ELECTRONICS WORLD

+ WIRELESS WORLD

Denmark DKr. 70.00
Germany DM 15.00
Greece Dra.760
Holland DFl. 14
Italy L 7300
IR £3.30
Spain Pts. 780
Singapore S$ 12.60
USA $6.70

SOR DISTRIBUTION

A REED BUSINESS PUBLICATION

JULY 1992 £1.95

RF ENGINEERING

Yagi model highlights the unexpected

PC REVIEW

Mistakes in your netlist?

SCIENCE

Electricity without magnetism

DESIGN

Computer controlled sine generator

AUDIO

Just 0.00015% distortion from an op-amp?

FREE: Motorola's MC33102 sleeping beauty of an amplifier

07
9 770959 833004

CONTENTS

FEATURES

REGULARS

In next month's issue: Direct digital synthesis provides the fast settling, low noise alternative to phase lock techniques currently used for programmable frequency generation. August *EW + WW* carries the first part of a major series dealing with the smart way to design the heart of an effective radiocomms systems.Plus, obtain your free copy of Easytrax PCB layout program.
AUGUST ISSUE IS ON SALE FROM JULY 30

Driving through the smog

EDITOR
Frank Ogden
081-652 3128

DEPUTY EDITOR
Jonathan Campbell
081-652 8638

CONSULTANT
Derek Rowe

DESIGN & PRODUCTION
Alan Kerr

EDITORIAL ADMINISTRATION
Lorraine Spindler
081-652 3614

ADVERTISEMENT MANAGER
Jan Thorpe
081-652 3130

SALES MANAGER
Shona Finnie
081-652 8640

CLASSIFIED SALES EXECUTIVE
Pat Bunce
081-652 8339

ADVERTISING ADMINISTRATION
Kathy Lambart
081-652 3139

ADVERTISING PRODUCTION
Shirley Lawrence
081-652 8659

PUBLISHER
Robert Marcus

FACSIMILE
081-652 8956

CLASSIFIED FACSIMILE
081-652 8931

I am quite sure that there are plenty of lessons about making the best use of limited resources that the developed world could learn from the remaining two thirds. But it won't, choosing instead to pursue its own hi-tech solutions to eco problems – that is if it finds the will to do anything at all.

One doesn't like to be totally negative about the possibilities of using technology to cut consumption and pollution but history should make us sceptical. Take the US experience with motor vehicles for example. A recent report by the National Research Council, a US government quango, points out that "technically achievable improvements" a phrase which translates to the use of special, lightweight materials coupled with very advanced electronic engine management systems, could raise the current average fuel consumption of 29 mpg to 36 mpg by 2006 at a cost of $2500 per vehicle. This of course does not take into account impending tightened US emission controls which make the vehicle economy targets harder, if not impossible to meet.

When it comes to developing vehicle engines, pollution, economy and performance are directly at odds.

Back in the 60s when choking brown Los Angeles smog spurred legislators into action, electronics seemed like a saviour. Close control of ignition and injection (coupled to a general reduction in car size) improved consumption from an average of around 16 mpg to the 29 mpg figure of today. Precise charge control allowed the use of catalyst converters, reducing mass emissions per mile to about one tenth of their previous level.

So this use of technology reduced petrol consumption? Not a bit of it. It actually increased from 6.7 to 7.2 million barrels per day over precisely the same period.

What did the combination of electronics and exhaust catalysts do for the environment? Not a lot really. Increasing traffic volumes meant that average speeds have fallen: catalysts have relatively little action in cleaning up slow running (low temperature exhaust) engines in the traffic jams which are the feature of cities the world over. Although no hard figures are available for net emission quantities, a 90% net increase in traffic coupled with inefficient catalyst action has marginalised the possible improvement.

We in Europe have always been driven to choose smaller cars because of the relatively high cost of petrol; the corresponding US price has actually fallen below that existing before the 1973 oil crisis in real terms. However, our euro-legislators have decided that vehicle emission control shall be based on electronics technology and exhaust catalysis. At a stroke, they have condemned us to using 10% more fuel than we need otherwise have done because, paradoxically, this exhaust clean-up method requires a 5 to 10% rich burn from stochiometric composition. It also costs absolute engine power if nothing else is changed.

Technology in general and electronics in particular has signally failed to stem petrol consumption or clean up city smog. A tax incentive switch to the trusty old 100% mechanical diesel engine would have done more for both consumption and emission control – these engines consume just 65% of the fuel while producing 25% emissions of their petrol equivalent, horsepower for horsepower.

The fact is that real action on consumption and pollution only happens when their presence causes hardship to the consumers and legislators. All other talk of action is just talk.

Frank Ogden.

Electronics World + Wireless World is published monthly By post, current issue £2.25, back issues (if available) £2.50. Orders, payments and general correspondence to **L333, Electronics World + Wireless World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.** Telex:892984 REED BP G Cheques should be made payable to Reed Business Publishing Group.
Newstrade: IPC Marketforce, 071 261-6745.
Subscriptions. Quadrant Subscription Services, Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone 0444 441212. Please notify a change of address. Subscription rates 1 year (normal rate) £30 UK and £35 outside UK.
USA: $116.00 airmail. Reed Business Publishing (USA), Subscriptions office, 205 E. 42nd Street, NY 10117.
Overseas advertising agents France and Belgium: Pierre Mussard, 18 20 Place de la Madeleine,Paris 75008. United States of America: Ray Barnes, Reed Business Publishing Ltd, 205 E. 42nd Street, NY 10117.Telephone (212) 867-2080. Telex 23827.
USA mailing agents: Mercury Airfreight International Ltd Inc, 10(b) Englehard Ave, Avenel NJ 07001. 2nd class postage paid at Rahway NJ Postmaster. Send address changes to above.

REGULARS

UPDATE

Semiconductor makers fight for your desktop

The announcement that Texas Instruments and Cyrix have signed a long term product cross-licence agreement signals the start of a major fight to control the desktop computer market. The first product coming from this agreement will be a Cyrix designed 486 chip produced on the TI production lines.

Intel is fighting in the courts to prevent Cyrix manufacturing the processors at the centre of every IBM compatible computer, but it looks likely to lose since TI already has a licence to manufacture Intel products.

Although the TI/Cyrix chip has a 486 designation, it doesn't include the floating point structure of the 486DX. However, it can deliver around twice the performance of the fastest 386SX device while retaining full software compatibility.

Intel is publicly confident about the challenge to its effective monopoly of the top end IBM business, possibly because the company's technologists have come up with an answer to keep its processors in a prime product slot. They have designed a special co-processor chip – Intel calls it Overdrive – which fits into the empty 487DX co-processor socket on the computer motherboard.

Looking for a cache

The upgrade device contains integer processing core and instruction cache elements which run at double the system clock speed effectively intercepting and bypassing the existing 486SX processor. Unlike floating point co-processors which only handle a limited range of instructions, the Overdrive element speeds up all application software. The amount of processing speed-up is determined by the hit rate on the internal cache: the co-processor is limited in external instruction fetch to the existing system clock rate. A 25MHz system (50MHz internal) device costs £459.

In a second development, Intel has redesigned its top of the range 486DX product to use the clock doubling circuitry of the Overdrive co-processor. The new device, coded 486DX2, is intended for sale to OEMs for incorporation into new machines rather than to provide an upgrade path for existing 486DX users. While it is theoretically pin and function compatible with existing products, direct replacement is likely to cause problems with time critical software loops, bus contention and timing for example. External cache, memory and house keeping design must take account of the higher processing speed. Once again, the effective performance boost will be determined by the cache hit rate.

TI and Cyrix are not alone in going for the Intel business. AMD has been manufacturing a range of improved performance 386 devices. Their selling point over the corresponding Intel parts include low power and fully static operation for the notebook computer market. They also undercut substantially on price.

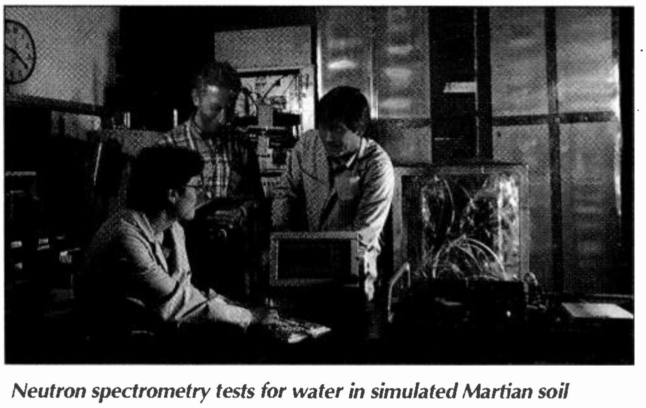
Chips and Technologies produce 386 equivalents which, part for part, deliver some 40 to 50 per cent more performance than the Intel original for a given clock speed. Like the TI/Cyrix design, the C&T speed improvement comes from an independently derived internal architecture – arrived at for legal reasons – with pin-compatible device function.

If the semiconductor companies are fighting a design war for the existing

Cosmic help for Martian water diviners

Workers at Los Alamos National Laboratory will use a neutron detector to discover the location of water on Mars. They believe there is water under the surface which may be made available to future astronauts working on the planet.

A future Mars Observer mission will make neutron measurements from orbit allowing scientists to search for locations of water as well as carbonates. The test could provide clues to previous life on Mars.



Neutron spectrometry tests for water in simulated Martian soil

"Space is filled with high-energy cosmic rays that mostly are protons, like the ones produced in linear accelerators" says Roger Bryd, a researcher at Los Alamos' Space Plasma Physics Group. "When they bang against the surface of Mars, they cause a series of nuclear reactions down to a depth of a metre or so and produce a complex set of neutrons at various energies."

Some of these neutrons find their way out of the soil and, by measuring the spectra of the particles, the orbiting remote detectors can analyse the composition of the soil.

To test the technology, the researchers are bombarding a barrel holding more than a ton of simulated Martian soil with a beam of protons from the half-mile-long linear accelerator at the Los Alamos Meson Physics Facility. The beams are 800MeV, or about 10,000 times more powerful than a medical X-ray.

The neutrons produced by this simulated cosmic shower are then funnelled down a pipe to strike a detector 28m away. Measurements include spatial distribution of the neutrons in the barrel and the time it took them to reach the detector. Researchers then compare these measurements to neutron spectra predicted by computer codes previously developed. **Martin Cheek** desktop computer market, there are plenty of battles ahead to replace dated IBM PC architecture.

Aces low

The Ace consortium made up of companies such as Compaq, Microsoft, SCO, DEC and Mips Computers were all set to produce a standard workstation-on-a-desktop based on the Mips risc R4000 device. This would rival the Sun Microsystems inspired Sparc powered workstations. The Ace consortium blew apart a couple of months ago in an explosion of self interests: this leaves the field open for Sparc architecture and its silicon manufacturers such as LSI Logic and Fujitsu.

Meanwhile cooperation between IBM and Apple Computer looks likely to bear fruit earlier than anticipated. Samples of the PowerPC microprocessor, a single risc chip implementation of the IBM 6000 series risc workstation processor core, will be available from Motorola as early as this Autumn, well ahead of the development schedule. The architecture will use an Apple designed operating system capable of running Unix, Apple and Microsoft based applications. Given the existing desktop presence of Apple and IBM, it positions this group to challenge the current Sun/Sparc domination of the workstation business. **Frank Ogden**

£1/2 billion programme goes out on HDTV

Camcorder, camera and business equipment maker Canon is leapfrogging conventional TV and jumping straight to HDTV and the new digital TV systems. Following recent breakthroughs in research the company has committed ¥100 billion (nearly £500 million) over the next ten years to the development and manufacture of a large flat panel high definition screen to hang on the wall.

The screen uses ferroelectric, rather than conventional twisted nematic, liquid crystal technology. As so often happens, the technology was invented in Europe, but only a Japanese company has been prepared to invest in commercial realisation. Although hard to make in any size, once the basic production problems for FE-LCDs have been solved, there is theoretically no limit on screen size. This, and the commercial failure of the giant conventional-tubed HDTV system launched in Japan last November, led Canon to abandon work on all other types of LCD screen.

Last October, at the Tokyo Data Show, the company demonstrated a 38cm FE-LCD screen for use with computers, and plans to start selling these next year. Canon has now displayed still images of near HDTV resolution on a modified screen. The next target is to display moving video, of HDTV quality, on a one metre screen. The technology will not be ready for sale until the end of the decade because there is a world of difference between the display demands of computer and HDTV. But Canon is playing a long-term game and the company's researchers have convinced its managers that FE-LCD will be the key technology for the next decade.

Ferro-electric material is bistable exhibiting two states of dielectric constant. It can only be switched between the two states, one or the other. This makes it ideal for computer screens and non-volatile semiconductor memories but unsuitable for TV which relies on a wide ranging scale of grey and colours. Now, says Ichiro Endo, Director of Canon's Research Centre in Atsugi, the new FE-LCD display system will more than match conventional LCD display technologies.

Like conventional, twisted nematic LCD

Continued over page...

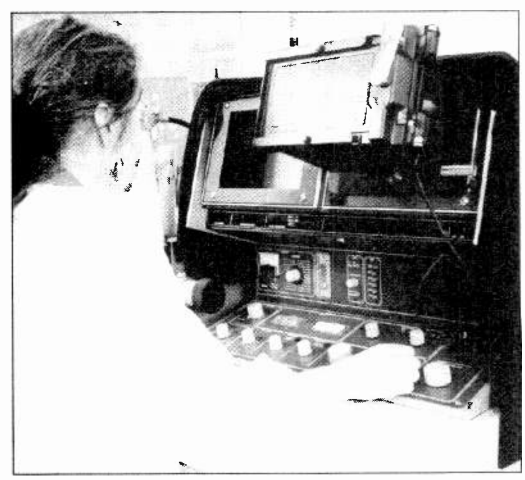
New material promises smaller, non-toxic systems

Aluminium nitride looks as though it might displace beryllium oxide as the chosen substrate for high performance hybrid packaging. Fears about the known carcinogenic properties of beryllia dust have prompted a search for alternatives to a material which, although a ceramic with outstanding insulating and dielectric properties, exhibits a thermal conductivity close to that of metallic aluminium.

Beryllia finds extensive use in such things as RF power modules for portable telephones, power transistors and other applications which require a combination of electrical insulation with heat conductivity. Standard alumina (Al_2O_3) substrates possess acceptable dielectric properties when pure but the material is a very poor heat conductor – about one sixth of BeO. AlN has about two thirds the thermal conductivity of beryllia. Although hybrid circuit makers would like to use the grey-coloured AlN substrate more widely, it presents considerable difficulties in production. The high firing temperature – 1900°C as opposed to 950° for alumina-glass composites – makes effective metalisation difficult and expensive. Special inks based on molybdenum/manganese will stand the firing temperature but are not as easy to work with as the Au/Ag/Pt/Pd compounds used at lower temperatures. Steve North of ceramic specialists Oxley Developments estimates that hybrid substrates built using AlN cost up to 10 times more than the cheapest alumina based process. However, this doesn't tell the whole story: "We would expect to use aluminium nitride substrates in systems which have particular thermal problems. For instance we see an emphasis on optoelectronics where you are able to drive semiconductor lasers that much harder and applications where thermal performance is critical."

Direct bonding of thin alumina substrates to a copper header with a eutectic can increase the heat dissipating qualities of the cheaper material although the reliability tends to be lower: differential expansion between the silicon die, the alumina substrate and the copper header with thermal cycling can lead to loss of thermal contact with the silicon. The result is overheating and chip death. AlN substrates by contrast possess, after firing, roughly the same coefficient of expansion as silicon.

Although the AlN processing temperatures are high, the material lends itself to conventional ceramic substrate manufacturing techniques. For instance, the pre-fired form is flexible and can be easily punched, stamped and pressed from sheet. Like other ceramic forms, it shrinks about 16% on firing. Individual layers can be assembled and, after pressing and firing, become a single unit with conducting vias. The lower dielectric constant, some 85 per cent of pure alumina, makes it attractive to RF and microwave designers although the material purity needs to be very high to avoid losses at frequencies above 1GHz.



Oxley: new ceramic developments

Oxley has applied its new substrate material in a range of electrically programmable capacitance trimmers for use in such things as crystal clock modules. The trimmer unit incorporates a series of weighted capacitor elements on a common groundplane connected by bonding wires to a common point. Starting out at maximum capacitance, fuse elements are selectively blown until the desired capacitance is reached. **FO** materials, FE-LCD changes the polarisation of light. Control of the change is by electrical field which alters the alignment of the liquid crystal molecules. With overlying polarising filters and colour filters, this creates variations in light intensity and colour. If the LCD material is separated into small cells, each individually switched, the variations can be made to display a picture.

But, whereas conventional LCD materials require a continuous field to maintain alignment, bistable FE-LCD has a memory. Once the molecules of a cell have been switched, they remain switched until a fresh field is applied. This saves on electric power because only those parts of the picture which move need be switched. It also gives a strong contrast (at least 40:1) between light and dark areas, which makes computer text very easy to read.

