a single user system.

Francis Griffith points out this can have repercussions in data acquisition where a PC is handling a lot of inputs and outputs.

"If a D-to-A converter is operating and you are trying to do something, you can

Other people are coming up with clones. This means you don't have to put all your eggs in one basket."

National Instruments provides software-transparent interface links between the Sparcstation and the VXIbus or VMEbus

find that the system will not cope. This is where parallel processing comes into its own".

Coom says that dos users can find the new command language difficult. "When Unix first came on the market it wasn't very user friendly compared with dos and often you had to use more commands to do the same job as dos. But there are now Unix front ends to Unix systems that are very easy to use."

Certainly dos graphics resolution is pretty basic compared with Unix and dos doesn't support the Windows environment very well as a result. Straight lines wobble which makes Windows hard to use. With dos the user has to continually flip between screens because the resolution is not good enough in the Windows.

There is a better level of graphics with Unix and a much faster environment. Sun machines have very high resolution displays so the characters and schematics can be read in smaller windows.

"Dos will succeed in retaining a share for some applications. Unix will not bite off anything more than a minority interest."

Unix engineering

According to Whalley at ARS there is a substantial growth in analogue simulation: "If you want large DSP designs you have to move to large horse-power machines and they are not the 486s. Unix software may be twice the price but you get more than twice the performance."

ARS has recently carried out benchmark tests running PSpice on various platforms using circuits of different type, size and technology. Compared with an 8MHz AT, the IBM PS/2 25MHz 486 OS/2 machine was 13 times faster but the Sun Sparcstation 1 was 23 times faster.

Despite this, Griffith still believes that Unix is not that prolific in engineering. "It is for cad, but not for data acquisition and instrument control."

Results that count

"Scientists and technical people don't really concern themselves with the operating system, they just want to get the job done," says Tim Bunning from the Scientific PC Users Group said. "They are looking at results and not how they are achieved. Unix will have a secure future but it won't really win the hearts of people. Unix will not bite off anything more than a minority interest."

Not surprisingly Scrace disagrees: "In the electronic engineering market Unix

National Instruments provides software-transparent interface links between the Sparcstation and the VXIbus or VMEbus.

has just about taken over from dos. There is a lot of blurring now. It used to be a hard line jump from PC to Unix, but not any more".

He is convinced that Unix is taking a significant part of the market, but says that the cad sector itself splits into different types of user, some of whom don't need big powerful machines.

Coom's assessment is that dos numbers are still massive, but that Unix is growing faster than anything else and that we are seeing the migration towards workstations.

He says: "People are choosing Unix rather than 486 PCs on the replacement market through Unix is not taking the low end PC business."

Perhaps the situation is best summed up by Charles Clark from Those Engineers:"It will not be an out and out fight with a clear winner. Both will have their places in the market." ■

Open a window on Dos and let in new life

Neil Fawcett, Computer Weekly PC Editor, sees new release Dos and latest versions of Windows giving Unix a run for its money.

AT&T's Unix operating system is the do-it-yourself wardrobe of the computer industry; we all know the pieces will make something very useful. But where do you start in putting them together?

First reaction to the Unix package is invariably that, as it stands, there is rather a lot to learn before it is possible to get to grips with even very basic tasks. An unpleasant piece of programming called the Unix command-line-prompt can be traced as the cause of this.

On an IBM this is the C:\ prompt — the interface between user and operating system that allows the obtaining of a disk directory, loading of a program or copying of a file.

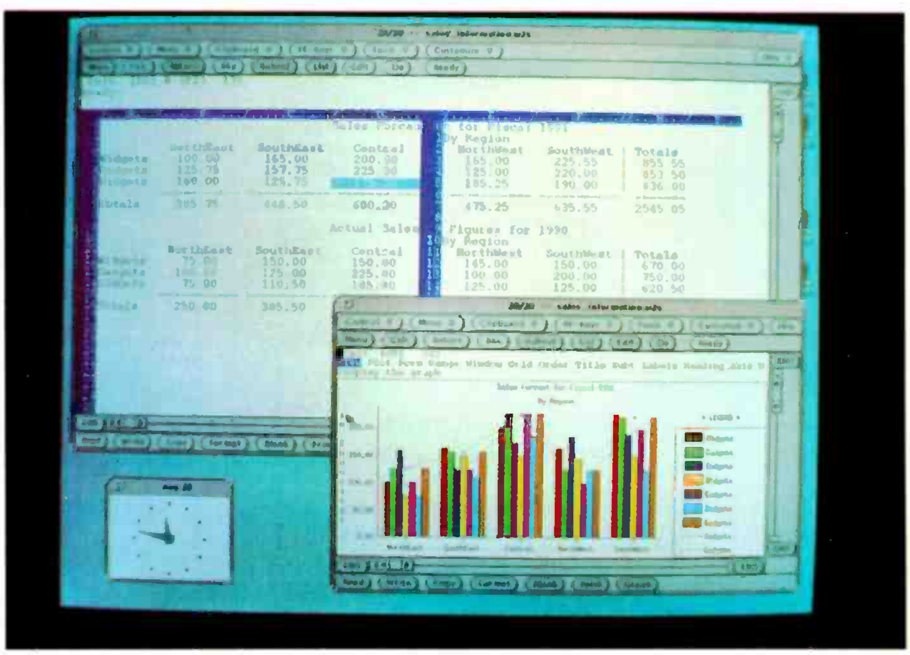
But the fundamental problem with the Unix (and dos) prompts is remembering the correct syntax for performing a particular function. This is additionally complicated by the fact that different companies' variants of an operating system usually use their own syntax.

Graphical interface for Unix

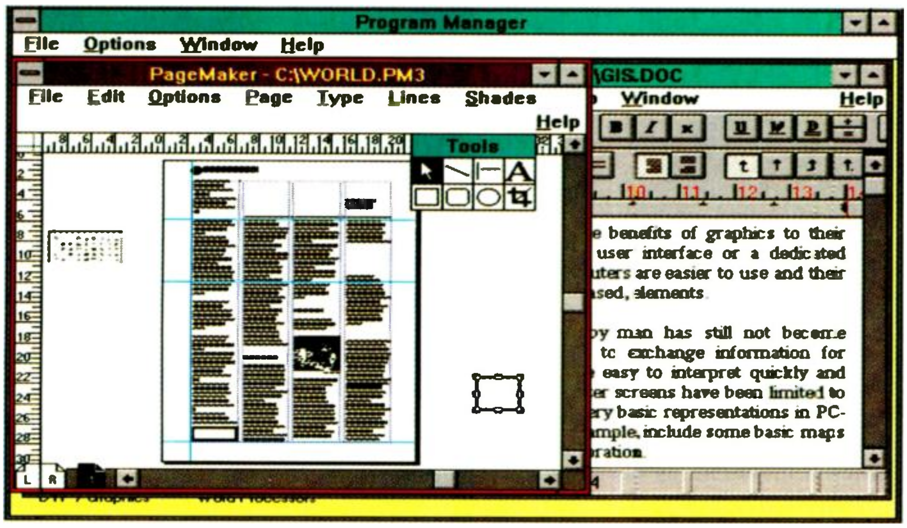
There has been progress in tackling the difficulties of entering commands, most notably the graphical user interface (GUI), a concept devised in the 1970s at the Xerox Palo Alto Research Centre (Parc), where the human computer interface was first investigated.

What the GUI offers is a simplistic method for performing common operating system tasks without the need for remembering syntax or using a keyboard.

In the Unix world there are two offerings in the war of the GUIs, OpenLook and Motif, although in all honesty it is dif-



Life under Unix. It hardly makes any practical difference to the user which operating system is in use. This is X-Windows.



Windows 3 provides multitasking with windows and icons enabling dos to do what the Mac has done for years.

ficult to tell the two apart. What really separates them more than anything else is the marketing drive imposed by the two governing bodies behind the products — Unix International and the Open Software Foundation (OSF) — proportional to the number of software and hardware companies joining each consortium so influencing their users.

With Unix the GUI interface has helped greatly to "standardise" an operating system that is 25 years old and has existed in more flavours than ice cream. Software developers modelling their applications around OpenLook or Motif can take advantage of a mouse-controlled environment that uses pull-down menus, scroll bars and windows.

From a training angle this means that once one application has been mastered the learning curve required for a second is greatly reduced. Market research also shows increased productivity from users running GUI-based applications as opposed to character-based programs requiring keyboard input.

Unix desktop doubts

Despite effectiveness of the GUI interface in the Unix world the use of Unix on a desktop computer is still very questionable. Does the user really need a full blown operating system that can have more than one application running in memory at any given time, and can have more than just one user using these multiple applications?

Personally, I find the ability to run more than one application at a time is useful - but this is probably due to my use of an Apple Macintosh which has had this facility for some time.

Take the example of a spreadsheet and graph-making program running simultaneously in memory. Inputting monthly sales figures in the spreadsheet running in one window on screen, will automatically update and create a graphical representation in the other. However having multiple users attached is not an important prerequisite of a desktop operating system.

> From the desktop computer perspective there is now no doubt that Dos will suffice for the next decade as the operating system of choice for the end user.

What the GUI interface offers the Unix user is a simplistic method of opening the required windows on screen, and its multi-tasking feature allows the programs to run in memory together.

Life in the old dos?

Dos is now getting on in years. Not as old as Unix, but it has been far more widely exploited by the computer industry. With 45 million PCs expected to be using dos by the end of the year and over 30,000 applications for it, there is difficulty in seeing why it is everyone's choice for a desktop computer.

However, how long can such a product can go on before it stops being useful and starts becoming a hindrance.

Dos has always been called unfriendly, because of its ugly command line interface, and chastised over its single-user single-application architecture.

In 1984 Microsoft announced a product called Windows, designed to sit on top of dos and extend its functionality by adding simulated program multi-tasking and a fully functional GUI interface. Could this really extend the life of dos and truly open up the power a PC to the user? The answer both yes and No!

Early versions of Windows offered a lot, but in real terms they were rather clumsy. But in 1990 Microsoft really got its act together and announced Windows 3.0, a product that has breathed fresh air into dos. From the desktop computer perspective there is now no doubt that dos will suffice for the next decade as the operating system of choice for the end user.

In April when Microsoft announces dos 5.0 - a quicker and slimmer version of the ten-year old operating system - a wave of excitement is guaranteed to spread through the PC industry.

Following this Microsoft will announce Windows 3.1, taking full advantage of the reduced program size of dos 5.0, and companies like WordPerfect and Lotus Development will ship Windows versions of their products.

Microsoft will be concentrating on improving the memory management of

NewWave from Hewlett-Packard runs under Windows 3 to provide batch file facilities, GUI style.

Windows — good news to users with only 640k of memory in their PCs — and will enhance the way in which Windows allows more than one application to run in memory at the same time.

Of course Windows will eventually run out of steam in its effect on extending functionality of dos; you can only do so much with an ageing product before you have to drop it and start again.

But for the average desktop computer user, a species now numbering many millions, dos and Windows will be the perfect partnership to meet their computing needs over the next decade.

Unix and dos networking

Unix is a far superior operating system to dos, with its true multi-tasking and the ability to handle more than one user on a system at a time, and OpenLook and Motif make it easier to use.

But Unix is still an operating system for the technical workstation, running complex computer aided design or scientific software, or for controlling mission-critical business applications, such as payroll or accounting software.

However, there is no reason why the two operating systems cannot work seamlessly together within a business. Networking of desktop computers around a company is on the increase. These networks are usually connected to a fileserver computer, commonly a very powerful PC based around a 33MHz Intel 80386 microprocessor, that in turn links back to an IBM 3090, AS 400 or a minicomputer running a variety of operating systems including Unix.

On a computer like a 3090 or AS400 a company will run its main business software, such as payroll or accountancy. The fileserver will act as a routing device for the network of PCs and will also serve as a central data repository.

Due to the nature of its tasks the operating system on a fileserver must be very powerful, which is where Unix will funtion perfectly. From a desktop computer's standpoint all the difficult jobs of a client/server architecture network, such as data storage, database interrogation or data transfer, are handled by a force external to its own operating system.

So the ageing dos using a Windows 3.0 interface can realistically last as a desktop operating system for sometime.

Role for OS/2

OS/2 operating system from IBM and Microsoft fits into the same part of the client/server equation as Unix.; it is a powerful multi-tasking operating system that can, like Unix, support multiple users.

But when first announced OS/2 required 4Mbytes of system memory to run, and chewed a large hole in a computer's hard disc drive. All this new-found power left the user with a price to pay, and stringent budgets coupled with the costs of buying new software to run under OS/2 has left this particular operating system with a small number of users.

But OS/2 does have an important role to play in the networked PC marketplace. Due to its powerful design it is a perfect candidate for installation on a fileserver. It can act as a router for high speed data flow between desktop PCs and a 3090 mainframe running a fourth generation language relational-database that holds vital corporate information.

IBM would have us believe that OS/2 is a desktop computer's ideal operating system. Adhering to this conviction the monolithic US computer company has announced a very trim version of OS/2, called version 1.3 but nicknamed OS/2 Lite, that it promotes as a desktop operating system.

OS/2 Lite needs only 2Mbytes of system memory and has much less of an impact on the hard disc. But the underlying problem with the system is the fact that many major companies around the world have invested countless millions in dos and dos-applications. They are loathe to scrap this investment to start again by installing OS/2 on their desktop PCs and commit more money.

So what is the best strategy to adopt when weighing up the various options?

Very simply, stick with dos on a desktop PC and use OS/2 on a fileserver to give that extra power for connecting into a mainframe. It is not difficult to make OS/2 act as a gateway for dos users into a network that eventually connects into a mainframe database.

Desktop users can continue to operate using familiar applications, already purchased, but can obtain the added performance of OS/2 without having to reinvest in software, retrain employees and go through the headache of re-implementing a network.

Common graphics

OS/2 also comes with a product called Presentation Manager. PM is a GUI interface and its on-screen familiarity with Windows 3.0 is amazing, but expected considering the fact that Microsoft jointly developed OS/2 and PM with IBM.

Release 2.0 of OS/2 will soon appear and at this time the PM interface will allow Windows 3.0 applications to run. The beauty from a user's standpoint is that a whole network, from lowly PC to mighty fileserver acting as a gateway into a mainframe, will have a similar graphical look and similar mouse control actions.

Eventually dos and Windows will cease to offer users the functionality they require to meet their needs, but this will not be for some time.

For the next 10 years we will continue to see a mixed computing environment where dos, Windows, Unix and OS/2 will all cohabit together. Until we reach a time when just one operating system rules, computer users will just have to put up with all the confusion generated by hardware and software vendors all persuading that their solution is the best.

As for the GUI interface, it will be interesting to see what the artistic programmers within the computer industry can come up with. ■

Controlled, high-voltage converter

Using the principle of the soft-switched flyback converter, a simple, compact and efficient high-voltage source can be made.

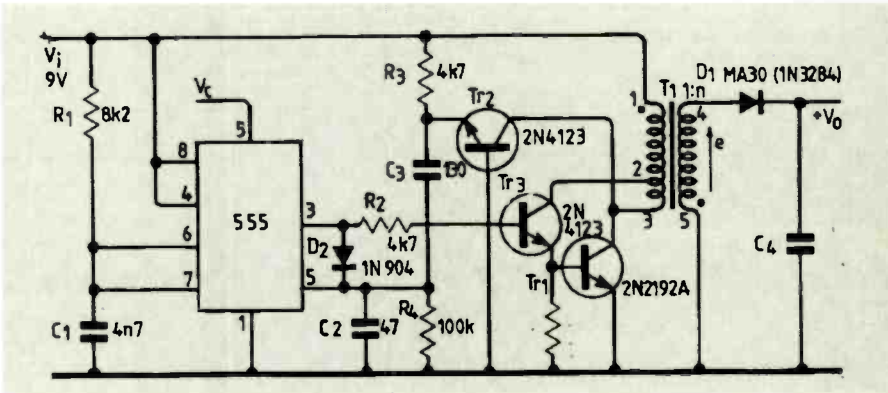
The conversion cycle has two intervals, T_2 and T_4, during which oscillation takes place. During interval T_1, Tr_1 is on and D_1 off; in T_3, Tr_1 is off and D_1 on.

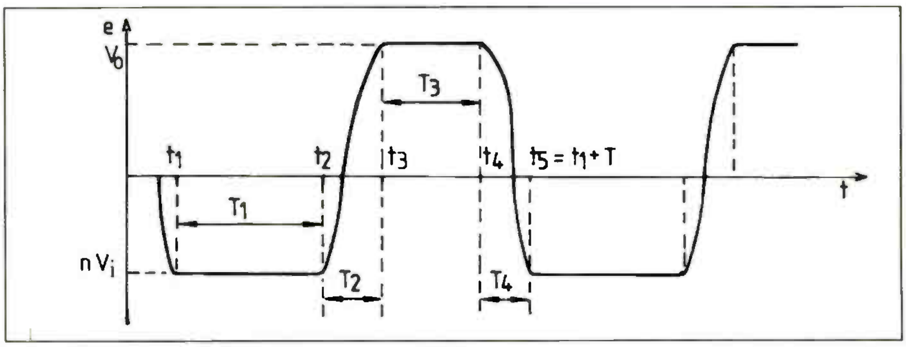
In the oscillatory intervals, the resonant circuit is T_1 inductance L and capacitance C_0, which comprises T_1 winding capacitance and Tr_1 and D_1 capacitances. Durations of T_2 and T_4 are set to provide soft zero-voltage switching of Tr_1 and D_1; this and the discharge of C_0 during switching reduces power consumption,,

Switching off Tr_1 and D_1 on are naturally at zero voltage and zero-voltage switching on of Tr_1 can be enabled by a diode in parallel with Tr_1, automatically turned on at T_1. However, to provide control of V_0 by variation of T_1, the collector-base junction of reverse-biased Tr_2 is used to trigger the 555 monostable at T1. Resistor R4, C2 and D2 trigger the monostable at initial switch-on.

Output power is 2W at an efficiency of 80%, voltage V_0 can be varied from 300V to 2kV, switching frequency varying between 35kHz and 80kHz. The transformer is wound on a Philips P18/11 3H3 potcore with an air gap to give 250nH. Winding 1-2 is 11 turns of 0.2mm wire; 2-3, 1 turn 0.2mm; 4-5, 500 turns 0.1mm.

Yevgeny Ivanov
Moscow



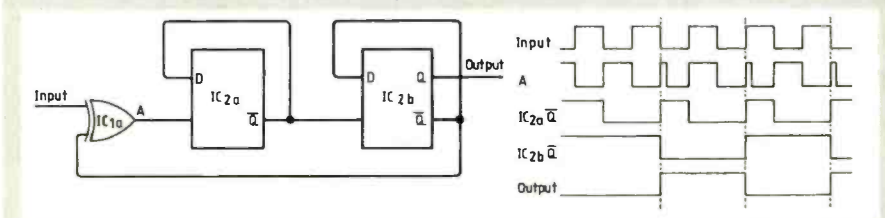


Divide-by-three with 1:1 M/S ratio

This alternative to that described by Watson in the August issue uses only two ICs.

Exclusive-Or IC_{1a} inverts the clock signal when IC_{2b} output is low and passes it when IC_{2b} output is high, the output being one-third the frequency of the input.

M. S. Babbra
Swindon
Wiltshire

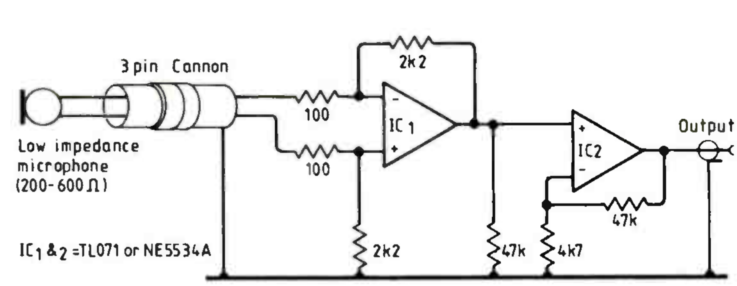


Balanced micro-phone amplifier

This amplifier is intended as a cheaper alternative to the conventional method of amplification using an impedance transformer. Low-noise op-amps provide equivalent performance to a transformer burt at a fraction of the cost.

The first stage is a differential amplifier connected to give a balanced-to-unbalanced conversion with 26dB gain, another 20dB being obtained from the second op-amp. With careful construction, the amplifier is hum-free and is usable with long cables.

Alan Morgan
Cheltenham
Gloucestershire



Controllable crossover network

A two-pole Butterworth crossover network has its crossover frequency set by a single potentiometer.

Figure 1 shows a network with normalised element values and w=1. Taking input and output of the amplifier to be 1, the two-pole Butterworth functions are:

$T_H=H/e=-p/(p+\sqrt{2}+1/p)$

and

$T_L=L/e=-(1/p)/(p+\sqrt{2}+1/p)$

If a gain control with two reciprocally related gain paths is inserted in the node shown dotted in Fig. 1, the crossover frequency is variable. **Figure 2** shows a way of doing this, in which

$V_1=(1/R)-1=(1-R)/R$

and

$V_2=(1/(1-R))-1=R/(1-R)$

which are, as required, reciprocal and the circuit of Fig. 2 can be inserted in place of the dotted circle in Fig. 1. The +1 gain amplifier can be eliminated, but the remaining five amplifiers are inconvenient.

In **Fig. 3**, voltages and currents are:

$e=(1/R)-1=(1-R)/R$

$v=3$

so gain is

$3R(1-R)$

If the lower end of the potentiometer is connected to another identical circuit, its gain is

$3(1-R)/(1-(1-R))=3(1-R)/R$

which is again reciprocal except for the common factor of 3.

For a practical circuit, add end resistors to the potentimeter and scale the component values.

McKenny W. Egerton
Owings Mills
Maryland
USA

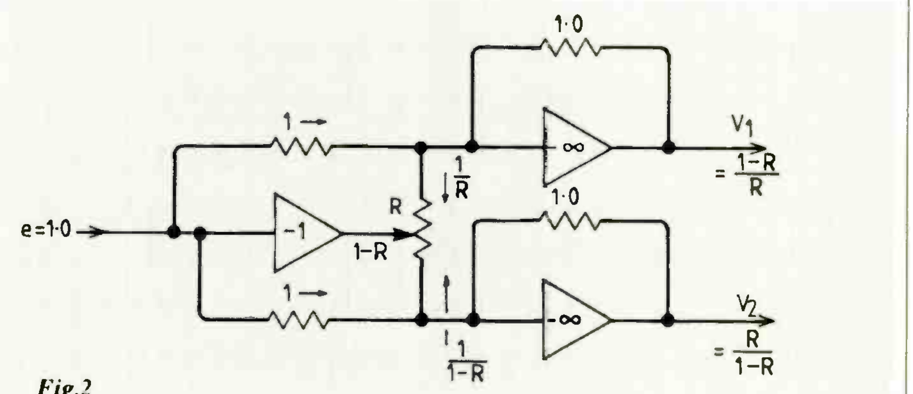


Fig.2

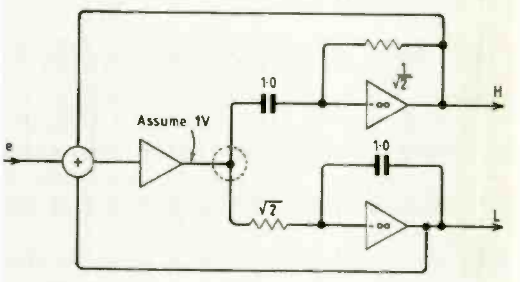


Fig.1

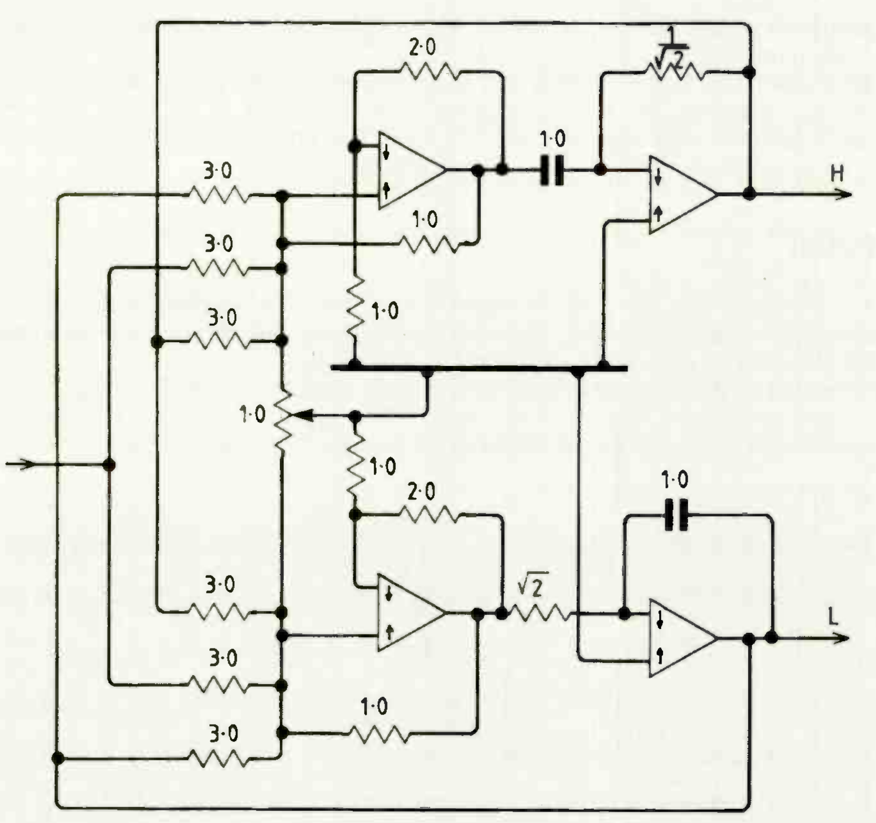


Fig.4

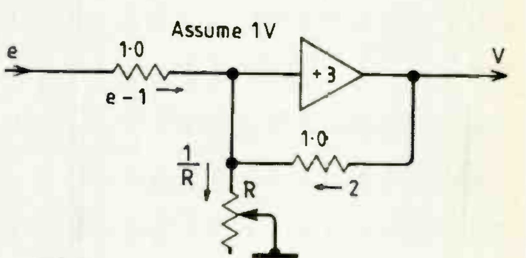
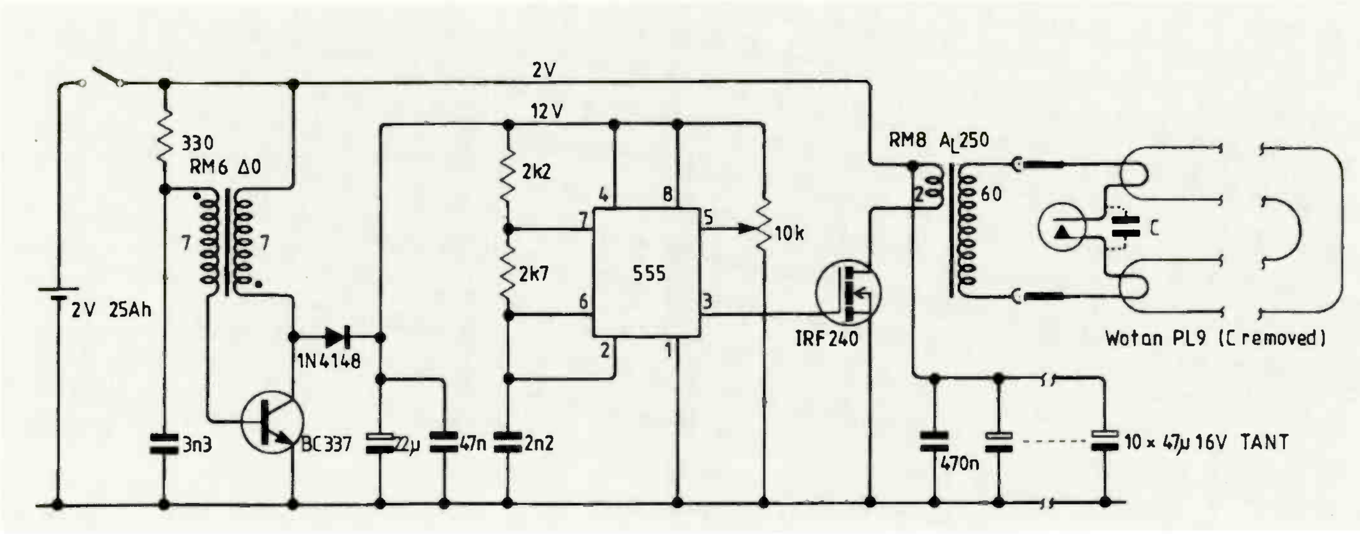


Fig.3



2V fluorescent-lamp inverter

This circuit powers a Wotan PL9 9W lamp from a single lead/acid cell, giving up to five hours at full brightness from a 25Ah cell.

At 2V, $V_{CE(sat)}$ and $V_{BE(sat)}$ of bipolar transistors would make the circuit inefficient, the gain and low saturation of a fet being required. A low-power, self-oscillating bipolar converter provides 12V for the output driver 555 — a better arrangement than the use of a self-oscillating output driver, since the magnetic components are now not critical and there is no need of a start-up circuit. The 10k potentiometer adjusts the duty cycle to allow one to achieve a compromise between current consumption and lamp brightness.

Use tantalum capacitors in parallel for output decoupling and copper foil for the two-turn primary. Retain the starter, but remove the interference suppression capacitor by bending its aluminium tags and drilling through the pins. Using the less-common four-pin version avoids this problem.

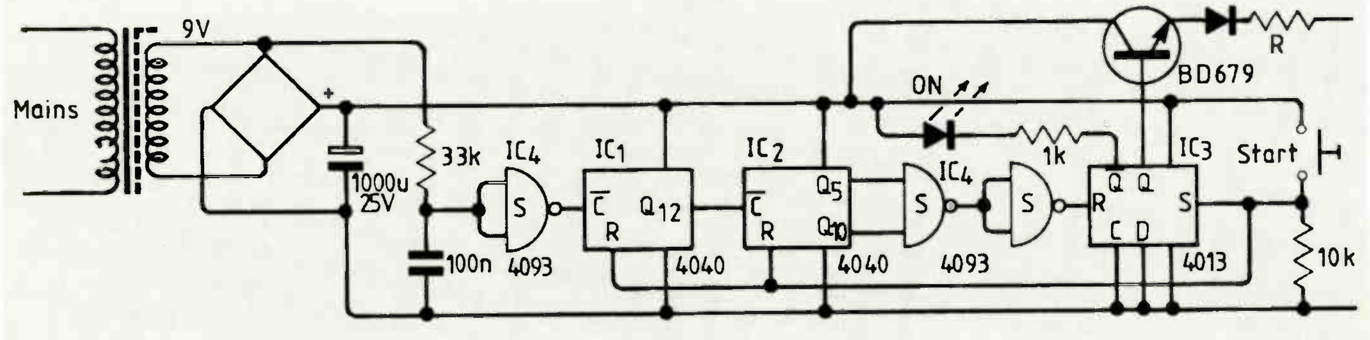
Paul Bennett
Stoke Gifford

NiCd charger with timeout

Charging batteries at one tenth of the rating for twelve hours can be inconvenient in that one has to remember to switch off. This circuit provides an automatic switch-off at the correct time.

A simple divider chain, using two 4040 twelve-stage dividers, turns off the supply after twelve hours. The switch clears the registers and sets the output flip-flop, reset occurring when Q_{10} and Q_5 are both 1. Charging resistor R depends on the cell size, but 180Ω is suitable for IEC R6 (AA) cells. Four such cells may be connected in series, providing all are at the same state of discharge.

Jens Langvad
Solrod Strand
Denmark



Landing on a radio beam

The Instrument Landing System which has been used by the world's airlines and commercial aircraft for 43 years is beginning a 10-year phasing-out period in favour of the Microwave Landing System. Greg Grant tells the story of radio landing systems, which saw a tentative beginning in about 1919.

From the first experiments with flying machines, landing has always been the most critical phase of a flight, from which few of the early pioneers came away unscathed.

In 1919, the American Bureau of Standards began trials using radio as an aid to landing in poor visibility. A 500W, 500kHz transmitter feeding two vertically-stacked horizontal loop antennas was used to produce vertical radiation and a cone of silence. However, even in the mid-1920s "... it was considered something of an achievement if a pilot could be given an indication by radio that the aircraft was over the airfield"[1]. Between 1928 and 1930, however, the Bureau initiated a number of other, more detailed experiments using an equi-signal beacon system, in the hope of developing an accurate landing aid.

These trials, in turn, led to the publication of a research paper by the two engineers involved, H. Diamond and F.W. Dunmore, in which they established the way ahead in the further development of landing aids for aviation. The relatively simple system evolved is shown in **Fig. 1** and its most original feature – suggested by Dunmore – was the VHF landing beam. This signal has the simple role of providing "... a pilot with the necessary vertical guidance to permit landing under conditions of no visibility"[2].