There is also no flicker because there is continuous scanning of the picture. The high contrast gives a wide viewing angle: ±50° in the horizontal direction and ±40° in the vertical direction. The switching voltage is low, around 10V DC, so there is no X-ray or electromagnetic radiation, and no static electricity to collect dirt on the screen. Switching power consumption is around 10W for a 38cm screen. Focus is as crisp at the corners and edges as at the centre.

The FE material is a mixture of twenty different low viscosity fluorine-containing chiral liquid crystals: the actual composition is a closely guarded industrial secret. This is sandwiched between two very thin, very closely spaced glass sheets. Switching is by a simple criss-cross of transparent indium tin oxide strip electrodes deposited on the plates. Because the strips are close to the material they can directly control it without the need to provide each cell with its own control transistor as in the active matrix thin film transistor LCDs currently used for TNLCD computer and TV screens.

In practice close spacing is very hard to realise, and this is what turned all the other companies in Japan off the idea of FE-LCD. The glass plates can only be one mm thick and spaced apart by 1.5µm, around one fortieth the thickness of a human hair. For consistent image contrast, the spacing must be accurate to ±0.05µm, one thousandth the width of a hair. Canon has solved this problem by coating the glass plates with a molecular layer of insulating material and peppering the gap with transparent spheres of insulating material which act as spacers. The plates are held in position against domestic shocks by an air cushion mount.

Because there is no need to provide each cell with a control transistor, the cells can be made very small. The latest prototype has a cell pitch of 0.2mm, with each cell representing a pixel made up from four smaller cells.

For monochrome display each quarter cell is clear. For colour, one quarter cell is covered with a red filter, one with blue, one with green and one is unfiltered clear white The 0.2mm pitch lets the 38cm screen display a matrix of 1280 by 1024 pixels. Each pixel displays a range of four shades of monochrome grey or 16 colours, built from varying switched combinations of the four components. This already comes close to the spatial resolution of HDTV. Canon's HDTV widescreen will use a stretched screen format with 1920 pixels in each of 1152 horizontal lines.

The results are dramatic when the screen is used to display computer image displays, with colour resolution four times better than standard VGA screens. But TV images require an 8-bit grayscale.

In a dither

The company already uses a dither technique colour printers. The printer analyses the colour required, compares it with the colours available and switches a jumble of single colour pixels to create a mix of colours which fools the eye into seeing colours which are not in theory available from the screen. The same technique is used for FE-LCD because it depends on the availability of small pixels which blend together even when viewed from a distance.

Canon's R and D laboratory believes it is close to finding a new mix of FE materials and configuration of electrodes which will switch to intermediate optical states, like conventional TN materials, but still be bistable. This will let the screen display a scale of grey, as well as a wider range of basic colours from which to build more subtle gradations by dither.

R and D Director Ichiro Endo says his team will to have a working system ready to demonstrate by 1993.

Existing analogue HDTV systems rely on signal bandwidth compression techniques which treat stationary and moving parts of the picture differently, updating the image only where necessary as it moves. This fits neatly with the operation of a bistable FE-LCD screen. The incoming signals need only switch the screen's pixels where necessary. **Barry Fox**

Memory chips are full of bugs

Scientists at the Centre for Molecular Electronics at Syracuse University, NY, are exploring artificial intelligence using a technology based on bacteria. Their aim is to create a computer memory chip from bacteria.

The research, which has taken place over the last eight years, involves a bacterium called Halobacterium halobium. Robert Birge, director of the centre has focused on this bug, found in salt marshes, because of its ability to harvest light energy.

When exposed, the bacteria creates a protein called bacteriorhodopsin, which releases a small electrical charge.

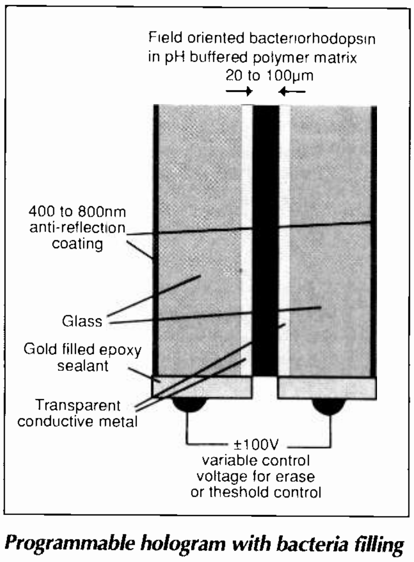
"Upon the absorption of light, an 'instantaneous' shift of electron density occurs with the negative charge moving along the polyene chain toward the nitrogen atom," explains Birge. A shift in electron density interacts with nearby negatively charged residues and activates a rotation which is complete in less than one picosecond. Rotation makes the organism a biological analogue of high electron mobility transistor devices.

Interaction with light makes the creatures able to be flipped off and on, the foundation for a digital technology. Light producing bacteria also produces its own energy supply through photosynthesis.

The combination of these two natural properties has led to experiments with the aim of creating computer memory chips. A laser is used to stimulate the substance by a laser in a container with five cubic centimetres of protein. In this way Birge claims to control the on/off function of the electrical charge and record information.

Currently, Birge is attempting to store a single bit of information in a minicube measuring 3µm on a side. A 5cm rectangle could theoretically have a capacity of up to 18Gbytes and with an access speed of picoseconds rather than the nanoseconds of current storage technology. He estimates a potential price per rectangle of $200.

The potential capacity offers the possibility of holographic associative memory techniques. Serial memories take an input data block or image and scan the entire memory of the data block matching the input independently of the central processor. Human brains operate in a neural, associative mode and many computer scientists believe implementation of large capacity associative memories will be required to achieve substantial artificial intelligence. **MC**



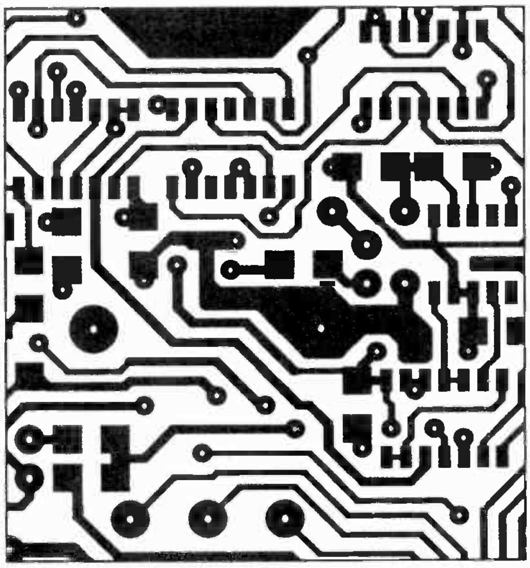
Programmable hologram with bacteria filling

EASY-PC, SCHEMATIC and PCB CAD

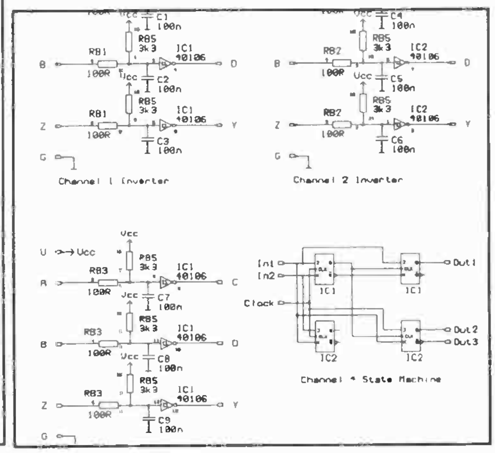
Over 12,000 Installations in 70 Countries Worldwide!

Still Only £98.00! Plus P&P+VAT

BRITISH **DESIGN** AWARD *1989*

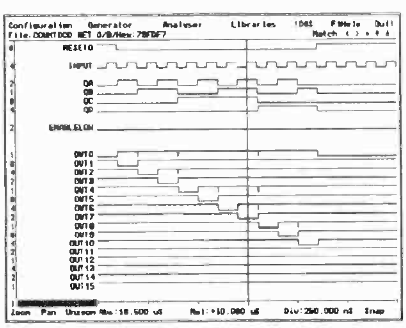


- Runs on:- PC/XT/AT/ 286/ 386/ 486 with Hercules, CGA, EGA or VGA display.
- Design:-Single sided, Double sided and Multilayer (8) boards.
- Provides full Surface Mount support.
- Standard output includes Dot Matrix / Laser / Inkjet Printer, Pen Plotter, Photo-plotter and N.C. Drill.
- Tech Support - free.
- Superbly easy to use.



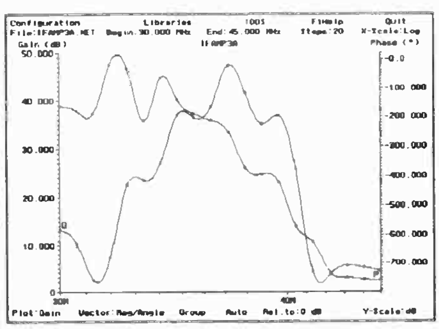
Options:-500 piece Surface Mount Symbol Library £48, 1000 piece Symbol Library £38, Gerber Import facility £98.

DIGITAL SIMULATION £195



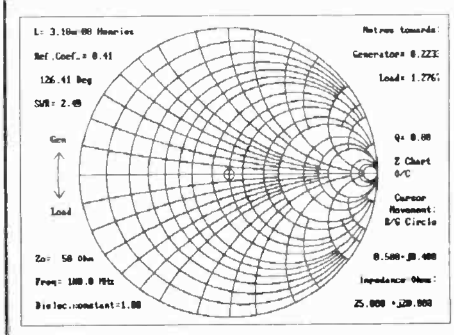
- At last! A full featured Digital Circuit Simulator for less than £1000!
- PULSAR allows you to test your designs without the need for expensive test equipment.
- Catch glitches down to a pico second per week!
- Includes 4000 Series CMOS and 74LS Libraries. 74HC/HCT libraries only £48.00 each.
- Runs on PC/XT/AT/286/386/486 with EGA or VGA.

ANALOGUE SIMULATION £195



- NEW powerful ANALYSER III has full graphical output.
- Handles R's,L's,C's, Bipolar Transistors, FET's, OP-amp's, Tapped and Untapped Transformers, and Microstrip and Co-axial Transmission Lines.
- Plots Input / Output Impedance, Gain, Phase & Group Delay.
- Covers 0.001 Hz to >10GHz
- For PC/XT/AT/286/386/486 with EGA or VGA.
- Very fast computation.

SMITH CHART CAD £195



- Z-MATCH II simplifies RF matching and includes many more features than the standard Smith Chart.
- Handles transmission line transformers, stubs, discrete components, S Parameters etc.
- Supplied with many worked examples.
- Superbly easy to learn and use.
- Runs on IBM PC/XT/AT/386/486, CGA,EGA,VGA.
- Ideal for Education and Industry.

For full info Phone, Fax, or use enquiry card!

- TECHNICAL SUPPORT FREE FOR LIFE!
- PROGRAMS NOT COPY PROTECTED.
- SPECIAL PRICES FOR EDUCATION.

Number One Systems Ltd. 1

REF: WW, HARDING WAY, ST.IVES, HUNTINGDON, CAMBS, ENGLAND, PE17 4WR.
Telephone: 0480 61778 (7 lines) Fax: 0480 494042
International: +44 -480-61778, Fax: +44-480-494042 ACCESS, AMEX, MASTERCARD, VISA Welcome.

CIRCLE NO. 106 ON REPLY CARD

REGULARS

RESEARCH NOTES

Scientists quantify designer lamp UV hazard

The effects of radiation of all types on the human body has come in for a lot of scrutiny recently – there now seems to be little between DC and gamma rays that does not cause some harm! Latest radiation source to come under the inquisitor's magnifying glass is the quartz-halogen lamp, the sort commonplace in homes and offices.

What is causing concern is the combination of the high operating temperature and quartz envelope, allowing through a significant amount of ultraviolet radiation.

Writing in a recent edition of *Nature* (Vol 356 No 6370), Silvio De Flora and Francesca D'Agostini describe experiments in which they took a variety of hairless mice – a type commonly used in cancer tests – and exposed them for 12 hours per day at a distance of 50cm from a 12V 50W quartz lamp equipped with a dichroic mirror. A similar set of mice was exposed to the same type of lamp, but with a 2mm thick sheet of glass to filter out the UV radiation, while a third group of mice was kept under ordinary room lighting.

After a year, the control mice remained healthy, as did the mice exposed to the filtered quartz lamp. By contrast, the mice exposed to the unshaded quartz lamp began to develop skin eruptions as early as three months. By the end of the 12 month experiment, some of the mice had up to 20 overlapping sores, some benign and some cancerous or pre-cancerous.

De Flora and D'Agostini admit that it's difficult to extrapolate from mice to humans, but they point out that the doses of UV received by the mice were not far below those to which some people are exposed in the work environment.

Two things are worrying: the fact that UV in sunlight is already known to cause a particularly aggressive form of skin cancer called melanoma and secondly that the radiation emitted by quartz lamps extends to much shorter (and biologically more active) wavelengths than sunlight. The earth's ozone layer, of which there's still mercifully some left, filters out all solar UV radiation below 290nm. By comparison, the UV from halogen lamps goes down – albeit in small quantities – as low as 250nm. This difference is highly significant because in diseases where the damage caused by different types of UV has been measured directly, the peak effect occurs at around 270nm.

How much need we worry about the latest findings? Colin Driscoll, head of the Optical Radiation Group at the National Radiological Protection Board, says that the NRPB drew attention to this potential danger about three years ago, and he points out that someone working very close to a quartz desk lamp could easily exceed the maximum recommended limits for UV exposure. On the other hand, someone using such a lamp domestically for, say, half an hour a week is unlikely to undergo any significant exposure.

Fortunately, as the Italian experiments confirm, there's a simple answer: a UV filter fitted in front of the lamp. Even a mm sheet of ordinary glass is a very effective filter of the wavelengths that cause the most damage. Colin Driscoll agrees with De Flora and D'Agostini when they argue that such filters should be fitted compulsorily to all quartz lamps in general use.

Look out! It's a twister!

A University of Mississippi physicist, Professor Henry Bass, has developed a smoke alarm-sized gadget that detects imminent twisters. If you live in North Surrey where hurricanes hardly happen, this may seem the ultimate in unnecessary technological gimmickry, but I'm assured that down there in the Deep South, you really do have to watch out for these meteorological wreckers as they sweep up "tornado alley".

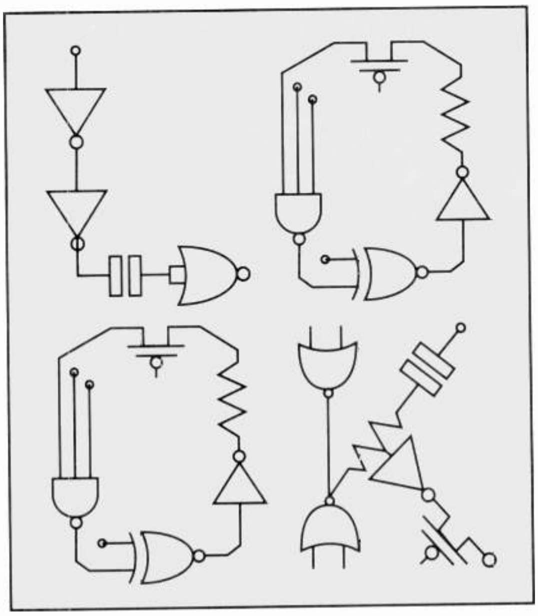
Bass and his colleagues hope that the new device can be manufactured for less than $50, thus making it something everyone can afford. Essentially it's a noise-operated device that is finely tuned to the recognisable sound of an approaching tornado. For those of us who have never been fortunate enough to savour this acoustic experience first-hand, Bass describes it as being like an old freight train or a jet aircraft landing with reverse thrust.

The mode of operation of the new device is quite simple: the sound is picked up by a microphone mounted outside the house and then analysed by a microprocessor in the "black box". If a tornado is within earshot, the system lets you know.

Earlier models apparently gave all sorts of false alarms, responding to jet aircraft and presumably steam locomotives. The latest device only sounds off if the noise is increasing in amplitude at the right rate. Bass says that it does occasionally respond to old slow propeller-driven aircraft, but that shouldn't be much of a problem in practice. Very few people, thinks Bass, will want to be flying ancient aircraft during the sort of weather conditions that generate tornadoes.

"Ha Ha! We've set off their alarm again!"

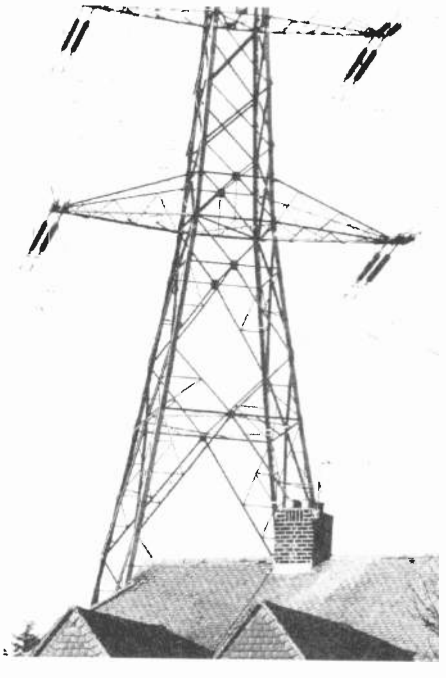
There is one problem. According to a spokesperson from the university: "When Henry Bass's alarm goes off, you'd better run like hell; it means the tornado is about to enter your back yard". Thirty seconds warning may seem like a complete waste of time, but apparently people in the American south get radio and TV warnings so regularly that they tend to ignore them, often with dire consequences. Thirty seconds warning that a tornado is about to strike for real is just enough time – says Professor Bass – to crawl under the bed.



Expert calls for more EMF/cancer studies

Studies into the biological effects of electromagnetic fields were given new impetus by the recent publication of a big review by an Advisory Group of the National Radiological Protection Board (NRPB). Chaired by the famous epidemiologist Sir Richard Doll (who proved the link between smoking and cancer) and including Professor E H Grant of King's College, London and Professor N E Day of the MRC Biostatistics Unit in Cambridge, this advisory group is by far the most authoritative panel ever to have weighed up all of the evidence.

The official purpose of the Group was to "review work on the biological effects of non-ionising radiation relevant to human health and to advise on research priorities". More specifically, its first object has been to review experimental and epidemiological evidence suggesting a carcinogenic (cancer causing) effect of electromagnetic fields. Much of this evidence is contained in the draft document issued by the US Environmental Protection Agency and has already received considerable publicity (See *EW + WW*, April 92).



Previous experimental work on the nature of environmental exposure to electromagnetic fields and also on the direct biological effects of such fields has been reviewed previously by the NRPB and was summarised briefly by Sir Richard Doll at a recent news conference.

Doll said: "Experimental evidence neither excludes nor supports the idea that electromagnetic fields could cause cancer. They do not cause mutations in cellular DNA, but there is weak and inconclusive evidence to suggest that fields produced by frequencies above 100kHz might, in some circumstances, act as tumour promoters". Doll added that lower frequencies have only been directly implicated for their possible effects on secretion of melatonin, which may have an effect on the risk of breast cancer.

The bulk of the latest report concerns epidemiological studies that have hinted at a connection between magnetic fields from power lines and the incidence of cancers, both in children at home and in adults at work. This latter category has generated the greater number of studies – some 60 in all – attempting to search for a link with leukaemia and cancer of the brain.

Nearly all of these reports, says Doll, claim that these diseases are slightly more common among workers in the electrical and electronic industries, though few studies have actually correlated the incidence of disease with directly measured levels of radiation. Arc welders who are known to have substantially increased exposure to electromagnetic fields are no more likely than anyone else to get leukaemia.

The only disease that does seem to have a weak positive connection with employment in the electrical industry is cerebral cancer, though Doll is cautious about implications. "We conclude that an occupational hazard of this disease may exist, but that the present evidence does not identify the cause."

Evidence relating to childhood cancers, says the Group, is even more difficult to assess. There is less of it and, in general, studies have not been adequately controlled. Eight studies were reviewed by the group, four from the US, two from the UK, one from Sweden and one from Taiwan.

Professor Day says that most of the studies suffer from serious methodological flaws, such as lack of comparability between cases and controls. There have also been few direct measurements of the electromagnetic fields affecting the experimental subjects. These, and other, problems are sufficient, says Professor Day, to generate biases at least as strong as the observed effects; that is, an increased risk of childhood cancer of between 50% and 100%.

The Advisory Group of the NRPB, having sifted all the evidence, concludes that there is currently no hard evidence linking ordinary levels of exposure to EM radiation below 100kHz with cancer. With higher frequencies, they say, there is more room for doubt. On one thing there is no doubt at all: the need for further research.

In a BBC World Service interview, Sir Richard Doll said: "There are three types of study that have to be carried out. We have to extend the experimental studies to see if we can find any possible ways in which electromagnetic fields might be able to cause cancer. Secondly, we must do a really large-scale study with proper controls to see if there is any suggestion of an increased risk from exposure in childhood. Thirdly, we must study the occupations where it has been suggested that there might be an increased risk of either leukaemia or brain cancer in adults to find out the extent to which people are exposed, so that we can make comparisons between heavily and lightly exposed people and see if there is any risk in industry".

A national study of childhood cancer has now been launched.

Great balls of electricity!

Notwithstanding recent reports of a black lozenge-shaped UFO over Southern England, most UFO sightings turn out to be aircraft, satellites and weather balloons. But according to John Derr of the US Geological Survey, some UFOs are actually mysterious balls of electricity that float in the air near earthquake epicentres.

There is now growing evidence (see last month's *Research Notes*) that underground stress generates radio signals immediately before quakes. Some seismologists believe that occurrences of ball lightning could be a related effect.

Derr's study into three medium-sized earthquakes that took place during 1951 and 1952 in New Mexico revealed an unusually high number of UFO reports within 100km of their respective epicentres. Derr describes a typical sighting as consisting of an orange ball of light (though some reports claim the colour to be green or blue) which floats slowly through the air.

This study deliberately eliminated reports where the sighting had an obvious explanation or where its authenticity was in some doubt. The latter category included reports from people whose sanity was questionable and accounts of close encounters with little green men.

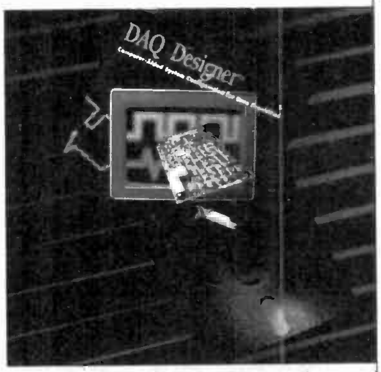
Of the remaining 150 UFO reports, nearly all referred to objects resembling ball lightning and more than half had a close geographical and temporal association with earthquakes.

Some earth scientists are naturally rather sceptical about this latest finding, and it would certainly be hard to prove any direct causal connection between quakes and UFOs. Nevertheless it is an interesting idea and not beyond the bounds of possibility.

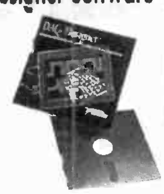
Research Notes is written by John Wilson of the BBC World Service

Get Your Data Acquisition System Right... The First Time!

DAQ Designer™ from National Instruments, is a free system configuration software tool for the PC that takes you step-by-step through your application, asking you questions, and recommending the right PC plug-in data acquisition boards, signal conditioning products, cable assemblies, and software packages. With DAQ Designer, you configure your system with exactly what you need – the first time!



Call for Free DAQ Designer Software



NATIONAL INSTRUMENTS®
The Software is the Instrument®

National Instruments U.K. Corporation
21 Kingfisher Court, Hambridge Road
Newbury, Berkshire, RG14 5SJ
Tel: (0635) 523545
Freephone: 0800 289877
Fax: (0635) 523154

U.S. Corporate Headquarters
Tel: (512) 794-0100
Fax: (512) 794-8411

CIRCLE NO. 139 ON REPLY CARD

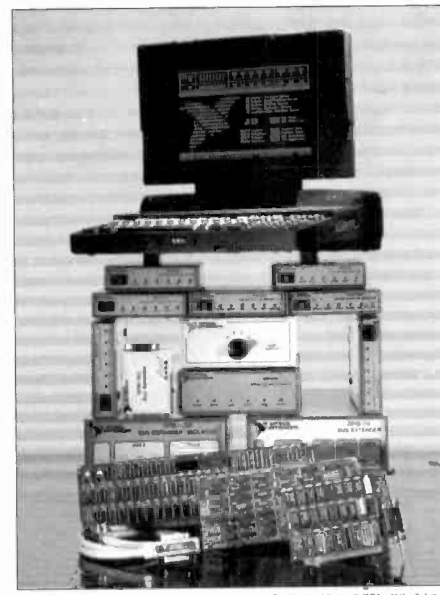
IEEE-488

Analyser • Extenders • Converters

IEEE-488 Support Products

- Bus Analyser
- RS-232 ↔ IEEE-488
- RS-422 ↔ IEEE-488
- SCSI ↔ IEEE-488
- Centronics Parallel ↔ IEEE-488
- GPIB Extenders
  - –High-speed parallel extender (900 kbytes/sec)
  - –Long-distance serial extender
- GPIB Expander Isolator
- GPIB Data Buffer
- GPIB 4-to-1 Switch
- GPIB Cables

Call for Free 1992 Catalogue



Simple solutions for the integration of IEEE-488, SCSI, RS-232, RS-422, and Centronics parallel devices

NATIONAL INSTRUMENTS®
The Software is the Instrument®

21 Kingfisher Court
Hambridge Road
Newbury, Berkshire
RG14 5SJ
Tel: 0635 523 545
Freephone: 0800 289 877
Fax: 0635 523 154

Corporate Headquarters USA (512) 794-0100
Branch Offices: AUSTRALIA 03 879 9422 • BELGIUM 02 757 00 02
CANADA 519 622 9310 • DENMARK 45 76 73 22 • FRANCE 1 48 65 33 70
GERMANY 089 714 5093 • ITALY 02 4830 1892 • JAPAN 03 3788 1921
NETHERLANDS 01720 45761 • NORWAY 03 846866 • SPAIN 91 896 0675
SWEDEN 08 984 970 • SWITZERLAND 056 45 58 80 • U.K. 0635 523 545

CIRCLE NO. 140 ON REPLY CARD

IEEE-488 Monitor/Analyser

Simplifies GPIB System Development

Capabilities

- Inexpensive, easy-to-use monitor analyser for any IEEE-488 application
- Use with portable PC for convenient, portable bus analysis
- Captures bus activity at speeds up to 1 MHz
- Background operation shares host PC with GPIB
- Emulates both Talker and Listener devices
- Triggering and pattern generation
- Capture size limited only by available PC memory

Call for Free 1992 Catalogue

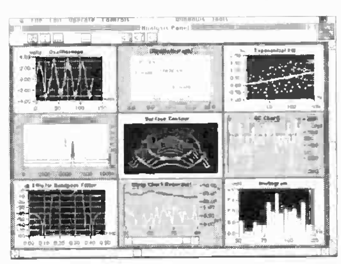
NATIONAL INSTRUMENTS®
The Software is the Instrument®

21 Kingfisher Court
Hambridge Road
Newbury, Berkshire
RG14 5SJ
Tel: 0635 523 545
Freephone: 0800 289 877
Fax: 0635 523 154

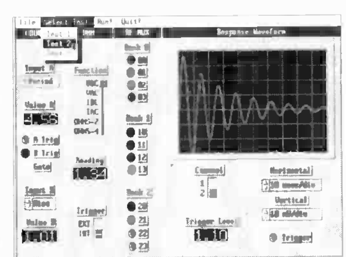
Corporate Headquarters USA (512) 794-0100
Branch Offices: AUSTRALIA 03 879 9422 • BELGIUM 02 757 00 02
CANADA 519 622 9310 • DENMARK 45 76 73 22 • FRANCE 1 48 65 33 70
GERMANY 089 714 5093 • ITALY 02 4830 1892 • JAPAN 03 3788 1921
NETHERLANDS 01720 45761 • NORWAY 03 846866 • SPAIN 91 896 0675
SWEDEN 08 984970 • SWITZERLAND 056 45 58 80 • U.K. 0635 523 545

CIRCLE NO. 141 ON REPLY CARD

INSTRUMENT CONTROL AND DATA ACQUISITION SOFTWARE



LabVIEW® 2 – For the Macintosh
Graphical Programming Environment



LabWindows® – For DOS computers
Program Development Tools For C and BASIC

ACQUISITION – Integrated libraries for GPIB, RS-232, and VXI instruments, and A/D-D/A-DIO plug-in boards

ANALYSIS – Extensive libraries for data reduction, digital signal processing, digital filtering, and statistical analysis

PRESENTATION – Flexible high-performance graphical user interface and report generation

CALL FOR FREE DEMO DISK

NATIONAL INSTRUMENTS®
The Software is the Instrument®

National Instruments UK
21 Kingfisher Court
Newbury, Berkshire
RG14 5SJ
Tel: 0635 523 545
Freephone: 0800 289 877
Fax: 0635 523 154

Corporate Headquarters USA
Tel: (512) 794-0100
Fax: (512) 794-8411

CIRCLE NO. 142 ON REPLY CARD

ELECTRICITY *without* MAGNETISM?

Straight thermocouples produce electricity very inefficiently. Harold Aspden and John Scott Strachan claim to have invented a generator system which performs many times better. Is it true thermocouple action or is there a piezo-electric factor producing the power?

This article is based on their hypothesis developed from a practical experiment which, they say, produced unexpected amounts of power.

Physicists know that thermoelectric bimetallic circuits have nothing practical to offer in design of devices aimed primarily at converting heat to electricity. Too much heat is lost by thermal conduction through the metal conductors linking the junctions in the circuit. Also, though an EMF is developed in the circuit when the junctions are at different temperatures, the power it can apply to current flow is swamped by heat conduction along the current flow path.

Semiconductors can increase the EMF ten-fold and decrease the heat conductivity a thousand fold. But the result is a device that is still poor in efficiency and, worse still, which cannot sustain a high power throughput rate for its size and cost. Such thermoelectric heat pumps, though commercially marketed as electronic circuit components, have a limited utility.

But instead of trying to avoid that heat conduction, why not try to harness it?

In the Thomson effect, a temperature gradient in a metal causes the free electrons to migrate under thermal pressure so as to set up an EMF in the axis of heat flow. Some 87μV of EMF is set up per °C of temperature difference.

The Aspden hypothesis

On the face of it the Thomson effect is a scientific curiosity with no specific practical application because it goes hand in hand with the standard design property of a substance known from its heat conductivity.

That, at least, is how things stood until we hit upon the idea of using audio or low radio frequency electronics to set up transverse current oscillations across bimetallic surface coatings on a dielectric substrate.

The Thomson effect has a positive coefficient in some metals and a negative one in others (as if electrons are the heat carriers in one and positrons or holes in the other). We believed that advantage could be taken of this by constructing a dielectric sheet material coated with vapour-deposited layers of aluminium and nickel, metals of opposite-polarity Thomson coefficients. A temperature difference between two opposite edges of the sheet material means that a current will flow one way in the nickel and the other way in the aluminium. The current will circulate – powered by the heat transfer – and would cross the bimetallic junctions at the interface, but in opposite directions.

The Thomson effect promotes current circulation: the task then is to draw power from the EMF set up normal to the sheet by Seebeck action resulting from excess of Peltier cooling on the hot side over Peltier heating at the other (see box below right).

All heat flow through the metal from the hot side would be intercepted, somewhere in its passage through the metal layers, by Peltier cooling – cooling promoted by a transverse current from discharge of the capacitor built from the dielectric sheets and their metal coatings.

Heat would also be blocked from easy transfer to the cold side by a staggered arrangement of heat sink contacts with the bimetallic coatings, forming an alternating sequence of capacitor plates in what would be a series-connected capacitor stack.

On the charge cycle, the cooled state of the junction on the heated side would result in a lower reverse transfer of energy by Peltier heating so that over a full AC excitation cycle a net output power would be delivered.

The capacitor dielectric may possibly be involved thermodynamically owing to its own special properties and serves as a thermal barrier to direct heat transfer through the main body of the device.

"Astonishing" performance

John Scott Strachan built a working system based on these principles. To stimulate oscillation of the capacitor current in what must – owing to the Peltier EMF – be a capacitor with a negative resistance, a piezoelectric oscillator system operating at 500kHz was built into the system powered by the heat-generated electrical output. The piezo material comprised the PVDF dielectric material sandwiched between the bi-metal plates. In September 1988, the first device was finished and ready for test.

One face of the device was cemented to a heat sink so that to extract power the upper exposed face had to be cooled rather than heated relative to the heat sink on the underside. Instead of feeding in a measured amount of heat from an electrically powered resistor the device was operated by placing a melting piece of ice from a domestic refrigerator upon its upper face.

Almost unbelievably, the device performed immediately and was astonishingly effective, spinning an electric motor connected to its output leads. There was no electrical input for test or other purposes. Electronics in the device were all powered by the electricity generated by the small piece of melting ice.

If an ice cube were placed on the surface with the motor disconnected it took seven times as long to melt as it did with the motor connected – hinting that the conversion efficiency had to be extremely high. Unfortunately that efficiency could not easily be measured because the device was powered by cold rather than heat! But what could be measured was enough to suggest that the device was operating on principles that were not quite those we originally had in mind.

We had built an electronic device that more than met our objectives but we did not fully comprehend its operating principles. The device delivered power by operating at 500kHz. It had no more than a 20°C temperature drop across its 8cm square heat surfaces yet was delivering useful output electrical power that scaled up to levels of kW/m^2.

Cold spot explains high EMF

Diagnostic tests and extensive theoretical analysis carried out as we tried to reverse engineer our own product, showed that the thermoelectric EMF being produced by the aluminium-nickel junctions was about 20 times greater than textbook data indicated. Since the factor of merit of a thermoelectric device increases as the square of this EMF and the metals used were good electrical conductors, the finding indicated a major discovery.