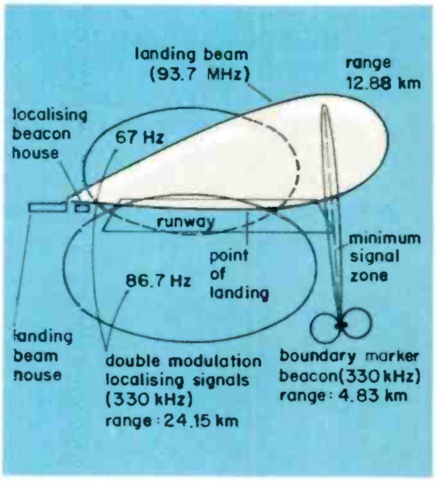


Figure 1: A 3-dimensional view of the Diamond-Dunmore blind landing radio system.

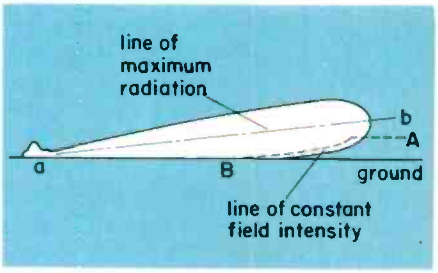


Figure 2: The vertical directive characteristic of the Diamond-Dunmore landing system.

Vertical aspects of this beam are shown in **Fig. 2**. Horizontally polarised, its angular displacement and directivity was such as to create a line of constant field intensity and thus a 'glide-path' which a correctly-equipped aircraft could follow. In the horizontal plane, the runway beacon transmitter beam functioned well. The on-board aircraft pointer indicator was operated by reading the currents in vibrating-reed pickup coils tuned to 67Hz and 86.7Hz and could register course deviation of as little as 1%. Consequently aircraft drift of ±6%, which meant a signal strength reduction of 5%, could be accurately displayed.

It was shortly discovered, however, that flying directly from b to a resulted in the swamping of the on-board indicator, due to the increasing proximity of the aircraft's receiving antenna to the beam transmitter.

Eventually, what could be called a 'decreasing glide' was developed, the aircraft dropping further and further away from the beam's maximum intensity path as it approached the transmitter. Thus the on-board instrument could be held at half-scale throughout the approach. This track is shown as **AB**.

From the data obtained, Diamond and Dunmore showed that if the beam was orientated vertically and given "... the proper degree of directivity, this line of constant field intensity may be made to co-incide with the landing path normally followed by a pilot in clear weather"[3].

By 1933, continuing development resulted in the addition of two marker beacons, one located some 600 metres from the runway threshold, the other one third of a kilometre from the threshold. Although they both operated on the same carrier frequency as the localiser transmitter, they were modulated by different frequencies, the approach marker using 1.25kHz and the threshold beacon 0.25kHz.

On the approaching aircraft, too, progress had been made, the combined indicator shown in **Fig. 3** – yet another Diamond-Dunmore origination – relieving the pilots "... of the need for considerable mental effort"[4].

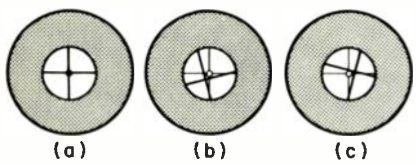


***Figure 3:** Diamond-Dunmore pilot's indicator. At (a) the aircraft is on course, at (b) below and left of course and at (c) above and right.*

By 1934, there were Diamond-Dunmore beacons in use at Newark, New Jersey and Oakland, California, the first blind landing using the system having been made three years earlier by M.S. Boggs at College Park, New Jersey.

In Europe, too, aircraft landing difficulties were receiving greater attention than formerly. The British government's installation at Farnborough, for example, used what was termed "leader cables" in the localiser role, as indeed did a French government installation at Chartres. Where the former entailed a complete cable circuit around the airfield, the latter made do with a simple, straight-cable arrangement.

In Germany, however, they took the American approach to such problems, the Lorenz beacon system dating "... from 1932, when the use of very high frequency (VHF) was suggested, using vertical polarisation for the equi-

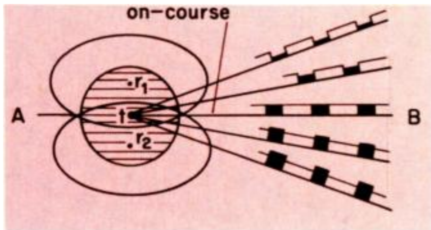


***Figure 4:** The antenna, reflectors and radiation pattern of the Lorenz Beam system.*

signal lateral guidance"[5].

Developed by E. Kramer and R. Elsner, this system was as simple and effective as the Diamond-Dunmore arrangement and bore some similarity to it. Both the localiser and the glide-path signals were radiated from a single transmitter, whose vertical antenna had a switch-operated reflector located either side of it, as shown in **Fig. 4**. One reflector's switch was operated by dots and the other's by dashes which, when interlocked, gave a continuous tone. The major axes of the two elliptical field patterns were parallel to the runway. Only one pattern was present at a time, inasmuch as a single source of energy was used to supply the energy in both patterns[6].

In other words, by open-circuiting one reflector as the other was simultaneously closed, beacon radiation was given a change in direction. Along the line AB in Fig. 4, though, there was an equi-signal course. In the interval between the opening and closing of the reflector switches, the main beacon transmitter was the sole radiator. Its polar diagram is shown hatched, the perimeter passing through the points of intersection of the two switched beams, thus preventing key-clicks as the reflectors were operated being received as interference on the on-course signal.

Vertical guidance – after Diamond-Dumore – was by following paths of uniform signal strength, as shown in **Fig. 5.** Horizontally polarised marker beacons were also provided, the first indicating the point where the glide

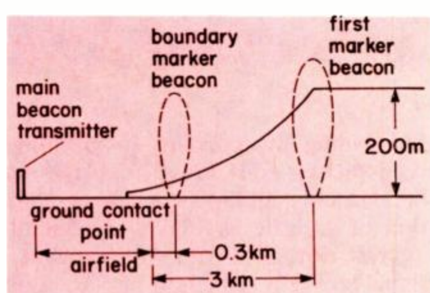


***Figure 5:** Lorenz glide path and marker beacons.*

path began, the second the imminent approach of the airfield threshold. Both beacons transmitted on a carrier of 38MHz, although their modulation characteristics differed, as shown in **Fig. 6.**

By the beginning of 1937, experience on both sides of the Atlantic had revealed a number of problems with the existing systems, whether they had been developed by governments, the airlines or both.

Later in the year, the American Bureau of Air Commerce – whose predecessor had begun it all a decade or more earlier – set out detailed specifications for the development of an efficient, workable Instrument Landing System, in concert with the Federal Communications Commission and the Radio Technical Committee for Aeronautics.

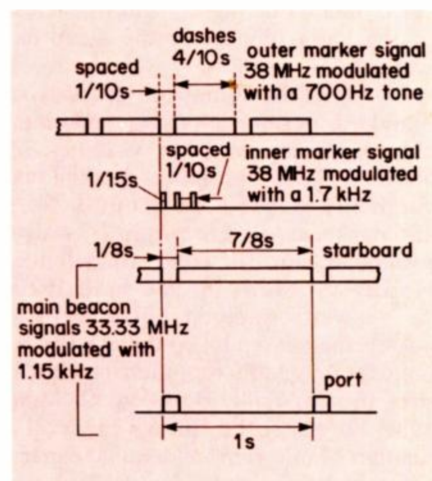


***Figure 6:** Signal characteristics of the Lorenz main and marker beacons.*

To begin with, it was decided that such an aid would be based on the elements already in use, and effectively monitored. Secondly, the localiser course should be narrower and thirdly, since a glide path based on constant field strength "... is at no time a straight line (and) is liable to start too steeply and to become too flat in the final stages"[7], the possibility of creating a constant rate-of-descent path would be studied.

These problems were investigated by a small group of engineers from the International Telephone Development Company, under the leadership of A. Alford. They shortly decided that horizontal propagation was one solution to their difficulties, the VHF loop antenna another. The latter provided almost pure horizontal radiation, resulting in a course pattern virtually free from the phenomenon known as "pushing", the seeming displacement of the signal as a result of the aircraft's direction of approach. Furthermore, using VHF loop antennas meant that arrays of three and more could be constructed, giving overlapping patterns and providing all-round coverage in azimuth and sharpening the beams considerably. Indeed a course pattern of 6dB per 1.5° deviation from the on-course became easily realisable.

Undoubtedly the team's most significant innovation was the Alford transmission-line bridge, which enabled them to ". . . obtain two independent modulations of a single carrier so that under no reasonable circumstances would their rates change, and thus affect the established course"[8].

Moreover, as the transmitter's mechanical modulator divided the RF output in two and modulated these carriers with 90Hz and 150Hz respectively, cross-modulation could have become a problem. It didn't, however, the Alford bridge maintaining distortion levels substantially below 10%.

The localiser was one problem; the glide slope quite another. In Germany, Kramer had taken a critical look at the Diamond-Dunmore constant-intensity glide slope, attempting to control the path's shape. He did this by off-setting the antenna from the runway centreline so that differing amounts of energy could be applied to straighten out this distinctly curved approach. He was only partially successful, his system being reasonably straight for only the final 600 feet or so.

Another concept undergoing investigation at this time was a glide slope akin to the localiser, with overlapping radiation patterns, developed by two other civil aeronautics engineers, J.C. Hromada and D.M. Stuart. The system used two antennas one above the other and a common carrier, tone-modulated by different frequencies. As with the localiser, the radiation patterns overlapped, this time in the vertical plane, establishing a reasonably straight line of descent.

Both these developments had shown that both the Diamond-Dunmore system and the Lorenz equipment were capable of improvement. The Hromada-Stuart system, however, had problems of its own. Firstly the frequency used, 90MHz, was still too low and secondly, the 5° descent path was too high.

Alford and his team proposed that two VHF loop antennas be mounted on a vertical pole, the lower one around half a wavelength above the ground, the upper one several wavelengths above the ground. This would give a cone-shaped beam, whose apex would be at the pole itself. Moreover, if this arrangement was offset from the runway centreline, the localiser's beam signal would be parallel to the cone's axis, giving a hyperbolic intersection.

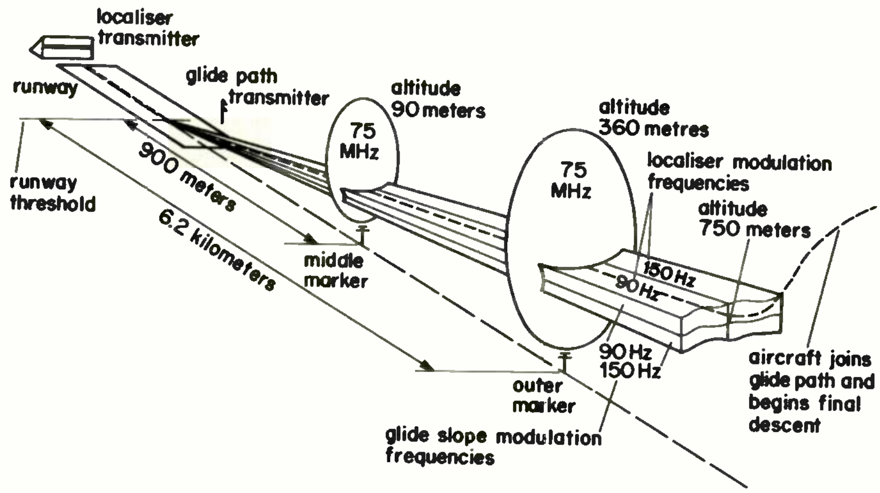


Figure 7; System drawing of the Instrument Landing elements and an aircraft's approach path to, and track along the installation, to runway letdown.

Such an arrangement would give a constant rate of descent from virtually any height, but the parabolic path would flatten out as it approached the runway touchdown point. There was a further advantage, too, in that the touchdown point would be adjustable, since glide-path angle is ". . . established by an amplitude ratio between the strength of signals from the upper and lower antennae"[9].

The final difficulty was that of choice of glide-path transmitter frequency. The development team had realised that any frequency below about 300MHz would present difficulties of antenna size. In the end, 330MHz was chosen, firstly because of the above problem, secondly because the localiser's 110MHz crystal-controlled drive unit could readily be provided with tripler circuits, thus being converted into glide-slope transmitter units.

The first complete, fully operational Instrument Landing System was the SCS-51, illustrated in **Fig. 7**. It was adopted by the American armed services in 1942, and by the International Civil Aviation Organisation for use throughout the world, in 1947.

Since that time, the glide-path segment of ILS has developed apace, particularly in terms of terrain adaptability. Currently there are four different types of glide path station in use.

Where the siting factors are average to good, the null-reference array is the preferred set-up. Although all sites have level ground immediately fronting the antennas, matters can differ greatly thereafter. Where the ground rapidly turns downwards, the sideband reference array is used; where it steadily rises, the quadrature clearance array is employed. Some sites, however, are far from ideal, and present particular problems of their own. In such situations, the capture effect equipment is usually the only solution.

Where the sideband reference array has its lower antenna mounted at $h/2$ above the ground and the upper one at a height of $3h/2$, the null reference assembly is simpler. Its antennas are 4.2m above ground and 8.4m high (for a 3° glideslope). The mast is located approximately 300m after crossing the runway threshold and 150m to the side of the centreline.

Another important facet of glide slope siting is longitudinal distance. If, as in **Fig. 8**, the ground is flat, then distance d is determined by the general formula

$$d\tan\theta = \text{threshold crossing height}$$

$$\text{and } d = \frac{\text{TCH}}{\tan\theta}$$

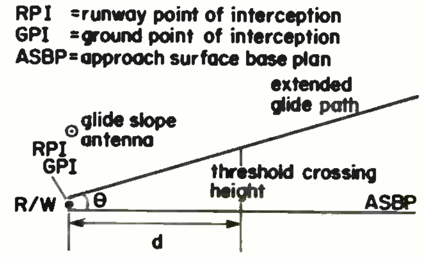


Figure 8: Glide slope longitudinal distance requirements.

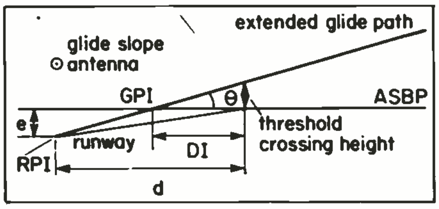


Figure 9: Glide slope with positive-sloping runway and terrain.

where, for such optimum conditions, the threshold crossing height is taken as 15m.

Not all sites are as straightforward as this, however, and where the glide-slope terrain has, for example, a positive-sloping runway as shown in **Fig. 9**, then distance *d*, whilst still being calculated as before, now includes an elevation difference factor *e*. So:

$$d\tan\theta = \text{TCH} + e$$

$$\text{and } d = \frac{\text{TCH}}{\tan\theta} + \frac{e}{\tan\theta}$$

If the runway has a linear gradient or slope between the threshold and the general area of the ground point of interception, the change in elevation can be expressed as a function of the slope rate and distance *d* or:

$$e = sd.$$

where DI = distance from the GPI to the threshold, *s* = slope of terrain (%), and *d* = longitudinal distance between TCH and the glide slope antenna,

This is positive if the threshold elevation is higher than the elevation of the ground point of interception, and negative if it is not. Consequently the expression

$$d\tan\theta = \text{TCH} + e$$

now becomes

$$d(\tan\theta - s) = \text{TCH}$$

$$\text{and } d = \frac{\text{TCH}}{\tan\theta - s}$$

Runways come with all directions and varying amounts of slope, which affect the siting of the glide-slope transmitter, variants of this calculation being necessary; some of them even exhibit a lateral slope. To cope with sites having particularly difficult terrain, the capture effect shown in **Fig. 10** can be employed.

A clearance signal with a power of around 0.16W is radiated at low angles, the 4W directional signal being radiated above 1.5°.

Close to the glide path, the aircraft's receiver responds, captures the stronger signal and rejects the clearance ground reflections. There is an 8kHz separation between these signals, although both still remain within the aircraft receiver's passband.

These techniques have enabled the world's civil aviation authorities to meet the ICAO landing performance requirements at some of the most difficult locations, worldwide. Indeed, there is little doubt that the very success of such technology has, through the enormous increase in air traffic over the last two decades, brought about its own demise.

Thus the instrument landing system will join other, earlier casualties of the relentless advance of electronics, such as the Four-Course sysem and aircraft navigators and radio officers. ■

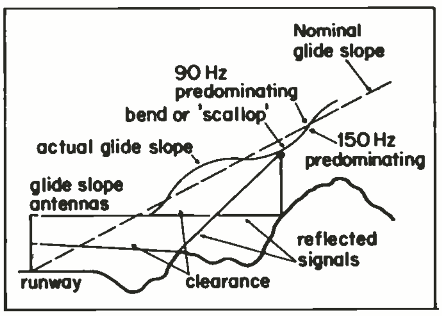


Figure 10: Illustration of the type of terrain where the capture-effect system would be used.

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BOOK REVIEW

The 386 PC Companion, by Allen Brown. The 386 PC Companion is actually a *PC companion*, but with the various aspects of hardware and software related to 386 machines.

As such it goes back to the basics of computing, explaining how a computer works and illustrating the roles undertaken by various hardware and software modules making up a computer system.

For example Allen Brown begins by introducing the 80386 chip, looking at how it functions, then defining the meaning of various types of ram and showing how disc memory operates.

In a similar way, and at a similar level, he goes on to describe the operation and range of peripherals available for linking to a computer, networking and multi-user systems, and computer add-ons.

The last 20% of the book is devoted to applications of the 386, briefly introducing Fortran compilers, DTP, cad, process control and data acquisition.

Like the foregoing, this section is a general introduction to potential applications of a 386 – really of most interest to readers who have never met the terms before.

Overall the author identifies four aims for his book: familiarise readers with the major aspects of 386 technology; help gain an appreciation of the 386; acquaint the reader with peripherals available, and help potential buyers of 386 machines.

Brown probably succeeds in the first three of these, but readers looking for advice to buy, usually have particular applications in mind which they need their system to satisfy. To give advice in this area requires a more in-depth treatment of this specific area than an overview book of this type can provide.

But for readers who already have a 386 machine and are curious to learn more about how computers work and what they can be made to do then this publication will be a useful purchase.

£16.95. Sigma Press, 1 South Oak Lane, Wilmslow, Cheshire SK9 6AR.

EMULATE OR SPECULATE?

With new microprocessor architectures and design methods, it is essential to use the correct development tool. Without it, says Geoff Lawday, design and test are imprecise, to the detriment of reliability

Formal specification and design methods for microprocessor-based systems are now finding acceptance, and the development task is undertaken at the human problem-solving level, away from the bit level.

Development-tool manufacturers are providing refined support for the new design methods and advanced microprocessor architectures. Moreover, the new tools are reducing the tedium of the development process, endearing them to engineers. Without the correct development tool, system design and test is speculative and the product reliability will be unknown.

At issue is the choice of tool for the development task, in which a software monitor, simulator, logic analyser or in-circuit emulator (ICE) could be appropriate. Real-time interrupt driven systems are normally non-deterministic, in that it is not feasible to test for every combination of interrupt after every instruction. When a system cannot be exhaustively tested the choice of development tool narrows to an investigative tool that will expose as many system characteristics as possible. New-generation ICEs are described that expose a microprocessor's use of time and space, the Sigma from Dux(UK), shown in **Fig. 1**, being a good example of the third-generation ICE.

New-generation ICE

Traditionally, ICEs or logic analysers are used to interrogate and record a microprocessor-based system's activity, the captured data being disassembled to give a

Fig. 1. PROICE Sigma in-circuit emulator from Dux (UK). Architecture provides range of 16 and 32 bit processors via exchangeable CPU modules.

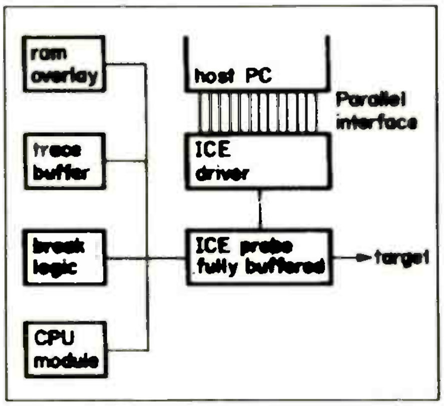


Fig. 2. Modular architecture employed by Sigma ICE allows for future developments.

view of the system's behaviour. Originally such ICEs were dedicated development units produced by silicon vendors to support their processors, such as the Intel blue-box system; these have become known as first-generation ICEs. Second-generation ICEs included those from independent emulator manufacturers who produced serially connected tools that worked with a variety of host computers. As larger and faster processors became commonplace and higher levels of abstraction were used for their software, the functionality of the test equipment moved to the third-generation ICE.

New-generation ICE architectures differ in concept and functionality; nevertheless, the fundamental purpose of real-time emulation is to exercise the target processor at full speed and to record a processor's activity without intruding into the target system hardware or software. Non-intrusive emulation is complicated by instruction pipelines, on-board caches and single-chip controllers, where there is a need to view a processor's internal bus activity. An ICE must differentiate between bus and processor activity; in other words, an ICE records what a processor is executing or what is being fetched on the bus. High-speed devices, reduced instruction-set processors and surface-mounted processors have all added to the challenge of real-time emulation.

Various techniques are used to overcome the problems of emulating very large scale integrated processors, such as extra connections to the internal bus or a discrete logic model of part of the processor. However, these techniques can change the electrical characteristics of the emulated device. Some risc and digital signal processors have built-in ICE communication circuitry, allowing on-chip emulation (OnCE mode). This term is also applied to the emulation of a surface-mounted processor which is literally on-chip emulated by placing the ICE probe over the target processor and tri-stating the on-site processor.

New-generation ICE architecture

The Sigma advanced ICE uses the 32-bit high-speed back-plane architecture with a modular construction, shown in **Fig. 2**, which gives the ICE an ability to support future CPU developments via interchangeable CPU modules.

Ram overlay. Ram overlay allows software development with an incomplete or partially populated target, whereby the target memory is mapped to the emulator, as in **Fig. 3**. Without the jargon, this means that the programmer can set up

Fig. 3. Memory mapping of target to emulator in Sigma package allows emulator to behave exactly as target hardware.

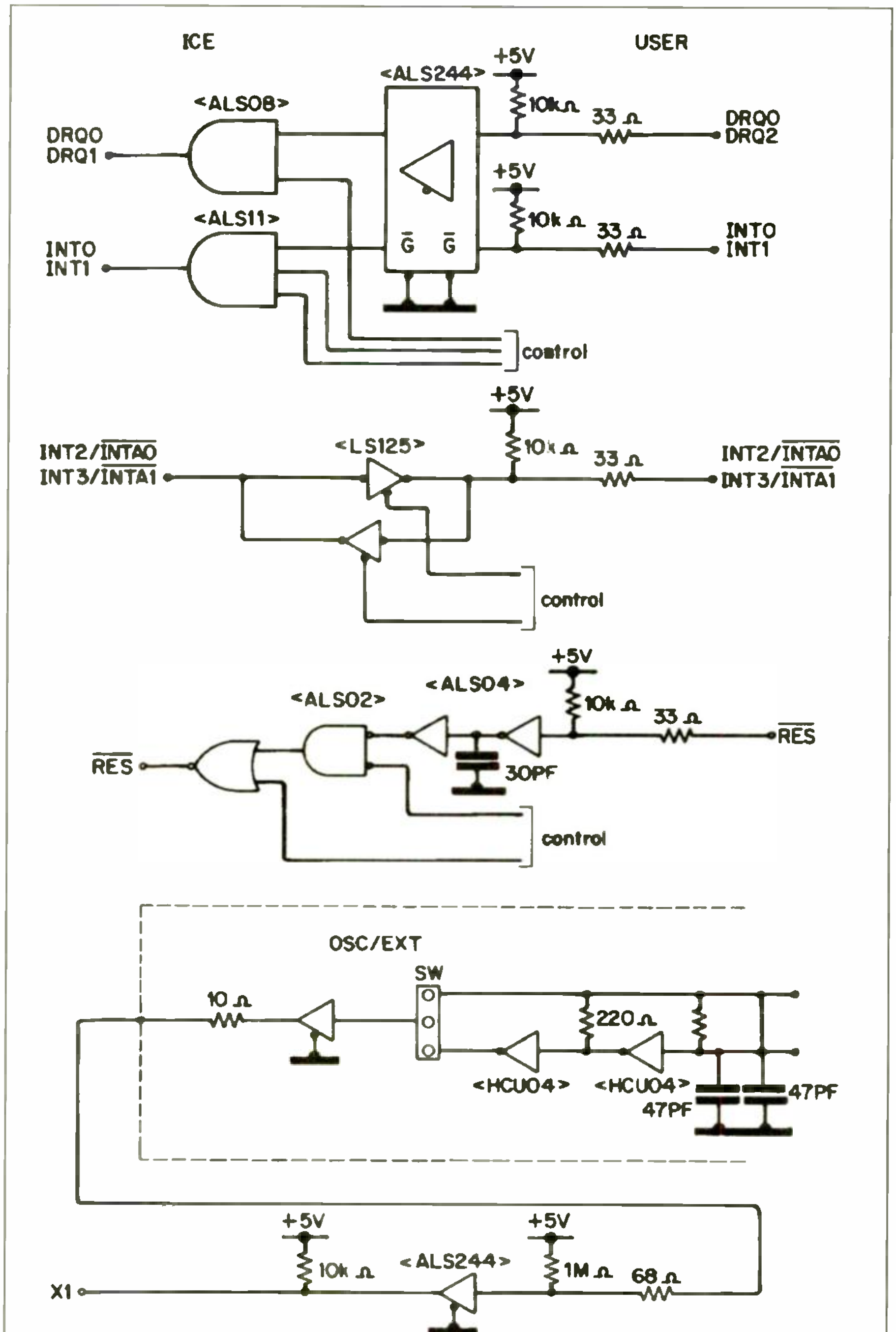
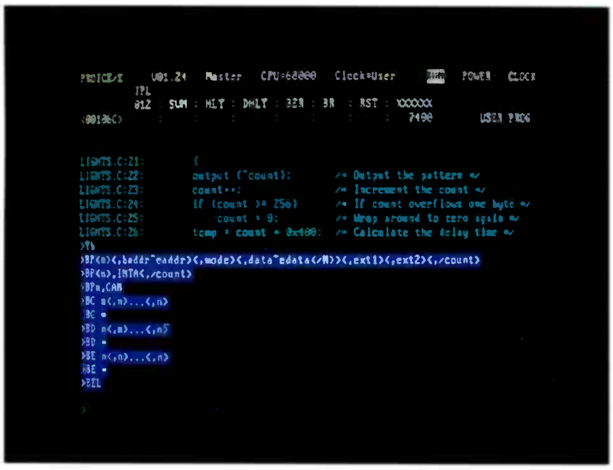
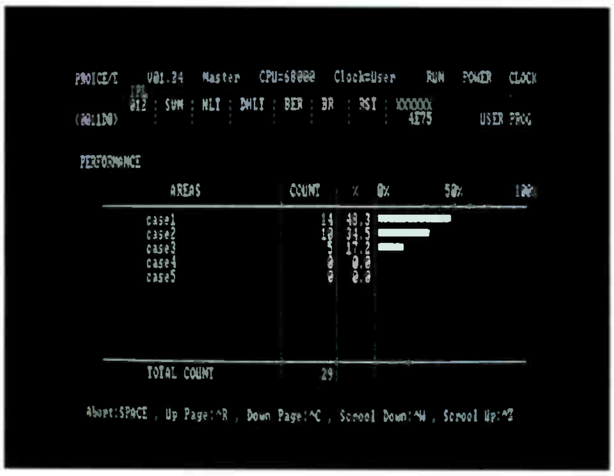


Fig. 4. ICE buffers must present the correct load, not only for address and data, but also for control.





Screen shots of Sigma ICE. Fig .5 (top left) shows on-line help screen and Fig.6 (right) demonstrates how menu-driven function keys allow debugging without cryptic commands. Performance analysis is shown in Fig. 7 .

memory in the emulator that will behave exactly as the user's hardware, then load the code into the emulator for development or test without waiting for the hardware to be completed. With emulator ram configured as rom or guarded, an illegal write will stop execution and display an appropriate error message, trapping unwanted memory writes such as a stack overflow.

An ASCII/hex display, setting, searching or disassembly of memory is normally provided. The facility to examine and modify the contents of the emulator ram without halting the target is useful, particularly during a DMA procedure or interrupt service, when the processor should not be stopped. An on-line two-pass assembler allows a code patch with symbolic references. This facility is ideal when testing ports; the danger associated with saving a patch is that the original source code does not relate to the patched code.

Trace buffer. High-speed memory to record a processor's activity is essential in an ICE. A typical trace buffer will contain 8192x72bit frames to record address, data, control and logic probe signals.

> The new tools are reducing the tedium of the development process, endearing them to engineers. Without the correct development tool,system design and test is speculative and the product reliability will be unknown

Filtering of specific information into the trace buffer, such as a program area or I/O access, is achieved via trace-buffer triggers which act upon combinations of address, data, control and logic signals.

So-called "on-the-fly" start, stop and display of a trace while emulating in real-time, along with the display of a trace buffer's contents relating the processor activity to its high-level source code was an important advance in ICE technology. This feature should support any language or compiler.

ICE timers give duration measurements of executed code, which can be combined with the trace buffer to time "snap-shots" of traced code.

Break logic. Comprehensive hardware break logic should allow the user's program or target to stop emulation when accessing a particular address, data, control signal, external logic or any number of combinations of these events, with their nth occurrence. Non-intrusive break logic allows real-time execution while trapping an elusive bug or checking the occurrence of a particular event. A common use of break points is in the elimination of an incorrect return after an interrupt service routine; the break logic would first detect an interrupt acknowledge, then the return instruction. When stopped, the processor's internal registers, stack contents and other information will generally reveal the cause of the bug.

Hardware break logic is normally built with registers and comparators which detect bus events, unlike software break points which intrude into the code and require the code to reside in ram.

Fully buffered ICE probe. Real-time non-intrusive emulation demands that an ICE presents the correct electrical load to the user's target. Buffering an ICE probe satisfies the single-device load requirement and isolates the ICE from the target, protecting the ICE circuitry. The ideal

ICE will have its buffers mounted in sockets for ease of maintenance; a buffer will fail if an ICE probe is inserted incorrectly or excess voltages are applied, not uncommon occurrences during development. Good practice in ICE manufacture can substantially reduce service costs and maintenance contracts.

Simple buffering of the address and data lines must be accompanied by similar buffer characteristics for the control signals if skewing of the processor signals is to be avoided (**Fig. 4**). Another advantage of buffering all the probe lines is the ability to enable or disable control signals such as interrupt lines via soft emulator commands. A well designed ICE will automatically sense the user power, clock and run-time signals, substituting internal ICE signals if the target fails. These probe features, coupled with an ICE control language, have made the new-generation ICE a powerful hardware debug tool.

CPU module. The personality of an ICE is the term used to describe the processor or family of processors supported by the emulator. Modern processors are fabricated in nmos and c-mos and integrate a range of peripherals to give a processor family any number of variants, including different speeds. A simple personality change may be achieved by swapping the processor in the emulator, but more often a major change is necessary where a complex module is exchanged within the ICE. However, this is more efficient than replacing the ICE, providing that the CPU module is well engineered and does not compromise the emulator at the expense of flexibility. Parallel processing with multiple processors requires master and slave CPU modules to be synchronised to enable their debugging.

ICE driver. Having an intelligent ICE driver module, whereby the emulator and host computer can operate independently, is an advantage during the flow of editing, compilation, linking and debug. Multi-job operation of the ICE and host development system allows a paperless debug, while a record of the debug history is automatically filed by the ICE for future reference.

A parallel connection between the ICE and host computer is essential for the fast communication of object and source code. Without an efficient ICE link, operation of the high-level debug is limited and the emulator becomes awkward to use. An ICE is restricted to particular object-code file formats when serially connected and a typical 64kbyte file transfer time of four minutes is needed at 9600baud, while a parallel bidirectional interface communicates 64kbyte in eight seconds, allowing the transfer of .ABS and .EXE files.

Inadequate testing produces a cost of correction which increases by a factor of 10 as a bug passes to the next phase of development. An undetected bug in the design stage can cost 1000 times more to correct when the system is with the customer

Systematic test and debug

It is generally accepted that the development process divides into three main activities: specification and design (40%); prototyping (20%); and test (40%).

The reason for using an ICE is to minimise the development time of each phase, while maintaining the product's reliability. Inadequate testing produces a cost of correction which increases by a factor of 10 as a bug passes to the next phase of development. An undetected bug in the design stage can cost 1000 times more to correct when the system is with the customer.

High-level debug

A software simulator is a computational model of a processor; working at a fraction of the speed of the actual processor, it predict the processor's behaviour. Some emulator manufacturers have allowed a simulator producer to put their simulator onto the front-end of an emulator, allowing a simulator to work in real time and interact with a user's hardware. Dux tools are an ICE with a special-purpose high-level debug front-end which will work with any language or compiler. Apart from the advantage of working with the language and compiler of your choice, there is generally a reduction in tool costs.