Eventually, it was reasoned that this was not some new strength in activating the thermoelectric power of bimetallic junctions, rather a technique for avoiding a weakness that had beset the normal metal thermoelectric devices. The difference was that we were operating at a high frequency and interrupting the current flow at that frequency, whereas a conventional thermocouple circuit is invariably DC operation.

Classical thermodynamic principles say the thermoelectric EMF across a junction should be of the order of 260μV/degree of absolute temperature (Kelvin) – the high EMF we realised in our experimental device. But tests on an aluminium-nickel thermocouple circuit operating under normal DC conditions reveal only a fraction of this power.

Perhaps the higher levels of thermoelectric EMF obtained in semiconductors hold the key. Semiconductors suited to thermocouple use have a resistivity decreasing with increased temperature – the converse behaviour to base metals. At a point in the junction interface between two metals at which Peltier cooling is occurring there is a concentrated cooling action confined to that interface which must, of necessity, cool rapidly.

If some points in the interface surface cool faster than others, conductivity will probably increase at those points and current will follow the path of least resistance: the more current flowing at a Peltier cooled spot in the junction surface, the greater the rate of cooling.

The action escalates and in the normal situation of DC flow the current will tend to form a filamentary flow path and cross the junction at a temperature far lower than that believed to exist at the externally heated junction. The result is that the actual effective junction temperature drops until it almost equals that at the Peltier heated junction and so very nearly sup-

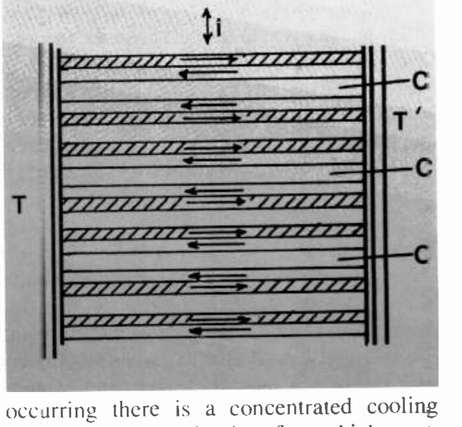
Device details

The device demonstrated, 5mm in thickness and 8cm square, comprises a capacitor assembly bounded by two aluminium plates. One plate is in contact with a heat sink at room temperature, the other supports a small piece of ice from a domestic refrigerator. As the ice melts it absorbs room heat to power 500kHz oscillations which deliver output power through a ferrite transformer and a rectifier to spin an electric DC motor.

When the ice has melted a battery is connected to its output leads and this revolutionary solid-state electronic heat engine operates in reverse mode. The water left on the aluminium plate freezes almost instantly.

Laboratory testing reveals a 70% of Carnot efficiency factor in energy conversion.

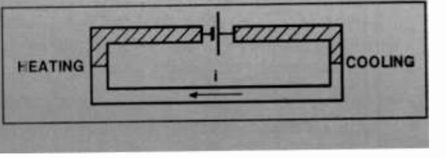
STRACHAN-ASPDEN ELECTRONIC HEAT ENGINE: Bimetallic coated dielectric layers, C, are assembled in a capacitor stack and interleaved with uncoated dielectric layers. The circulating DC current i in each coating is powered by the EMF set up by the Thomson effect and AC oscillations allowing a transverse AC current i are powered by the EMF set up by the Seebeck effect. Upon superimposition of these current components there is a cooling junction current 2i at the hot side (T') for one AC half cycle and a heating current 2i on the cool side (T) during the other half cycle. Result is an AC thermoelectric pile of panel form having very low internal resistance to AC current throughput.



The Peltier effect

Peltier, in 1834, advanced on Seebeck's work by establishing that a current across a bimetallic junction can cause either local heating or cooling at a junction, according to the direction of current flow.

Peltier discovered that flow of current across a junction between two different metals will cause cooling at one junction and heating at the other. The effect is proportional to the current strength and reverses when the current reverses.



THOMSON EFFECT:
Even with no current flow, a temperature difference between the ends of a metal strip will set up an electric potential of the order of 87µV/°C . The effect is positive in some metals and negative in others.

presses all current flow.

In short, the normal DC all metal thermocouple strangles itself by choking off almost all its power capacity.

The way to avoid the situation seems to be to switch the current on and off so rapidly that the current filaments cannot form for long enough to be trapped in the cold spot positions – the analogy is spot formation on the mercury pool in the old-fashioned mercury arc rectifiers. Current tends to break up into filamentary flow paths and maybe that is just what is happening even in metals, so that the current must be kept moving across any boundary surfaces.

Second device

Whatever the truths of this phenomenon, a second device was built relying on this discovery and the principles exploiting the Thomson effect. It also worked immediately and performed as well as the first system. However, this device was intended for diagnostic testing and efficiency measurement and included no piezoelectric oscillator or magnetised tape and had no staggered construction features.

Output was gated through a low impedance switch under the control of a function generator feeding negligible switch control power. Design was simple (see figure) in the extreme, relying on the Thomson effect to circulate current and the Seebeck and Peltier Effects to set up a thermally induced negative resistance in the low resistance AC throughput channel of the capacitor stack. The device operated over a wide range of frequencies but optimum performance was at 1 kHz and a 70% of Carnot efficiency was measured for generation of electricity from heat supplied at water temperatures. The efficiency is not deemed optimum and can almost certainly be improved.

Status of the invention

No R & D project funded by a government body or a corporation led to this technological breakthrough; it is the product of individual effort addressing the challenging question of alternative energy sources. To see the potential for generating electricity efficiently from heat, look at the heat wasted at water temperatures in the steam condensers of electric power plants. Or contemplate setting up a small temperature differential between the inside and outside of a greenhouse by trapping the ambient radiation (even under cloudy conditions) to realise that a thermoelectric panel fitted in that structure could become a source of electricity.

A US patent application on the device has been granted – the US patent examiner first declared that it was impossible for a melting piece of ice to generate electricity as suggested in the patent specification. But he did accept the evidence presented and the patent was allowed.

Now it remains to be seen whether the invention will attract interest and be developed to its true potential.

There are problems. The dielectric PVDF material with the bimetallic coating is no longer available commercially, as far as we know. The aluminium coating was bonded to the PVDF by a nickel layer and technological progress has allowed the industry PVDF material to be manufactured in a single coating stage, making the intervening nickel layer unnecessary. So the essential bimetallic material used in prototype test construction can not be easily obtained and this scales up the R & D funding requirement for the invention to develop further. As a result development is currently in limbo owing to the curious situation where technological advance in one industry has blocked progress in an entirely different field. ■

About the inventors
Dr Harold Aspden is a visiting senior research fellow in the Department of Electrical Engineering at the University of Southampton. He is a former Director of European Patent Operations in IBM but retired to pursue private research in the energy field.
John Scott Strachan is a research scientist, formerly with the Pennwalt Corporation researching piezoelectric applications of PVDF material, now engaged on research as a director of Optical Metrology Ltd and located at the Technology Transfer Centre at King's Buildings of the University of Edinburgh

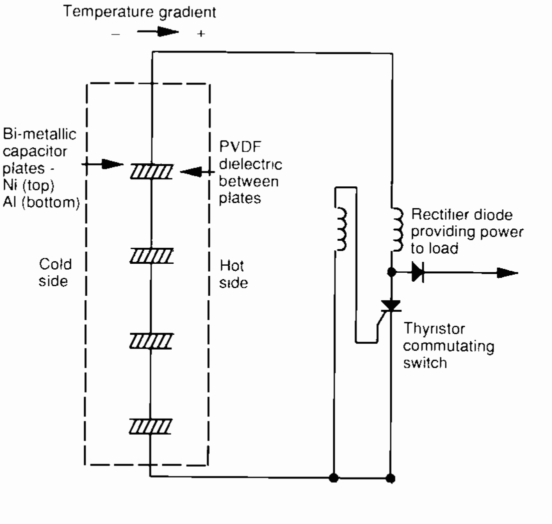
SUPER THERMOCOUPLES – THE MAGAZINE'S VIEW

Editor Frank Ogden and consultant Derek Rowe write: If the authors' observations are correct, there is definitely a mechanism worth investigating although the generating effect may have more to do with the highly piezo-active nature of PVDF plastic than with thermo-electricity.

During lenthy conversations with the authors, it emerged that the generating device comprised a stack of up to 1000 PVDF metalised film discs effectively connected in series with the whole assembly – which forms a giant piezo-active capacitor – connected across a ferrite transformer via an SCR. The gate of the SCR is driven via a small feedback winding on the transformer. The authors report that the assembly self-oscillates when subjected to a heat gradient orthogonal to the bi-metal layers. Surplus power can be drawn off by rectification from the top of the thyristor. A 20°C temperature gradient across the stack causes it to deliver a rectified output of around 50mA at 2V.

Strachan emphasises that the device requires a kickstart to commence oscillation; he originally employed a separate piezo oscillator element physically attached to the top of the stack. He also states that the oscillator frequency is determined by resonance between transformer primary inductance and the intrinsic stack capacitance.

Trapping highly piezo-active material between metals of differing thermal expansion coefficients could produce enough stress to power a commutating system. This doesn't explain the authors' observation that power flow could be reversed leading to a Peltier style cooling effect. How they achieved this with the general arrangement shown in our drawing isn't too clear.

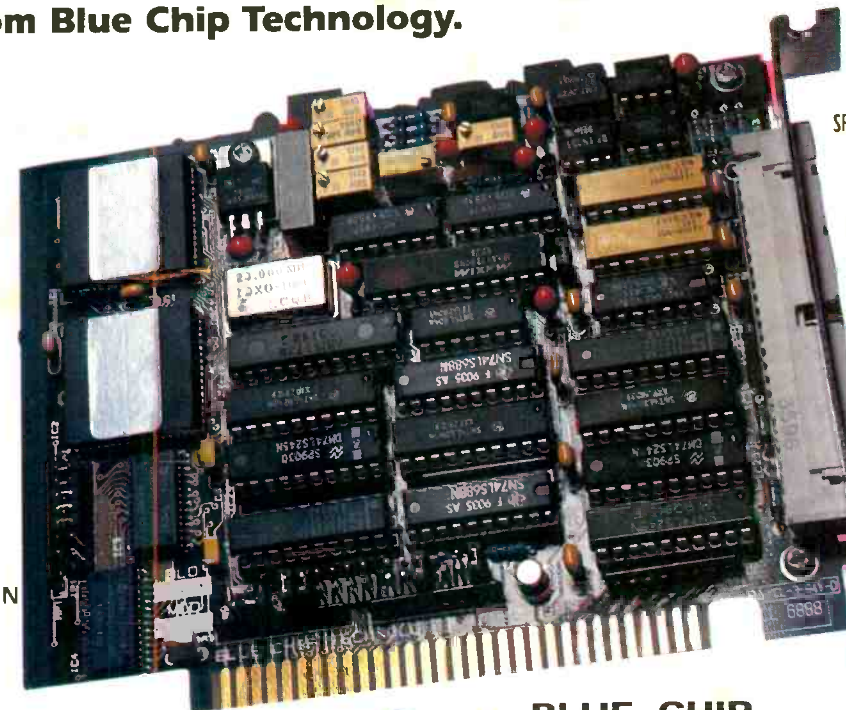


Our interpretation of the authors' test circuit

MORE SPEED, LESS SPACE !

**Hi-performance A to D conversion on a card less than half standard size.
The new AIN-24 from Blue Chip Technology.**

- 4μs CONVERSION RATE
- 24 CHANNELS
- 32K ONBOARD CACHE RAM
- DIRECT MEMORY ACCESS
- 80 KHz TRANSFER RATE
- 12 BIT RESOLUTION
- SOFTWARE SELECTABLE GAIN
- DOS DRIVER SOFTWARE



SPECIALLY DESIGNED FOR

- HI-SPEED DATA CAPTURE
- TRANSIENT ANALYSIS
- DATA LOGGING

BSI REGISTERED FIRM
FM/10497

BLUE CHIP TECHNOLOGY

A KEMITRON GROUP COMPANY

Hawarden Industrial Park
Manor Lane Clwyd CH5 3PP

CALL THE HOTLINE NOW !
0244 520222

CIRCLE NO. 110 ON REPLY CARD

TWIN TWIN PPM

Comprising two PPM9 boards, featuring inherent stability with law under micro-processor control, the unit gives simultaneous monitoring of A/B on red/green and M/S on white/yellow pointers. Together these provide complete information about stereo signals. Manufactured under licence from the BBC.

PPM10 In Vision PPM and Chart Recorder generates a high quality colour video display emulating the well known coaxial twin movements, long regarded as a most satisfactory way of monitoring stereo audio levels and mono compatibility. The eye can judge the level displayed, at a glance, from the angle of pointers, without needing to refer to scale markings.

Advanced Active Aerial 4kHz-30MHz *Stabilizers and Fixed Shift Circuit Boards for howl reduction *10 Outlet Distribution Amplifier 4 *Stereo Variable Emphasis Limiter 3 *Stereo Disc Amplifier *Peak Deviation Meter *PPM5 hybrid and PPM8 IEC/DIN −50/+6dB drives and movements *Broadcast Stereo Coders *Philips DC777 Short Wave Car Combination: discount £215 + VAT.

SURREY ELECTRONICS LTD
The Forge, Lucks Green, Cranleigh,
Surrey GU6 7BG.
Telephone: 0483 275997. Fax: 276477.

COMMERCIAL QUALITY VHF/UHF RECEIVER

The IC-R7000, advanced technology, continuous coverage communications receiver has 99 programmable memories covering aircraft, marine, FM broadcast, Amateur radio, television and weather satellite bands. For simplified operation and quick tuning the IC-R7000 features direct keyboard entry. Precise frequencies can be selected by pushing the digit keys in sequence of the frequency or by tuning the main tuning knob FM wide/FM narrow/AM upper and lower SSB modes with 6 tuning speeds: 0.1, 1.0, 5, 10, 12.5 and 25kHz. A sophisticated scanning system provides instant access to the most used frequencies. By depressing the Auto-M switch the IC-R7000 automatically memorises frequencies in use whilst it is in the scan mode, this allows you to recall frequencies that were in use. Readout is clearly shown on a dual-colour fluorescent display. Options include the RC-12 infra-red remote controller, voice synthesizer and HP-2 headphones.

ICOM

Post to: Icom (UK) Ltd. Dept WW
Sea Street Herne Bay Kent CT6 8LD
Tel:0227 741741 (24hr). Fax: 0227 360155

10

Name/address/postcode ....

....

Call sign: .... Tel: .... Dept: WW

CIRCLE NO. 111 ON REPLY CARD

DSR or DAB – worlds of difference

News that digital radio transmissions have begun on two German satellites may have prompted memories of the BBC's demonstration of digital broadcasting, using a coach driving round Birmingham a year or so ago. But the systems are quite different, with virtually nothing in common.

The system the BBC was demonstrating is dab (digital audio broadcasting), a Eureka project of some complexity, not expected to deliver a working service until 1995. When it arrives, dab will provide high-quality interference-free reception in all sorts of currently-difficult conditions, including built-up areas and even tunnels. Dab is being developed particularly with in-car use in mind. Receivers will probably be low-cost.

Digital satellite radio (DSR), by contrast, is here already, but without the advantages of mobile or portable reception – or of low-cost receivers. However, it does offer what will probably remain the finest medium for transmission of studio quality sound. Its proponents describe it as a no-compression, no-compromise system. In effect, it transmits the full stream of digital information read off a compact disc, which, when it reaches the receiver, is put through a digital-to-analogue conversion, in the same way that the relevant part of a CD player handles the information picked up by its laser optic scanner.

German development

DSR was developed in Germany, with the involvement of Telefunken. The service currently broadcasting from Kopernikus 1 and, duplicated on TV-Sat 2, provides 16 channels on a single frequency. The system has a capability for four such 16-channel packages, and existing programmes comprise eight "classic and culture", five pop/rock music and three news and information. All are broadcast round-the-clock, or nearly so.

Access, on the receiver, can be direct to a particular channel, or via a system of programme classification. Choose from up to 15 types – news, sport, classical, rock, jazz etc; the receiver will select the right type of programme and also indicate on its led display other channels carrying the same type.

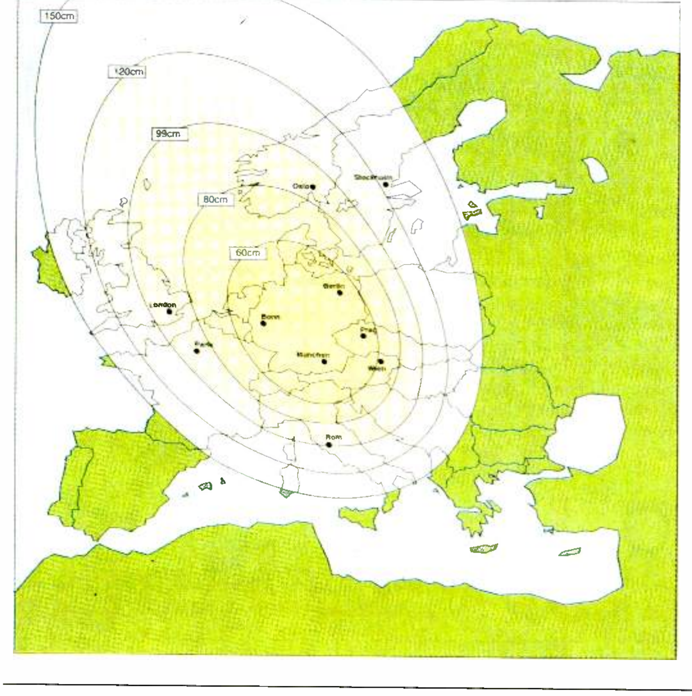
When the chosen category of programme ends on one channel, the receiver will search for it on the other channels.