A high-level ICE interface gives the development engineer the ability to work at higher levels of abstraction, whereby source code is shown including comments, local and global variables, register, memory and stack contents. Operation of the ICE is via menu-driven function keys allowing break points, start and stop triggers of the trace buffer, single step and other debug activities to be achieved without the need to enter cryptic commands — see **Fig. 6.**

A source code display switch changes the displayed code between mixed source and its corresponding assembler, produced by the compiler and source only. Single-step execution can be carried out in low or high level, according to the source code display switch. Variations of single-step allow called functions to be executed at full speed while stepping through the main code, or full speed execution of the main program with automatic pauses to display the parameters passed to and from called functions.

Performance and coverage

Since it is not feasible to test real-time interrupt-driven code exhaustively, a measure of the code's use of time and space is essential. A particular interrupt or combination of interrupts at a critical part of the main program can produce unwanted events in a system. Moreover, the time taken to service an interrupt is often dependent upon the parameters being processed, the so-called interrupt latency, possibly resulting in too much time away from the main program.

Performance analysis continuously records instruction, statement, function or module executions, the information then being displayed by the host computer as a histogram showing the frequency or duration of the executed code, as in **Fig. 7.**

Real-time analysis

Real-time analysis should not be confused with a software statistical package; an ICE performance analysis will show what the code is doing while it is exercised in the user's target. Typical applications are checking that all switches in a case statement have been exercised and the time taken to execute them or any number of procedures. Analysis information can be used to optimise code by rewriting the identified inefficient, frequently run routines or interrupt routines.

Coverage analysis shows memory usage where unwanted memory writes occur or the so-called memory hot-spots are identified for reallocation of system memory. ■

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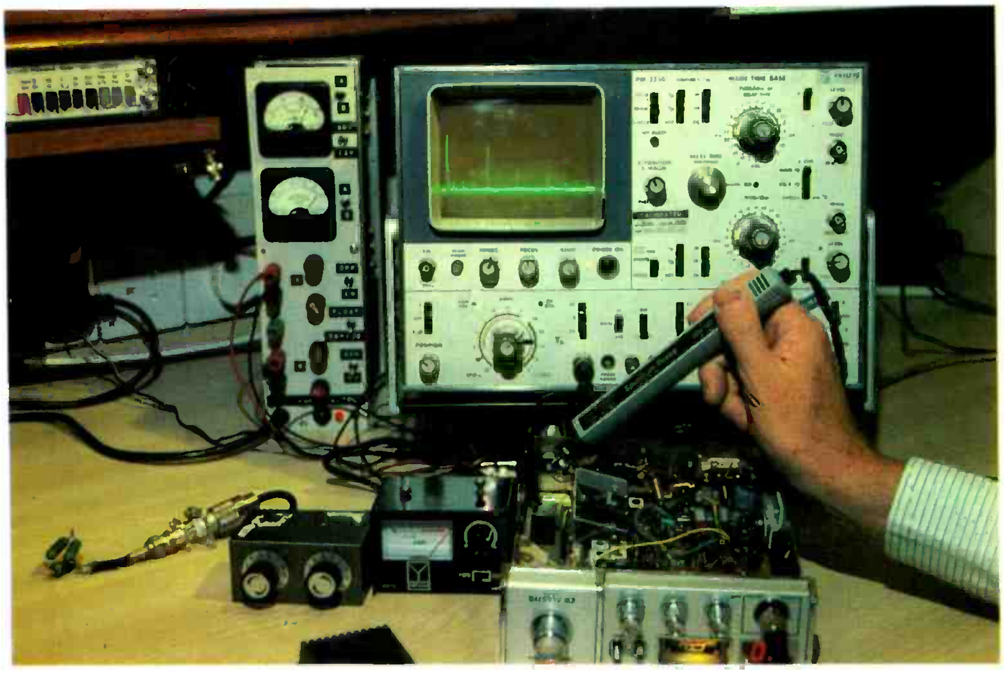

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SPURIOUS RESPONSES: Generallly -40dB
IF BANDWIDTH: 180kHz at -3dB
MAX CW INPUT: +15dBm, 1V at 100MHz
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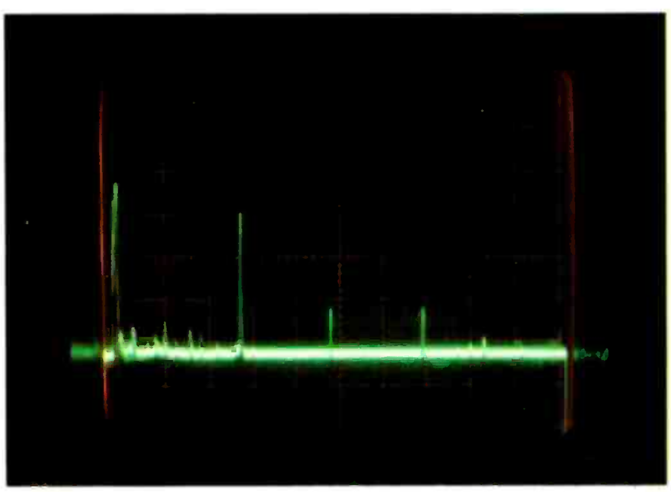

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Mike Tooley reviewed the Laplace Instruments Spectrum Probe in the November 90 issue of Electronics World+Wireless World. This is what he had to say: "***The ability to display signals in the frequency domain on a conventional low-cost oscilloscope should not be underestimated. Indeed, it should be stressed that the Spectrum Probe can display signals at 100MHz far outside the bandwidth of, for example, a 10MHz oscilloscope.***"

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Trial by three tones

Testing audio amplifiers by the triple-tone method is simple, uses a similar signal to that encountered when playing music and produces informative data. Ivor Brown describes the method and presents results

In the field of audio systems, and particularly with amplifiers, there is a long-standing problem of what measurements should be made to make a quantitative assessment that is in agreement with subjective listening tests. It is well known that amplifiers found to be very linear in the laboratory do not always perform well in listening tests.

Most tests use repetitive waveforms that have a defined spectrum; the relative amplitudes of those frequency components in the output waveform that are not present in the input signal can then be used to assess the performance of the amplifier. The simplest test is to apply a single sinusoid to the amplifier and to find the harmonics in its output. Taking the square root of the sum of the squares of the amplitudes of the harmonics and relating the result to the fundamental leads to the total harmonic distortion (THD) figure. It is now accepted that THD has little relevance to audio performance. However, a poor THD does suggest that all is not well, while a low figure is encouraging, in that the amplifier may be capable of good subjective results.

A slightly more complex approach is to use two sinusoids and to find their intermodulation products, which are generally larger and more numerous than the harmonics. The same distortion mechanisms are involved, so little more information is gained about the amplifier.

Some have employed pulse waveforms. Hirata[1] proposes an input composed of asymmetrical positive and negative pulses, arranged so there is no DC component in the signal. Any DC present in the output waveform is due to non-linearities in the amplifier and forms the basis for the assessment. The 'no–DC' requirement for the input waveform is critical, and not easy to satisfy if low-distortion amplifiers are being tested; Belcher[2] uses computer-generated pseudo-random binary waveforms. The process involves digital frequency shifting and comb filters to isolate the distortion components generated within the amplifier. It is a complex system, but good agreement with listening tests is claimed.

Amplifiers in the 1990s

What are the critical areas of amplifier performance that should be investigated? The days of worrying about reproducing the full audio frequency range are past, as is the concern over obvious distortions present in the output signal; yet most systems cannot create an effective illusion of a live performance, which surely should be a principal aim. Two important qualities necessary for the illusion are clarity and definition.

Until the arrival of the CD, all sources of reproduced music contained appreciable noise, which served to mask low-level distortions produced by amplifiers. Low levels of noise, being steady and not related to the music, are easily tolerated by most listeners. Without noise, such distortions can be detected, not as definite sounds, but as a lack of clarity. In stereo and other

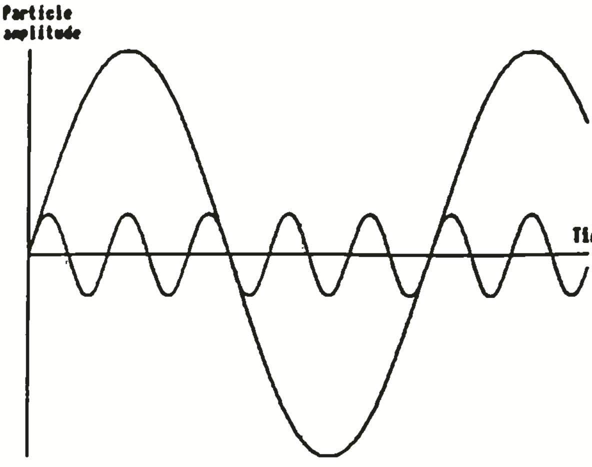


Fig. 1. For two sinusoidal waves with different frequencies to have the same peak particle velocity, relative amplitudes must be inversely proportional to frequencies.

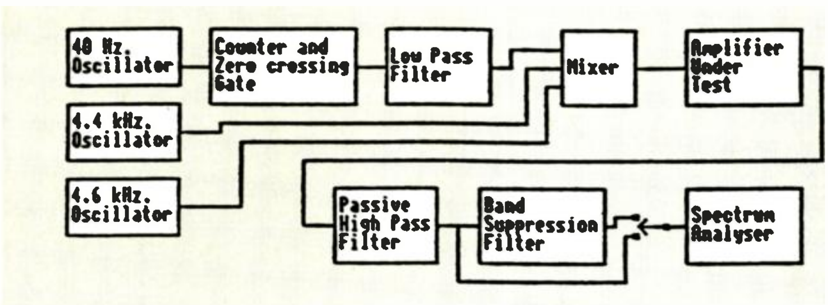


Fig. 2. Triple-tone test system.

multi-channel systems, this will be experienced as a loss of definition, with the spaces between the performers filled with a variable background derived from, but not simply related to, the programme material. It follows, therefore, that we should measure distortion components down to lower levels than has been the practice. (The fact that audio masking occurs is evidenced by the literature accompanying some CD re-issues, apologising for distortion and/or spurious studio noise that was only found when the master tapes were digitised.)

Some basic acoustics

The power in a plane sound wave is given by the product of the square of the RMS particle velocity and the specific acoustic impedance of the medium, air in our case. **Figure 1** shows the particle amplitudes of two sinusoidal sound waves with different frequencies. They have the same gradient at the zero crossings, and hence the same peak particle velocity. To achieve this, their relative amplitudes have to be inversely proportional to their frequencies. The specific acoustic impedance is resistive and independent of frequency for a plane wave, so the power in the waves is the same. The amplitude of a 100Hz sound will be 100 times, or 40dB, greater than a 10kHz one of the same power.

This is a simplified situation; most sound waves met in audio reproduction are not plane and the ear does not have a flat frequency response, but these considerations do not alter the basics. In fact, the situation is worse when non-plane waves are considered. If a 100Hz sinusoid produces high-order harmonics 70dB below the fundamental, they are only about 30dB below a 10kHz signal of equal energy. High-frequency sounds are not effectively masked by large-amplitude, low-frequency ones; consider how the piccolo or triangle can be heard through a loud orchestral climax.

This was discussed by Wigan[3] in 1961. He applied a weighting factor to each harmonic up to the tenth, so increasing the significance of high-order ones, but that number of harmonics is surely too low for current amplifiers. This is a lengthy process that requires the measurement of very low level harmonics.

Triple-tone method

Figure 2 is a block diagram of the test system. The first signal is a low-frequency (40Hz), large-amplitude sinusoid, gated at its zero crossings to form tone bursts. The other two signals are equal-amplitude continuous sinusoids and come from low-distortion oscillators. They are smaller than the low-frequency signal and their frequencies are close together (nominally 4.4 and 4.6kHz). All three are added to make the input signal to the amplifier under test. Using two high-frequency signals enables harmonic and intermodulation products to be investigated.

A low frequency is chosen for the first signal so that the variable current taken from the amplifier's power supply during each cycle is likely to cause the rail voltages to alter, the effect being enhanced as the signal is in bursts. After gating, it is passed through a low-pass filter to reduce the high-order harmonics produced by the switching process. Another advantage of gating is that it lowers the dissipation in the amplifier for a given peak output. Most amplifiers are not intended to operate continuously at high power levels, music signals having a high peak-to-mean power ratio.

The low-frequency signal sweeps the two small signals over most of the amplifier's working range, changes in their amplitude and waveform being observed as harmonic and intermodulation products. The cross-over region is critical for class-AB amplifiers, which are by far the most common type; the gated 40Hz allows the small signals to remain in this region during its off periods, hence giving it extra weighting.

A passive, high-pass RC filter effectively removes the 40Hz signal and its low-order harmonics, leaving the two high-frequency signals and distortion products to be displayed on a spectrum analyser, with each fundamental at a level of approximately −6dB. If the fundamentals do not appear in a given spectrum they can be suppressed and the analyser sensitivity increased. To show the fine detail of the spectra only a narrow range of frequencies can be displayed, using a slow sweep rate and narrow bandwidth.

In this instance, the 40Hz bursts have equal on and off periods of eight cycles, with a peak level at the output of 15V. The corresponding steady-state sine-wave power is 14W in 8Ω, so the output voltage sweeps about two thirds of a 30W amplifier's dynamic range. Each high-frequency signal is about 30dB below the peak output level; RMS voltages of the individual signals at the output are 9.94V at 40Hz and 0.34V at 4.4 and 4.6kHz.

Spectra are centred on multiples of 4.5kHz, with an analyser bandwidth of 3Hz. When the 4.4 and 4.6kHz compo-

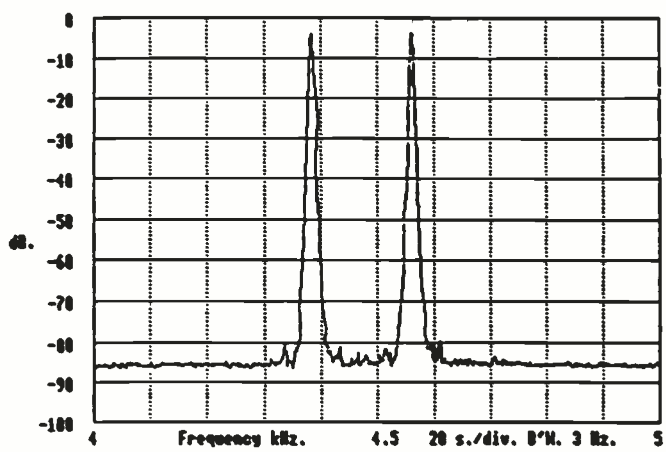
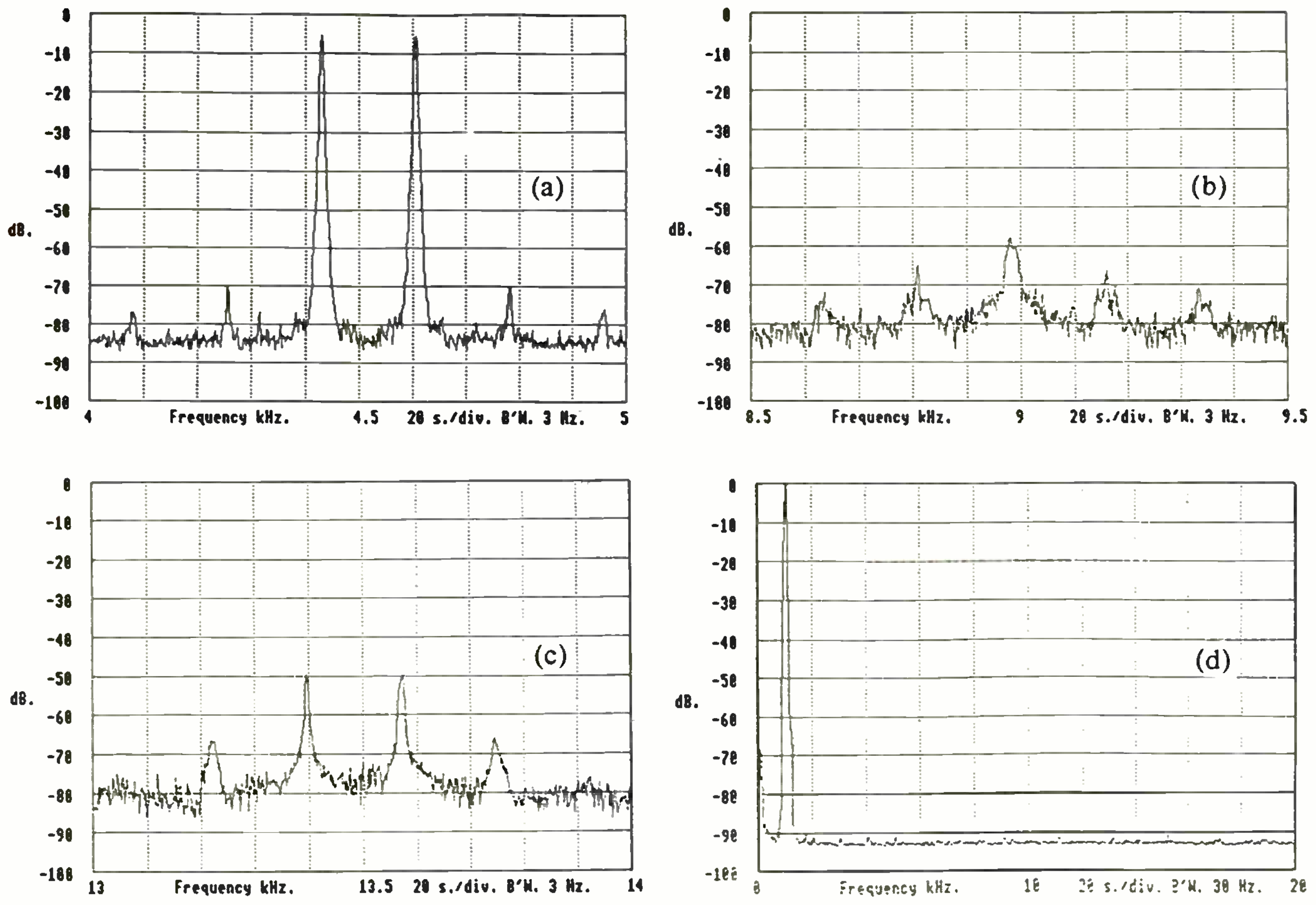


Fig. 3. Input spectrum centred on 4.5kHz.



nents are displayed on the analyser at −6dB, its noise level of around −85dB is some −109dB below the peak output signal, enabling components of 0.0004% of the peak to be revealed. For higher-frequency spectra with the suppression filter in circuit, this figure is reduced by 10dB.

Input waveform

For all distortion measurements it is important to check the spectrum of the input signal and to be certain that no significant distortion is being introduced by the equipment. **Figure 3** shows the input spectrum centred on 4.5kHz with small side components 50Hz away from the main signals. The higher frequency spectra have no components above the noise level and are not shown.

Results

Spectra labelled (a) (b) and (c) are from triple-tone tests and are centred on 4.5 9.0, and 13.5kHz respectively, with the analyser sensitivity increased by 10dB for spectra (b) and (c). The frequencies of the two small signals (f_1 and f_2). and the frequency scaling on the spectra depend on manual setting up, so will not be highly accurate. In this context, this is of no importance.

Fig. 4. Triple-tone testing of amplifier 1 centred on (a) 4.5kHz; (b) 9.0kHz; (c) and 13.5kHz; and a check spectrum for 1kHz 15V peak output (d).

Amplifier 1. Many component distributors offer an encapsulated module that will provide an output of 30W into 8Ω at 1kHz, with less than 0.02% distortion. Considering these figures alone, it seems suitable as a good-quality domestic power amplifier. **Figure 4** shows the results of testing one of these modules.

(a) Intermodulation components at $(2f_1-f_2)$; $(3f_1-2f_2)$; etc. There are no specific peaks to relate to the 40Hz signal, but there is a rise in the noise level near the peaks, indicating many small intermodulation products.

(b) Second harmonics at $2f_1$ and $2f_2$ are present, with the intermodulation sum component at (f_1+f_2) and others at $(3f_1-f_2)$ etc. Again, the noise level rises near the peaks.

(c) Third harmonics are present with peaks at $(2f_1+f_2)$ and $(2f_2+f_1)$ between them. These intermodulation products are only some 54dB (0.2%) below the signals they are derived from.

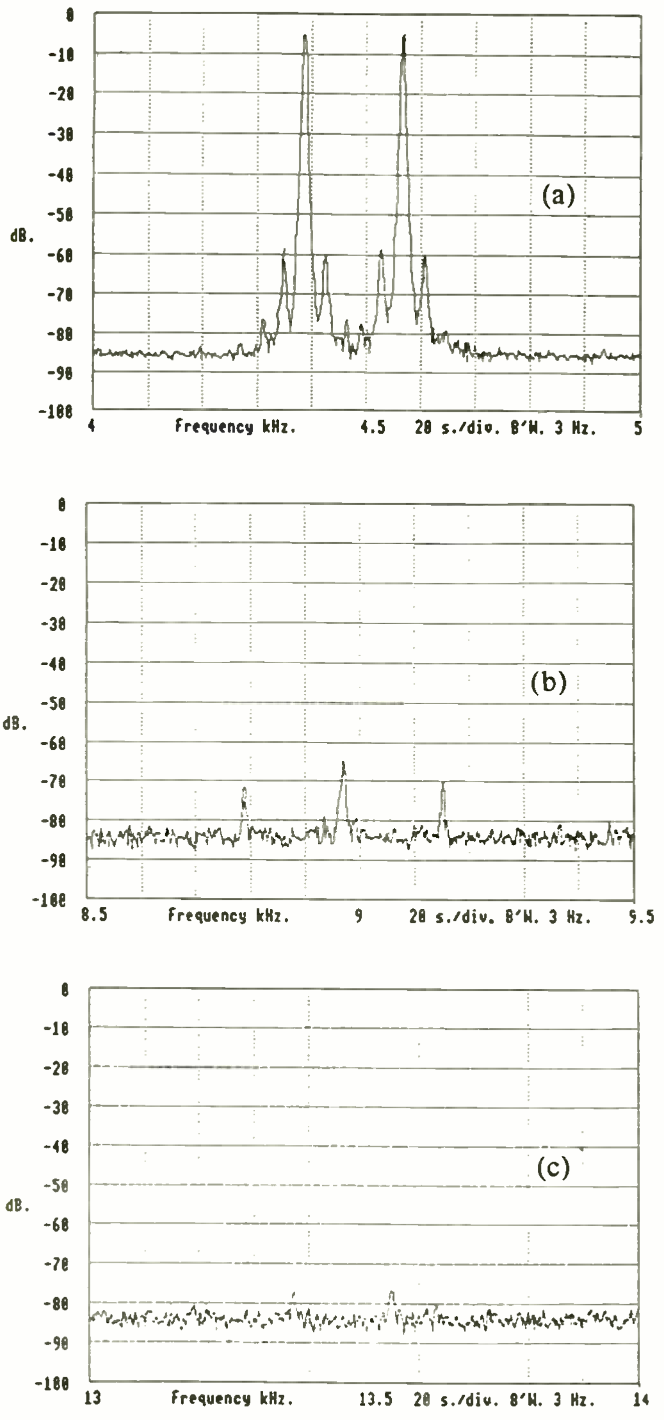
All these components come from only three input signals. How many more will occur with a complex music waveform? It is worth noting that when the 40Hz signal is made continuous, most of the intermodulation components disappear. The weakness of the design clearly lies in the cross-over region.

(d) As a check, the spectrum for a 1kHz 15Vpeak output is also included. There are no apparent problems, at this level the specification was handsomely satisfied, with all distortion components at −90dB or better.

Amplifier 2. Figure 5 shows the results from a well considered amplifier designed some twenty years ago. It has a single supply rail and feeds the load via a large output capacitor. Both channels were driven.

(a) Significant components are present at multiples of 40Hz away from the fundamentals. There is no evidence of intermodulation products from the two high-frequency signals.

(b) Shows second harmonics and the



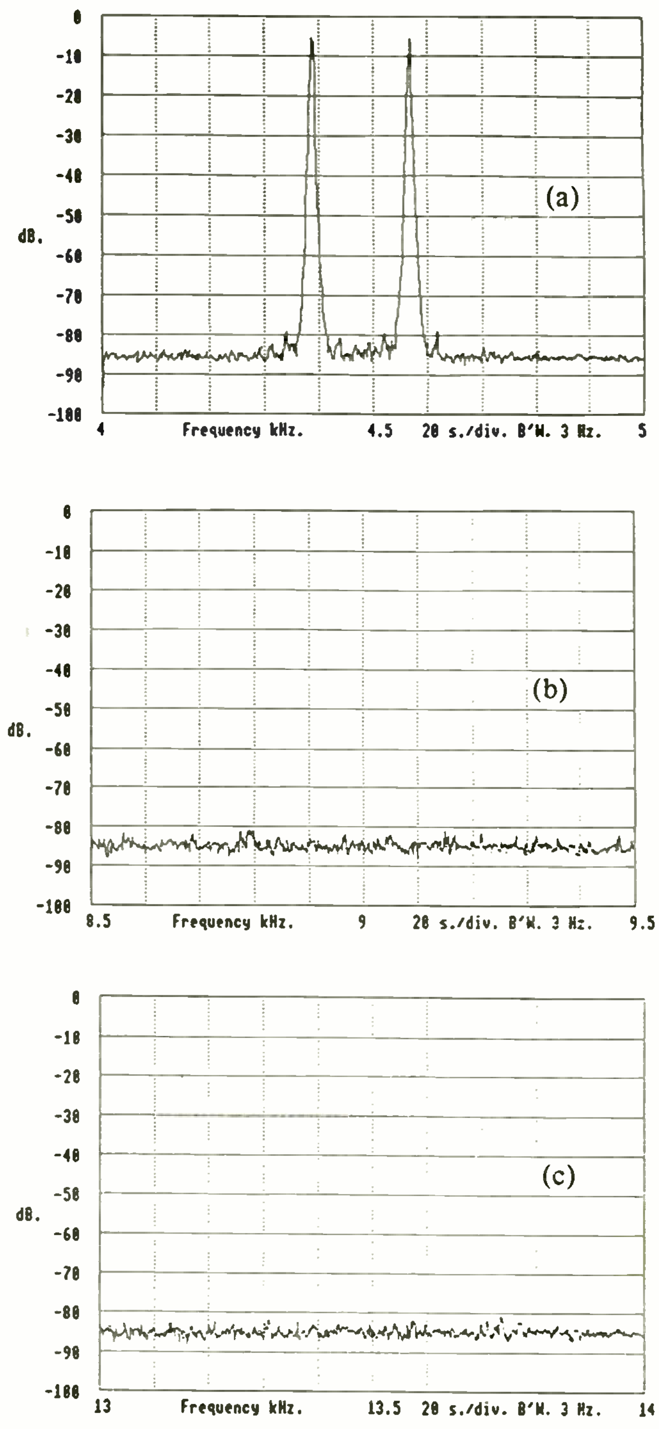


Fig. 5. Triple-tone testing of amplifier 2 centred on (a) 4.5kHz; (b) 9.0kHz; (c) and 13.5kHz.

Fig. 6. Triple-tone testing of amplifier 3 centred on (a) 4.5kHz; (b) 9.0kHz; (c) and 13.5kHz.

sum component.
(c) Only very small peaks at $(2f_1+f_2)$ and (f_1+2f_2) are present.

The cross-over region is better managed than in the first amplifier, but variation of the supply rail voltage with signal does cause problems.

A "classic" valve design and a class-A transistor design, both of about the same vintage as amplifier 2, were also investigated, their spectra showing similar 40Hz-related features. Is it a coincidence that all three have a single unbalanced power supply?

Amplifier 3. This is my experimental mosfet design, previously described in this publication[4,5]. Spectra in **Fig. 6** are for one channel of a stereo pair, with both channels driven and fed from a common, unstabilised power supply. The reservoir capacitors were 2200μF; an appreciably lower value than would normally be used.

Apart from an increase in low-frequency noise, shown by the rougher base line to the spectra, they are little different from those for the input waveform. The noise can be lowered somewhat with larger reservoir capacitors.

Other amplifiers. A number of amplifiers belonging to Brunel University students have also been tested; most of them commercial products. They outperformed amplifiers 1 and 2, but all had defined distortion components in their spectra. None were quite so clean as amplifier 3.

Conclusions

This triple-tone method is a by-product of my work on mosfet amplifiers. Equipment that has to be made is not complex and the rest is readily available in audio laboratories. The composite signal "exercises" the amplifier in a similar manner to music signals, and has a simple, well defined spectrum. It does not directly investigate transient distortion mechanisms, but these should not be a problem with careful design. (Antoniazzi and others[6] describe a method for determining whether transient effects are a problem.)

Frequencies and relative amplitudes of the signals were chosen because they fitted in reasonably well with acoustic theory, suited the equipment available and gave informative results. It may be that more meaningful results would be obtained if these were changed. Some amplifiers tested produced worse-looking spectra with different amplitudes and frequencies, but a standard condition is necessary for comparisons to be valid.

As a university lecturer, my main concern is electronic circuits, so I have neither the time, nor resources to perform laboratory and subjective listening tests on either a wide range of amplifiers, or costly ones. My mosfet amplifier has now been heard by a considerable number of people, who confirm that it does have the qualities of clarity and definition. From the number of significant distortion components in the spectra, their frequencies and amplitudes, it may be possible to derive a figure of merit for amplifiers that agrees with subjective assessments. I must leave that to other interested parties.

Triple-tone testing, as a development tool in the laboratory, has already proved very useful, and should be more so if the sensitivity of the system can be increased further. ■

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BREAKING THROUGH THE BARRIER

METAi is claimed to integrate more features in one package than any other PC-based assembly-language software-development system. Kevin Dineley investigates the claims

Anyone who designs microprocessor-based systems needs some kind of software-development method to make the hardware do its intended task. Basic requirements are an editor to construct the source code, an assembler to convert this into the microprocessor's native machine code and a means of testing and debugging this code on the target system—an eprom, an eprom emulator or an in-circuit emulator (ICE).

The METAi development system from Crash Barrier is an integrated solution to this thorn in the development engineer's side. It provides all the necessary tools in one PC-based, user-friendly package and consists of an editor, assembler, serial communications and debugger, gathered under the umbrella of the Crash Barrier Environment, or CBE as it is referred to. A disassembler and a collection of utilities are supplied as separate programs, the package being completed by a versatile eprom emulator.

Crash Barrier environment

CBE is the heart of the METAi development system, providing an organised, structured method for editing, assembling and debugging assembly language programs.

Pull-down menus display and select the options available, or they can be selected by the function keys. A very useful feature is that CBE remembers your position in each of the different menu options; for example, if you leave the editor to use the serial comms, it will restore the screen on return.

Function and soft keys are redefinable to accommodate individual whims. Some of the colours used were not quite to my taste; perhaps a future update would provide a configure utility to allow the user to choose his own palette.

Editor

This is where a programmer spends most of his time, firstly when he types in the code and secondly when he is trying to find his mistakes. The editor has an excellent "feel".

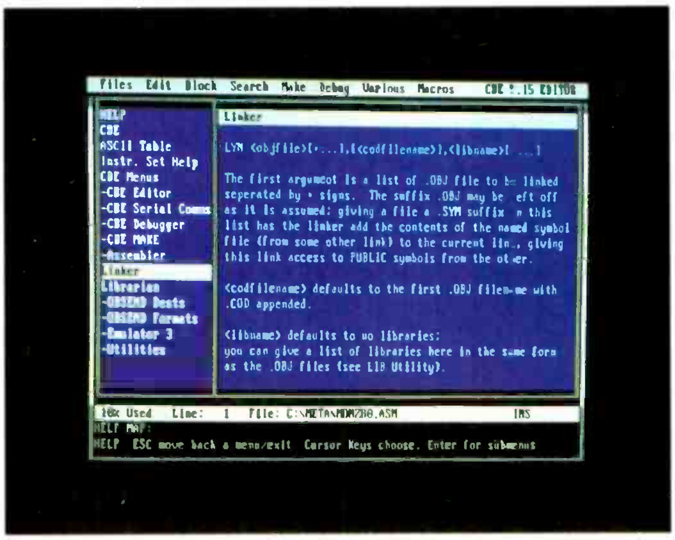
Its major feature is that you can open two files in separate windows on the screen at once. You can scroll them independently and copy or move blocks between them as simply as moving a block within a file; an extremely useful feature. It has all the other features that you would expect from a good editor, including search and search/replace, but extended to search through all the files in the MAKE file if required. It also supports folding, where sections of code can be hidden under a single line, which makes it easier to visualise the operation of the program as a whole, ignoring inapplicable code and allowing you to concentrate on the salient points. Macros remember sequences of key presses and are automatically reloaded each time the editor is used.

HELP is fairly comprehensive, providing information on most areas, including instruction-set-information specific to the selected processor, and displaying the format of the instruction and legal addressing modes. It knows reset and interrupt vector addresses, along with details of special function registers, common in microcontrollers such as the 8051 and the pin-out of the chip itself. Finally, the editor provides four functions useful for debugging. It finds the line in the source-code file for a given address and reports the address of the current line. A numeric parser can do some instant calculations, using the values of PUBLIC symbols, if necessary, and the value of a given PUBLIC label will be reported.

Serial communications

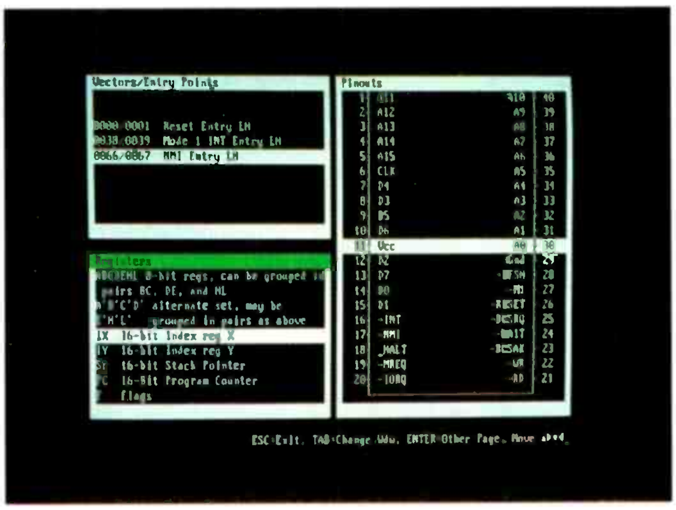
Serial Comms is a fairly standard terminal emulator with all the usual comms functions. In addition to using the serial ports, it can communicate with the Back Channel, a feature of the eprom emulator described later. Addresses obtained from the previous editor functions can be directly transmitted to your ICE or monitor program by pressing a function key.

One criticism of the user interface is that the ESC key is used to access the pull-down menus. This means that it is not possible to transmit the ESC character (1bh), which may be inconvenient in some circumstances. *(Crash Barrier says that Ctrl-ESC will work in these circumstances — Ed.)*

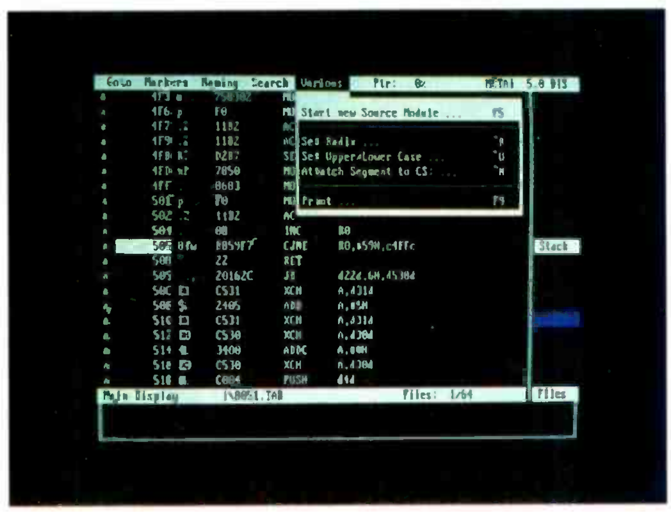


Opening screen of METAi. Pull-down menus are used throughout the system

METAi editor screen, with file. Two files can be opened in separate windows, with copying between them.



Help screen providing interrupt-vector addresses, pin-out and bit meanings of special-function register.



Main disassembler, turning bare object code back to labelled source code for editing and assembly.

Debugger

Debugger is a simple but powerful program used to track down errors in your source code, communicating with a simple monitor program in the target system via the serial port or Back Channel; this is what you use if you can't afford an in-circuit emulator. It can't provide all the features of an ICE, but is adequate for most applications, setting breakpoints, setting/dumping register or memory contents and single stepping if the processor (for example, the 68000) supports this. Disassembly can be performed if source code is not available.

It is necessary to add a small monitor routine to the target software to provide these functions—called MONST for Monitor Standard. This is a processor-independent language which provides several simple functions which are used by the debugger to build more complicated functions; examples of this program are provided for several processors. It is a simple matter to adapt them to suit the appropriate processor.

Assembler

This is where the METAi system excels. It can assemble source code for any processor without compromising on speed. It is a relocatable, linking assembler, assembling only those files which have charged since the last assembly and saving a great deal of time when working with large files.

It has all the features you would expect to find in any other assembler, including conditional assembly and macros, in addition to a few unique facilities, and handles the four different radix styles from each of the major manufacturers: Intel, Motorola, Texas and Zilog. Error-trapping is particularly powerful; it will return to the editor, with the cursor automatically positioned on the pertinent line. This can be a major time saver in correcting silly syntax errors.

A utility called TABGEN is used to generate the tables used by the assembler to define the properties and features of the instruction set. These are then compiled to a format which is used by both the assembler and the disassembler. Table files are provided for all the major processor families and upgrades are available free for new processors; it is also fairly easy to construct your own tables. The assembler does not, however, recognise names of special function registers, for example TCON in the 8051, which have to be defined in a header file with your source code.

Librarian is another very useful facility, which generates libraries of object files and includes the appropriate one at link time. This allows the programmer to re-use routines in other programs with ease.

Processor families supported by METAi

PIC1650A	6502/C02	M740...	8035
1802	65C812	M7700...	8051
1805	65C816	µPD7500A	8031
V25	6800	µPD7500B	8080
V35	6801	µPD75104/6	8085
TMS370...	6301	µPD75106/8	8086
TMS32010	6802	µPD75206/8	8088
TMS320C15	6803	µPD78C10	8096
TMS320C17	6303	µPD78C11	80196
TMS32020	6303X/Y	µPD78C14	80188
TMS320C25	6804	µPD7806	80286
3870/F8	6805	µPD78310	ST6...
COP400...	6809	µPD78312	SCMP
COP440...	6309	µPD77P20	TMS9900
COP800	68HC11	H8/300...	TMS9995
HMCS400	68000	H8/500...	TS94110
64180	68010	8048	Z8
647180	TMS7000...	8039	Z80

If changes are required, only one source module needs to be modified. Updates are then implemented by simply re-linking the appropriate programs.

Disassembler

This is an extra option, costing £300. It uses the same table files as the assembler, and generates source code for any microprocessor.

Disassembler is able to generate re-assemblable, labelled source code from bare executable code. This is not a trivial task and requires a careful, structured approach. It is done in two phases. The first phase does an initial disassembly; the user then has to work through the code, marking data areas (which are indistinguishable from op-codes) and splitting the file into manageable modules. In the final phase, all the source code files are generated, complete with labels, EXTERN and PUBLIC directives, a #INCLUDE file and even a MAKE file.

Disassembler uses the same kind of layout as the CBE, with several features to make the task a little easier. In short, it makes an almost impossible task fairly straightforward.

Utilities

A collection of utility programs includes file format converters, splitting and combining files and a hex. file editor.

Eprom emulator

Using an eprom emulator is the most usual way of testing out your code on the target system. Executable machine code is downloaded into dual-ported ram, which then looks like an eprom to the target system. This avoids having repeatedly to program, plug-in, remove and erase eproms each time a modification to the code is made.

Emulator 3 is based on Xilinx asic technology, which allows the hardware to be reprogrammed to adapt to many different types of eprom, up to 64Kx8 or 256Kx8 on the extended version. It can thus emulate more types than any other emulator currently available. 87C64 and 87C257 latched eproms are as yet outside its range, but I believe this is a fairly straightforward software upgrade. Connection to the parallel printer port (up to three emulators on one cable), means that data transfer is very quick indeed.

Operating environment

IBM PC/XT/AT/386/PS2 with at least one 360K/1.2Mbyte disk drive; MSDos or PCDos 2.00 or greater; at least one parallel printer port; at least 512K memory; MGA, CGA, EGA, VGA or equivalent with standard 80x25 mode.

Although it is theoretically possible to run METAi on a single disk drive, it is not very practical; a hard disk is a more realistic requirement. After installation and unpacking of files, METAi uses about 1.5Mbyte of space, although this can be reduced by deleting any processor instruction table files that are not required. A serial port may also be required for communicating with your target system or ICE.

Back Channel allows the target system to communicate with the debugger, in both directions, reading only from a 16byte block at any specified address in the eprom space. This avoids the need for a serial link with its associated hardware and software to implement the monitor and debugging functions.

The emulator is of robust construction, housed in a low-profile metal case with connectors to the PC and the eprom cable and some leds to indicate status. It is configured by software through the printer port, although the address (used if more than one emulator is required) needs to be set by links inside and it is powered by an external mains adapter. All address and data lines are current-limited, so it should be fairly difficult to damage it by incorrect connection.

Conclusion

The METAi Development System is a comprehensive, well thought-out system for developing assembly-language software. It provides all the tools required for development: editing, assembling and debugging in one easy to use, time-saving package. The manual is written in a clear, unambiguous manner and well laid out, with indexes for each section. I did find one minor bug in the software, but this will undoubtedly be corrected. Crash Barrier also provides excellent backup and technical support.

If you are the type of development engineer who only uses one processor, has plenty of spare time and never has to do any debugging, then this package is probably too expensive. The rest of us will find it indispensable.

Supplier

METAi is supplied in three different versions.

METAi-01 CBE, assembler, linker, loader, utilities £395

METAi-02 CBE, assembler, disassembler, linker, loader, utilities £695

METAi-03 CBE, assembler, disassembler, linker, loader, utilities, eprom emulator 3 £940

METAi-11 eprom emulator 3 £295

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Crash Barrier has a very enlightened policy of providing free software updates on demand for the life of the product. It is even possible to get updates immediately by calling a bulletin board. ■

Removing the bottleneck

Every designer knows that hardwired solutions run faster than their software equivalent. Intelligent reconfigurable hardware where the schematic circuit diagram is the program may offer a fundamentally new type of computer architecture. By Archie Medes.

The power and speed of the digital computer has doubled every two years for the past forty years. We are constantly hearing of the "unbelievably fast" computers that are just around the corner. Yet to date there has not been a computer built that can do things that ants can, such as building cities. This is rather surprising considering that an ant's brain is really very small compared with a modern supercomputer. Yet it is apparent that at some tasks, such as arithmetic, computers are exceedingly fast.

Electronic computers and biological nervous systems can be described in terms of the two axiomatic elements of the "passive wire" and the "active switch". These "wires and switches" are abstract concepts but on a practical level they are analogous to the metallic wires and semiconductor switches of electronic computers and to the neuronal processes and synaptic switches of nervous systems.

Wires, in this scheme of things, are distinct conduits that meet each other at points called switches. The function of a switch is to isolate or connect the wire at its input to the wire at its output. An inactive switch will allow any logic level on the output wire. An active switch will cause the output wire to mirror whatever is happening on the input wire. Switch state depends on the program.

The function of the wire is to propagate the impulses unchanged throughout its space. It is the moving impulses that interact with each other and the switches that do the computing. I stress again that these concepts are abstract and the various names are not to be taken too literally. But they do enable easy comparison between differing types of computer. For instance in the first four columns of **Table 1**, I have listed the relevant details for the top and the bottom of the range of electronic and biologic computers. Note that these figures are only an order of magnitude estimate.

A turn of speed

The bottom line is a speed index, a measure of the maximum number of impulses that can propagate through any of the computers in one second. This speed in impulses per second is a reasonable indicator of the activity going on inside any of these computers and so presumably also of their computing potential (although I note that activity is not always equated to productivity).

It appears that current electronic computers have a similar capability in impulses per second to their biologic counterparts. The numbers of wires, the length of the wires and their equivalent length of the switches (the measure of the switch propagation delay) are also within an order of magnitude. But electronic and biologic systems achieve their speed in different ways.

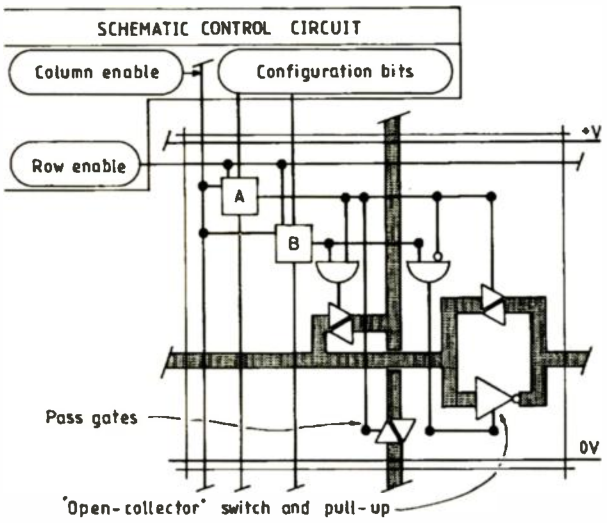
The strength of electronic computers is the high propagation velocity of their impulses and the high speed of their switches. Against this their low efficiency in terms of the fraction of wires and switches that can be actively involved in the computing. Conventional von Neumann computers will typically have 99% of their machinery sitting idle while only 1% does any computing. The only other significant inference is the number of switches per wire in average electronic computers have less than ten transistors to each wire compared with more than a thousand synapses per neuron for biological systems.

This greater interconnectivity of neurons means that an impulse on one neuron can simultaneously interact with a greater number of synapses than is the case in electronic computer. While electronic computers have a clear advantage in speed, they lose it by using only a few of their available wire and switches—and in an inefficient manner.

The von Neumann trouble

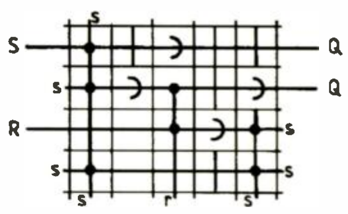
An ordinary computer runs a program one instruction at a time or, at most, a few instructions when they are pipelined. The memory, which forms the bulk of the electronics, serves only as a temporary store of the program and data and is never actively involved in the computing.

The computer produces the greatest output per machine cycle when the processor is executing its most complex instruction, that is when most of the processor circuitry is active. But in practice even the processor cannot sustain it maximum speed because the most complex



A	B	CELL	FUNCTION
0	0		Insulator
0	1		Switch
1	0		Crossover
1	1		4-way wire

Fig. 1a (left) Impulse matrix cell.
Fig. 1b (above) Cell configurations and (below) an S-R flip-flop



instructions are the least used. The majority of design effort in alternative computer architectures are based on parallel von Neumann computers interconnected as parallel processing machine.

Now instead of there being one large memory that sits idle, there are many small memories that sit idle. The overall efficiency (by the author's definition—<I>ed) remains as low as before. No amount of fiddling with the hardware will solve this "one word at a time" problem. The problem can only be solved by changing the way in which the computer is programmed.

The Impulse Matrix

My putative architecture is based on the observation that a hardwired implementation of a digital circuit will run faster than a software simulation of the same circuit. For instance a hardware Fast Fourier Transform chip will run several orders of magnitude faster than a software FFT. But hardware implementations are inflexible and only suited to the specific function for which they have been designed. What we need is a more flexible arrangement of wires and switches.

The impulse matrix consists of a large number of identical cells arranged in a regular two dimensional grid. **Fig. 1a** shows a simple version of one of the matrix cells. Each cell has a unique row and column address and two bits of memory that can be written to but not read. The two bits of memory define any of four configurations of programmable wire or switch that the matrix cell can adopt **(Fig. 1b)**.

This enables the matrix cell to be set up to perform the functions of an insulator, a switch or two types of wire cell. By appropriately setting adjacent matrix cells, any conceivable digital circuit can be constructed (for example **Fig. 1c**).

The matrix can be thought of as a reprogrammable gate array. Conventional gate arrays are chips that consist of a regular array of gates that are connected by a unique layer of metal wires during the final stages of manufacture.

The matrix is even more economical since the customisation is "soft" and can be changed as easily and quickly as loading a program into a memory. The program in this case is a circuit schematic: the idea of programming with schematics is the major difference between von Neumann computers and the matrix. It frees the hardware from the "one program word = one hardware operation" constraint and allows the hardware to perform the many functions that can be represented in a schematic simultaneously. The impulse matrix is simply a hardware architecture suited to schematic programming.

Another way to think about the matrix is as the ultimate risc parallel processor. In the case of the matrix, each cell can be

Table 1	1989 supercomputer	1989 microcomputer	Mammal CNS	Insect CNS	1990 impulse matrix
volume	1m^3	1litre	1 litre	1mm^3	1 litre
power	100kW	10W	100W	100μW	1kW
efficiency	0.1 percent	0.1 percent	100 percent	100 percent	10 percent
V_{prop}	10^{10}m/s	10^5 m/s	10 m/s	10 m/s	10^8 m/s
no of wires	10^8	10^7	10^{11}	10^5	10^9 (narrow) 10^7 (wide)
switches	10^{11}	10^8	10^{14}	10^8	10^{10}
switch time	100ps	1ns	1ms	1ms	100ps
wire length	10cm	1mm	1cm	1mm	10^{-4} (narrow) 10^{-2} (wide)
switch length	1cm	100μm	1cm	1cm	1cm
speed index $\eta.N_s.V_p/(L_w+L_s)$	10^{17}	10^{13}	10^{17}	10^{11}	10^{19}

> *"... von Neumann computers will typically have 99% of their machinery sitting idle while only 1% does any computing..."*

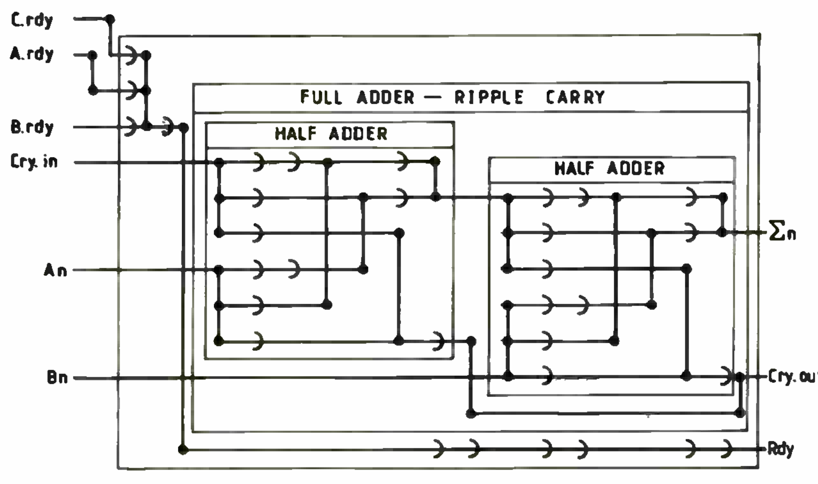
thought of as a single computer node consisting of a processor with only one active instruction, the switch (or impulse) and no memory that can be accessed by the processor. The program is formed by connecting many copies of this single fastest possible instruction via the passive wiring functions of the adjacent cells. The program has become the simultaneous definition of the settings of all the matrix cells. Thus, in effect, the whole program is being "read" all of the time.

The impulse matrix as described above needs some peripheral circuitry to create a self-contained system. Foremost is the requirement for a "schematic control circuit" that consists of the pass gate (Fig. 1a) and controlling configuration bits and also the row and column drivers that allow the configuration bits to be written.

Since it is most likely that the schematics would be loaded from a serial mass storage device such as a disk drive, the row and column drivers would be very similar to the addressing circuits of conventional memories. The schematics would be loaded into the matrix similarly to the way that conventional programs are loaded into conventional memories. Hardwired circuitry that initiates or "boots" the loading of the first schematic and also provides specific input and output functions is also required and would be analogous to the bios of conventional computers.

Once the first schematic (for instance the operating system) is loaded it could assume control of the entire system. It would then communicate either directly or via thebios with the I/O port to load other schematics and so on. Before leaving the hardware I would like to point out that the matrix cell in Fig. 1 is not the only one possible and is in fact not very efficient. I show it simply because it is easy to describe. Typical circuits would devote more area to wires than switches.

I have not the space here to argue all of the pros and cons of schematic versus language programming but I will make the two points.



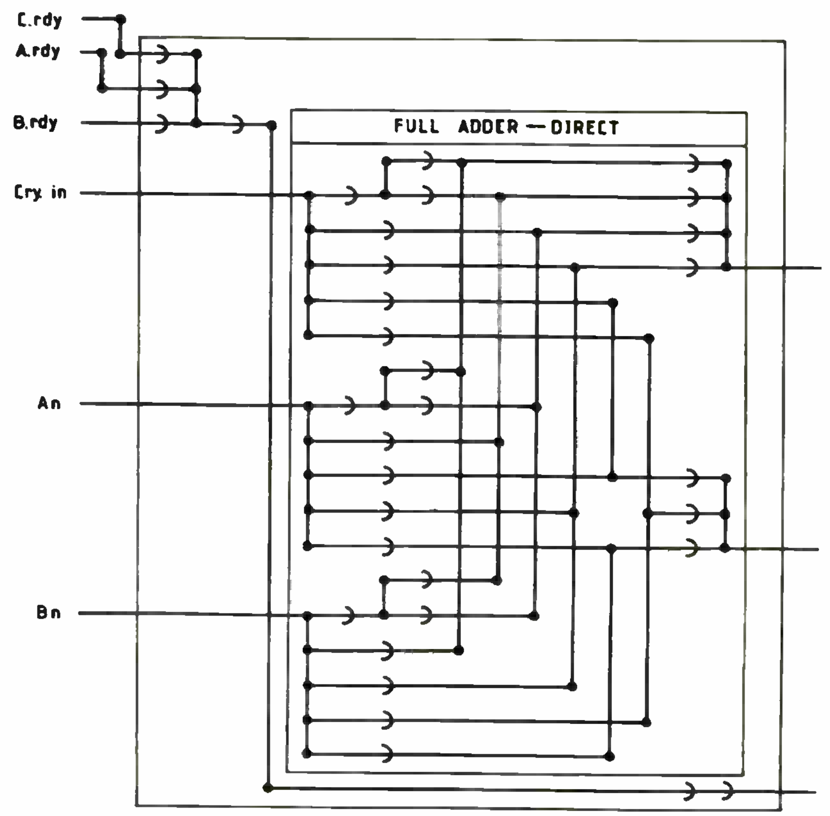


Fig. 2a. Ripple carry adder. The circuit is long and narrow because it traverses the three input bits two bits at a time. Fig. 2b is the "short and wide" variation which does the addition all at once.

Firstly it seems that some programmers have lost sight of the fact that anything that can be programmed in a software language can be represented (usually better) by a schematic and so implemented as a hardware circuit no matter how abstract.

Secondly it is a matter of history that the hardware industry has outperformed the software industry. For instance fourth generation 486 PCs must still run second generation 286 software such is the pace of software development.

In practice

Given that the matrix will be programmed with schematics let us consider two approaches to solving the same small problem (**Figures 2a** and **2b**) Fig. 2a is a ripple carry full adder that adds three bits together by first breaking the addition up into two half adds where only two bits are

> "... self-clocking means that different parts of the matrix can run at their own full speed..."

added at a time. It then combines the results to give the sum and carry bits This circuit is "long and narrow" since it must traverse the three input bits two bits at a time before it can complete the calculation. Figure 2a can be converted to the "short and wide" circuit of Fig. 2b which also adds three bits but now does the addition all at once.

The circuits of Fig. 2 take as inputs impulses that indicate that the bits to be added are ready for the addition. These impulses are banded together and propagated through the circuit via a path slightly longer than the longest addition path. This means that when the ready impulse reaches the output, the addition will be complete. The circuits are self-clocking. Self-clocking means that different parts of the matrix can run at their own full speed. No part of the matrix need slow down because it has to keep step with the clock of a slower part of the matrix.

The output bits are calculated simultaneously and the calculations for each output bit take approximately the same time. The method of converting one circuit into the other is straightforward and can be applied to any similar circuits (that is any first degree circuits. In general equivalent switch lengths are longer than the physical size of the switches. Therefore long narrow circuits like Fig. 2a will be slower than short wide circuits like Fig. 2b because the calculation has to pass through many more switches and must therefore cover a greater equivalent distance. The penalty paid for the faster configuration of Fig. 2b is that the number of wires and switches in its middle plane grows exponentially with the number of bits to be added. The impulse matrix can be programmed in either of the above ways the choice is up to the programmer.

In the above I have touched on only two aspects of programming the impulse matrix: narrow versus wide focus and self-clocking. I would like to stress once more the futility of trying to program a machine as flexible as the matrix with something as restrictive as a language. To describe the sample figures with a language would result in an incomprehensible netlist of wire and associated switch interconnections. Using high level verbal instructions such as "ADD (A,B)" is not a solution since the words can only be connected in one dimension and the inner details are lost. Schematics can also have high level components but unlike a programming language the schematic components can be connected in three dimensions and also successively disassembled and examined until only wires and switches are left.

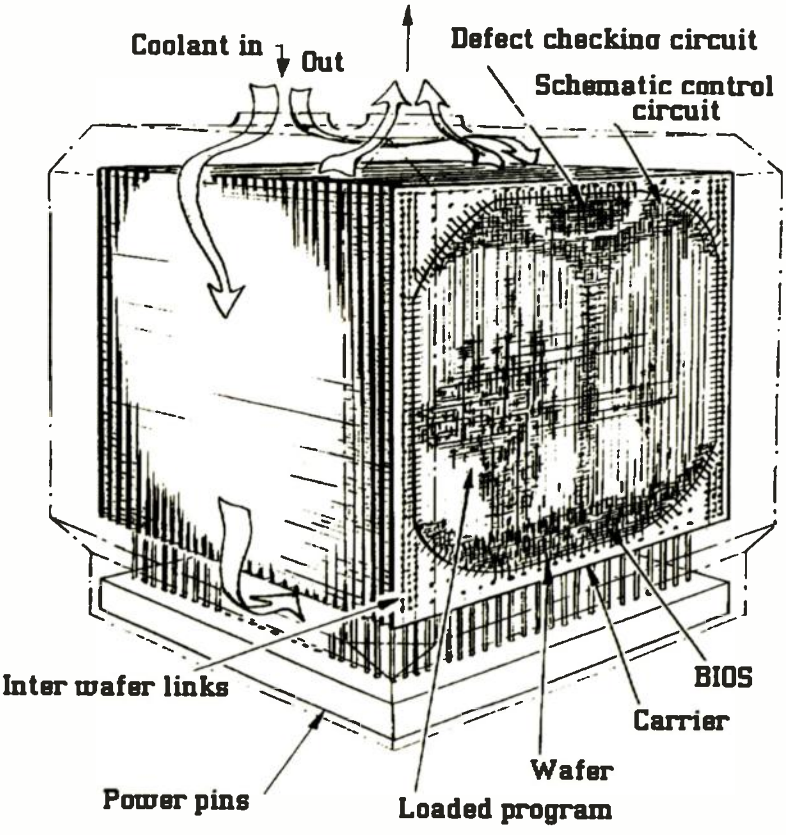


Fig. 3. Author's impression of a practical impulse matrix machine. It bears a strong resemblance to Ivor Catt's models.

Practical implementation?

A practical matrix might comprise 64 silicon wafers each 10cm across stacked in a cube 10cm on a side. The technology would be cmos with about ten million transistors per wafer or a billion switches in total. The switching time and propagation velocity would be similar to those of a microcomputer. This matrix would he classed as a high performance workstation or even a mini-supercomputer. I give this example for illustrative purposes only, the regular nature of the matrix means that it could be easily scaled up or down.

The matrix of Fig. 3 uses waferscale integration similar to that currently used in memory arrays. The cell based design together with the powerful schematic control circuitry make the matrix ideally suited to this type of fault tolerant design.

The speed indices for conventional computers are based on the assumption that the processor is working at full speed, that is the processor is perfectly matched to the program. This is rarely true. Few specific programs will ever be able to use all the resources of a conventional general purpose processor simultaneously—except perhaps to run advertised benchmarks. The matrix is configured so that the hardware becomes the program and thus always runs at a speed limited only by the hardware.

Being able to model conventional von Neumann computers, the matrix can compete most favourably with them. It can also model and so compete with special purpose circuits such as digital signal processors or customised gate arrays. But it can also be programmed to model nervous systems efficiently. While it doesn't look as though it would operate as fast as the mammalian brain, it could be considerably faster than an ant's. One might therefore expect it do perform all the things which an ant's brain can achieve but which a conventional computer cannot.■

Reference:

1. Archie Medes Wires + switches = digital circuits EWW August 1988.

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vibration/test/calibration/design/examination/realtime/digital

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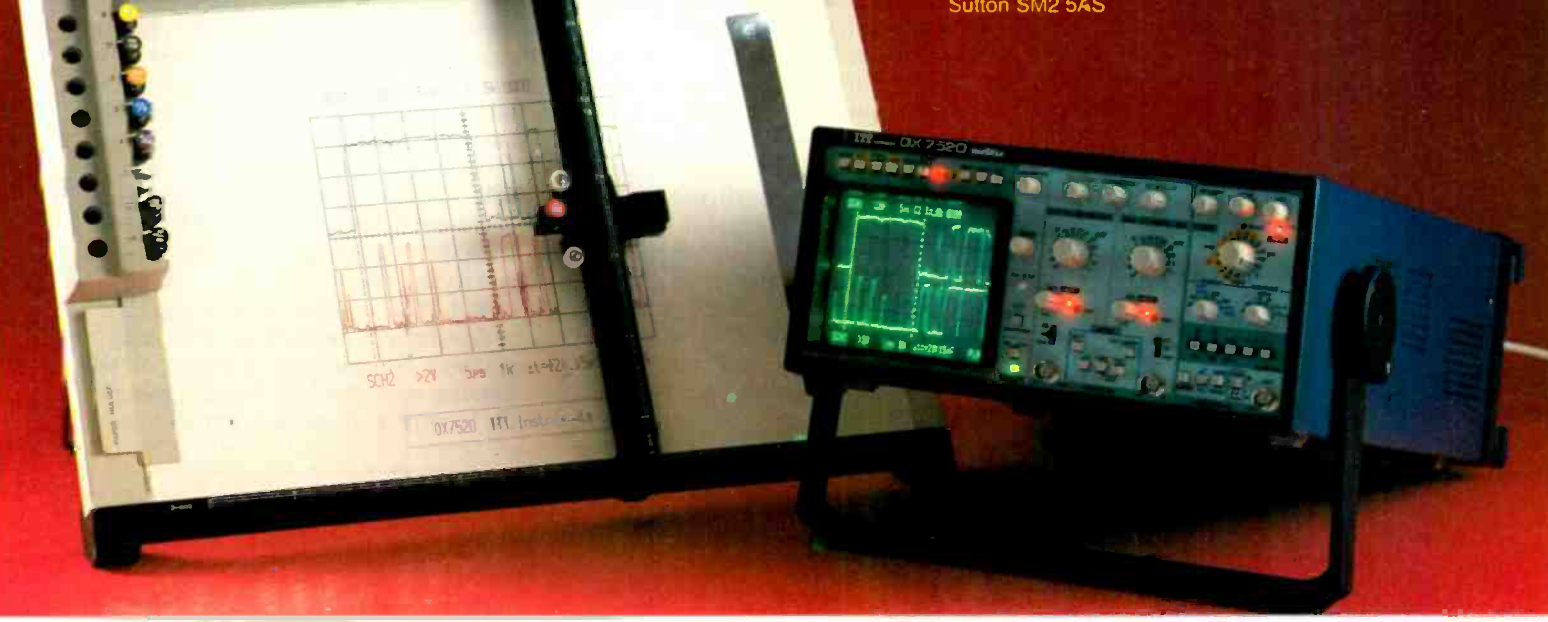


INTERFACING WITH C

PART 10

Correlation is an effective method of detecting signals buried in noise. Howard Hutchings describes the concept, approaching it by way of matching signals to systems.

Correlation methods using a PC

In the detection of small signals, noise is the limiting factor. There are four principal methods of recovering signals in the presence of noise. These are:
(1) Filtering
(2) Averaging
(3) Correlation
(4) Coding

As high-performance instrumentation systems have become available, increasing interest has been expressed in correlation methods. Although autocorrelation is an interesting signal-processing operation in its own right, it remains an abstraction. It is preferable to identify a practical problem. This should provoke further discussion and illustrate the principles of this method of signal processing.

How do you recover the characteristics (such as amplitude and frequency) of a periodic signal embedded in noise? Conventional filtering is inadequate if the wanted signal and unwanted noise share frequency spectra. In such a case, filtering out the noise removes the signal as well. An effective technique is averaging if the signal can be considered stationary using, for example, a 2- and 5-term moving averager, as demonstrated in Chapter 2. This chapter will describe the effects of matching signals and systems from an engineering point of view, and this will lead conceptually towards the correlation methods.

Many advanced signal-processing methods used to recover signals corrupted by noise have their origins in the analytical procedures developed by Gauss and others in the nineteenth century. Statistical analysis of data is routine using a PC — what is stimulating and exciting is the application of these techniques in conjunction with a data-acquisition system. The aim is to discover if there is any statistical regularity, or correlation, in a random process. The opportunity of using the PC as part of a data-logging and signal-processing system encourages more detailed numerical analysis. It also offers alternative methods of displaying the characteristics of signals detected and recovered in the presence of noise.

Linear systems and random inputs

Discussions in previous chapters have been restricted to finding suitable mathematical models of signals and systems in the time and complex frequency domains. In keeping with the assertion that the principles should precede the applications, this section will demonstrate how mathematical representation can be used to determine the response of a linear system when the input is a random signal rather than a deterministic one.