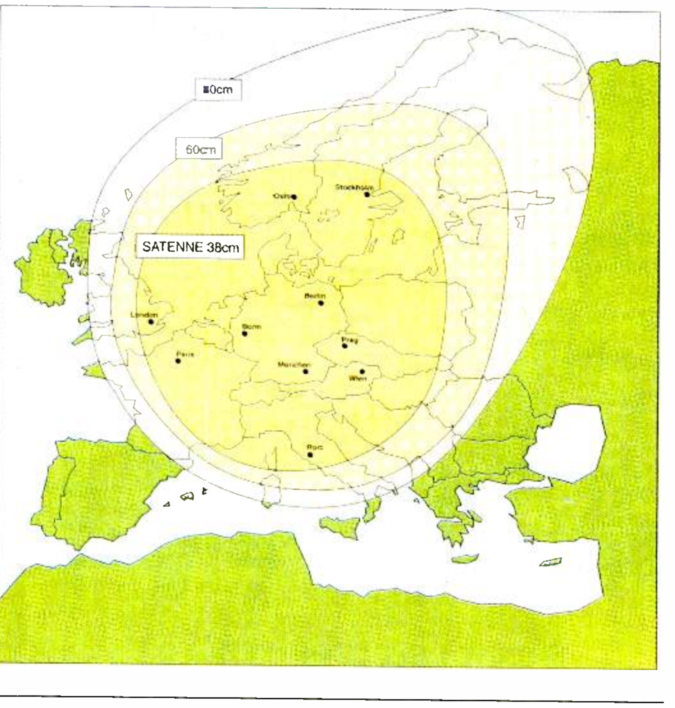
Reception of DSR is, exactly like satellite TV, by means of a fixed antenna, pointed at the satellite. Both the Kopernikus and TV-Sat beams are centred on Germany, but both offer possibilities for reception in the UK.

TV-Sat will be the best option for most UK listeners. Its concentrated beam has a large central area, in which, according to TechniSat, reception on its 38cm square antenna is possible. This takes in the South-East of England as far west as Chichester, and as far north as Hull. Most of the rest of the mainland can be reached with either a 60 or an 80cm dish, but the footprint does not take in the west of Scotland, south-west Wales or Cornwall.

Kopernikus has a more diffused beam, covering the whole of the UK and a large part of Ireland, but requiring large dishes – 100-150cm.

Receivers are far from cheap. About half a dozen are on sale in Germany, including models by Telefunken, Philips and Grundig. Typical prices are £500-800. So far only two manufacturers have indicated an intention to





Kopernikus and TV-Sat beams, centred on Germany, can be received in the UK, with TV-Sat offering the best option for most UK listeners. Its concentrated beam has a large central area in which reception on its 38cm square antenna is possible. Kopernikus has a more diffused beam, covering the whole of the UK and a large part of Ireland, but requiring large dishes.

bring models into the UK, and they as it happens are respectively the cheapest and the most expensive.

TechniSat, which uses its own D-to-A chip processor, originally developed in East Germany, charges around £300 for its 5000 DSR. Swiss company Revox is more tentative about the UK market. Its H7 tuner, due to enter production this summer, would retail in the region of £1000-1200. Despite these prices, this kind of digital radio is relatively easy to transmit, and to decode, using straightforward PCM coding. However, its high transmission bit-rate, 20.48Mbit/s (in two parallel data streams, each carrying eight stereo channels), makes it an extravagant user of bandwidth.

DSR takes up 14MHz (on a 27MHz transponder channel) for its 16 channels, which compares with a proposed 7MHz for a 20-channel dab service.

Dab on the road

Impressive though DSR sounds, it is hard to see a commercial future for it without access to the in-car market.

But it may operate viably as a sort of wholesale broadcaster, providing high-quality feeds to cable stations and to local, terrestrial broadcasters. It is precisely the problems DSR avoids which dab is being developed to overcome. Dab (occasionally, and confusingly, referred to as DSB, digital sound broadcasting) is a Europe-wide Eureka project, No 147, involving broadcasters, including the BBC, and manufacturers. Most of the German participants in DSR are also working on dab. Dab aims to provide a robust signal capable of surviving difficult multipath conditions – where reflected signals from tall buildings and hills currently create interference.

As the BBC tests on its bus trip showed, dab is well advanced, and is capable of giving perfect reception even when the vehicle is passing through a tunnel. Indeed, such are its design characteristics that as well as being picked up on a moving receiver, Dab can happily be broadcast from several adjacent or overlapping transmitters – even moving ones.

A proposal under consideration is that dab might be broadcast from a number of low earth-orbit satellites, passing in succession across the sky. The key to this versatility is a very low transmission bit-rate – so low that the reflected signals can arrive in time to be combined with the same part of the main signal, thereby reinforcing it, rather than confusing it. In digital terms, interference starts to become a nuisance where the delay between main and reflected signal becomes greater than one-quarter of the interval between symbols. By the time the delay is equal to the symbol period it can become impossible to decode the signal.

With Nicam, which has a symbol period of 2.7μs (a symbol consists of two bits), a delay of 0.7μs – equivalent to a reflection from a building 100m behind the antenna – can create interference. That is why Nicam is fine for fixed, elevated TV aerials, but would be hopelessly confusing for a whip aerial attached to a car travelling through a built-up area.

DSR receivers are far from cheap and supplies into the UK are going to be limited.

A working dab system would have to be able to cope with even greater delays – reflections from up to 5km away in mountainous areas. This would imply a symbol period of around 140μs, or around 7.3ksymbols/s, about one 50th the rate of Nicam and far too slow to convey music. The challenge to dab is to make this possible.

Coping with delays

Two distinct techniques have been developed and combined to achieve this. One is compression, crudely summarised as reducing the bit-rate by leaving out those you don't need. Any audio signal, such as a piece of music, includes sounds which are inaudible to the human ear, as a result of being masked by louder sounds at similar frequencies.

The phenomenon is known as the masking threshold, and sounds which fall below the threshold can be dispensed with, without affecting the perceived quality of the signal. Variants of the technique are already in use on digital compact cassettes and on Sony's mini disc system. The initial low bit-rate system, known as mascam (masking pattern sub-band coding and multiplexing) has now evolved, along with other systems, into an international standard, CD11172 Layer II. A 20kHz audio signal now requires only 128kbit/s – a sixth of that used by Nicam.

The second trick is to split this signal onto a number of separate carriers, each of which carries its part of the message at a low enough data rate to resist multipath interference. Thus, if the bits in a 128kbit/s signal were assigned sequentially to 20 carriers, this would give each of them a rate of only 6.4kbits/s.

In practice, additional data is included, and the number of carriers per sound channel is much higher. The system developed to achieve this, and to fit the carriers into as narrow a frequency band as possible is known as COFDM, coded orthogonal frequency division multiplex. Data on the different carriers remains separated, until reassembled in the receiver, despite being carried on the same frequency band.

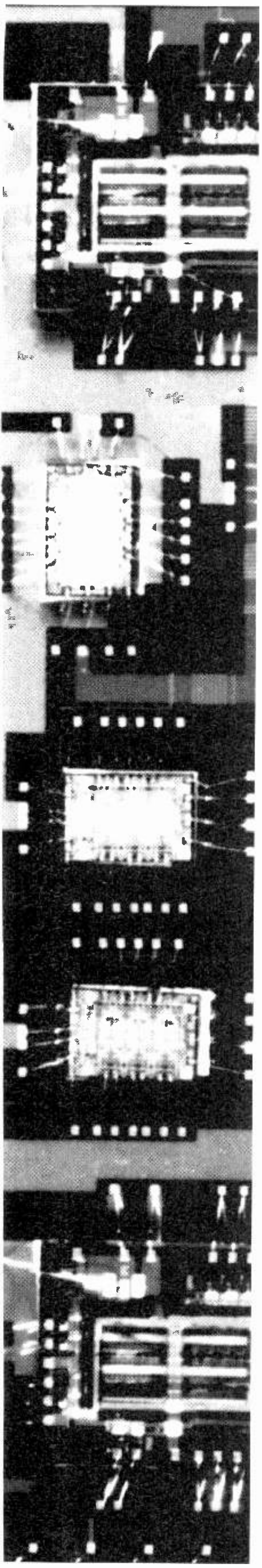
Spectrum-efficient spectrum

Combination of COFDM and compression has enabled the broadcasters and manufacturers in the Eureka 147 project to develop a spectrum-efficient sound broadcasting system.

The currently-proposed system would provide five stereo radio services, modulated onto around 1500 low data-rate carriers, taking up 1.5MHz of spectrum. This is the proposed European standard. With a 250kHz guard band separating each 1.5MHz, four such blocks could give 20 programmes in 7MHz. Dab's ability of the reflected signal to combine with the main signal not only solves a problem, but brings positive advantages. It is this feature that would permit reception from non-geostationary low-orbit satellites, or from a geostationary satellite boosted by terrestrial relay transmitters ("active deflectors" in dab parlance) which would assist reception in difficult areas such as city centres. Similarly, a national network, operating on a single frequency from overlapping terrestrial transmitters becomes a possibility. Clearly, dab receivers will have to have large powers of number-crunching. Philips has suggested that the dab receiver of the future will consist solely of two VLSI chips. With virtually no mechanical parts and volume production, unit cost could be very low, and this is one of the Eureka project's declared objectives. For developing countries a dab service is likely to be a cheaper proposition than a VHF-FM network.

Although dab could be ready by 1995, there remains the problem of finding frequency space for it. The recent Warc 92 decided to allocate 1452-1492MHz for satellite transmission, but this will not become fully available until 2007. A future conference will look at the issue of complementary terrestrial broadcasting and another will consider terrestrial digital broadcasting on VHF.

For the time being, DSR has the field to itself, a partial alternative to dab – but not a competitor. **Peter Willis**



The sleeping beauty of an intelligent op-amp

Low power applications benefit from standby states in power hungry parts of the circuit. Automatic recognition of activity usually requires additional components, but Motorola has produced a device which thinks for itself. By Frank Ogden

An amplifier or comparator circuit doesn't always need to deliver its maximum possible performance. Many battery powered applications spend their time waiting and watching for activity which, when detected, turns on other high current, high performance circuits.

The new Motorola *MC33102* op-amp recognises this requirement and incorporates both low current, low performance and high current, high performance states in the device characteristics. It also possesses the intelligence to determine the level of performance required at any particular time.

Motorola refers to the ability to switch between these states as "Sleep-mode" operation. In the sleep state, the device still functions as an operational amplifier but with the current consumption reduced to typically 45μA per amplifier until an input signal is detected that requires the amplifier to source or sink 160μA or more. Once this condition is detected by the amplifier, it changes to the awake state within a few microseconds. Each amplifier consumes approximately 750μA in this state but enjoys a ten-fold improvement in width and slew rate.

When the input signal is removed, the amplifier returns to the sleep state after a delay time. An on-chip delay circuit prevents the amplifier from returning to the sleep mode at every zero crossing of the output voltage waveform. This same delay circuit also eliminates crossover distortion which is a problem in most conventional low power amplifiers. Frequencies as low as one hertz can be processed without the amplifier returning to the sleep mode condition.

Incredibly, this is achieved without any external timing components. The pin out is of the same form and number as any other operational amplifier.

MC33102 cardinal parameters

Characteristic	Sleep	Awake	Unit
Supply current	45	750	μA
Input offset voltage	0.15	0.15	mV
Output current	0.15	50	mA
Input offset drift	1	1	μV/°C
Gain bandwidth 20kHz	0.33	4.6	MHz
Slew rate	0.16	1.7	v/μs
Input noise 1kHz	28	9	nV/√Hz

Applications details

The *MC33102* was designed primarily for applications where high performance is required only part of the time. The two state feature of this device enables it to conserve power during idle times, yet be powered up and ready for an input signal. Possible applications include laptop

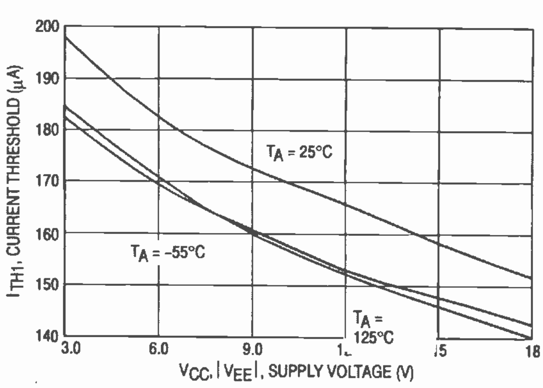
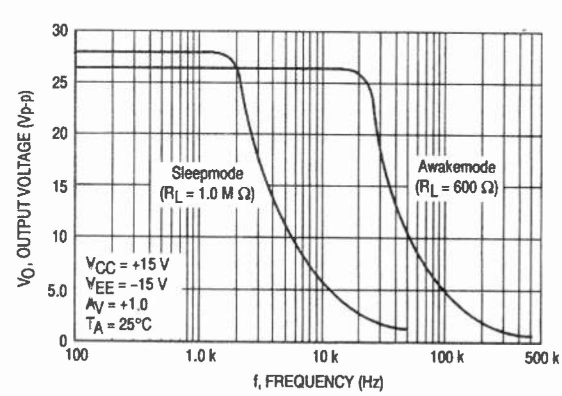
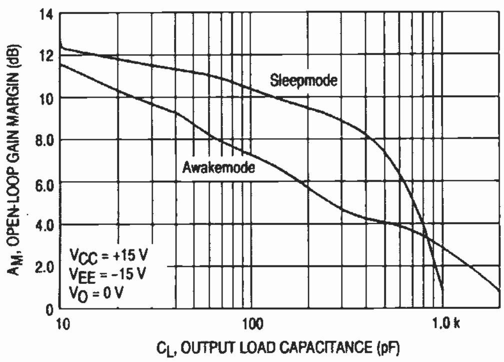


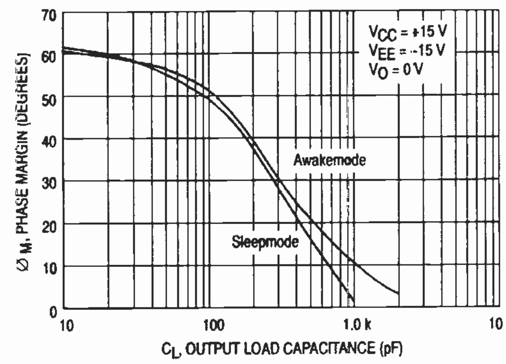
Fig. 1. The typical output current required to cause the device to switch states. It varies as a function of temperature and supply voltage.



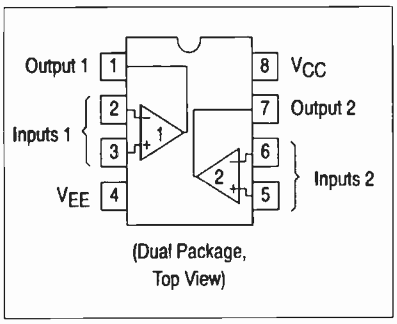
Output voltage swing versus frequency



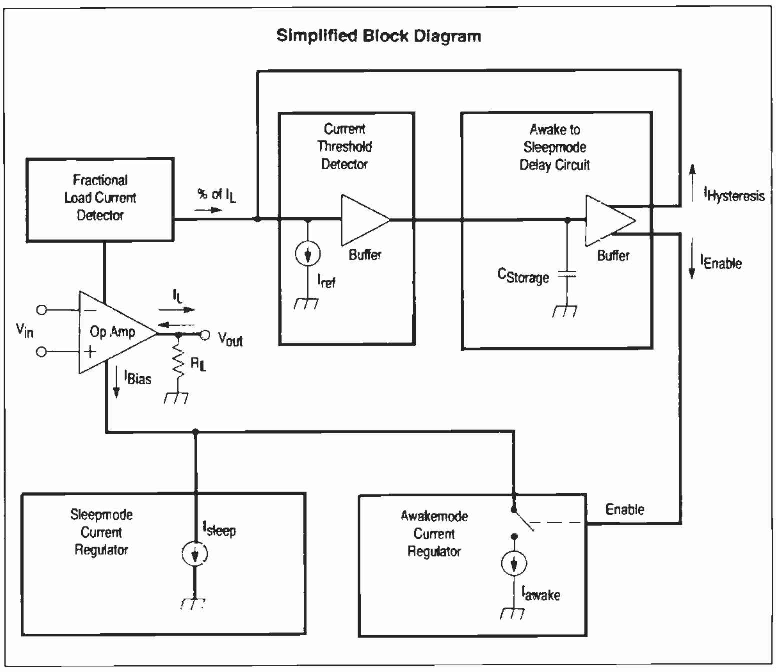
Voltage gain margin vs capacitance



Phase margin



Pinout



computers, cordless phones, battery operated equipment and baby alarms.