An incisive method of describing a system's behaviour is in terms of the impulse response $h(t)$ transformed into the complex frequency-transfer function $H(s)$ or the frequency-transfer function $H(j\omega)$. The fundamental attraction of this approach is that the output $Y(s)$ is related to the input $X(s)$ by the operation of multiplication. This is shown using the system diagram, **Fig. 7.1**.

When the input signal is a random waveform, this simple relationship no longer exists and the spectral characteristics of the input signal cannot be modelled in terms of transforms. To retain the simple operation of multiplication associated with complex frequency-domain analysis, it is necessary to recast the input signal into an alternative form to make it transformable.

To ensure that a Fourier transform exists, it is necessary that:

$$\int_{-\infty}^{\infty} |x(t)\, e^{-j\omega t}|dt < \infty$$

Since $|e^{-j\omega t}| = 1$, a sufficient condition is:

$$\int_{-\infty}^{\infty} |x(t)|dt < \infty$$

With one eye on the answer, this can be rewritten in the form:

$$\int_{-\infty}^{\infty} |x(t)|^2 dt < \infty$$

where the integral is finite as before. The use of Parseval's theorem gives the frequency-domain model:

$$\int_{-\infty}^{\infty} f(t)\, g(t)\, dt = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(\omega)\, G(-\omega)\, d\omega$$

Write $f(t) = g(t) = x(t)$ to show that the integral on the left is an expression for the mean-square power in the time domain.

$$\int_{-\infty}^{\infty} |x(t)|^2 dt = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(j\omega)\, X(-j\omega)\, d\omega$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty} |X(j\omega)|^2 d\omega$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty} P_{xx}(\omega)\, d\omega$$

It is particularly important to grasp the significance of this result, which describes how the average power in the various frequency components of the signal are distributed in the frequency domain. This concept is sufficiently important to be given a special name — the power-spectral density function — symbolised by $P_{xx}(\omega)$. **Fig. 7.1** shows the operation required to model spectral-power density as a transfer function.

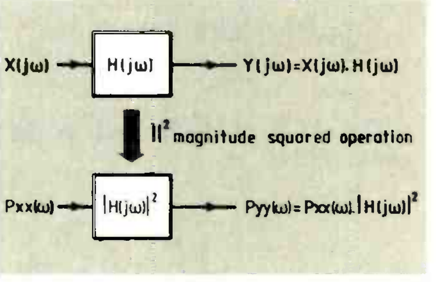


Fig. 7.1. Multiplying input spectral power density by system function $|H(j\omega)|^2$ gives output spectral power density.

Total average power contributed by all the frequency components is given by Parseval's theorem:

$$P_{average} = \frac{1}{2\pi}\int_{-\infty}^{\infty} P_{xx}(\omega)\, d\omega$$

The factor $1/2\pi$ is necessary since the units of average power are V^2, while $P_{xx}(\omega)$ has units V^2/Hz. The integration is with respect to $d\omega$, which has units rads^{-1}.

An alternative description of the average power P_{av} can be deduced by recognising that $P_{xx}(\omega)$ is symmetrical about the origin, and that the limits of integration are from $-\infty$ to ∞. This is simply twice the integral from 0 to ∞, so that:

$$P_{average} = \frac{1}{\pi}\int_{-\infty}^{\infty} P_{xx}(\omega)\, d\omega$$

As explained in Chapter 6, Fourier transforms are necessary to commute between the time and frequency domains. Stated formally, the transformation from time to frequency domain is:

$$H(\omega) = \int_{-\infty}^{\infty} h(t)\, e^{-j\omega t} dt$$

while the inverse transformation is:

$$h(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} H(\omega)\, e^{j\omega t} d\omega$$

Fig. 7.2 shows how the Fourier transforms relate to time and frequency domains. It is helpful to consider the reality behind the abstraction of these last two equations. The first describes how the energy of $h(t)$ is continuously distributed as a function of angular frequency in the range $\omega = \pm\infty$. In the second equation, the original time-domain function $h(t)$ is recovered by reassembling the weighted frequency components by means of summation.

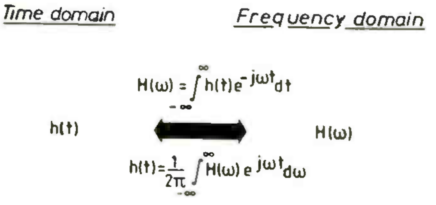


Fig. 7.2. Commuting between time and frequency domains requires Fourier integral relationships.

The Fourier transforms are needed to commute between the time and frequency domains. To acquire a little hands-on experience of using the power-spectral density function, consider the transformations required to express the decaying exponential:

$$x(t) = Ae^{-\alpha t}$$

in the power-spectral density form. **Fig.**

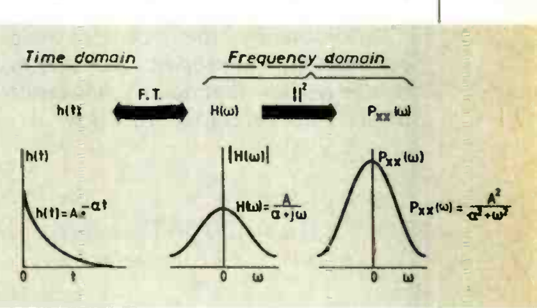


Fig. 7.3. Matching the transform of the signal to that of the system produces the power spectral density without integration.

7.3 avoids integral relationships. Instead, it features the transformations using the concept of the matched filter.

Wiener-Khintchine theorem

If the inverse form of the Fourier transform is used and $H(\omega)$ is replaced by $P_{xx}(\omega)$, the autocorrelation function can be written as:

$$r_{xx}(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} P_{xx}(\omega)\, e^{j\omega\tau}\, d\omega$$

Note that $P_{xx}(\omega)$ is an even function and that the exponential term $e^{j\omega\tau} = \cos\omega\tau + j\sin\omega\tau$ is composed of an even and odd function. The autocorrelation function ACF can be written in the equivalent form:

$$r_{xx}(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} P_{xx}(\omega) \cos\omega\tau d\omega + \frac{j}{2\pi}\int_{-\infty}^{\infty} P_{xx}(\omega) \sin\omega\tau d\omega$$

Notice that $P_{xx}(\omega)$ and $\sin\omega\tau$ are mutually orthogonal over the interval $\pm\infty$, so that the second integral is zero. Hence:

$$r_{xx}(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} P_{xx}(\omega) \cos\omega\tau d\omega$$

Since $P_{xx}(\omega)$ is symmetrical about the origin, the autocorrelation function can be expressed in the form:

$$r_{xx}(\tau) = \frac{1}{\pi}\int_{-\infty}^{\infty} P_{xx}(\omega) \cos\omega\tau d\omega$$

Additionally, the Fourier integral relationship expresses the spectral-power density function $P_{xx}(\omega)$ in terms of its autocorrelation function:

$$P_{xx}(\omega) = 2\int_{-\infty}^{\infty} r_{xx}(\tau) \cos\omega\tau d\tau$$

Hence, the ACF and power-spectral density function are related as a Fourier-transform pair. This is shown in **Fig. 7.4**.

Fig. 7.4. Wiener-Khintchine theorem relates autocorrelation function in time domain and power spectral density function in frequency domain as a Fourier transform pair.

Autocorrelation

Autocorrelation is a useful method of detecting signals in the presence of noise. The time-domain signal-processing operations applicable to aperiodic pulses or finite energy signals is given by:

$$r_{xx}(\tau) = \int_{-\infty}^{\infty} x(t)\, x(t+\tau)\, dt$$

The ACF of continuous or finite power signals is:

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

Fig. 7.5 is a system model of the processing required to obtain the ACF and **Table 7.1** shows the autocorrelation functions of a variety of common signals. Consider the meaning of these expressions in conjunction with the system diagram. Expressed simply, the operation of autocorrelation involves multiplying a signal by a delayed version of itself, and then taking the average of the product. Once you have understood what autocorrelation means, and intend to apply it, you will prefer a more precise exposition of the facts. That is the reason for presenting the integral relationships. Before confirming the results, recognise that comprehension of the signal-processing operations requires a little mathematical talent. It also needs a genuine understanding of the reality behind the abstraction.

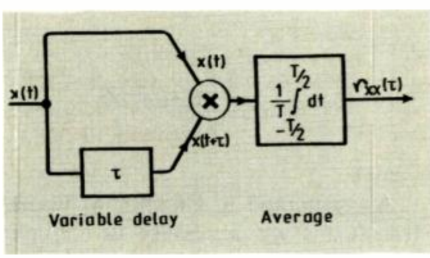


Fig. 7.5. System to calculate autocorrelation function.

Table 7.1. The properties of the ACF are such that all phase information present in the input signal is lost under the operation of autocorrelation. Amplitude information is retained, although in a modified form. Periodic signals in real-time retain their periodicity in parametric time. The substitution $\tau = 0$ gives the mean-square value of the signal.

Real-time $x(t)$	ACF →	Parametric time $r_{xx}(\tau)$
$A\sin(\omega t + \phi)$		$\frac{A^2}{2}\cos\omega\tau$
$A\cos(\omega t - \phi)$		$\frac{A^2}{2}\cos\omega\tau$
$A + B\sin\omega t$		$A^2 + \frac{B^2}{2}\cos\omega\tau$
Ae^{-at}		$\frac{A^2}{2a}e^{-a\lvert\tau\rvert}$

Effect of finite observation time

It is interesting to examine the effect of the finite observation time T associated with the proposed signal-processing system advertised in **Fig. 7.5**. Consider the problem of evaluating the ACF of the signal $x(t) = A\sin(\omega t + \phi)$ over the interval $[0,T]$. Write the ACF as:

$$r_{xx}(\tau) = \frac{1}{T-\tau}\int_{0}^{T-\tau} x(t)x(t+\tau)dt$$

and substitute $x(t) = A\sin(\omega t + \phi)$, so that:

$$r_{xx}(\phi) = \frac{A^2}{2}\cos\omega\tau - \frac{A^2}{4\omega(T-\phi)}\cos$$

$$2[\omega(T-\tau)]\sin(\omega\tau + 2\phi)$$

The first term is the theoretical ACF and the other term represents an error. Provided the observation time T is very much greater than the delay, the error will be small.

Calculating discrete autocorrelation functions

Sampled data sequences can be readily processed to obtain the discrete form of the autocorrelation function. This is probably best understood by calculating the autocorrelation coefficients which make up the function. A sampled data sequence of length $2N + 1$ samples has the autocorrelation coefficient defined by:

$$r_{xx}(k) = \frac{1}{N}\sum_{n=0}^{N-1} x_n x_{n+k}$$

$$k = 0, 1, \dots N-1$$

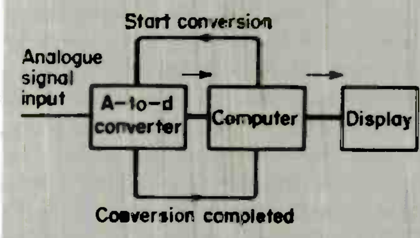
The autocorrelation function is simply a graph of the calculated coefficients, plotted as a function of k. The next step is to endorse the results of Table 7.1 using numerical methods with the help of the computer. Consider the sampled data form of the sinusoid $x(t) = \sin \omega t$, sampled every T seconds. **Fig. 7.6** contains the details of the shift-multiply and summate structure of discrete autocorrelation.

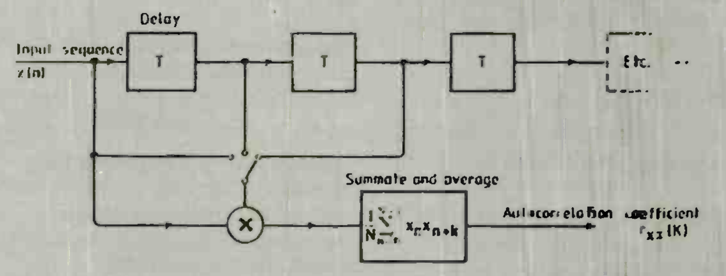
Computing the autocorrelation function

Pencil and paper confirmation is a necessary first step, but it does take time. Once the abstraction has been mastered, a more satisfactory approach is to implement the algorithm in software form. A suitable program is shown in **listing 7.1**. Initially, the sampled input will be generated synthetically. This provides an opportunity to examine the ACF of a variety of signals, in addition to testing the algorithm.

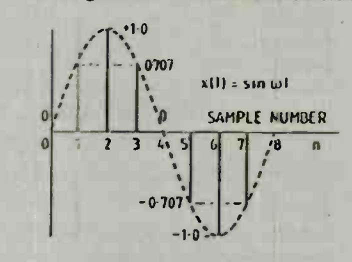
Listing 7.1

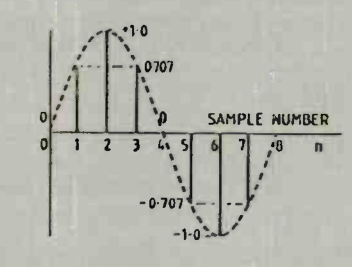
```
/ ************************************
*             ELEMENTARY             *
*           AUTOCORRELATION          *
************************************ /
#include<stdio.h>
#include<math.h>
#define PI 3.14159
#define N 8
main()
{
int x, k;
double t;
double contents[2*N + 1], sum[N];
/*------------------------------------------------
GENERATE SYNTHETIC DATA SINEWAVE
125 Hz : T = 1.0ms
------------------------------------------------*/
for(x = 0; x <= 16; x++)
{
contents[x] = sin(2 * PI * 125 * t);
t = t + 1.0e-3;
}
/ ************************************
*    ACF ALGORITHM STARTS HERE       *
************************************ /
for(k = 0; k <= N; k++)
{
sum[k] = 0;
for(x = 0; x <= N; x++)
{
sum[k] += contents[x] * contents[x + k] / N;
}
printf("Sample No.%d\t acc = %f\n", k,
sum[k]);
}
}
```

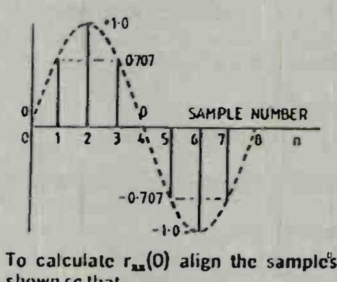




Evaluating the autocorrelation coefficients.







To calculate $r_{xx}(0)$ align the samples as shown so that,

$$r_{xx}(0) = \frac{1}{8}(x_0x_0 + x_1x_1 + x_2x_2 + x_3x_3 + x_4x_4 + x_5x_5 + x_6x_6 + x_7x_7 + x_8x_8)$$

$$= \frac{1}{8}(0 + 0.707^2 + 1.0^2 + 0.707^2 + 0 + 0.707^2 + 1.0^2 + 0.707^2 + 0)$$

$$= 0.5$$

To evaluate the value of $r_{xx}(1)$ shift the sampled waveform one place to the left so that,

$$r_{xx}(1) = \frac{1}{8}(x_0x_1 + x_1x_2 + x_2x_3 + x_3x_4 + x_4x_5 + x_5x_6 + x_6x_7 + x_7x_8)$$

$$= \frac{1}{8}(0 + 0.707\times1 + 1\times0.707 + 0 + 0 + (-0.707\times-1) + (-1\times0.707) + 0)$$

$$= 0.3535$$

The other coefficients follow by progressively shifting the sample of interest one place to the left until none of the samples overlaps. My results are,

$r_{xx}(2) = 0$
$r_{xx}(3) = -0.3535$
$r_{xx}(4) = -0.5$
$r_{xx}(5) = -0.3535$
$r_{xx}(6) = 0$
$r_{xx}(7) = -0.3535$
$r_{xx}(8) = 0.5$

So that the autocorrelation function of the sampled-data sequence is $r_{xx}(\tau) = (V^2/2)\cos\omega\tau$ as expected.

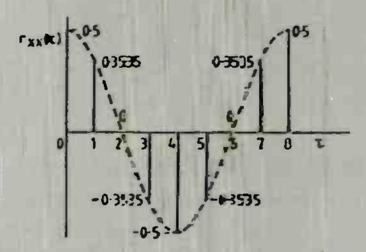


Fig. 7.6. Signal processing needed to generate autocorrelation coefficients from captured and sampled data sequence.

Anatomy of the program

An ordered approach is needed to process sampled data sequences. Notice that the algorithm requires $2N + 1$ samples. Sequential data storage is provided by incorporating the array construction, contents[x], inside a controlled for-loop. The intention is to imitate the results of sampling a sinewave of unit amplitude and frequency 125 Hz. The selection of a sampling interval of 1.0ms ensures two complete cycles will be digitised.

The ACF construction consists of a pair of nested for-loops to provide the necessary multiply-summate and shift structure.

```
for(k = 0;k <= N;k++)
{
sum[k] = 0;
for(x = 0;x <= N;x++)
{
sum[k] += contents[x] * contents[x + k] / N;
}
}
```

Observe how the pseudo-sampled data, contents[x], is declared as a double. The shifted and multiplied data array is summated by the addition assignment operator sum[k] +=. This is divided by the number of samples to generate the autocorrelation coefficient. The modest results of running this program are shown in **Table 7.2** and they confirm that the ACF is a cosine waveform of amplitude $V^2/2$. This agrees with **Fig. 7.6**.

Table 7.2 Computing the autocorrelation coefficients using 2N + 1 points

Sample number	autocorrelation coefficient
0	0.5
1	0.3535
2	0
3	−0.3535
4	−0.5
5	−0.3535
6	0
7	0.3535
8	0.5

Graphical autocorrelation

In the previous program, the computer existed simply for the purpose of generating data and calculating the ACF numerically. Greater insight, plus an intuitive feel for this form of signal processing, is achieved by plotting the results graphically. This example, which is a modification to **listing 7.1**, is designed to be run through an EGA card and colour monitor. In keeping with good practice program development is simplified with bottom up design.

Listing 7.2

```
/ ***********************************
*    ACF WITH COLOUR GRAPHICS     *
*         SYNTHETIC DATA          *
*********************************** /
#include<stdio.h>
#include<graph.h>
#include<math.h>
#define PI 3.14159
#define N 320
main()
{
struct videoconfig screen_size;
double t;
int x, k;
double sum[N + 1], contents[2*N + 1];
for(;;)
{
_setvideomode(_DEFAULTMODE);
_setvideomode(_HRES16COLOR);
/*-----------------------------------------------
                 EGA MODE
-----------------------------------------------*/
_clearscreen(_GCLEARSCREEN);
_setbkcolor(_GRAY);
_getvideoconfig(&screen_size);
_setlogorg(screen_size.numxpixels/4,
screen_size.numypixels/2);
_moveto(0, 0);
_lineto(320, 0);
_moveto(0, 0);
_lineto(0, -90);
/*-----------------------------------------------
              DRAW X & Y AXES
-----------------------------------------------*/
_settextcolor(3);
_settextposition(4, 13);
_outtext("A.C.F.");
_settextposition(14, 50);
_outtext("Parametric time");
/*-----------------------------------------------
          COLOUR AND POSITION TEXT
-----------------------------------------------*/
for(x = 0; x <= 641; x++)
{
/*-----------------------------------------------
        LOCATE SYNTHETIC DATA HERE
        SEE TEXT FOR SUGGESTIONS
-----------------------------------------------*/
}
/*-----------------------------------------------
              ACF ALGORITHM
-----------------------------------------------*/
for(k = 0; k <= N; k++)
{
sum[k] = 0;
for(x = 0; x <= N; x++)
{
sum[k] += contents[x] * contents[x + k] / N;
}
_setcolor(14);
_moveto(k, -7.2 * sum[k]);
_lineto(k, -7.2 * sum[k]);
/*
/*-----------------------------------------------
            PLOT AND SCALE ACF
-----------------------------------------------*/
}
_settextposition(16, 20);
printf("Mean-square value = %f\n", sum[0]);
getch();
/*-----------------------------------------------
           HIT ANY KEY TO EXIT
-----------------------------------------------*/
}
}
```

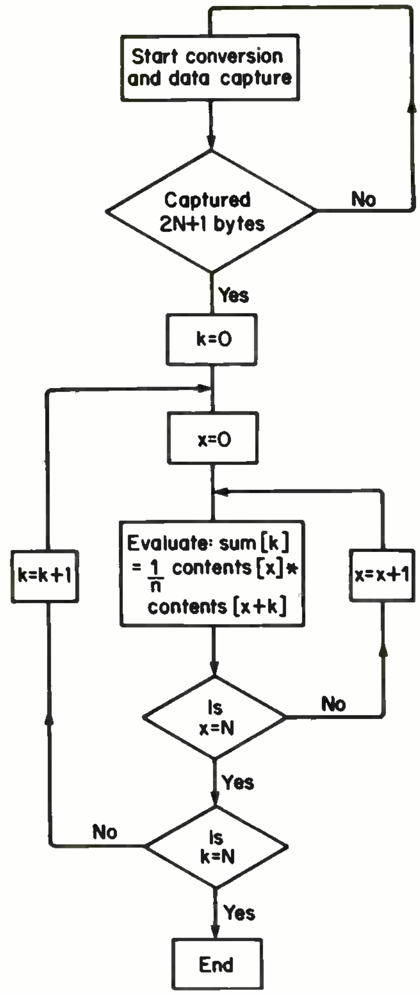


Fig. 7.7. ACF flowchart.

Applying the program

The program will allow confirmation of the results of Table 7.1 without any unpleasant mathematics. Rather than pedantically working through the first two entries, attention is focussed on the final two. The work should stimulate further thought, and encourage the autocorrelation of more ambitious synthetic signals using the PC. The following functions are software-generated. The pseudo-sampled data is stored in the array contents[x] prior to processing. The choice of sampling frequency is not coincidental. These routines will be used later to process real signals captured through an a-to-d with a minimum sample cycle time of 25μs.

ACF of sampled sinewave

This example generates a DC component of 2V and a sinewave of amplitude 2V and frequency 750 Hz. The signal is digitised into $2N + 1$ (641 samples), where the sampling interval T is 25μs. The effect of autocorrelating this signal is illustrated in **Fig. 7.8**.

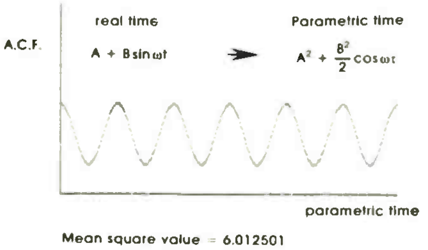


Fig. 7.8. Graphical autocorrelation, obtained by combining listings 7.2 and 7.3.

Listing 7.3

```
/ ***********************************
*   GENERATING A SINEWAVE 2V PK    *
*   750 Hz. PLUS D.C. COMPONENT    *
*   SAMPLING (T) 25 MICRO-SEC      *
*********************************** /
for(x = 0; x <= 641; x++)
{
contents[x] = 2 + 2 * sin(2 * PI * 750 * t);
t = t + 0.25e-4;
}
```

ACF of decaying exponential

Interpretation of the ACF requires care for wideband aperiodic pulses. When applied to signals of limited duration, the average value will be zero for large values of T. It may help to reconsider the definitions of finite power and finite energy signals. Finite power signals, such as the continuous sinusoid, have a well-defined average power when measured over long observation times. Finite energy signals, such as pulses, have a zero average value and a mean-square value of zero. The following example generates a decaying exponential of amplitude 8V and time constant 1.6025ms. As before, the signal will be synthetically sampled at 25μs. The processed output is shown in **Fig. 7.9**.

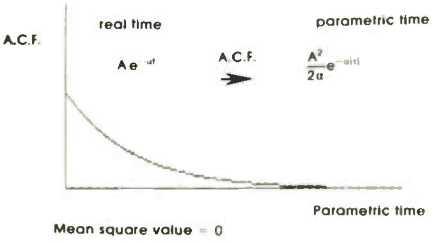


Fig. 7.9. Incorporating listing 7.4 as a source of synthetic data into listing 7.2 produces ACF of signal, $Ae^{-\alpha t}$.

Listing 7.4

```
/ ***********************************
*    GENERATING A DECAYING         *
*         EXPONENTIAL              *
*  TIMECONSTANT = 1.6025 MILLI-SEC *
*  SAMPLING INTERVAL 25 MICRO-SEC  *
*********************************** /
for(x = 0; x <= 641; x++)
{
contents[x] = 8 * exp(-624 * t);
t = t + 0.25e-4;
}
```

White noise

A random signal in which all frequencies are present with equal weighting and random-phase distribution is defined as white noise. Imagine the analogy of white light, which has a constant spectral density over the visible spectrum.

Such a signal cannot exist physically — the mean-square value would be infinite. Despite this limitation, it is a useful mathematical model. It can be adopted with confidence provided the bandwidth of the random signal is very much greater than the bandwidth of the linear processor.

To evaluate the autocorrelation function of band-limited white noise shown in **Fig. 7.10**, use the Wiener-Khintchine relationship, so that:

$$r_{xx}(\tau) = \frac{1}{\pi}\int_0^B P_0 \cos\omega\tau\, d\omega$$

$$= \frac{P_0}{\pi}\left[\sin\frac{\omega\tau}{\tau}\right]_0^B$$

$$= P_0\frac{B}{\pi}\left(\frac{\sin B\tau}{B\tau}\right)$$

The sampling function $\sin(x)/x$ characterizes the autocorrelation function.

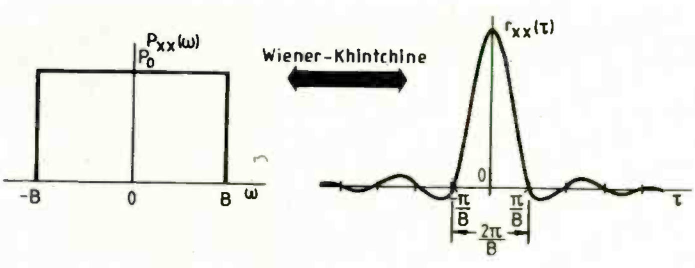
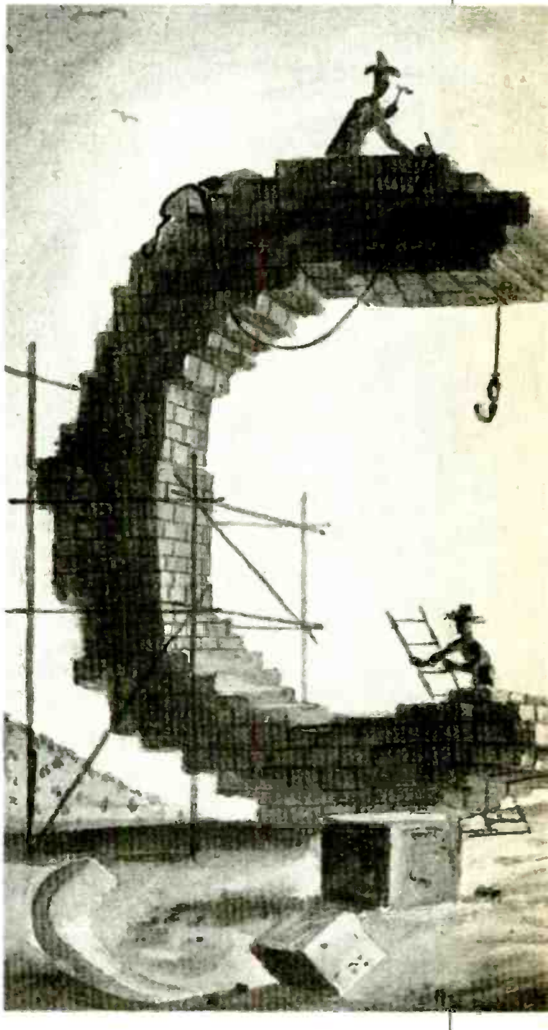


Fig. 7.10. Increasing upper angular frequency B of band-limited model reduces width of ACF pulse. In the limit, as bandwidth becomes infinite, autocorrelation function is modelled by an impulse function.

Clearly, the greater the upper angular frequency (B) of the band-limited model, the narrower will be the central pulse of the autocorrelation function. If this is treated as a limiting process, it can be concluded that, as the noise bandwidth increases towards infinity, so the ACF tends towards the weighted impulse centred on zero. By inspection, the ACF has a maximum value for zero delay and, as before, $r_{xx}(0)$ equals the mean-square value of the random noise. ■



Radio quiz

I have recently purchased an RDS car radio, and following initial enthusiasm now find that the unit does not entirely function as the European Specification intends.

In my case the unit's audio is not muted during AF scan modes and the unit cannot handle the Regional Editorial Area's now in place on the BBC local radio network. I have had considerable support from both the BBC and the IBA.

I wish I could say the same about the manufacturer, in my case the Japanese firm with the Omega logo.

Having spoken to other users of RDS equipment there appears to be various "grey" area's in such units' operation.

So through your magazine I should like to ask other readers who may have experienced similar or different problems if they would contact me. The manufacturers argue there is no market for RDS units but there will only be a market when the units function correctly.

TG Parrott.

Signally strange

During experiments with "Earth Loop Antennas" as an alternative to ordinary antennas, for reception of very low and extremely low frequencies, I came across continuous signals on 1.6, 2.2 and 3.3kHz plus several more intermittent signals between 1.0 and 9.0kHz, but so far, I have been unable to obtain any explanation on their origin.Any information would be greatly appreciated. The waveform ofthese ELF signals varies considerably, but all appear to be generatedby some kind of damped wave oscillator. Indeed, the most commonwaveform, **Fig. 1**, is to all intents and purposes identical to that ofa spark-type transmitter, where amplitude rises suddenly at themoment of the spark, followed by a chain of about ten waves of diminishing amplitude. Sometimes, a new chain commences before the first chain has completely decayed **Fig. 2**. At other times, the chain completely decays before a new chain commences. Occasionally, the waveforms of all three signals is complex, typically as Fig. 3. The receiver system consists of a pair of earth rods, spaced 35m apart, orientated NE/SW sited along my garden boundary with the adjoining open farmland. The soil is heavy clay overlying limestone. The

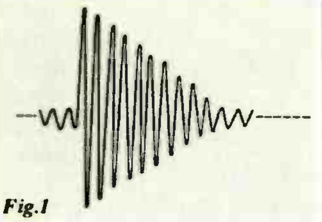


Fig.1

receiver consists of a 20mH inductor wound with 1.0mm wire on a large ferrite rod to give a DC resistance of only a few ohms and tuned by a capacity "box". The "tapped" coupling coil is located at the end of the tuning coil. Visual indication of the waveforms is by means of an oscilloscope connected directly across the tuning coil.

Signal strength with all three

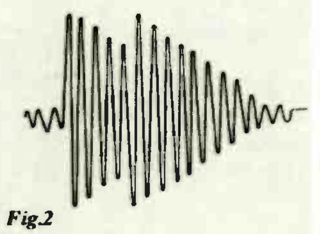


Fig.2

frequencies in their "quiescent" mode is typically 40 to 80mV pk-pk (max amplitude of damped waves), but suddenly, and apparently at random, rises to several hundred mV However, unlike 16kHz (marine) and 60kHz (time) signals radiated from Rugby (approximately 45km away) which consistently produce

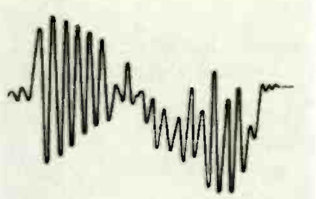


Fig.3

300 to 400mV, and Radio 4 on 198kHz (radiated from Droitwich 110km away) which produces a 1.6V across an alternative tuner connected to the same earth pins. I have found no evidence of acomplementary electric field with the ELF stations. Possibly because my 35m elevated antenna is too short to be effective. Nonetheless, the question comes to mind as to whether the ELF signals actually arrive as Hertzian waves. Indeed, if they are propagated as Hertzian waves, I would be most interested to know the kind of antenna employed. Now, if the ELF signals are not propagated as Hertzian waves, is it possible that they arrive as "true" earth currents, or do they arrive as "earth standing waves"?. I was struck by the remarkable similarity of the damped waves with those which would have been generated by Tesla's "Magnifying Transmitter". Am I therefore witnessing the resurrection of Tesla's system, or is there some less exciting explanation?

George Pickworth
Surrey

No interaction on CFA

There appears to be a lack of communication between the school against the CFA and those who support it. The important aspect of the CFA proposal is its ability to synthesise an EM wave; we know that in free space two EM fields will not interact in any way to produce a product, they will simply add as vectors. Consider two plane polarised EM waves in the same plane and direction, having components E1, H1 and E2, H2. The vector sum can be written:

E1H1 + E2H2 + E1H2 + E2H1
E1+E2)(H1+H2)

The vectors are in respect of magnitude and phase. The vector product has an argument which is in fixed relationship to **E** or **H** arguments which are in quadrature.

The terms **E1H2** and **E2H1** do not imply any "synthesis", as can be seen from the RHS; the two waves simply add as voltage vectors. An EM wave could only be synthesised if an alternating **E** field could exist without an associated **H** field and vice versa, but this is impossible because it contradicts Maxwell's Laws.