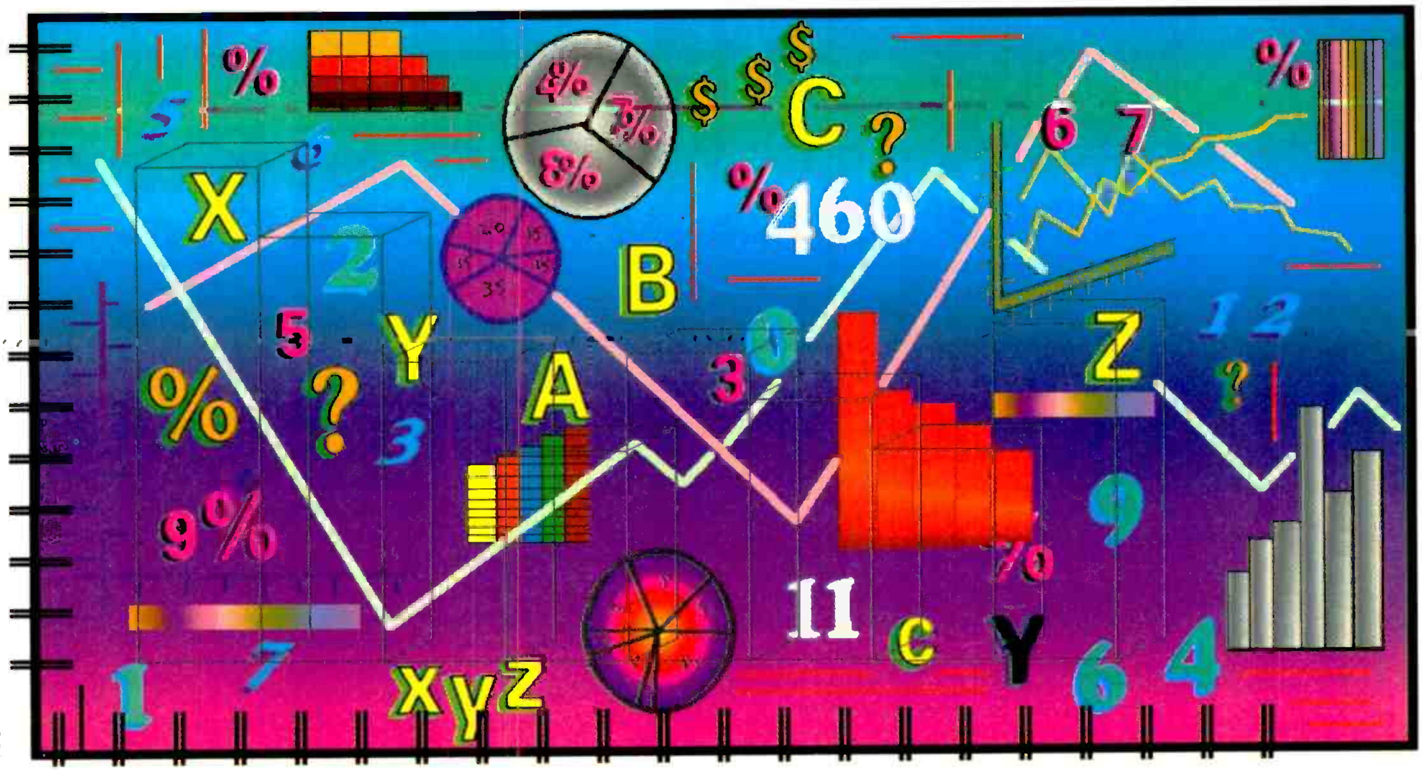
When a signal is applied to the amplifier causing it to source or sink sufficient current (see **Fig. 1**) the device will automatically switch to the awake mode. This takes about 10µs for a 600Ω load rising to 20µs for a 10kΩ load. In the high bandwidth state, the device will swing 27V peak to peak into a 600Ω load for a ±15V supply. A first stage PNP differential amplifier exhibits low noise characteristics in both operational modes while an all NPN output stage behaves symmetrically for both source and sink with AC waveforms.

The *MC33102* will begin to function at power supply voltages as low as V_s±1.0V at room temperature although the output swing will be limited to a few hundred millivolts. The input voltage must range between the power rail voltages and, specifically, must never go more than 0.3V below the negative power rail. Also, exceeding the common mode voltage range may cause phase reversal.

When power is initially applied, the part may start to operate in the awake mode as the internal capacitors charge up. Without further signal, it will revert to standby in about one and a half seconds. Bringing up the power rails slowly prevents premature switching to the awake state.

The amplifier is designed to switch from standby to full operation whenever the output terminal tries to deliver more than 160µA to the load. The output switching threshold voltage is thus determined by the load resistance. Large value load resistors require a large output voltage to switch but reduce unwanted transitions to the awake state. The importance of this concerns circuit configurations requiring a large closed loop gain. Care should be taken that the input offset multiplied by the gain can produce an output offset voltage large enough to trigger the awake state when coupled into low value loads.

Since mode switching depends on output current, capacitive loads will trigger the change. Generally speaking, about 1000pF is the maximum which can be connected across the output without the device changing state. ■


TRACY MARTIN

Expert touch turns damned lies into statistics

How appropriate is your statistical analysis? Don Bradbury finds SNP is an expert that is happy to provide the answers.

What does my data actually mean? Even statisticians faced with an overwhelming choice of statistical analysis probably welcome a little help from an "expert" from time to time.

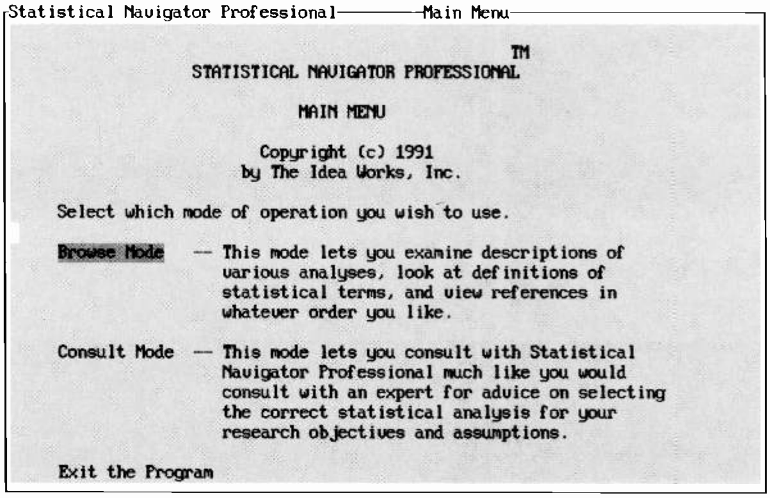
But most industrialists, executives, scientists, engineers, and even mathematicians are only involved with statistics on an amateur basis. Some may have had formal training in the subject, but statistical techniques have evolved at such a rate in recent years that an amateur's expertise is rapidly out of date.

Unfortunately, inappropriate statistical technique can give totally misleading results. What would be ideal would be to have an expert on tap to help ensure avoidance of an incorrect choice of test, and this is the aim of *Statistical Navigator Professional* (*SNP*) from The Idea Works, Columbia, Missouri. Written using Borland's Turbo Pascal and the hypertext (see box) expert system shell *Knowledgepro* from Knowledge Garden, it offers advice on appropriate forms of statistical analysis for research projects, dissertations and published articles.

The package even goes so far as to suggest software to carry out the analysis, aiming the user at such well established programs as *SPSS*, *SAS*, *Systat*, and *Statgraphics* among others.

The expert system is described by its authors as a "thought tool". But users should bear in mind that there is no substitute for a little of the old grey matter – after all, you have to ask a live expert the right questions to prompt the appropriate responses. In just the same way if you misinform the expert system it will probably not give the answer you need.

Main menu allows users to decide on two different operation modes



Graduated terminology

Lack of familiarity with statistical terminology can frequently be a problem – any user fully understanding the questions would probably be sufficiently expert to manage without the software. But *SNP* attempts to overcome this difficulty by providing a choice of four different levels of interrogation.

The first level assumes a good understanding of the subject and offers a wide choice of common statistical methods, such as causal analysis, measures of association, and scaling and classification. From here the user can go directly to obtaining a recommendation from the system.

For those less sure of their ground, wanting to select a general category of analysis, level two starts with a brief list of common questions, allowing selection of the option that best describes the objective. The expert system then guides the user to an appropriate general category of analytical techniques.

Thirdly, the enquirer can peruse several lists of questions, more detailed than the shorter list, with answers allowing the expert system to define the problem more fully.

Finally, for those who need just the most basic assistance, *SNP* offers a natural language interface where the user can enter a statement, in English, from which the system tries to identify suitable categories of statistical analysis.

In this mode, *SNP* attempts to recognise key words or phrases by which it can identify an intended analytical procedure.

I made several entries in this mode – confining myself to the sort of statement a novice statistician might use – and the expert system generally came up with something meaningful that was useful as a starting point.

Whichever method is used, the outcome is identification of a category of analytical techniques. But if the result is not good enough, any of the other methods of interrogation can be used as well. The process can continue until a user is confident that the recommendation is appropriate – a useful option as the expert system is given the chance to investigate various forms of terminology commonly used in research literature. In specialist fields, statements can mean different things to different people.

Consult or browse

SNP main menu lists a choice of BROWSE or CONSULT and in the latter mode, users are guided to a selected form of statistical analysis. Screens require input of an objective, assumptions being made, and the intended readership of the analysis. The report provided by the system can be saved to disk for later use so that the consultation does not have to be completed in one session. Reports may be viewed on screen or printed out.

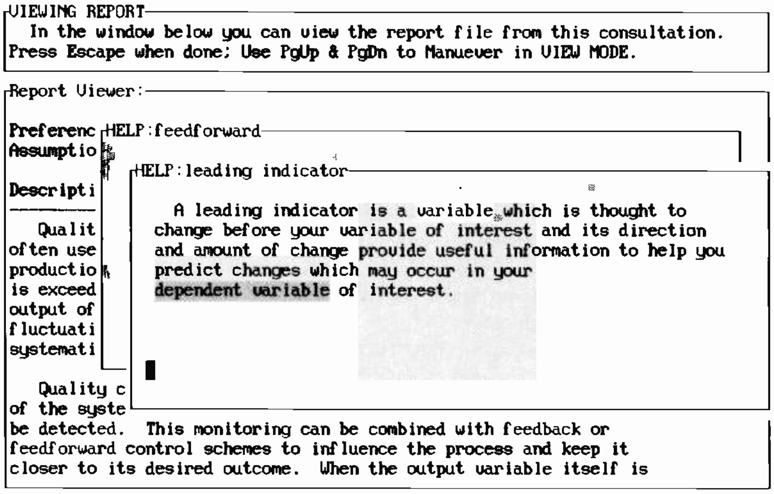
In CONSULT mode *SNP* offers such a weight of information – and unavoidably uses so much statistical jargon – that users need to know at least what the terms mean. Although liberally sprinkled with excellent hypertext links to key terms, the too-frequent recourse to looking up terms not only slows progress but is also a little frustrating.

Running the system on quite powerful hardware does not provide conspicuously rapid progress. There are noticeable delays in production of help screens and submenus, for example, so there is a tendency to avoid looking up too many references or using too many of the hypertext threads to subordinate material.

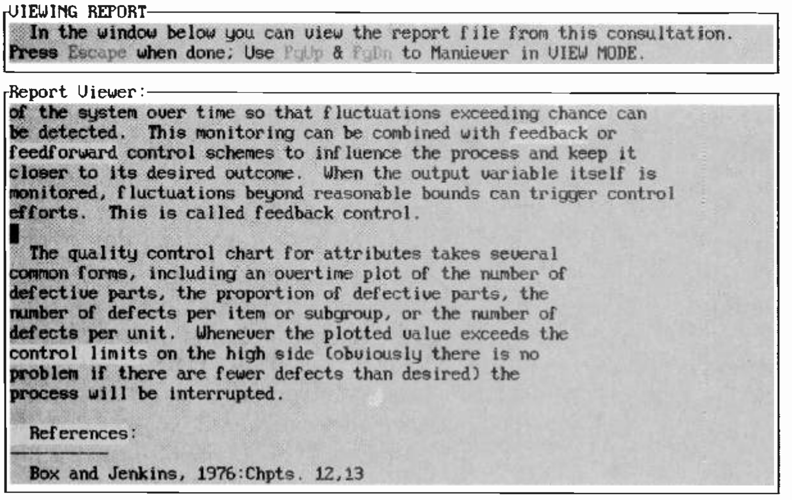
But for looking up the odd reference or two, they are really excellent and useful .

SYSTEM REQUIREMENTS
IBM-compatible PC
512K free ram
One floppy drive
Hard disk
All common graphics modes supported
Mouse speeds navigation of the menus.
Install batch file has to be applied in the form INSTALL C SN 5 COLOR, where C is installation drive and 5 (or 3) is the floppy disk size
Zipped files on the five 5.25in install disks are "exploded" by PKWare's Pkunzip
SNP can be run under Windows using the dos command prompt
Expanded/extended memory not currently supported (SNP periodically "gathers memory" as required; a delay not too protracted on reasonably quick hardware).

Hypertext linking allows detailed information to be accessed on specific problems.



CONTINUED OVER PAGE


VIEWING REPORT
In the window below you can view the report file from this consultation.
Press Escape when done; Use PgUp & PgDn to Maneuver in VIEW MODE.

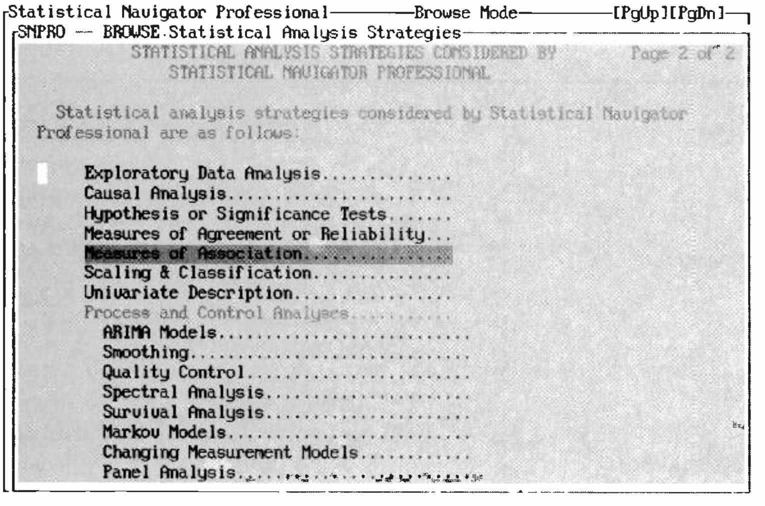
Report Viewer:
of the system over time so that fluctuations exceeding chance can be detected. This monitoring can be combined with feedback or feedforward control schemes to influence the process and keep it closer to its desired outcome. When the output variable itself is monitored, fluctuations beyond reasonable bounds can trigger control efforts. This is called feedback control.

The quality control chart for attributes takes several common forms, including an overtime plot of the number of defective parts, the proportion of defective parts, the number of defects per item or subgroup, or the number of defects per unit. Whenever the plotted value exceeds the control limits on the high side (obviously there is no problem if there are fewer defects than desired) the process will be interrupted.

References:

Box and Jenkins, 1976:Chpts. 12,13

Report of an SNP interrogation.


Statistical Navigator Professional—Browse Mode—[PgUp][PgDn]
SNPRO — BROWSE Statistical Analysis Strategies
STATISTICAL ANALYSIS STRATEGIES CONSIDERED BY STATISTICAL NAVIGATOR PROFESSIONAL
Page 2 of 2

Statistical analysis strategies considered by Statistical Navigator Professional are as follows:

Exploratory Data Analysis..............
Causal Analysis........................
Hypothesis or Significance Tests.......
Measures of Agreement or Reliability...
Measures of Association................
Scaling & Classification...............
Univariate Description.................
Process and Control Analyses...........
ARIMA Models...........................
Smoothing..............................
Quality Control........................
Spectral Analysis......................
Survival Analysis......................
Markov Models..........................
Changing Measurement Models............
Panel Analysis.........................

SNP suggests a strategy for the best analysis of data.

Consultation type

The main screening menu is presented as a choice of the four basic consultation methods; general types of analysis, list of research questions, a different list of questions organised by major category of analysis, and the natural language procedure.

In the first category, nine divisions are itemised and a user must decide whether to apply causal analysis, significance tests, measures of association or reliability, scaling and classification, process and control analysis, or exploratory data analysis. The final category is "none of these, let's try another approach" – a comment typical of *SNP*. The package tries hard not to let the relatively inexperienced feel high and dry, in what is a relatively esoteric subject, by inviting consideration of a different method of investigation.

A further attraction is that the list of possible approaches is not just a menu, it is also a link to other screens achieved through hypertext threading. Hypertexted information on the subject is selected by using either a mouse, or by function key F3 to locate the item and then F4 to select. If no information is needed on the subject, the broad category of analysis is selected by entering the number of the category in the list.

Common phrases

The "list of common phrases describing research objectives" mode of interrogation is mainly provided because of potential terminology difficulties. Workers in one discipline will recognise stock expressions common to their work, but others may not.

For example one phrase reads "develop and test causal models"; another, "assess the impact of an independent variable on a dependent variable"; and a third, "compare the value of one group with a known population value".

As before, the last option is "none of these appear appropriate, let's try another approach", so, again, there is some continuity for the hesitant.

Most workers will be able to associate with one or two of these expressions, and it will be fairly obvious in most cases which of them best describes the problem in hand. If it is still not clear, remember that other options will let you supplement one conclusion with another, and thus build confidence in the overall methodology finally selected.

The natural language interface is the last category, and here, it has to be admitted, there may be some ambiguity. But it is a useful option, not to be lightly dismissed, and its use can add weight to conclusions drawn by other modes of attack. Usually it will be the mode chosen by the novice since it is probably the least specific approach.

More than one approach

It is worth pointing out that a single statistical appraisal of a data set is unlikely to produce a complete analysis. There may well be two or more tests to apply before a satisfactory conclusion can be reached. But unlike some programs, *SNP* suggests the four procedures that appear the most suitable – given the information the user provides. The procedures are ranked in order of likely suitability for the problem, and the four best are identified out of what might be a substantial array.

A detailed report is then given showing *SNP*'s recommendation and an appropriate selection can be made from the list of recommended analysis software. Finally, a point-by-point explanation is given of just how appropriate, or otherwise, a particular technique is for the problem.

Hypertext

Hypertext refers to presentation of text or graphics in a layered arrangement. The top layer contains the main body of information while lower tiers hold subsidiary detail, referenced by hypertext phrases. Detail information overlays the top layer screen until removed by users and it too may contain reference to still lower levels of detail. Any number of layers is theoretically possible.

Objective versus aim

The program also concerns itself with the "audience receptivity" of a selected analytical technique. After it has been given all the information concerning objectives and assumptions, *SNP* proceeds to calculate scores for each analytical technique.

Four best-fit approaches satisfying the objectives are given, and from these the user is asked to indicate the extent to which an "audience" expects or prefers to see the analysis used with respect to their problem. A 0-10 score is requested, and audience receptivity is then graphically indicated.

The four best techniques are again hypertexted, and any unfamiliarity with a particular approach can be quickly described and cross-referenced by following the threads.

The comprehensive manual, after describing in detail all of the foregoing processes, proceeds to add weighty material on specific topics of interest and relevance to the subject, and it includes notes concerning the on-line, context-sensitive help system (summoned by F1), specific statistical techniques which are extensively discussed, a broad list of references, and an index. Well-bound and paper-backed, the manual constitutes a reference that would surely find a welcome home in appropriate establishments.

Wide appeal

There is little point in delving further into the mysteries of statistical analysis of data sets as tackled by this excellent program.

It is enough to say that *SNP* will be found invaluable in many laboratories, schools, scientific institutions and government departments. In fact anywhere that does not have access to a specialist in the subject.

At only £130, the package will be valued by any PC user working in a relevant field of activity and after just a little time gaining familiarity, applying the program becomes second nature.

Within an organisation, *SNP* will probably be handed to someone who has the time and natural inclination to wrestle with such problems. The package will surely transform that person into the resident specialist, becoming the reference point for others less familiar with statistics. ■

```
Statistical Navigator Professional——————Browse Mode——————[PgUp][PgDn]
SNPRO -- BROWSE:Alphabetized list of terms
                              TM
                          HYPER-STAT
              A HYPERTEXT GLOSSARY OF STATISTICAL TERMS
              Copyright (c) 1991 by The Idea Works, Inc.

                    ALPHABETICAL INDEX        15 Pages
                                         [PgUp] [PgDn]
About the browse mode
accelerated failure time model
actuarial analysis
acyclic function
additive
age effects
aggregate change
agreement
agreement among multiple items
Alphabetized list of terms
analysis of variance
association
assumptions
ASSUMPTIONS
```

The package tries hard not to let the relatively inexperienced feel high and dry.

SUPPLIER DETAILS
Statistical Navigator Professional, £130, is sold by The Core Store Ltd., The Studio, Hawthorn Cottage, Marbury Road, Comberbach, Northwich, Cheshire CW9 6AU. TEL: 0606 891980, who also provide support for the program within the UK.

Auto-validation for neater netlists

John Anderson ***reports on software that could mean checking for netlist errors is just that little bit easier.***

SUPPLIER DETAILS

The software currently works with netlist files for Seetrax Ranger 1 software, and runs on a standard PC - text mode only. For more information contact Markie Enterprises, 60 Park Drive, Ascot, Berks SL5 0BE.

Syntax checking program Wirechek was born to help overcome the problems encountered in tracking down errors in hand-written netlists.

David Markie, developer of the software, had been working with the Seetrax Ranger 1 PCB package, and wanted to introduce a degree of automation into the validation process.

He designed Wirechek to be used as a filter for netlist errors prior to PCB layout to screen before committing to copper. The program could prove most useful for schematics captured as netlists by hand and for checking all nodes of a design for floating inputs etc.

Some PCB cad programs offer this facility as standard – Protel Autotrax for example. But for those packages that do not, Markie's program is a useful tool.

On start up, a set of text windows is displayed, and the program is controlled by moving a cursor through the static set of options presented in the text windows. Cursor movement can be controlled by cursor keys or a mouse. Function key F1 gives brief context sensitive help.

Wirechek comprises two parts: the input parser and syntax checker and a library of components.

Checking reads in the netlist and checks the pins of the device against the library model; any pins remaining once the whole file has been scanned represent unconnected nodes. If any of these are inputs, then they are floating and a warning is generated. After completion, the program produces a report file detailing errors and warnings.

The component library is stored in simple ascii format, and can be supplemented as required.

Wirechek can be run from floppy drive, but the performance is rather slow because of the almost continuous disc accesses required.

In practice this program could be organised as a simple filter with a command line interface. But it is its syntax checking function that is important, and clearly there are applications where it could save time and improve quality.

It will be interesting to see if Markie develops the program to work with, and translate, other netlist formats. ■

REPORTED ERRORS

Some of the syntax errors reported by the program in its basic mode are:

Invalid component pin number

Pin number greater than maximum allowed, currently 255

String representing pin number longer than three characters

No component name found – "." read before any component name

Duplicate link name – remainder of line ignored

Duplicate entries of component pins

Only one connection on link

Neither valid link name nor continuation found

Multiple outputs on link

Input/s not driven

Unused pin connected to link

Output connected to supply rail

Open Collector output with no passive pull up

Warning if more than 10 inputs connected to link

Warning if tri-state port is connected to an output

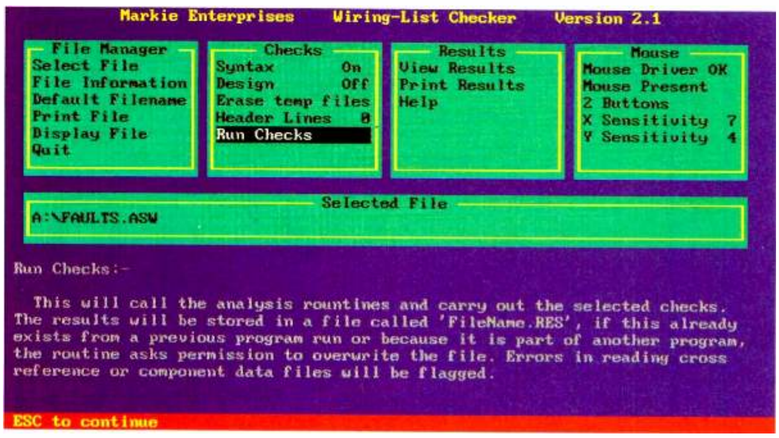
Warning if input/output port is connected to an output

Component name not found in cross-reference file

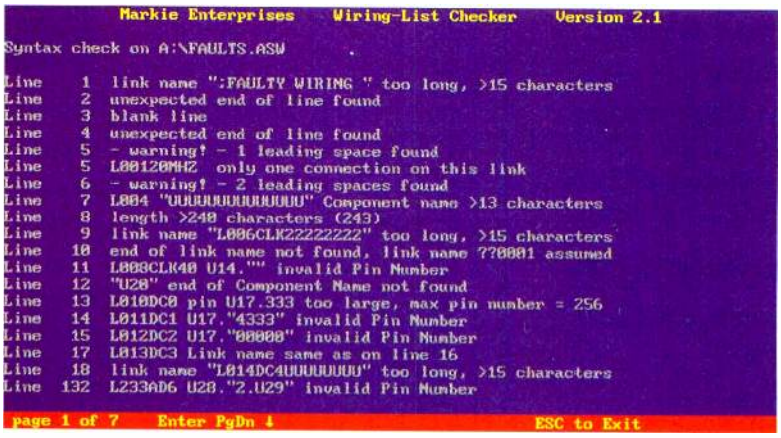
Component not defined in data file

Pin number greater than highest pin number on component

Pins not connected to any link



Window format user screen



Typical Wirechek netlist error report

LOW COST RANGER1 PCB DESIGN FROM SEETRAX

- Circuit Schematic
- Circuit Capture
- PCB Design
- Host Of Outputs

REDUCED PRICE!

All-In-One Design System
£100
Fully Integrated Auto Router
£50

Ask Us About Trade-In Deals

Call Now For Demo Disk on 0705 591037

What The Press Said About RANGER1

For most small users, Seetrax Ranger1 provides a sophisticated system at an affordable price. It is better than EasyPC or Tsien's Boardmaker since it provides a lot more automation and takes the design all the way from schematic to PCB - other packages separate designs for both, that is, no schematic capture. It is more expensive but the ability to draw in the circuit diagram and quickly turn it into a board design easily makes up for this.

Source JUNE 1991 Practical Electronics

Seetrax CAE • Hinton Daubnay House
Broadway Lane • Lovedean • Hants • PO8 0SG
Tel: 0705 591037 • Fax: 0705 599036

Pay by Visa or Access

VISA

CIRCLE NO. 144 ON REPLY CARD

WE HAVE THE WIDEST CHOICE OF USED OSCILLOSCOPES IN THE COUNTRY

TEKTRONIX 2445B Four Channel 150MHz	£2000
TEKTRONIX 485 Dual Trace 350MHz Delay Sweep	£800
IWATSU SS5711 Four Channel 100MHz Delay Sweep	£700
TEKTRONIX 475 Dual Trace 200MHz Delay Sweep	£550
SCHLUMBERGER/ENERTEC 5218 Three Trace 200MHz Delay Sweep	£550
TEKTRONIX 2225 Dual Trace 50MHz Delay Sweep	£500
TEKTRONIX 465 Dual Trace 100MHz Delay Sweep	£450
PHILLIPS PM3217 Dual Trace 50MHz Delay Sweep	£400
GOULD OS3000A Dual Trace 40MHz Delay Sweep	£250
TELEQUIPMENT D75 Dual Trace 50MHz Delay Sweep (with V4 & S2A)	£200
TELEQUIPMENT V3 Differential Amplifier for above	£40
HAMEG 605 Dual Trace 60MHz Delay Sweep	£400
GOULD OS300 Dual Trace 20MHz	£200
IWATSU SS5702 Dual Trace 20MHz	£225
GOULD OS1100 Dual Trace 30MHz	£180
GOULD OS250B Dual Trace 15MHz	£150
TEKTRONIX 422 Dual Trace 15MHz	£125
FARNELL DT12-5 Dual Trace 12MHz	£125
HITACHI V209 Dual Trace 20MHz (AC/DC Operation)	£400

THIS IS JUST A SAMPLE • MANY OTHERS AVAILABLE

ELECTRON MICROSCOPES

A.E.I. Corinth 500 – Transmission
I.S.I. Super 111A – Scanning

MARCONI 2440 20GHz Microwave Counter	£1500
MARCONI 2610 True RMS Voltmeter	£800
FARNELL SSG1000 Sig Gen 10MHz–1GHz Synthesised	£1750
MARCONI 2019 Sig Gen 80kHz–1040MHz	£1800
MARCONI 2022A Sig Gen 10kHz 1GHz	£1500
FARNELL Synthesized Oscillator DSG1 – 0 0001Hz 99 99kHz	£275
MARCONI TF2015 AM/FM 10-520MHz Sig Gen with TF2171	£400
MARCONI TF2015 without Synchroniser TF2171	£250
MARCONI TF2016 AM/FM 10kHz–120MHz with TF2173	£350
MARCONI TF2016 without Synchroniser TF2173	£175
MARCONI TF2356/2357 Level Osc/Meter 20MHz the pair	£950
MARCONI SANDERS Sig Sources Various models Covering 400MHz 8 5GHz	from £300
RACAL 9009 Mod Meter 10MHz–1 5GHz	£350
RACAL Instrumentation Recorders Store 4D and Store 7D	from £500
KEITHLEY 224 Programmable Current Source	£1000
FERROGRAPH RTS2 Recorder Test Set	from £150

FARNELL SSG520 Synthesised Sig Gen 10–520MHz	£600
FARNELL TTS520 Transmitter Test Set. Consisting of RF/AF Counter, RF Mod Meter, RF Power Meter, AF Voltmeter, AF Distortion Meter, AF Synthesiser	£600
SOLD as a pair for **ONLY**	£1000

SPECTRUM ANALYSERS

ANRITSU MS68B 10kHz-4 4GHz	£4000
ANRITSU MS62B 10kHz–1700MHz	£2000
HP 141T with 8555A & IF Plug-in 10MHz 18GHz	£2500
HP 141T with 8554B & 8552B 500kHz 1250MHz	£1500
HP 140T with 8554L & 8552A 500kHz 1250MHz	£1200
HP 141T with 8556A & 8552B 20Hz 300kHz	£1250

PHILLIPS PM2525 Multi Function DMM 4 5–5 5-digit with GPIB/IEEE-488	Only £300
THURLBY PL320T-GP Bench PSU 0 30V 2-Amp Twice with GPIB	£350
HAND-HELD MULTIMETERS – 3 5-digit DM105 14 Ranges DC–2Amp.	Only £18
M2355 – 32 ranges AC/DC 10 Amps, Diode/Transistor Tester, Freq counter etc	Only £32.50

RACAL/DANA Syn Sig Gen 9084 0 01–104MHz	£500
RACAL/DANA RF Power Meter 9104	£800
RACAL/DANA 202 Logic State Analyser with 68000 Disassembler	£500
WAYNE KERR LCR Meter 4210 Accuracy 0 1%	£600
WAYNE KERR LCR Meter 4225 Accuracy 0 25%	£500
AVO AC/DC Breakdown Leakage & Ionisation Tester RM215L/2	£600

MARCONI DIGITAL FREQUENCY METERS

Type 2430A	10MHz 80MHz	£125
Type 2431A	10MHz–200MHz	£130

MARCONI UNIVERSAL COUNTER TIMERS

Type 2437	DC–100MHz	£175
Type 2438	DC 520MHz	£225

THORN PSU 0 40V, 0 50Amps Metered	£300
FARNELL PSU H60/25 0–60V, 0–25Amps Metered	£400
FARNELL PSU L30E 0–30V; 0 5Amps Metered	£80
TELEQUIPMENT CT71 Curve Tracer	£250
MARCONI TF2700 Universal LCR Bridge Battery	from £125
MARCONI TF2337A Auto Distort Meter 400Hz 1kHz 0 01%	£175
RACAL 9915 Freq Counter 10Hz 520MHz (Crystal Oven)	£150
MANNESMAN TALLY Pixy 3 X Y Plotter RS232	£100

AVO MULTIMETERS

MODEL 8 or 9 (what's available)	£40 each
Test Set No 1 8X, 9SX	from £45
8 Mk 5 with Carrying Case	£90
8 Mk 6 with Carrying Case	£120

All Meters Supplied with Batteries & Leads

NEW EQUIPMENT

HAMEG OSCILLOSCOPE HM1005 Triple Trace 100MHz Delay Timebase	£792
HAMEG OSCILLOSCOPE HM604 Dual Trace 60MHz Delay Sweep	£610
HAMEG OSCILLOSCOPE HM203 7 Dual Trace 20MHz Component Tester	£338
HAMEG OSCILLOSCOPE HM205 3 Dual Trace 20MHz Digital Storage	£610

All other models available – all oscilloscopes supplied with 2 probes

BLACK STAR EQUIPMENT (P&P all units £5)

APOLLO 10 100MHz Counter Timer Ratio/Period/Time interval etc	£222
APOLLO 100 – 100MHz (As above with more functions)	£325
METEOR 100 FREQUENCY COUNTER 100MHz	£109
METEOR 600 FREQUENCY COUNTER 600MHz	£135
METEOR 1000 FREQUENCY COUNTER 1GHz	£178
JUPITOR 500 FUNCTION GEN 0 1Hz-500kHz Sine/Sq/Tri	£110
ORION COLOUR BAR GENERATOR Pal/TV/Video	£229

All other Black Star Equipment available

OSCILLOSCOPE PROBES Switchable ×1 ×10 (P&P £3) £11

Used Equipment – With 30 days guarantee. Manuals supplied if possible.
This is a VERY SMALL SAMPLE OF STOCK. SAE or Telephone for lists Please check availability before ordering
CARRIAGE all units £16 VAT to be added to Total of Goods and Carriage

STEWART of READING
110 WYKEHAM ROAD, READING, BERKS RG6 1PL
Telephone: (0734) 268041. Fax: (0734) 351696. Callers Welcome 9am–5.30pm Mon–Fri (until 8pm Thurs)

VISA

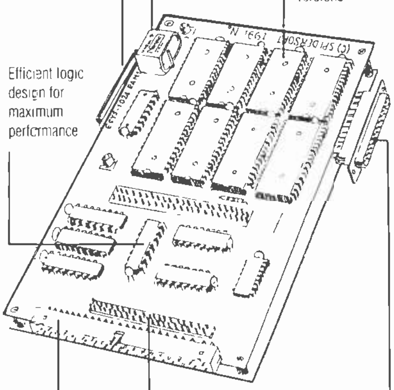
CIRCLE NO. 145 ON REPLY CARD

21st Century Electronics
56b Milton Park
Abingdon
Oxon OX14 4RX
Great Britain

ESYS

ROM EMULATORS

- *Fastest download on the market – over 500 Kbits/second*
- *Connects to PC parallel port – no special interface card required*
- *Supports 8/16/32 bit applications*
- *Portable – battery backed memory*
- *Comprehensive download/upload software for Binary, Intel Hex and Motorola S-Format*
- *Optional add-in board for full 2-way host-target communications*



CALL, WRITE OR FAX FOR MORE INFORMATION:

Tel: 0235 832939 Fax: 0235 861039

A Division of 21st Century Entertainment Limited

CIRCLE NO. 146 ON REPLY CARD

Split personality of hybrid directional couplers

Splitting power equally between a directional coupler's normal load and one of the coupled ports creates a hybrid circuit. Dick Manton looks at the hybrid's operation and application.