The CFA will produce an EM wave from the E plates, and also an EM wave from the D plates, since they have finite spacing. The question we must answer is whether or not there is a term in the EM output of the aerial which is proportional to the product of the two applied voltages. This can easily be verified experimentally by applying different frequencies to the two sets of plates; if a product term exists then frequency conversion will take place.

A 2-in high CFA has been tested at 70MHz: there is no EM output term which is a product of the two input voltages, no matter what phase difference they applied with. The EM output is the sum of the radiation from the two sets of plates. When fed with different frequencies, frequency conversion does not occur.

P Brooking & P Burgess
Ryde
Isle of Wight

Quack technology

I witnessed the original demonstration of Alec Jones' device on *Tomorrow's World* in about 1975 when the trolley did indeed appear to move forward. I subsequently wrote to professor Laithwaite, suggesting an improved version using four gyroscopes to neutralise spurious side thrust and torque.Professor Laithwaite seemed to think this of little value so I built a replica of the original machine as a starting point.Sure enough the trolley moved forward; however closer inspection revealed that the gyroscopemovedbackwards.

Marking the centre of gravity revealed that there was no apparent movement whatever of the overall mass in the direction in which the trolley was free to move.

There the matter rested until December 26 1988 when Channel 4 showed a program called *The Man who wants to Change the World*.

This was the story of a Scottish engineer who had spent a large amount of money and time constructing a machine similar to the one I had proposed.

I was unable to observe any thrust from this machine although it was claimed to work. This prompted me to devise a simple modification to Jones' original machine, which consisted of adding a counterbalance to the pendulum and then using a motor to force-precess it. Again there was no observable departure from Newtonian behaviour.

Finally I suspended the device from the ceiling, so that even a small effect would be observable, but to no avail.

In conclusion I would point out that, if such an effect did exist, it would manifest itself in natural phenomena; and since people have been trying for 20 years to produce results without success, it is fairly obvious that the device is a dead duck.

D. Austin
Birmingham

Civil unrest

As a reluctant Civil Servant, I find your assertion that "Civil Servants are by and large amoral" (Comment November *EW + WW*) deeply offensive. There are thousands of civil servants who are not involved in policy making decisions and surely they should not all be tarred with the same brush.

I should also like to draw attention to the difficulties of "whistle blowing".

It would be an interesting exercise to estimate how many people in the UK have had to sign that detestable document the Official Secrets Act. It seems that almost any job except mending roads and cleaning toilets has the rider: "Oh and just sign this" (The Post Office, BBC, army, navy, air-force to list but a few). Regarding your mention of index linked careers; first the index listing. Each year we do get rises usually two or three percentage points below the rate of inflation.

As for careers, we don't have careers, we have jobs. Many Civil Servants have FTC or HNC since after the war with the country virtually bankrupt only the very well off could go to university.

In those days it was possible to achieve CEng without a degree but as you are aware this path is now closed. The situation now in the Civil Service is that we have "Chartered Professional Engineers", some of whom I would not trust to change the spark plugs on my car. These people have careers, and the rest of the staff with devalued FTCs and HNCs just have jobs.

But in many cases it is the people with the jobs who make things work.

Name and address supplied

Robot recruiting

The android, as a humanoid robot from science fiction, has been with us for many decades; now the time has come for it to take form.

Knowing that many different talents will be needed to achieve this it is proposed that a research and development initiative be set up, in association with committed universities.

The idea is for a coordinating body to provide guidance on the work that needs to be done, and to disseminate information. The aim will be to allow participating researchers to pursue their own ideas as far as possible, while ensuring that their combined efforts merge towards the android robot objective.

Potential researchers must first be clear on what an android robot is and how it differs from conventional robotics technology. An android is a humanoid robot for doing manual work and must be human-sized and shaped so it can use our tools, walk in our buildings, operate our machines, and use our transport.

It should be able to go wherever we go and will need to be physically lightweight (no heavier than a human), and be able to walk, run, jump, and travel quickly over rough terrain.

It will also need considerable intelligence to be cognisant of surroundings, have coordinated movements, instantaneous responses, and be able to learn complex tasks. Furthermore it must be able to communicate with people. The android will be ideal for hazardous tasks.

Initially I would like to make contact with *anyone* interested in the idea of an android robot. If there is sufficient interest then the initiative will be launched.

Phase I will be to produce an android robot using only current technology, a remotely driven version relying on a remote operator.

This "tele-droid" version would be an essential step in evolution of the true autonomous android. Researchers would have the means to study and create an artificial brain in the laboratory: a learning machine to assimilate and coordinate all the experiences of a free moving entity.

If this vision of android robot technology interests you, then I would like to hear from you. Please write to

Dr Matthew Duggan
8 Grand Avenue
Worthing
West Sussex, BNll 5AN.
051-259-5436 (home)
051-794-4596 (work)

Tagging response

In November *EW + WW* Mr JJ Trott asks whether any work has been done on tagging devices for people suffering medical conditions where they can wander at risk to themselves and others, to the consternation of those responsible for their care.

I would bring to his attention the case of a boy living on a Cotswold farm who was brain-damaged at birth but is now aged ten. He is very agile and wanders with no fear of farm-machinery or traffic.

His parents initially discussed the case with their local occupational therapist, as his mother put it so neatly: "He is getting faster and I am getting slower." The problem was referred to the Gloucestershire panel of Remap (part of Radar) which provides voluntary engineering help for the disabled.

Radio tagging is widely used for tracking and monitoring wildlife for a variety of purposes. Such a tracking receiver and Yagi aerial normally used to track badgers were borrowed and a radio transmitter on 173MHz was fitted in a money-belt which the boy readily took to wearing.

His mother soon became familiar with using the receiver to find which way he had gone. But although a great help it soon became apparent there were limitations.

The tracking receiver with its separate aerial was heavy and somewhat cumbersome; a combined aerial and tracking receiver is under development which will be much easier to use.

More importantly, while the equipment did enable his mother to find where he had gone it did not help with the problem of warning when he was going.

There are several alarm systems in use for hospital patients and also the proposed systems for tagging prisoners on remand. But these all need a complex central installation which is much too costly for just one individual.

The money-belt transmitter sends a 30ms pulse every second. A prototype alarm receiver was developed to give an alarm when the signal strength falls below a predetermined level for ten seconds. This was adjusted to give an alarm if the boy wandered more than 50 yards from the house.

The system has been working for a year satisfactorily. Anyone wanting to find out more about the equipment should contact Dr J French, Mariner Radar, Bridleway, Campsheath, Lowestoft, Suffolk NR32 5DN tel; 0502 567195 who supplied it all.

The prototype would seem to have many applications, but two notes of warning are necessary. This is specialised radio equipment, made in small quantity and so costs are very much higher than mass produced broadcast receivers.

The tracking receiver is hand-held so requires no special installation but the same is not true of the alarm receiver.

Also radio signals are very much affected by local terrain, buildings and trees, and therefore each location presents different problems in giving the carer a reliable warning system free from false alarms.

DC Green
Hadley
Che
pstow

Clipped sine waver

Thank you for printing my note on clipped sine-waves (letters *EW + WW* December 1990. Your presentation was excellent but unfortunately some important brackets were left out.

Should any reader need the corrected solution please write directly to me enclosing a stamped address envelope. Also Fig. 2 should be labelled Fig. 3. and vice versa.

JE Diggins
Swinley Wood
Coronation Road
Ascot
Berkshire SL5 9LL

Division rule

A word of apology to readers. In my article "Direct-conversion FM design" (*EW+WW* November pp.962-967) the diagrams but not the captions of Figs. 1. and 3. have become transposed. So where the text refers to Fig. 1 refer to that for the caption but to Fig. 3. for the block diagram, and vice versa.

As I mention in the article, if the denominator of equation (3) is ignored, there will be no AM suppression: the amplitude of a demodulated signal will vary as the square of the amplitude of the incoming RF signal. This is even worse than a conventional FM receiver operating below limiting, where incidental AM is not suppressed, but at least it is not enhanced.

For signals such as PMR and broadcasting, incidental AM is common, due to reflections from vehicles, aircraft etc, so for such signals dividing by the denominator of equation (3) would clearly be appropriate.

For some other signal types, eg FDM/FM services via satellite, variations in received signal strength are, I believe, relatively small and slow, while additive Gaussian white noise rather than impulsive or adjacent channel interference is the major problem. In this case, the question of whether to divide by the denominator of (3) or not is not a simple question.

Not to do so is equivalent to multiplying the recovered modulation by the square of the received signal envelope (see letter "Dephi-ning design")

Whether this is advantageous or not depends on type of modulation, type of interference and signal to noise ratio.

For a fuller discussion readers are referred to Chapter 9 of Mr Roberts' own excellent book "Angle Modulation".
Ian Hickman
Hampshire

CFC response

I was saddened to read your editorial "A world class confidence trick" (*EW + WW* September).

We at ICI are deeply involved in dialogue with our customers in an attempt to discover, and subsequently provide, solutions to CFC phase-out that actually work for each customer. This is a highly complex area in which a journal such as yours could have materially contributed to a balanced technical debate. We are sorry that the opportunity was missed in September. Perhaps one of our technical staff could offer a piece for a future issue?

On one point we do agree; there is absolutely no panacea for the electronics or any other industry. This is why, in sharp contrast to your assertions, ICI has not restricted its efforts to fluorocarbon solutions, or even to chemical solutions. In fact we estimate that one-third of all CFCs can be replaced by "not-in-kind" substances or technologies which include different ways of doing things (eg "no-clean" solutions) as well as the so-called "non-chemical" processes such as aqueous cleaning.

A further third of all CFCs could in our view be dispensed with altogether by adopting conservation measures, control of emissions, recovery and recycling. The refrigeration industry and some of the larger electronics companies are making good progress in this direction. Nevertheless, a recent UK government report showed that less than 30% of small electronics companies (fewer than 100 employees) were operating procedures to maximise solvent effectiveness, and only 50% of the largest companies (more than 500 employees). What a pity your editorial didn't exhort all of your readers to follow the example of the best.

We believe, it is important to make an objective assessment of *all* available alternatives. ICI is deeply involved in multi-million pound studies to asses the toxicological and environmental acceptability of proposed new fluorocarbons.

But even aqueous cleaning is not "innocuous": the sort of integrated environmental assessment carried out by ICI (and espoused by the Green Bill) would take account of the global warming contribution of the energy required to evaporate the water, and of the biological oxygen demand of the contaminated effluent.

Similarly, while there is no doubt that a refrigerator could be made to operate with propane as refrigerant, this option has been available for decades and not adopted by the appliance industry.A sober analysis may well ask why, if this solution is the answer you imply, the appliance industry is spending so much time and money evaluating fluorocarbon options. As for the toxic products of combustion from chlorinated compounds, surely the point is that they don't burn and that the leading new refrigerant, KLEA 134a, is entirely chlorine-free.

Perhaps we could look forward to an objective technical and economic appraisal of all of the alternatives in a future issue?
Michael R Harris
Regulatory Affairs Manager
ICI.

Dephi-ning design

Regarding the article on direct conversion FM design (p.962 *EW + WW* November issue), the idea of using the numerator of the expression for dø/dt as a design basis goes back some years. Colleagues at Plessey (LC Walters), and at GCHQ Cheltenham (Dr R Hamer) hit upon the idea in the mid 1960s, while articles by Park and Schemel using much the same approach (see p 215 of ref. 1, below) appeared around that time.

On first acquaintance there would seem to be a high expectation that only small differences should arise in noise performance compared to that offered by a conventional FM receiver.

However an analysis of the analogue situation using the tools of noise theory reveal the following:

a) The presence of any FM modulation on the input signal must not be ignored in the working.

b) No sudden collapse in output signal quality (the onset of an FM threshold effect) occurs as the signal-to-noise ratio falls.

c) At large signal-to-noise ratios the performance is poorer than that given by a conventional device. (See Figs 9.11 & 9.12 of ref 1).

The degradation referred to in c) depends on the FM deviation ratio - the larger the ratio the poorer the performance, but in view of the ease of construction pointed out in Mr Hickman's article, a designer may be prepared to accept this degraded performance, especially when an element of FM threshold extension is available also.

Interestingly, with binary FM data (decisions are made on the sign of the instantaneous frequency), no corresponding worsening of the error probability arises, but this is not the case with data to other bases.
J H Roberts
Hampshire

References
1 "Angle Modulation", J H Roberts. No 5 in IEE Telecommunications Series, Peter Peregrinus London 1977.

Gassing on the phone

Your series of articles on "Light Comms" in December issue *EW + WW* smacks of "jam tomorrow", just as earlier updates of the telephone system, like ISDN, have been so long arriving. Worse perhaps, the systems cover only megabaud solutions for business purposes, while Joe Public can see no hope of improving on a 5kHz line now that fibre optics have been deemed too expensive for wholesale replacement of subscriber's twisted pairs.

Surely better A-to-D converters and faster modems are a limited answer to the inductance and capacitance of the circuit.
But there could be hope at a more mundane level from another direction, because British Gas has decided that it needs a better gas meter with remote readout, and has conducted trials of data collection by radio.

Recently it announced that it is going ahead with 200 prototype gas meters using ultrasonic measurement, with a view to a larger trial in 1993 and production in 1995.

The small wall-mounting unit meter is driven by a battery lasting ten years. However, the standard pipe material for both gas and water (where a similar metering problem arises) is now polyethylene, which seems an ideal location for a copper circuit which could be in the form of a high frequency strip-line.

If this is carried back to the end of the street, connection can be made to the trunk fibre-optic cables of the PSTN, so there is the basis for ISDN service at every house at minimal extra cost.

The standard weld-joint fitting (with built-in electric heater) seems extendable to join the communication circuit as well. Best of all, the whole system could be line-powered from one central battery, so that apparatus could be connected anywhere, with fully buffered input and output signals, for various facilities and services.

It could also provide a versatile telephone system which is completely cordless. A good cordless telephone would make public call-points and house wiring unnecessary as each section of gas or water main would be a local community cell-system.

Further, we could deploy the master station to cover the area using very low power PCN handsets. One central transmitter, say 1W, would suffice but a dozen small receivers distributed on lamp-posts and high buildings would mean diversity pickup from milliwatt pocket handsets.

It would be the humble CT 1 again, but with a broad-band audio to suit the pipes strip-line; 200kHz would appear adequate for 10-30 phone conversations.

Less than ten frequencies would give separation between cells, and with a smart card, everyone could have a personal telephone, and use it anywhere.
Robert Redding
Maidenhead

CIRCLE NO. 139 ON REPLY CARD

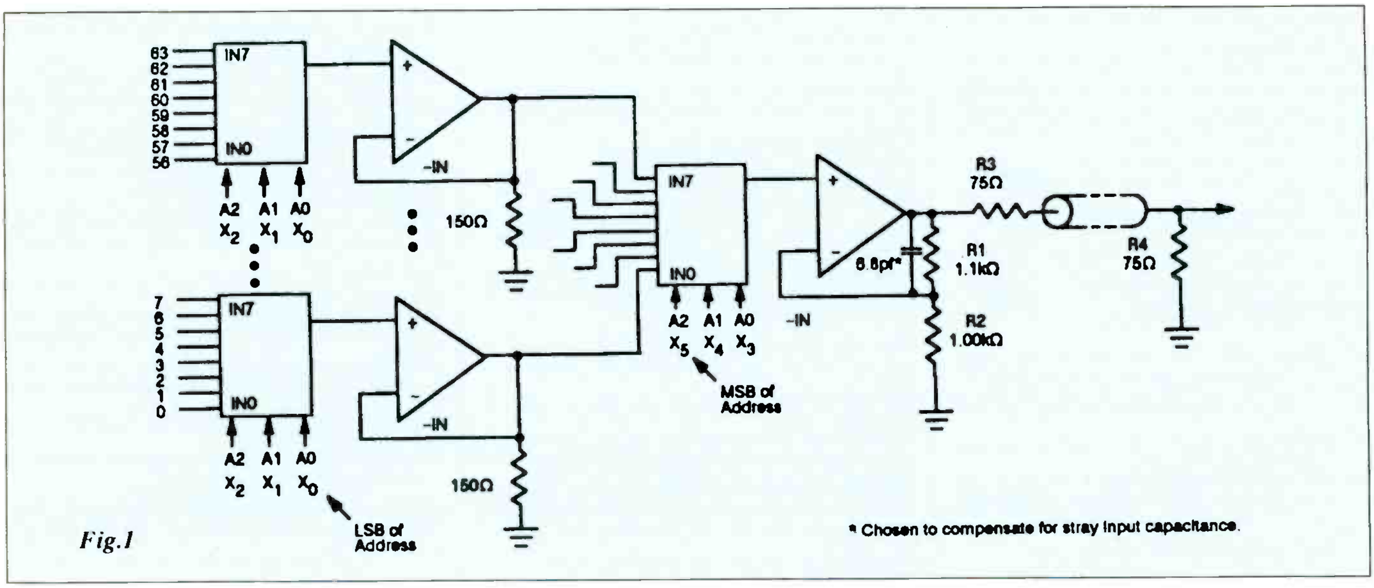


Fig.1

C-mos video multiplexer/amplifier

MAX 453/4/5 from Maxim are unity-gain-stable, 50MHz video amplifiers which will drive a 75Ω load and which contain multiplexers for two four or eight channels respectively. All the devices produce a ±2V swing into 150Ω or ±1V into 75Ω and need no external frequency compensation.

In **Fig. 1**, nine MAX455s are used to multiplex 64 channels, eight of them being used to select eight from 64 and the ninth to select one from these eight. The eight MAX455s are used as unity-gain amplifiers with 150Ω loads to give a gain of 0.99, these loads causing the amplifiers to peak at about 40MHz and partially cancel the rolloff of the final amplifier, which has a gain of 2. Overall gain is set by R_1 and the amplitude/frequency response is 3dB down at around 35MHz.

Since the output of the amplifier is a current proportional to the input voltage minus feedback, g_m is 0.5mA/V and output impedance is 1kΩ; unloaded voltage gain is 0.5*1000=500 (54dB).

Figure 2 shows the method of driving a capacitive load, the 27Ω resistor providing isolation and reducing peaking at high frequencies. Choose the resistor to give an RC product of 10ns or more, but do not use the arrangement if R is greater than 150Ω or C is less than 100pF, which is driveable directly without an isolation resistor.

When the input signal is of one polarity, as in many video applications, phase distortion may be reduced by biasing the amplifier as in **Fig. 3**. Instead of supplying a current of 0-13mA, the amplifier now produces a symmetrical ±8mA, which reduces phase distortion to about 1° at 4MHz. Since the amplifier has a gain of 0.5mA/V, the current from R_2 introduces an offset voltage, which is compensated by R_1. Gain is set by R_3 and R_4.

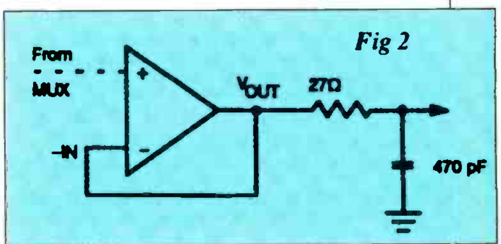


Fig 2

Maxim Integrated Products UK Ltd, 21C Horseshoe Park, Pangbourne, Reading, RG8 7JW. Telephone 0734 845255.

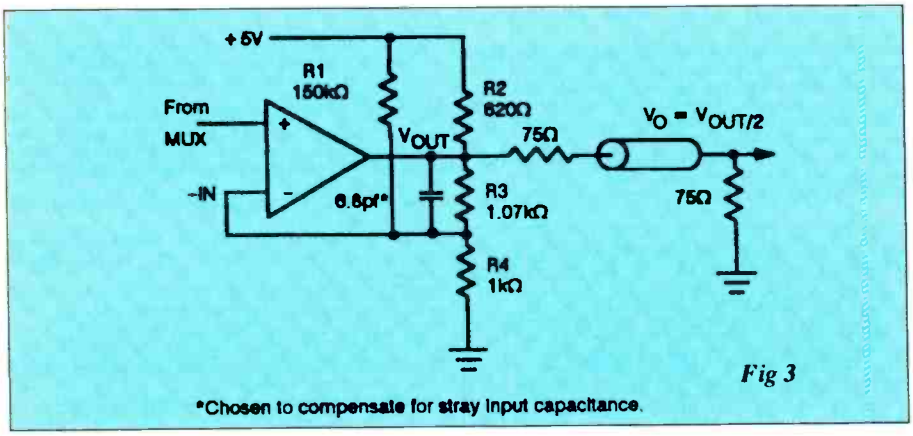


Fig 3

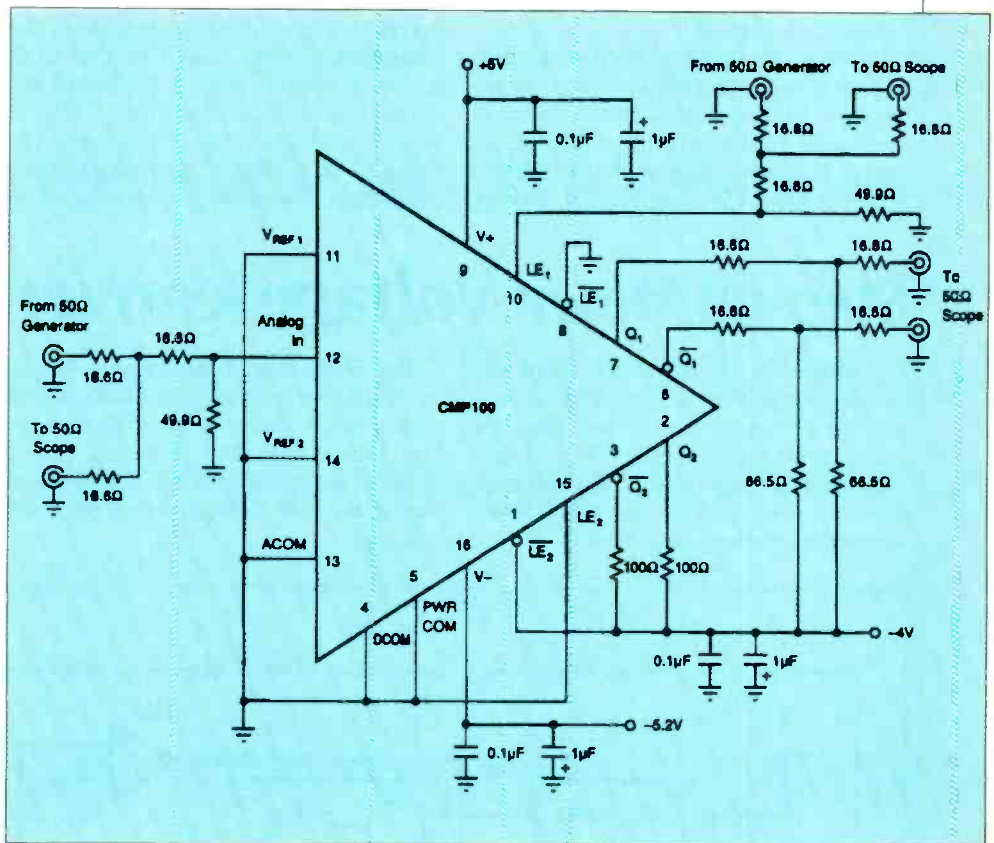
Transient detector

Burr-Brown's CMP100 is a high-speed dual comparator intended to be used as pin receiver in automatic test systems, although it is also used threshold detection and window comparators. There are two reference inputs and a common analogue input and all are attenuated to provide high common-mode voltage operation by voltage dividers, that on the analogue input being optimises for high-speed inputs. Latch-enable inputs allow the device to function as a sampling comparator.

In the circuit shown, the CMP100 detects and holds transient events above and below threshold voltages set by V_{REF1} and V_{REF2}. Comparator outputs are fed back to to the latch-enable inputs, so that the outpts are latched, the reset input unlocking the outputs when the transient has been observed. Outputs are combined in the output Nor to provide a single window comparator signal. The transient must stay above or below the reference voltages for 3.5ns or more to overcome the propagation delay of the CMP100 and the two Nor gates at the output.

If only one polarity of transient is to be detected, comparator 2 is not latched and, using a different part of the analogue input to give V_{REF2}, can be used to provide the reset signal to unlock comparator 1. This stretches the transient during the time V_{REF2} is present.

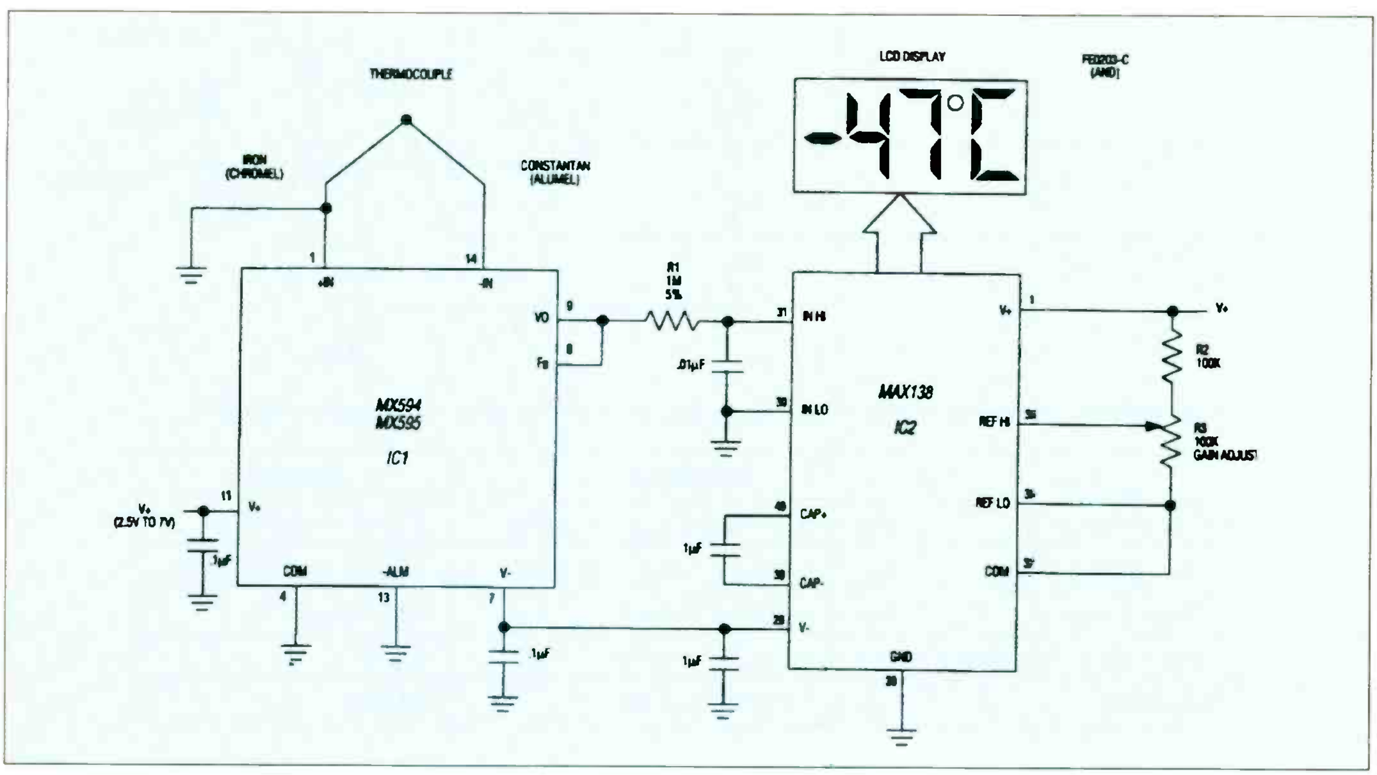
Burr Brown International Ltd, 1 Millfield House, Woodshots Meadow, Watford Hertfordshire WD1 8YX. Telephone 0923 33837.



Digital thermometer

The Maxim 1990 Applications Handbook contains a large number of circuits for various types of power supplies, A-to-D and D-to-A converters, linear circuits, digital circuits and filters, one of which is this design for a portable thermometer.

It uses a single-chip thermometer amplifier, the MX594, which contains cold-junction compensation and provides a laser-trimmed, 10mV/°C for J or K thermocouples. This chip works with only a positive supply, but needs a bipolar supply for negative temperatures, which is not a particularly attractive requirement in



a portable instrument.

A MAX138, used as the DVM chip, overcomes the drawback by using an internal charge pump to provide a negative supply of the same magnitude as the positive line voltage at up to 0.5mA. Since the MAX594 needs only 300mA maximum from this negative line, the combination works well. Using an LCD and a 6V positive supply, the instrument measures temperature from -350 to 400°C; with a 3V lithium battery, the range is -50 to 100°C. Low temperature-coefficient resistors at R_2 and R_3 and a better reference in place of the internal bandgap reference in the MAX138 improve accuracy from the ±1°C normally obtained.

Maxim Integrated Products (UK) Ltd, 21C Horseshoe Park, Pangbourne, Reading RG8 7JW.

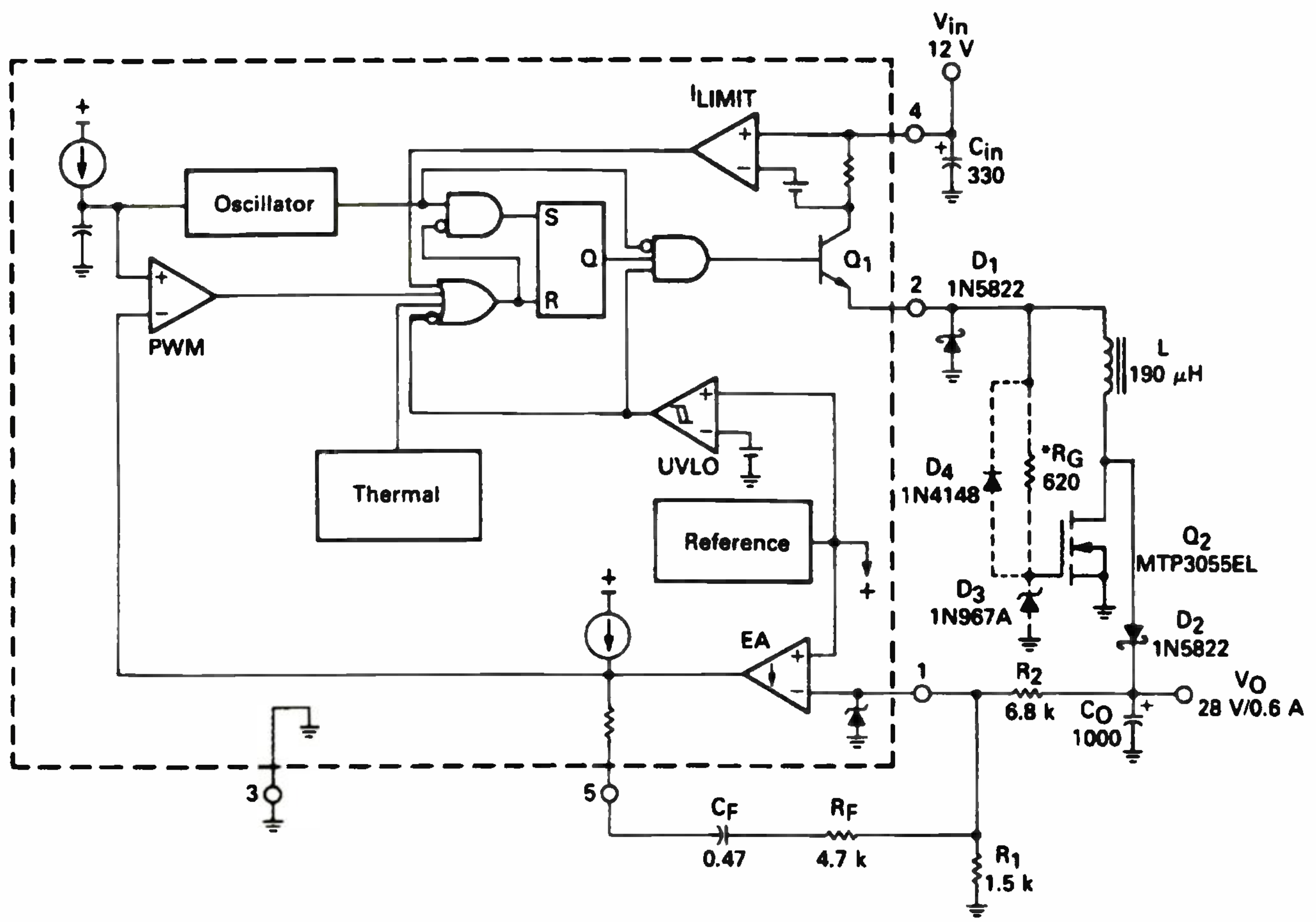
Step-up/down voltage converter

Motorola's MC34166/33166 power switching regulators are intended particularly for DC-to-DC conversion. They are fixed-frequency (72kHz) voltage-mode regulators that will perform step-up, step-down or inverting functions with a small number of external components.

The 34166 is configurable as a step-up or step-down converter with an external power mosfet at the output. During the "on" time of transistors Q_1 and Q_2, energy is stored in the inductor and is transferred during the "off"time to the output filter and load.

Output short-circuit protection is afforded by the fact that Q_1 is in series with V_{in} and the load. If V_{in} is over 20V, the mosfet gate protection network Rg, D_3 and D_4 is needed.

Motorola Ltd, European Literature Center, 88 Tanners Drive, Blakelands.



*Gate resistor R_G, zener diode D_3, and diode D_4 are required only when V_{in} is greater than 20 V.

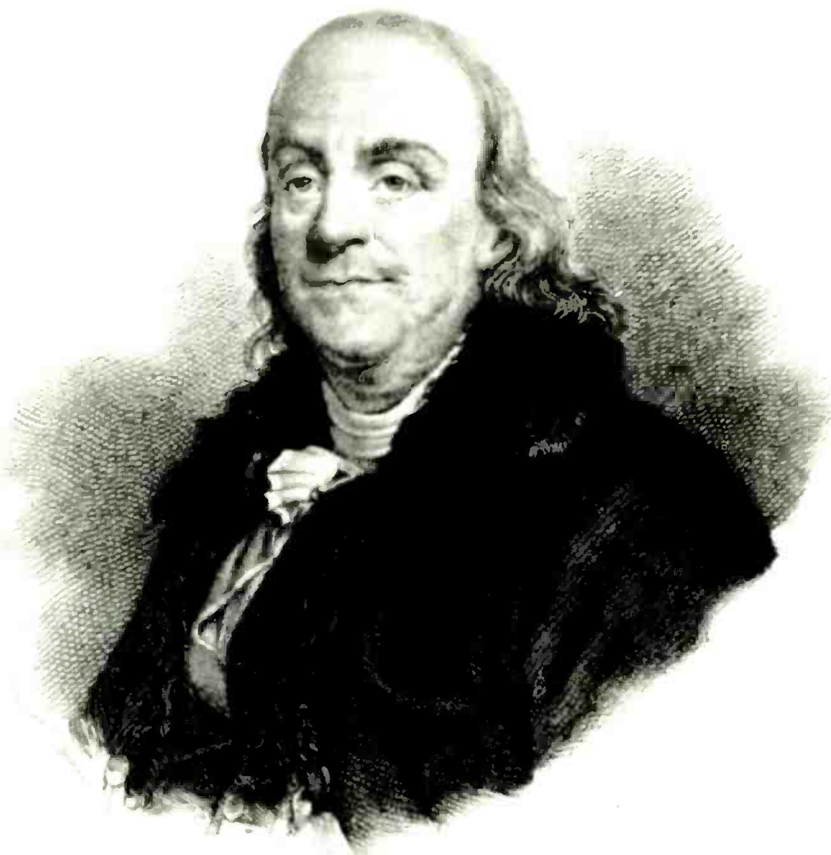
Test	Condition	Results
Line Regulation	V_{in} = 8.0 V to 24 V, I_O = 0.6 A	23 mV = ±0.41%
Load Regulation	V_{in} = 12 V, I_O = 0.1 A to 0.6 A	3.0 mV = ±0.005%
Output Ripple	V_{in} = 12 V, I_O = 0.6 A	100 mV_{p-p}
Short Circuit Current	V_{in} = 12 V, R_L = 0.1 Ω	4.0 A
Efficiency	V_{in} = 12 V, I_O = 0.6 A	82.8%

PIONEERS

Benjamin Franklin 1706-1790 Printer, postmaster, scientist and statesman

Mention Ben Franklin's name to an electronics engineer and he will probably say "kite experiment". It was, by far, his most famous (and dangerous) moment, but it was not his most important contribution to electrical science. As important, if not more so, were his contributions to the "single-fluid theory" of electricity and his introduction of the words "plus", "minus", "positive", "negative", "charge", and "battery" into electrical terminology.

In other scientific areas, Franklin added to our understanding of the Gulf Stream, atmospheric convection currents and storms. Outside the field of science, he was a well-known publisher, politician and statesman; his contribution to American politics before, during and after the founding of that nation ensured him a lasting place in history. After failing to reconcile Britain with her American colonies, he helped to draft the American Declaration of Independence, negotiated French support for the War of Independence and conducted the preliminary negotiations for the Peace of Paris in which Britain recognised American independence. He was also a member of the Constitutional Convention in 1787. His final public act, on December 12, 1790, was an attempt to persuade the American Congress to abolish slavery. It was to be nearly another 75 years before the American Civil War brought that about.



Franklin was born in Boston, Massachusetts, on January 17, 1706 of Josiah and Abiah Franklin. It was his father's second marriage and Benjamin was the youngest son of 17 children. He died in Philadelphia at the age of 84 on April 17 1790 and was, therefore, one of that very small band of early pioneers of electrical science, and one of the greatest.

When he was eight, Franklin was sent to a grammar school, as his father was intent on preparing him for the priesthood. Father, however, changed his mind and Benjamin was soon moved to a School for Writing and Arithmetic — where he failed arithmetic. At ten, he left school to help at his father's business, which was that of tallow chandler and soap boiler. At twelve, he was apprenticed to his brother James, a printer; the two did not get on and Benjamin eventually obtained his release from his indentures by the following subterfuge.

James wrote and printed a newspaper and some of his reports annoyed the authorities. He was imprisoned for a month and banned from continuing to print the paper. To circumvent the ban, a scheme was arranged whereby Ben was released from his apprenticeship on condition that the newspaper be printed in his, not James's, name. But he also had to sign new, secret, indentures with his brother. After another quarrel, Ben realised his brother could hardly hold him to the secret deal without revealing all to the authorities. So, at the age of 17, Benjamin Franklin walked out on his brother and his father, who had supported James. Though at the time he had no regrets, he later regarded this as "one of the first errata of my life[1]".

Realising that his family would try to stop him leaving Boston, he convinced the captain of a New York sloop that he had "got a naughty girl with child, whose friends would compel me to marry her, and therefore I could not appear to come away publicly[2]". Three days later he was in New York, alone and a stranger.

The local printer could not employ him but referred him to his son in Philadelphia, a hundred miles further on. Further adventures followed, including another sea journey in which Franklin rescued a drunken Dutchman from drowning. He reached Philadelphia, got a job and came to the notice of Governor Keith, who happened to have a low opinion of the two local printers.

Flattering the young Franklin, Keith offered to finance him in setting up a new business and sent him to London to make acquaintances and buy types — but without money or letters of introduction. Once in London, Franklin worked hard and further perfected his trade. After nearly two years he returned to his old employer in Philadelphia, but was soon in business on his own account.

Through ability, hard work and a social conscience, he became a man of some importance, first in Philadelphia and then in the colony of Pennsylvania. He strove to improve his mind and character, even defining his own set of honourable rules to live by. He had a love for books and taught himself to read French, Italian, Spanish and Latin.

In 1727, he set up a debating club and was continually looking for ways to benefit the community. From 1736, for 15 years he was Clerk of the Pennsylvania Assembly before becoming a full Member, and for 16 years from 1737 he was Deputy Postmaster of Philadelphia. He relinquished that title to become Joint Postmaster General of the Colonies 1753. Four years later he was sent to England to represent the Pennsylvania Assembly in settling some local dispute. A decade later he was the London agent of, in turn, Pennsylvania, Georgia, New Jersey and Massachusetts.

"... electrical fire is a real element, or species of matter, not created by friction but collected only". Electrical experiments were explained by the transfer of this real element of matter

Electrical research

Franklin was a gifted inventor and loved to "construct little Machines for my Experiments while the Intention of making the Experiment was fresh and warm in my Mind." This practical skill complemented his philosophical abilities and William Watson described him as having a "head to conceive" and "a hand to carry into execution" whatever was needed to "enlighten the subject matter".

Franklin's introduction to the fledgling science of electricity came in the mid-1740s when he saw some demonstrations of electrostatics performed by Adam Spencer. About the same time, a present of a "glass tube" was received from London by the Library Company of Philadelphia; glass tubes were much prized for their use in the generation of electrical charge by friction. Franklin enjoyed repeating the experiments he had seen and read about and added new ones to the repertoire.

One of his first discoveries concerned the action of a pointed body. A grounded point would discharge a charged body when still some inches away from it, whereas a blunt-ended body had to be much nearer to do the same. A friend, Thomas Hopkinson, found that a needle attached to a body would prevent it from becoming charged; the "electrical fire" continually "running out from the point".

Franklin and his friends were soon speculating on the nature of electricity: "electrical fire is a real element, or species of matter, not created by friction but collected only", they concluded. Electrical experiments were explained by the transfer of this real element of matter.

Franklin considered that all bodies had a "natural" amount of "electrical fire". If some of it was lost, then the body would have less than its natural amount, so he called it electrically negative or minus. Similarly, if it had more than its natural amount, it would have a "superabundance" and be electrically positive or plus; he can hardly be blamed for not foreseeing that electrons would turn out to be

When electrical matter was introduced into an ordinary body, it immediately diffused through the whole body as if it were " a kind of spunge". When the "spunge" was saturated, the surplus "fire" stayed on the surface and formed an "electrical atmosphere".

negatively charged. His ideas led him to conclude that if one body gained "electrical fire" then another body must have lost it. In this we can see an early version ot the law of conservation of charge.

Franklin conveyed his thoughts and descriptions of his experiments to friends at home and abroad. His letters to members of the Royal Society in London, a book he wrote on electricity which appeared in England and France as well as at home and articles he wrote for the Philosophical Transactions in London ensured that his name gained prominence among those interested in science.

Parallel-plate capacitor

His evolving theory of electricity bore fruit when he analysed the Leyden jar capacitor, a glass bottle partly filled with water or metal shot and having the outside clad with metal sheet. He showed that, when the wire connected to the internal conductor was charged positively, then the outside conductor was charged negatively and vice versa (1747); the next year, he found that the two charges had the same magnitude.

Before long, he had proved that the charge resided in the glass and not in the two conductors. He then questioned whether the bottle, as such, was necessary or just a convenience. He changed the shape, using a flat pane of glass with sheets of lead on either side — the first parallel-plate capacitor — and found he could store the "force" just as easily as in a Leyden jar. He made an "electrical-battery" of eleven panes of glass with lead plates pasted to each side and joined by wire and chain.

He assumed that "electrical matter" was made up of particles. Particles of ordinary matter attracted one another, according to his theory, whereas particles of electrical matter were mutually repulsive. When electrical matter was introduced into an ordinary body, it immediately diffused through the whole body as if it were "a kind of spunge". When the "spunge" was saturated, the surplus "fire" stayed on the surface and formed an "electrical atmosphere".

This atmosphere caused positively charged bodies to repel one another. Though his theory did not explain the repulsion between negatively charged bodies it was very successful and still influences our thoughts today. Our convenience of "conventional" current flowing from positive to negative is pure Franklin.

Lightning

Franklin's contributions to electrical understanding are especially noteworthy, since he was acting almost in isolation, separated by the Atlantic from the great centres of Europe. Written accounts of his work appeared in England and France and in them was a discussion, and a proposed experiment, about lightning.

By April, 1747, Franklin was convinced that clouds were electrified and that lightning was an electrical discharge; he produced a list of 12 similarities between laboratory sparks and lightning. As the "electrical fluid" was attracted by pointed objects, he surmised the same would be true of lightning and proposed an experiment. Even before the experiment was performed he warned that hills, towers, trees and so on would attract lightning because of their "prominencies and points" and advised his readers not to shelter under a tree during a thunder storm. He also suggested that the "power of points may possibly be of some use to mankind." Sharpened upright rods of iron, gilded to prevent rusting, could be fixed to the tops of buildings and run down the side and into the ground. These would "draw the electrical fire silently out of a cloud before it came nigh enough to strike". Later, he found that his lightning rod would conduct a strike safely to ground.

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Franklin's proposed experiment, suggested in April, was to mount a 20ft or 30ft rod on an insulating stand and have the pointed end sticking up in the air. A man, well insulated, was to hold a grounded loop of wire by a wax handle (insulator); the stand, and the man, were enclosed in a sentry box to keep them dry and so preserve the insulation. The rod would draw the "fire" from passing clouds and the experimenter would be able to draw sparks from the rod with the wire loop.

The experiment was performed first in France in May, 1752, with great success and reported to the French Academy of Sciences on the May 13. It was duly repeated in a number of countries, but not always with satisfactory results. If you play with fire...

In St Petersburg, a Swedish professor, G.W. Richmann, set up to imitate the experiment. When a thunderstorm approached, Richmann hurried eagerly to his equipment only to be struck dead by a blast of lightning. "It is not given to every electrician to die in so glorious a manner as the justly envied Richmann", was the comment offered by Joseph Priestley in one of the first books to be published on the history of electricity. Richmann, however, did not die in vain. In death he provided the first specimen for a study of the effects of lightning on (once) living tissue.

Meanwhile, in Philadelphia, Franklin had grown tired of waiting for an opportunity to erect a rod on a tall building. So he devised another experiment, the lightning kite, and probably flew his kite before hearing of the success in France. As a thunder storm approached, Franklin drew sparks from a brass key which was tied to the wet silk thread which held the kite. The image this has presented over two centuries has left countless people wondering how he escaped with his life.

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The discovery that lightning is a form of electricity was a huge step forward in experimental science: Priestley called it "the greatest, perhaps, since the time of Sir Isaac Newton". Like Newton's discoveries about light, it showed that experimental science can have some meaning beyond the toys of the laboratory. Further, it proved that electricity was not only generated by man but existed freely in nature. It also showed that man's tinkering with science could lead to useful and practical inventions, in this case the lightning rod. Two hundred years after his death every tall building around us has Benjamin Franklin's invention sitting proudly at its top. ■

References

1. Dictionary of Scientific Biography.
2. J. Bigelow (Ed.) "Life and Letters of Benjamin Franklin", Ward, Lock & Co., London, New York & Melbourne, 1891.

ACTIVE

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

Sampling at up to 40MHz. Motorola says its newest pair of 40Msample/s 8-bit video speed converters are capable of driving a 75Ω cable, with appropriate terminations, to EIA-170 and EIA-343-A video levels. The MC10322 has TTL compatible logic inputs; MC10324 logic inputs are ECL compatible. Key parameters are 8-bit linearity; latched data and video control inputs, or transparent mode; differential current outputs with >2.0V swing capability; modulation (multiplying mode), and power supply rejection ratio of >60dB. $4.36. Motorola Inc, 0101 602 897 3615.

Monolithic flash. The MN5901 is an ultra-high speed, 8-bit monolithic device with a conversion speed of 100MHz. It offers differential linearity of ±0.95LSB max over operating temperature range and a signal-to-noise ratio of 38dB. Dynamic linearity (effective bits) is ±0.5LSB min. Packaged in a 24-pin, hermetically-sealed, ceramic DIP and offered commercially for operation over -25°C to +85°C (case), and for extended temperature ranges, -55°C to +125°C (case, "H" models). Micro Networks, 010 1 508 852 5400

Linear integrated circuits

Dual 70MHz c-mos video amplifier. Max457 is a monolithic IC comprising two 70MHz c-mos video amplifiers which can drive 75Ω loads. The amplifiers operate from ±5V supplies, and consume 350mW. Only external components needed are two resistors for gain setting, and two decoupling capacitors. They are stable at gain of 1 when driving 75Ω loads, and 2 when driving 150Ω. Isolation between the two amplifiers is greater than 60dB. Maxim Integrated Products. 0734 845255.

Microprocessors and controllers

Graphics chip. TVGA 8900 graphics chip is a VGA-compatible colour graphics interface using only a handful of active components. Standard PC graphics resolutions of up to 1024 x 768 pixels (non-interlaced) in up to 256 colours from a 16-million colour palette are supported. 32-bit architecture. £25 sample quantities. Dean Microsystems, 0734 842165.

Single chip 1750. The MA31750 said to be world's most advanced c-mos-SOS MIL STD 1750A microprocessor, with powerful performance characteristics of a standard DAIS throughput of 3Mips at 22MHz clock rate with a target of 4Mips at 29MHz, and 11 x 10^6 32-bit floating point operations per second at its standard cycle time of 90ns. It has a 32-bit internal bus structure with a 24 x 24 bit multiplier and a 32 bit ALU and can directly access 64K words of memory. 1M words when used with memory management unit (MMU). GEC Plessey Semiconductors, 0793 518000.

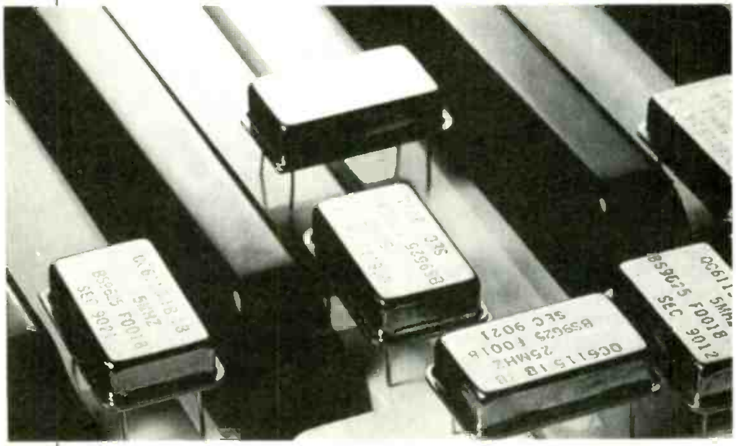
Programmable peripheral devices. The PSD301 programmable chip works directly with any 8-bit or 16-bit microcontroller or microprocessor by providing programmable features including I/O ports, buses, address mapping, port tracking, 256K of eprom and 16K of sram on a single chip. It can also be programmed on industry standard programmers, such as Data I/O. It is available in commercial speeds of 150ns and 200ns and in industrial and military speeds of 200ns. Micro Call Ltd, 0844 261939.

High-speed, low-power. NEC's V-Series has been extended by introduction of V20H and V30H, fully-static low-power versions of V20 (μPD70108) and V30 (μPD70116). Clock speeds can now range from DC to 16MHz (with 25MHz planned). Power savings at low frequencies can be substantial; in 'stop' mode only 50μA is required. A 3V version is available to minimise number of cells required in battery applications. The V20H/V30H instruction set is a superset of the μPD8088/μPD8086. NEC Electronics (UK) Ltd, 0908 691133.

Oscillators

Tri-state DIL oscillator. Maximum drive capability of SEI's QC6115 quartz oscillators is eight standard TTL inputs or 150pF of hcmos loading. The hermetically-sealed modules have a tri-state output which reduces component count and provides instantaneous oscillator start-up. They are available in frequencies from 5 to 25MHz, hcmos or TTL compatible. Maximum power consumption is 200mW at 25MHz. Maximum frequency stability of the 6115 varies between ±25 and ±100ppm. SEI Ltd, 0706 67501.

SEI's Tri-state DIL oscillator drives up to eight TTL loads



Programmable logic arrays

Gate-array with mixed ECL/TTL I/O. ET-2600VH is an ECL gate array with mixed ECL/TTL inputs and outputs, including 2544 equivalent gates, 72 I/O buffer gates and 32 input buffer gates. Internal cell structure comprises 2016 low power gates and 528 high power gates organised as 36 low power M-cells and 12 high power M-cells. Delay times of the TTL I/O buffers are about 1.3ns (input) and 2.9ns (output). For the ECL I/O buffers signal delay times are 0.1ns (0.3ns including package delay) at the input, and 0.5ns (1.0ns). Fujitsu Microelectronics Ltd, 0628 76100.

Power semiconductors

High-side power IC. IR8400P from International Rectifier (LMD18400 from National Semiconductor) is the first power integrated circuit providing full diagnostics and thermal warning features. It is rated for 6-28V operation with an 80V transient capability. Each of the four independent power switches can conduct a continuous 1A (3A peak). All switches together have a current rating of 6A peak. International Rectifier, 0883 713215.

Power transistors. Manufactured in Glenrothes by Semelab, the BUL46-51 range of n-p-n power transistors is claimed to overcome problems with fast switching at high temperatures and high gain at low temperatures. As a result, a typical 1000V TO3 device can switch in 50ns, even at 25°C. BUL46-51 is offered in TO3 metal cans. 300W. Verospeed, 0703 461111.

5A transistor. ZTX851 is claimed to be the first TO92-compatible transistor to handle 5A collector current continuously, made possible by a low saturation voltage of 0.2V at maximum continuous current. At its limit, it can switch 60V at 5A equating to 300W. Gain is a minimum of 65 at 5A, given a 2V collector-emitter voltage. Under pulsed operation, the device can be used at up to 10A, where it still has a gain of 20. Zetex plc, 061 627 4963.

Compact photoconductive cells. In the Tocos CdS 2PBL 5x photocells, normal packaging has been replaced by a tough resin coating, for a compact component with wide angle of incidence. 5.4mm diameter by 2.4mm high excluding leads. Available in ten ratings from 4.5kΩ to 200kΩ at 10Lux and spectral peaks of 540 to 650nm. 100V DC. Young Electronic Services, 06285 31417.

PASSIVE

Connectors and cabling

Woven braid for up to 390A. Available in nominal widths from 0.25 to 3in, Alpha's flat braid can carry up to 390A. Tubular braid provides 95% shield coverage with nominal inside diameters ranging from 0.031 to 1.5in and maximum current carrying capacity of 190A. The tinned copper oval braid varies from 0.063 to 0.78in inside diameter and handles 85A. Alpha Wire Ltd, 081 751 0261.

Subminiature.. Chomerics/Steward EMI absorbers reduce radiated emissions on data and power cables without affecting data transmission. They install by sliding on to, or clamping around, I/O cables, ribbon and power cables. Most recent addition is a subminiature D-type connector. Mounting packages accommodate cable diameters up to 0.45in as a single sleeve or split for retrofit applications. Chomerics (UK) Ltd, 0628 486030.

Low price PLCC sockets. Low price is the aim of the 709-2000 series plastic leaded chip carrier sockets for industry standard Jedec j-lead packages; 68 pin version is <£1 for more than 500 pieces. Available in sizes from 20 to 84 pins. Gas tight contacts prevent contact corrosion and provide a low contact resistance. Interconnection Products Ltd, 0433 21555.

Data Loggers

Data acquisition. Small size and portability are features of the 3kg Fluke Hydra series offering flexible measurement capability on up to 21 universal analogue input channels and 12 digital I/O channels. Two models include the 2620A for use with a PC or printer, and the enhanced 2625A data logger featuring built-in memory for full stand-alone logging. Philips Test & Measurement, 0923 240511.

Displays

16-grey scale plasma. FPF12000SA is a 15-in, high-resolution, plasma display offering a matrix of 1024 x 768 dots of 0.3mm pitch. It incorporates an automatic brightness control, progressively adjusting image intensity as the density of the displayed image is altered. Power dissipation is 30W. Neon orange display against black background. Effective screen area of 307mm x 230mm. Fujitsu Microelectronics Ltd, 0628 76100.

Filters

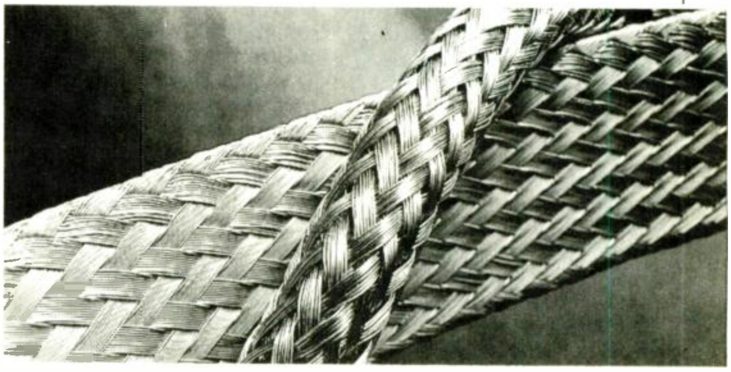
RFI mains filters SDX415 (15A) and SDX425 (25A) filters are for three-phase four-line applications, designed for protection of sensitive equipment. They can also be used as general suppression components. Models are compact, using current compensated inductors, and are enclosed in steel cases. Termination is by screw terminals. Roxburgh Electronics Ltd, 0797 223777.

Instrumentation

Portable ARB. Farnell Instruments' SFG25 arbitrary waveform generator is being offered with more horizontal resolution, improved software, LabWindows support, and a different graphics tablet option. It will provide sine, square and triangle waveforms from 1mHz to 1MHz. Arbitrary waveforms can be programmed in the range DC to 12.5MHz. The 12-bit vertical resolution waveform can be output at up to 25 megapoints per second. Farnell Instruments, 0937 61961.

Nanovolt DVM. Model 182 with a 1nV sensitivity, has an input resistance of greater than 10GΩ on all ranges. Noise levels are held to 15nV pk-pk. The 6.5 digit instrument has a dual display showing reading and range, and can make over 50 readings/s, into an internal buffer of 1024 points. 1 to 3000 variable gain analogue output. Multiple trigger sources. Keithley Instruments Ltd, 0734 575666.

Picoammeter. PCI-3 has a resolution of 0.01pA on its lowest range with an accuracy better than 0.3%, rising to 0.05% on higher ranges. Eight ranges allow the PCI-3 to measure up to 20mA. Manual or digital autoranging. 4.5 digit LCD. Analogue outputs of the log and linear values are provided. Matelect Ltd, 071 221 6784.



Tight specification woven braid carries currents up to 390A

Voltage and magnetic indicators. Tek 100 and 200 models are for conductors energised at AC voltages from 100-600V. They will detect live cables at 2-23mm dependent on voltage and frequency. Tek 100 is a non-contact voltage indicator with red led and an audible tone for voltage, and green led for battery state. In Tek 200, when switched to magnetic field mode, the red led indicates South Pole magnetic and the green North Pole. Magnetic sensitivity is ±10mT. 150g. 9V battery. Tek 100 £19.99, 200 £29.99. The Instrument Centre Ltd, 0633 280566.

Programmable function generator. TG1304 is based on an analogue voltage controlled main generator, with a frequency range of 10mHz to 13MHz, which can produce sine, triangle and square waveforms of up to 20V pk-pk EMF from a 50Ω source impedance, as well as unipolar pulse waveforms. Symmetry and DC offset are fully variable. A second independent generator, 5mHz to 50kHz, can provide sine, triangle and square waveforms from a 600Ω auxiliary output and can be used as a source for comprehensive amplitude and frequency modulation of the main generator. £1295.00. Thurlby-Thandar Ltd, 0480 412451.

Interfaces

Multifunction I/O board. Capable of being installed in any compatible, the CIO-AD 08 turns the PC into a medium speed data acquisition and control system. It provides eight single-ended inputs with a 2μs sample and hold circuit to minimise conversion errors. The signal is then sampled by a 15μs, 12-bit A-to-D converter. In addition to the 24 line digital I/O port there are eight other digital I/O lines. Amplicon Liveline Ltd, 0273 608331.

Production equipment

Heavy duty wire stripper. Rotary blade stripper for large cables, the CMI can strip solid, stranded, multicore, or shielded cables. Tungsten carbide tipped blade strips, peels and removes the insulation slug from cables, leaving a clean edge with no nicking of conductors. Adjustable strip stop for consistent strip lengths up to 15cm. Blade and drive mechanism guard. Rush Wire Strippers, 0264 51347.

Power supplies

UPS systems for single-phase. Single-phase versions of the series 5000 office power uninterruptible power supplies have been introduced. Flexibility of the new systems allows computer users requiring UPS between 5kVA and 12kVA to use UPS5000 supplies - small, lightweight, and with minimal cooling requirements. Appearance designed to blend into office environment. Fiskars Electronics Ltd, 0734 772599.

5-pin power switching regulator. Capable of controlling currents in excess of 3A, the MC34166 is available in a 5-pin TO-220 type plastic power package. It has a fixed frequency oscillator (72kHz) with on-chip timing; precision 2.0% reference; high gain (80dB) error amplifier; duty cycle adjustable 0-95% and 7.5V to 40V operation. Switching regulator has an internal resistor divider which sets the output at a nominal voltage of 5.05V. This eliminates the need for an external resistor divider in 5.0V power supply applications and provides an extra 50mV to compensate for a 1.0% voltage drop in the cable and connector from the converter output. Motorola Inc, 0101 602 897 3615.

Radio communications

RF amplifier. Model 03.50.140 covers the frequency range 10kHz to 32MHz, with an output of 200W at 1dB compression. Nominal gain is 50dB and output flatness ±1dB. The amplifier is obtainable as a 19-in rack mount unit, or bench mount case, both with forced air cooling. Suitable for EMC applications. Telonic Instruments Ltd, 0734 786911.

Transducers and sensors

Displacement transducer. Redesigned DCT and LDC transducers give greater adaptability. The DCT is for simple unregulated power supplies of +20 to +40V DC or dual supplies of ±10 to ±20V DC. LDC is physically identical to DCT but is for low input voltages ±5V DC, regulated or ±6 to ±18V DC, unregulated, and generates an output signal of ±2V. RDP Electronics LTd, 0902 457512.

COMPUTER

Board level products

Kit for dos evaluation. Qualcomm Q2334 evaluation kit implements a direct digital synthesiser (DDS) system on a single PCB. It includes pre-programmed microcontroller, a Sony CX2020A-1 10-bit D-to-A, three selectable analogue output ports, an RS232 terminal port with switchable baud rates, and switches to allow basic operations in stand-alone-mode. Synthesised waveforms can be output direct from the D-to-A as a low-pass filtered output, or processed by a zero crossing detector to produce a TTL logic output. Chronos Technology Ltd, 0989 85471.

PC board for line scan cameras. DT2856 interface board is designed for high speed acquisition and processing of data from line scan cameras made by EG&G Reticon and Loral Fairchild. The makers say it will lower the cost of automating inspection applications, and offer increased functionality. A PC AT, configured with the DT2856 line scan processor and line scan camera, would cost £10 000 to £15 000. The board is £3325. Data Translation Ltd, 0734 793838.

Dual VGA card. V^{2}GA board, for use in the Texas Microsystems PCbus industrial computers, has resolutions up to 1024 x 768 pixels, non-interlaced, with 256 colours. The board is furnished with a software interface permitting emulation of the IBM8514/A hardware standard, without the need for microchannel architecture. Internal cacheing. 1Mbyte of on-board video memory can be installed. 16-bit data path to the CPU is used. Memory data bus is 32-bits wide. Gothic Crellon Ltd, 0734 788878.

Multi-function counter-timer board. Arcom's PCPIC module provides nine counter-timer channels in an adaptor board for PCs. It offers period and interval timing, event counting, frequency counting or generation up to 5MHz, and digital and interrupt input functions. Nine channels with 16-bit counting capability. Support hardware for expansion I/O is routed from the board via a 50-way D-connector. £148.00. Arcom Control Systems Ltd, 0223 411200.

High performance real-time control board. Real-time microprocessor control board, IDS2500 based on a V25 16-bit cmos processor, is designed for engineers with little experience of programming. An 8086 compatible IDS2500 costs between £250 and £400. The system runs at 8MHz with zero wait state, features a large address space, with eight user-selectable address maps, plus up to 100k on-board memory. Four RS232 ports, two connected directly to V25 chip and two via an on-board Zilog 8350. Integrated Data Systems, 0442 65256.

Free software. Three PC software packages, normally priced at £200, are being offered with any PC Lab data acquisition card from IMS. Labtech Acquire is a data acquisition package; PC Scope converts the PC into a four channel digital storage oscilloscope; Labdas provides menu-driven functions for user programmable data acquisition and control. Integrated Measurement Systems, 0703 771143.

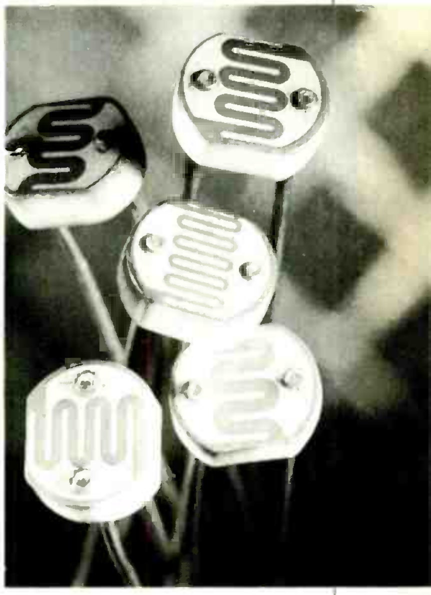
Data acquisition. Up to four quadrature encoder inputs, 333kHz maximum input pulse rate, and 24-bit counters are offered by Metrabyte's M5312 series cards. Phase 0, phase 90 and index pulse inputs are provided for each encoder. Inputs may be single ended or differential. Maximum input rate in quadrature decode mode is 333kHz. In count mode, 1.25MHz. Each input is conditioned by a four-stage digital filter. Keithley Instruments Ltd, 0734 575666.

Low pass filter. Techfilter is a 16-channel, analogue low-pass filter designed for PC compatible based data acquisition systems. Low-pass filters are required in front of A-to-D converters to prevent aliasing of high frequency signals or noise. If left unfiltered, this noise can "fold over" onto lower frequency signals and cause errors. By setting the cut-off frequency of the Techfilter to approximately 0.5 sampling rate, aliasing is eliminated. 700 incremental frequency steps. Laplace Instruments Ltd, 0565 50268.

50Mflop 96002-based DSP board. The PCS/96002 board is for Motorola's IEEE 754-compatible DSP96002 chip. Local resources and a fast PC interface have been allocated to port A. Port B has a fully-arbitrated expansion port. Four boards can be connected in multiprocessor configurations. Up to 544kword of on-board fast sram can be allocated to each port. Two channels of analogue input and output. The PCS/96002 incorporates all the logic to make use of the DSP96002's on-chip Once debug circuitry. Loughborough Sound Images Ltd, 0509 231843.

Computer systems

Fastest workstation. Sparcstation 2 is said to be the fastest workstation Sun has so far developed. Models range from a base system to a pair of high-performance 3-D graphics workstations and a new, low-cost server version. Sparcstation 2 delivers nearly twice the speed of Sun's top of the line Sparcstation 1+. Sun Microsystems, 0276 20444.



Light and compact unencapsulated photoconductive cells.

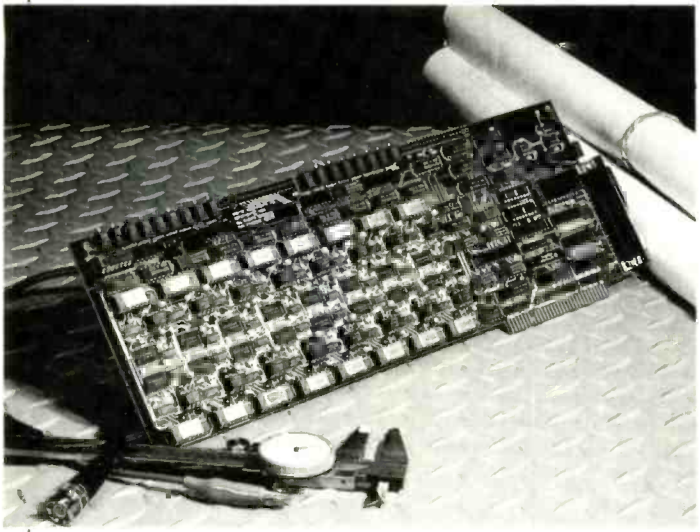
Development and evaluation

Software package. A software development package comprising Stag Stratos, 1Mbyte memory emulator and Turbo Trace - claimed to reduce development time by 95% over conventional serially driven emulators running at 9600baud, is available at £850. 1Mbyte of code can be downloaded in <20s including verification.Flash Designs, 0293 611722.

Evaluation boards. The OM4700 evaluation kit provides all the functions to develop 46/49MHz cordless telephones. Comprising two boards - one for the remote unit and one for the base unit, it has echo protocol with 16-bit security coding, and improved data link protocol between the base and remote units which makes use of the sub-audio band for out-of-band signalling. Built around the PCF84Cxx and PCD33xx families. Philips Components, 010 31 40 72 43 24.

Computer peripherals

43Mbyte drive for laptops. Teac sd-340 hard disk drive provides 43Mbyte storage capacity in a 1-in high by 3.5-in



Techfilter aims to eliminate aliasing during data acquisition

wide, enclosure. The head assembly rotary actuator provides circular arc-head motion about the support point, so that the drive can be installed in any orientation. Shipping lock automatically parks head when power is off. Data Peripherals (UK) Ltd, 0785 223206.

Colour monitor.. Leader 5130P is a high-performance 6-in colour monitor that can be used as a free-standing unit; rack-mounted as a single unit; as dual units, or in conjunction with Leader's vectorscope/waveform-monitor unit. AC or DC. Thurlby-Thandar Ltd, 0480 412451.

Programming hardware

Multiprogrammer. EZ-Writer C3 can program 24, 28 and 32 pin eproms and eeproms without modules or adapters. It supports Quick Pulse, Flash and Snap. Integral LCD shows clear English messages. Three keys. Lightweight and compact. Standard 512kbit ram is expandable to 8Mbits, and it can also be expanded to gang or set programming of up to four devices simultaneously. £395.00. Control Telemetry, 071 328 1155.

Programmer for large EPLDs. A180 adaptor, for the 5-145 logic programmer, provides direct programming facilities for large EPLDs manufactured by Altera, Intel and Texas Instruments including part numbers EP1800, EP1810, 5C180. Elan's 5-145 logic programmer provides PLD coverage for all other EPLDs up to the EP900, EP910, EP1210, 15C090 and 15C121. 2Mbit ram with expansion available. Elan Digital Systems Ltd, 0489 579799.

Universal programmer. PC-Uprog can program over 1000 different devices from its standard library and new devices may be added. Driven by a PC card and supplied with menu driven software. Full screen editor allows contents of device to be viewed or modified. Bi-directional transfer of data from device to file is possible in various standard formats. Integrated Measurement Systems 0703 771143.

Software

Video conferencing on a PC. With IDVN software and a graphics overlay card, a user can take in a video or digital signal via a codec to display a live image on a PC screen. IDVN applications software operates under windows allowing multi-tasking. Under windows a telephone icon flashes when the PC is called. By use of the mouse a window is opened in which the caller is displayed. Software allows a VTR to be activated to record both a video and audio message. Cameron Video Systems Ltd, 041 633 0077.

24-bit colour image processing. Global Lab colour (£1995) image processing software for the DT2871 frame grabber board takes advantage of the DT2871's real-time hue-saturation-intensity processing capabilities. Menu and mouse driven. No programming required. It can be calibrated to perform linear and angular measurements. Histograms generated automatically from image data. Data Translation Ltd, 0734 793838.

Cameron Video Systems offers video conferencing on a PC

Pads for large designs. Enhanced version Pads-Logic is a schematic capture package handling designs of up to 1000 EIC's. Version 2.0 has hierarchical design capability, design-oriented database, automatic gating and pinning, and support for a range of popular simulation and cad layout tools including P-Cad, Futurenet, Cadstar, P-Spice and Susie. Amongst other improvements library browse function covers 5000 electrical devices and parts. £595.00. Export Software Ltd, 0242 222307.

LabView 2 for image processing and analysis on Mac. Concept VI is based on the Ultimage Mac application software and LabView 2 graphical programming software. It allows use of LabView's graphical interface to develop image processing applications. The packages require LabView Version 2.06 or later and a Mac with at least 4Mbyte ram and a 40Mbyte or larger hard disk. The packages work with previously stored image data or can acquire data directly. Graftek France, 33-1 4631 24 24.

Updated cad package. HiWire II incorporates improvements to make HiWire more powerful, more versatile and an easier-to-learn and use electronic cad system. Menu-driven interface simplifies common operations such as extracting a net list, creating a bill of materials, producing checkplots and plotting final artwork. Mouse or keyboard. £695.00. Riva Ltd, 0420 22666. ■

LOSSLESS COILS FOR LC FILTERS

Many solutions to the problem of lossy filter inductors have been proposed, but Luiz Amaral and G. Puppin put forward their own ideas for coil compensation that avoid most of the associated problems

In precision LC filter design, problems often arise from the use of non-ideal components — lossy capacitors and inductors. The latter are much more important since, although modern capacitors are practically lossless, it is very difficult to avoid losses in the windings and cores of real inductors.

This severely degrades the performance of, for instance, frequency-division multiplex low-frequency filters, "rounding" the knees in the boundaries between pass and stop bands and affecting the depth of pole resonances in the stop band (**Fig. 1**). This occurs because the design of filters involves coefficients that are calculated on the basis of lossless transfer functions.

There are many suggested solutions in the literature to overcome this difficulty. One of them employs tables of pre-distorted coefficients which give the required attenuation characteristic, but at the expense of a greater insertion loss in the pass-band (**Fig. 2**); another solution uses crystal resonators to get the desired slopes of the curves. If the compromise created by the solution is not acceptable, more work is clearly needed.

Fig. 1. Example of low-pass filter, showing effects of coil losses. There is little change in the pass-band, but in the transition region, rounding occurs.

Fig. 2. Band-pass filter showing theoretical and measured curves and the result of using pre-distorted coefficients, which recovers the shape of the curve, but with a different insertion loss.

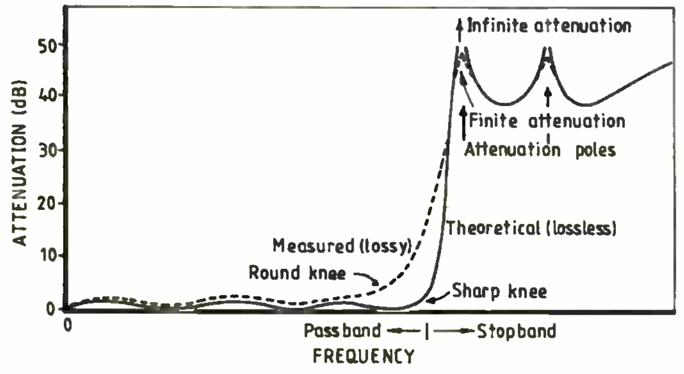
Proposed solution

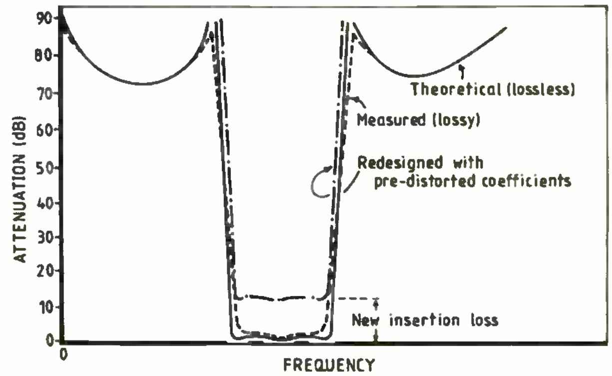
In the design of ladder filters assuming lossless components, there is a minimum Q for each inductor to obtain satisfactory practical results. It is more difficult to satisfy these Q values for series inductors than for shunt ones, which means that, if the Q condition for the series coils is satisfied, the theoretical lossless design can easily be approached.

The proposed solution is actually very simple. In the days of valves, Q-multipliers were used to increase the Q of coils when the desired values were not attainable with passive components; the same procedure may be used in this case.

Let R_p be the parallel equivalent loss resistance of the inductor L, as in **Fig. 3a**. Another resistor with negative value $-R_p$ in parallel with the first provides zero total value (**Fig.3b**). Current in a negative resistor flows in the opposite direction to that in a positive one and is therefore that of a generator. Moreover, a negative resistor produces energy and is therefore a generator.

To compensate for the losses in the inductor, a signal equal to that lost in R_p,





and also that introduced by the generator itself, must be generated. As shown in **Fig. 4**, a sample of the inductor signal is amplified and fed back to the inductor in such a manner that the feedback is positive and of the correct level to cancel the total loss of the circuit.

If all the inductors are so modified, adjusting the amplifier gain to compensate exactly for the losses produces "ideal" coils. This means that the circuit can now be accurately described in terms of its "lossless" transfer function; the attenuation curve recovers its original shape with greatly steepened edges. As already mentioned, only the series inductors need to be compensated for, the shunt ones having little influence on the general shape of the curve.

Despite the use of active devices, the filter is still passive; the local activities are used only to compensate for losses. Thus, the filter is passive with ideal characteristics.

Amplifiers are unidirectional devices. Since the principal signal flow in the inductor does not pass through the amplifier, the original bidirectionality of the filter is preserved. This is sometimes an important point. The same feature maintains the reliability of the circuit, particularly in multi-channel communications, since amplifier failure merely degrades the filter characteristic close to the corners of the curve, without total communication blackout. This would happen if the compensation amplifiers were in the signal path.

The method introduces no extra insertion loss and, with good amplifiers, it is possible to avoid degradation of the signal-to-noise ratio. It also preserves the theoretical group-delay curves. Inductors are each compensated separately, making filter alignment a minor problem.

Circuit operation

To compensate for the losses, the amplifiers must have large bandwidth in terms of both amplitude and phase to preserve the phase relationship between input and output. They must also exhibit low noise to avoid degrading signal-to-noise ratio and enough gain to compensate for all the losses. Good stability is important because, without losses and with the positive feedback, the circuit shows a tendency to oscillate.

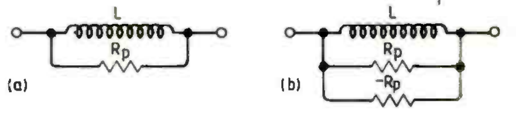


Fig. 3. Parallel equivalent loss resistance in (a) can be nullified by negative resistance of same value (b).

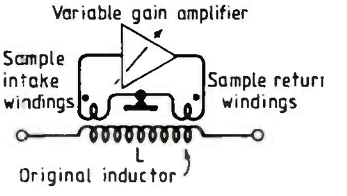


Fig. 4. A sample of the inductor signal is amplified and fed back positively to cancel losses.

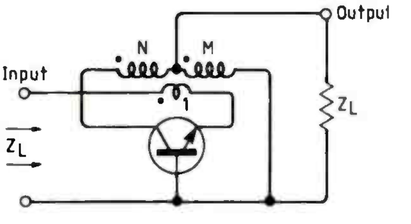


Fig. 5. Norton amplifier. With load Z_L, $N = M^2-M-1$ and high-beta transistors, input impedance = Z_L and power gain is M^2.

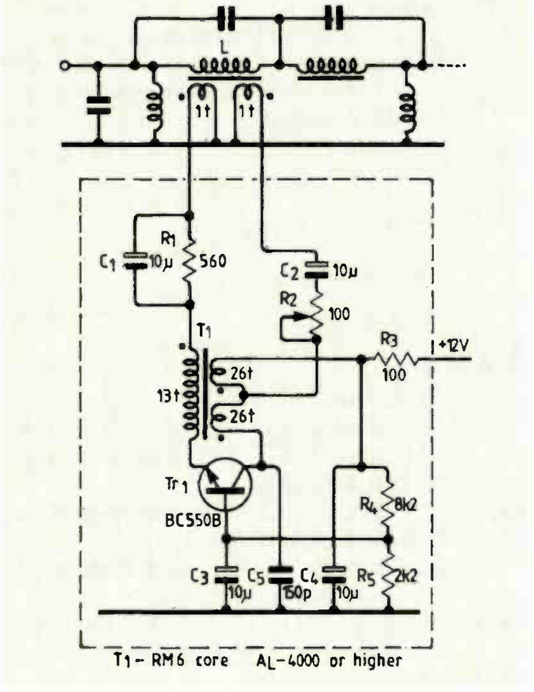


Fig. 6. Band-pass filter with one series coil compensated for losses; all series inductors must be so treated. The section forms part of a 60-108kHz filter.

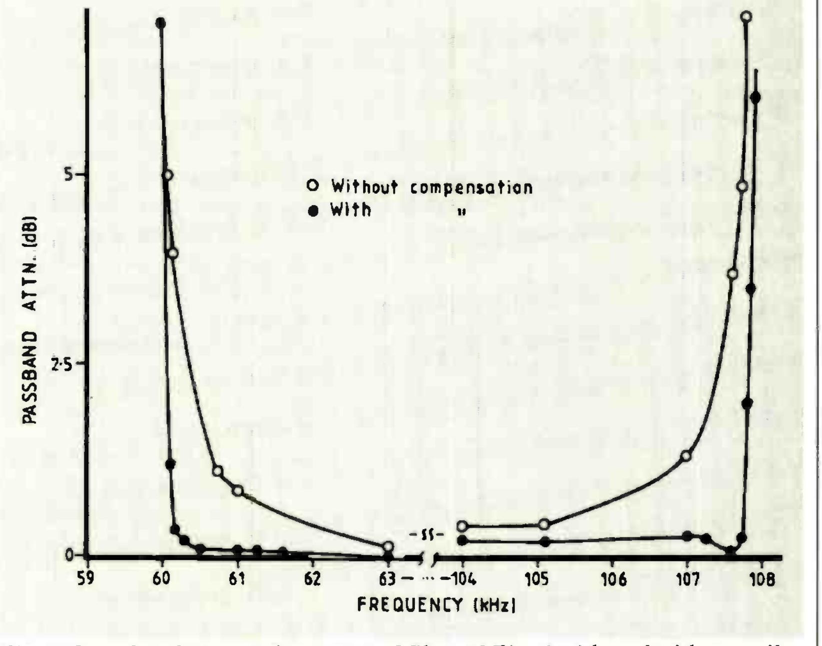
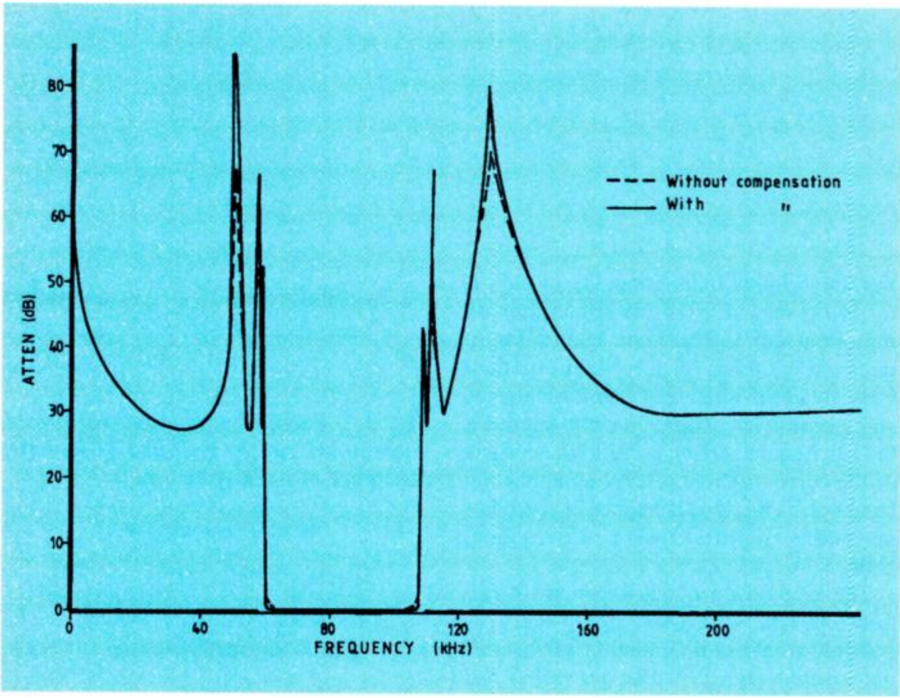


Fig. 7. Pass-band attenuation curve of filter of Fig. 6 with and without coil compensation. Note difference in "knees", rounded by losses.



A circuit topology that easily satisfies these requirements is the Norton amplifier of **Fig. 5**, which approaches an ideal amplifier except for two points: it is a very poor isolator because its input impedance is highly dependent on the output load impedance; and the gain is fixed, with no provision for variation. These, however, are of no importance for this purpose.

A quick analysis of the circuit, for high-beta transistors, yields

$P_g = M^2$ = power gain = P_o/P_i,

$Z_i = Z_L$,

assuming $N = M^2 - M - 1$.

Connecting the Norton circuit as in Fig. 5 produces

$Z = R + Z_o$,

which is the load impedance of the amplifier (R is an artificial provision for gain variations in the amplifier).

Therefore,

Fig. 9 Pass-band attenuation curve due to coil over-compensation. At the peaks, attenuation is negative; that is, undesirable real gain occurs.

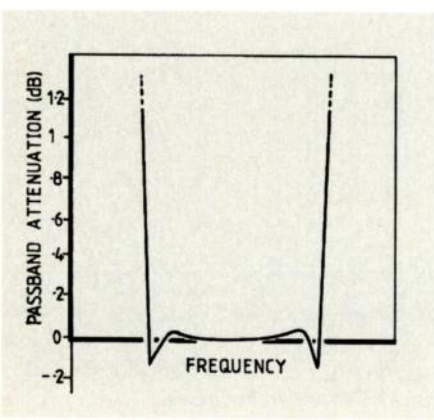


Fig. 8. General attenuation curve of the assembled unit. Note the deeper pole resonances with coil compensation due to higher Q values.

$$Z_i = R + Z_o, \quad (1)$$

$$P_o = M^2.P_i, \quad (2)$$

$$P_{Zo} = P_i + P_p$$

or;

$$V_o^2/Z_o = (V_i^2/Z_i) + (V_p/R_p). \quad (3)$$

From transformer relations:

$$V_o = n_o.V_i/n_i;$$

$$V_p = n_p.V_i/n_i. \quad (4)$$

To cancel all losses,

$$P_o = P_r + P_p + P_i = P_R + P_{Zo}$$

or

$$P_R = V_R^2/R = V_o^2/Z_o \quad (5)$$

where

P_o = power output of amplifier,

P_i = power input,

P_R = power lost in R,

P_p = power lost in equiv. parallel loss resistance R_L,

P_{Zo} = power in n_o windings,

V_o = voltage across n_o windings,

V_i = voltage across n_i windings,

V_p = voltage across coil itself,

V_R = voltage drop in R.

Using these equations and remembering that $L = n_p^2 A_L$ (A_L being core-dependent),

$$R = 2\pi f A_L Q n^2 (M-1)^2/m \quad (6)$$

Remember that this result is based on the use of a Norton circuit with a series resistor for loss compensation; the formula would be different in another type of configuration.

Although the values of R in equation (6) give zero theoretical loss, they would result in instability and oscillation. A variable resistor must be used and adjusted by experiment to shape the filter curves; equation (6) is used to evaluate the order of magnitude of R. The transformer must be as closely coupled as possible and, to avoid stray capacitance disturbances to the filter, the number of turns n must be as small as possible, n = 1 preferably.

Practical results

To demonstrate the feasibility of the approach, we built a multisection 60-108kHz band-pass filter, one of the sections being shown in **Fig. 6**; the coil L is to be compensated for losses. Signal is taken from L through the single-turn winding to the left, entering the Norton amplifier inside the dashed line and returning via the single-turn winding to the right. Resistor R_2 adjusts the gain and C_5 prevents HF oscillation caused by stray capacitance in the transformer.

Figures 7 and **8** show the filter attenuation curves with and without loss compensation, Fig. 7 being the pass-band expansion of Fig. 8. There is clearly considerable improvement in both stop-band and pass-band. Compensation is not greatly affected by temperature variations.

Adjustment

To align the filter, use the normal adjustment procedure but with the amplifier's power supply disconnected. When all the inductors are aligned, turn on the power with maximum resistance in the gain controls. Observe the resonance dips in the stop-band and, for each pole, increase these dips by means of the corresponding gain control. This increase must be 10dB. While observing the attenuation curve, make further adjustments to obtain the desired shape. These must be done with care not to overcompensate the coils and produce oscillation or undesirable peaks in corners of the pass-band, as in **Fig. 9**. ■

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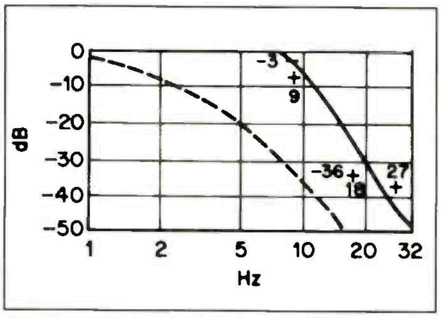
Improving AM broadcasting

With some of the ILR local radio stations testing C-Quam AM stereo on the medium-wave band, the time has come to consider the advantages of using wide-band receivers, with a daytime IF bandwidth of about 12kHz for both stereo and mono reception. This might reverse the writing-off, worldwide, of AM as an audio source of high or, at least, medium quality. For years, AM has been steadily losing ground to FM broadcasting, Nicam digital stereo on TV, CD and analogue tape and disc.

But, as A.N.Thiele, formerly head of the Australian Broadcasting Commission, has pointed out in "An improved pre-emphasis standard for AM broadcasting" (JEEE, Australia, March 1990), "It is not only the superior quality of its competitors that has made AM radio the poor relation. The rising tide of man-made electrical interference, the generally poor quality of receivers and broadcasters' operating practices, especially heavy limiting and processing of the sound, which has lately included pre-emphasis, have all contributed to its decline. The result has been that AM has acquired the reputation of an inherently low-quality medium which the experience of most listeners confirms. Yet the truth is otherwise. AM may not be capable of the highest quality, but it can deliver a good medium quality, given reasonable care but not excessive expense in the design of transmitting and receiving equipment and the receiving antenna".

He emphasises that AM is now usually received under conditions and using equipment that are far from ideal. Most AM receivers are built to ever-decreasing size, cost and sound quality. In attempting to match signals to the narrow-band IF characteristics of such receivers, broadcasters are using additional per-emphasis, or proposing to do so, that is far from optimum and could destroy what hope remains for AM as a good-quality medium.

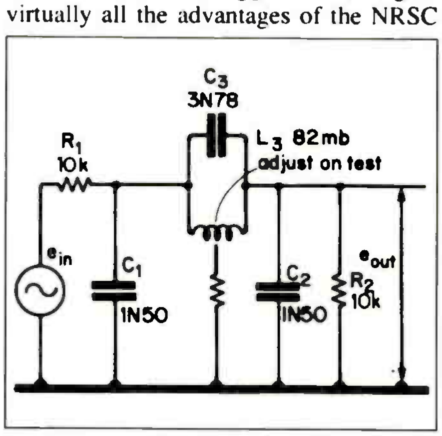
He also points out that broadcasters are reluctant to forego the last 0.5dB of level that causes distortion with envelope detectors, further emphasised by maintaining excessive level for a high proportion of the time by heavy limiting "so that each spoken sentence starts with an exaggerated intake of breath while background level rises relentlessly between sentences — the dynamics of speech are squashed flat".

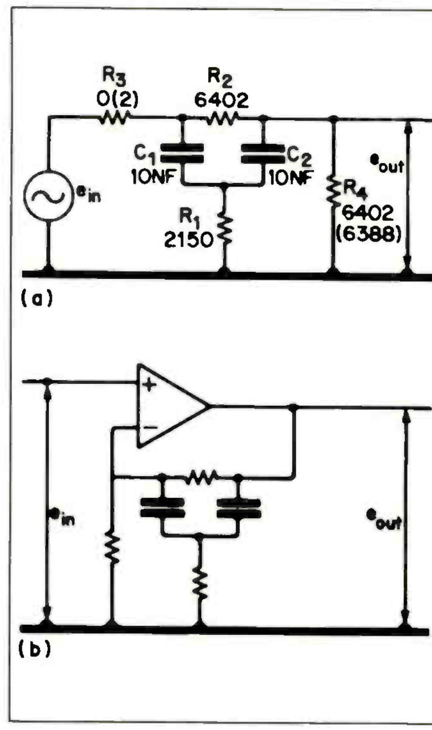


Band-pass response with receiver 'IF 'Q of 100. Solid curve is Chebyshev filter providing 0.03dB ripple, using four tuned circuits. Dashed curve obtained by three synchronously tuned circuits for narrow-band response. Only upper halves of responses shown.

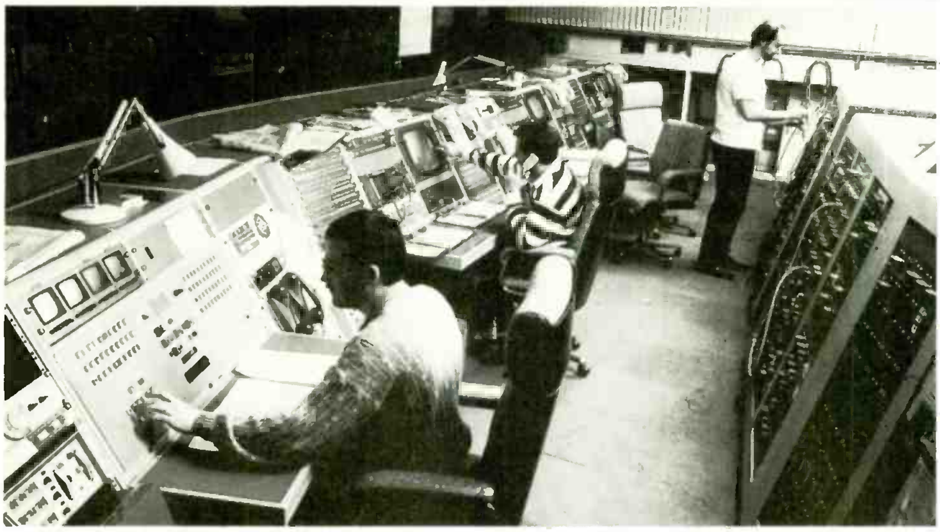
Thiele criticises the modified 75-microsecond pre-emphasis standard proposed by the American National Radio Systems Committee (NRSC) for the 10kHz FCC channels. Australia, like Europe, is now committed to 9kHz channels with significant overlap permitted into adjacent channels. He believes that the NRSC standard impairs the quality received in the wanted channel, increasing interference from adjacent channels.

Instead, he proposes a pre-emphasis characteristic compatible up to 4kHz with that of the NRSC standard but falling thereafter; this, he suggests, would give virtually all the advantages of the NRSC standard and none of its disadvantages and would also be suitable for reception on both narrow-band and wide-band receivers. He shows that this could be achieved with relatively simple networks. Additionally, he shows that a 9kHz "whistle filter" could remove the heterodyne interference from adjacent-channel carriers, resulting in receivers that could make full use of the transmitted audio quality with a minimum of added complexity and cost and "allow AM to retain its rightful place as a quality broadcast medium".





Above is proposed passive de-emphasis network.. Values with no brackets give time delay of 75.01µs, otherwise 75µs. At (b) is proposed pre-emphasis network based on an op-amp, with component values as in '(a'). Left is passive form of Cauer-type "whistle filter". Depth of null optimised by adjusting R. Response about -38dB at ±20Hz, -45dB at ±10Hz.



BT is to invest more than £1 million in building an automatic switching centre for television signals at London's BT tower.

The National Switching Centre will provide facilities to carry signals between studios, transmitters and TV HQs for national and private television networks.

BBC—Big Brother Corporation?

Some of the provisions in the Broadcasting Act 1990 have receives surprisingly little public comment. For example, the BBC becomes responsible for collecting licence fees and is now given the right to authorise persons to enter and search any premises suspected of possessing an unlicensed television receiver.

Part VIII of the Act makes changes to the Wireless Telegraphy Act 1949 the go well beyond broadcasting. There is a new offence of keeping a wireless telegraphy station or apparatus for unauthorised use, as well as a number of new offences aimed at pirate broadcasters.

Clause 168, in particular, seems all-embracing and affects not only pirates but also those with unauthorised CB or amateur transmitters, permitting prosecution without the authorities having to catch offenders using the equipment. Even those who have cause to believe that someone else is going to use it are guilty.

Surrey microsatellites

Surrey University's new faculty of satellite engineering under Professor M.N.Sweeting is to carry on the work of the Spacecraft Engineering Research Unit at the university by launching UoSAT-F, a microsatellite.

More than 20 satellites have now been launched, starting with the university's participation in OSCAR and including the four UoSATs. Among the experiments in UoSAT-4, which suffered a power-supply failure soon after launch, was one designed to measure the relative deterioration due to radiation of GaAs, InP and Si diodes made by English Electric. This experiment is to be extended in the new satellite, which will also carry Earth-imaging and technology demonstration experiments and a store-and-forward communications payload to co-ordinate scientific, disaster, rural development and medical information. It will also be the first UoSAT to use frequencies outside those in the amateur satellite service.

Ariane launchers can carry up to six microsatellites, weighing from 10 to 100kg, at a launch cost of about £100,000 each.

Preparing for WARC 92

The key document for all users of the radio spectrum is the ITU Radio Regulations, including the Table of Frequency Allocations, even though the allocations have become increasingly blurred by many footnotes that attempt to meet the demands of over 160 member countries.

The World Administrative Radio Conference to be held in Seville in February 1992 will have selective power to change the regulations and frequency table and is expected to have a major impact.

The Agenda for WARC-92 was set in June 1990 and, at least in some countries, draft proposals have been drawn up and are now being co-ordinated with industry and other countries; the FCC, for example, have released a 150-page first draft of proposals for comment. The UK is cooperating closely with the new European Radio Committee of CEPT, which now includes several East European PTTs. In the past, problems have arisen with delegations arriving at the conference with inadequate preparation and very different needs to those of developed countries. A major demand this time will be for more spectrum for land-mobiles and in-flight passenger telephones.

HF broadcasters are still seeking more spectrum and argue that, with the rise of satellite communications, there is now less demand for HF point-to-point links, although less-developed countries still use inexpensive HF links. Draft US proposals include an attempt to harmonise the 7MHz broadcasting and Region 2 amateur band by moving the amateur band to 6.9-7.2MHz, with broadcasting from 7.2 to 7.525MHz.

WARC is expected to tackle the question of broadcast satellites in highly elliptical orbits and to examine the demand for 5MHz of spectrum below 1GHz for low Earth-orbiting satellites.

Digital-audio broadcasters seek a new allocation of 50 to 80MHz in the range 0.5-3GHz, both in space and terrestrially, but the FCC suggests DAB sharing with TV between 728 and 788MHz and 1493-1525MHz, moving telemetry to 2930-2420MHz and ovens to 2450±30MHz.

Proposals for European HDTV are either 21.4-22GHz or 24.25-25.25GHz and there is a wish to revise the WARC-77 plan for DBS in the 12GHz band with more DBS channels, in spite of the uncertain outlook for D-MAC Metrosats.

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