Uses of directional couplers in monitoring forward and reverse power have already been reviewed (*Sorting out the plumbing with directional couplers, EW + WW*, June, pp. 468-470). Here we are going to concentrate on circuits splitting power equally between the directional coupler's normal load and one of the coupled ports to create what are called hybrids or, sometimes, diplexer circuits.

For instance the BBC uses a high-power hybrid, consisting of inductors and capacitors, to combine the power of two 250kW transmitters into its Droitwich low-frequency antenna. Printed circuit hybrids are used throughout the communications industry for combining and splitting low or medium power in the VHF and UHF frequency ranges. Tiny copper-tape-wound hybrid transformers, potted in resin, have various uses in low power circuits below 100MHz.

In a hybrid network, power fed into any port is split equally between the two adjacent ports (**Fig. 1**) and, provided that the loads are perfectly matched, no power reaches the opposite port. But this is not the whole of the story as there is always a definite and important phase difference between the input and two output voltages. The result is that there are two distinct classes of hybrid: quadrature and sum-and-difference.

Quadrature types have two output voltages,

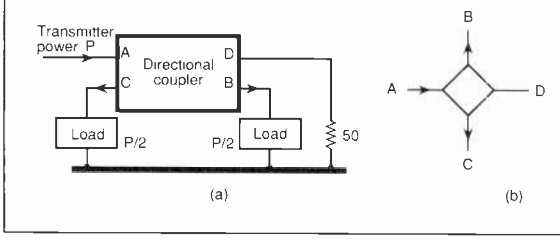


Fig. 1(a). A directional coupler in which the forward power is split equally between two output ports. 1(b) symbol for a hybrid.

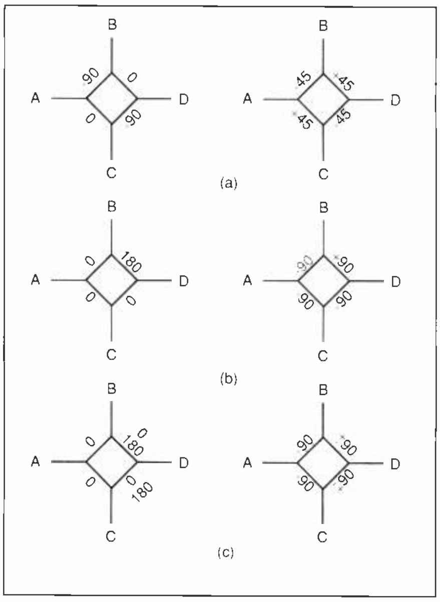


Fig. 2. Symbols showing phases: (a) quadrature type; (b) 0-180° or sum-and-difference type, (c) 0-180° type with some balanced terminals.

Table 1. Theoretical bandwidths of principal types of hybrid.

Hybrid	used as a splitter			used as a combiner	
	Input reflection <10%	P_B/P_C <±0.5dB	P_A/P_D >30dB	Input reflection <10%	$(P_B+P_E)/P_D$ >30dB
3dB coupler	∞	42%	∞	∞	44%
2.8dB coupler	∞	58%	∞	∞	60%
Maxwell bridge	∞	11%	∞	∞	12%
Capacitively-coupled	11%	3%	3%	8%	3%
Rat-race	27%	22%	11%	17%	11%
Wilkinson	37%	∞	∞	37%	∞
Bridged-T	30%	∞	∞	30%	∞
Transformer	can be several octaves depending on manufacture				
Waveguide magic-T	up to 50%				

The figures indicate bandwidth as a percentage of operating frequency

differing in phase by 90°, and two planes of symmetry. The 0-180° or sum-and-difference type has the two output voltages either in phase or 180° out of phase with each other, depending on which port is used as the input. Symmetry is limited to one plane.

If the paths between ports are labelled according to phase change in proceeding from one port to the next (**Fig. 2**), the properties of hybrids can be seen more clearly. Some types have ports which are balanced, or not directly connected to ground, so voltage phases are somewhat ambiguous and alternative phases have to be given (**Fig. 2c**).

In this article we shall consider only applications where a single modulated or unmodulated signal is involved – multiple-frequency applications will be considered in a later article – and, unless stated otherwise, assume a 50Ω system where all output ports of the hybrid are terminated by 50Ω resistive loads. In most circuits, account should be taken of the phasing of hybrids and so separate circuits are shown for quadrature and 0-180° hybrids.

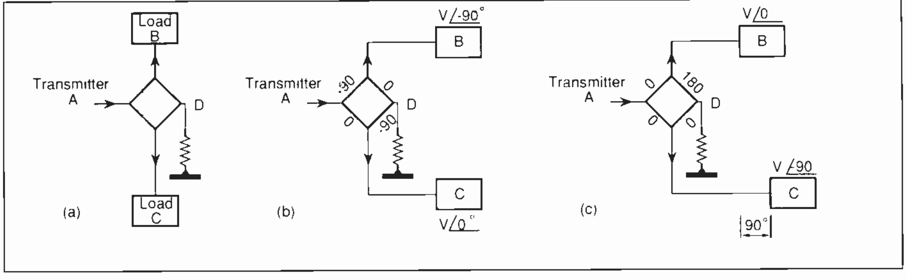


Fig. 3. Hybrids used as power splitters: (a) simple split; (b) quadrature feed with quadrature hybrid; (c) quadrature feed with 0-180° hybrid.

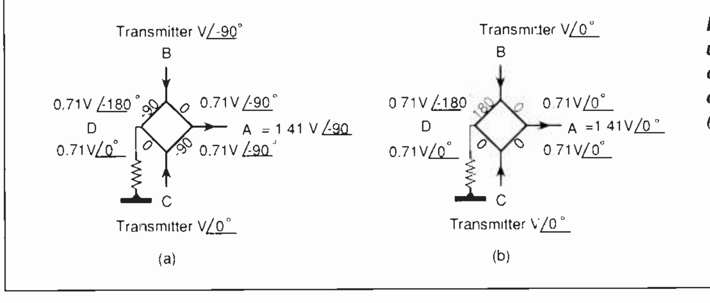


Fig. 4. Hybrids used as power combiners: (a) quadrature type; (b) 0-180° type.

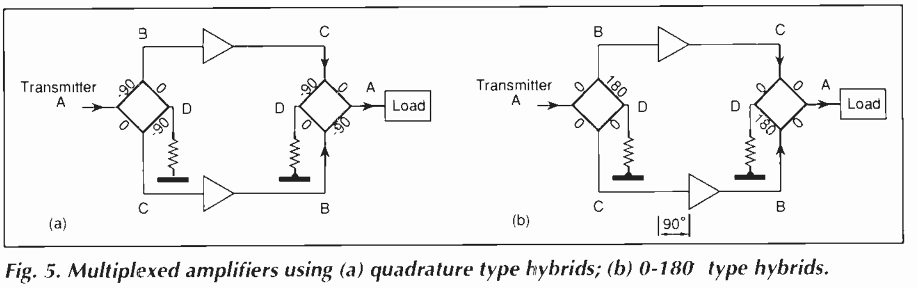


Fig. 5. Multiplexed amplifiers using (a) quadrature type hybrids; (b) 0-180° type hybrids.

Splitting transmitter or antenna power

When power is split between two loads (**Fig. 3**) simply by a transformer and T-junction, there is a high probability that failure of one load or its removal will result in a large change in the amount of power arriving at the remaining load. In the limit, an open-circuit a quarter-wavelength away from the T-junction would result in no power reaching the remaining load. A hybrid with a balancing load used to split the power overcomes this difficulty. Equal-amplitude forward waves, with phases appropriate to the hybrid, always reach each termination and any reflected power is split equally between the transmitter and the load on port *D*.

Any change in voltage applied to one load, brought about by a change in the other, results from a mismatch of the load *D* or the transmitter. The worst voltage reflection coefficient that can be presented to a transmitter by a single fault on a load is 50% (VSWR=3).

Equal loads, arranged to be fed with equal quadrature currents (**Fig. 3b** and **3c**), will receive their correct relative currents regardless of mismatch. A matched load is always presented to the transmitter and all reflected power is transferred to load *D*.

Combining the power of two transmitters

Output power of transmitters operating on the same frequency can be combined (**Fig. 4**) into a single matched load *A* by appropriately locking their phases and feeding them into ports *B* and *C* of a hybrid. In this way the two transmitters remain isolated and independent of each other. If *V* is the input voltage of each transmitter, 0.71V arrives initially from each transmitter at ports *A* and *D*. But phases are such that these voltages add at port *A* and subtract at port *D*.

One transmitter can be removed altogether, without power from the other transmitter reaching its terminals, provided that the loads on ports *A* and *D* are matched. But in this case the remaining power would be divided equally between ports *A* and *D*.

In general, where equal cophased input voltages would add in load *A* (**Fig. 4b**), the powers in loads *A* and *D* are given by

$$P_A = 0.5(P_B+P_C)+\sqrt{(P_BP_C)}\cos\theta$$
$$P_D = 0.5(P_B+P_C)-\sqrt{(P_BP_C)}\cos\theta$$

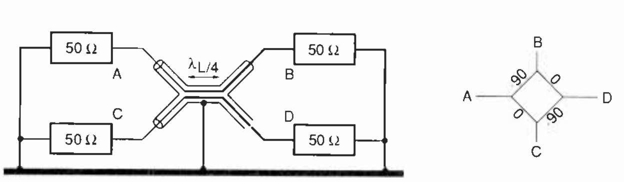
where θ is the phase difference between P_B and P_C.

Multiplexing amplifiers

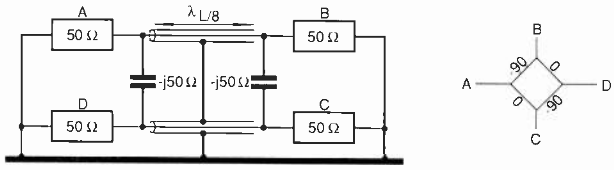
The above principles may be combined where multiple low-power amplifiers are used

Hybrid circuits

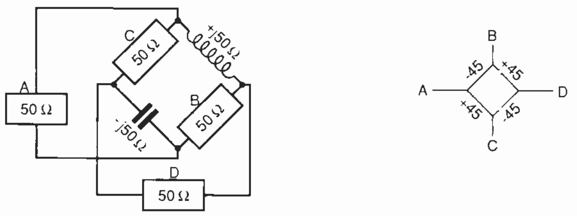
Three of the example hybrid circuits given here are derived from ordinary directional couplers and are quadrature. The remainder do not have any familiar low-coupling equivalents and are all 0-180° types. Indications of bandwidths for stated parameter variations are given in Table 1.



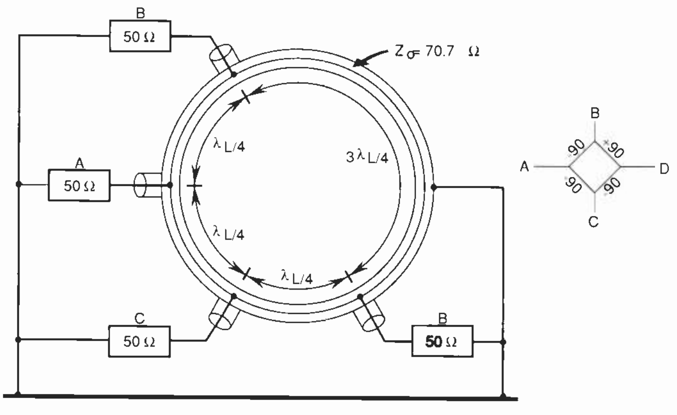
3dB coupler – quadrature type. Equations relating to the design of coupled transmission lines were given in the last issue of EW + WW. In the 3dB coupler the voltage coupling factor $k_{max} = 1/\sqrt{2} = 0.707$ and the coupled electrical length is $\lambda_A/4$. Greater useable bandwidth can be obtained by overcoupling the lines to give kmax = 0.725 (2.8dB coupler). These types of hybrid are useable in the frequency range 30-1000MHz.



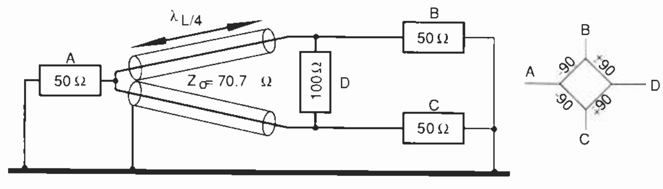
Capacitively-coupled transmission lines – quadrature type is a very narrow-band hybrid which can be used between 10MHz and 100MHz.



Maxwell bridge – quadrature type is a useful hybrid for frequencies below 30MHz, with the disadvantage that, without the use of transformers, not more than two ports can be connected to ground.



Rat-race or Lorenz ring – 0-180° type normally consists of a ring of transmission line with a characteristic impedance of 70.7Ω. It has a good bandwidth and is useful in the frequency range 30-3000MHz. (A 50Ω transmission line version has three arms $0.152\lambda_L$ long and one arm $0.652\lambda_L$, but its bandwidth is inferior to that of the 70.7Ω version).



Bridged T – 0-180° type has a good bandwidth and is useful for frequencies below 30MHz. One load has to be isolated from ground.

(**Fig. 5**) to form a medium-power transmitter. Some power from the drive oscillator will reach each amplifier, regardless of its input impedance and if one amplifier fails, half of the remaining power will continue to be delivered to load *A*. If the two amplifiers are identical, then the drive will see a matched load. Also, any reflection from the load on the second port *A* will be absorbed and cannot be re-reflected. Only a single pair of amplifiers is shown, but the process can go on being repeated in powers of two as far as is practicable.

Varying amplitude and phase of a signal

If ports *B* and *C* are terminated by identical networks and port *D* is terminated by a matched load, the input will be matched (**Fig. 6**). But the voltage at *D* will be dependent on the input impedance or return-loss of each network. In the simplest case the networks can be switches, opened and closed to give phase changes of 180°. Ganged variable capacitors will change the phase of the signal by 90° as each reactance changes between –jω and –j50Ω.

Similarly, ganged variable resistors will form an attenuator which increases towards ∞dB as each resistance approaches 50Ω. Networks with suitably designed return-loss characteristics can be used to provide any desired voltage/frequency characteristic across the bandwidth of a channel. ■

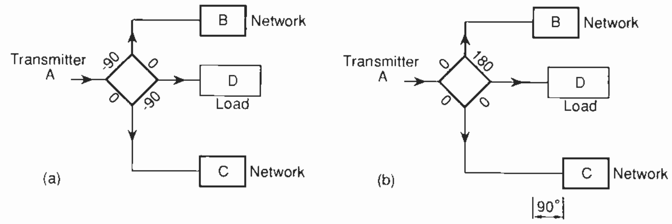
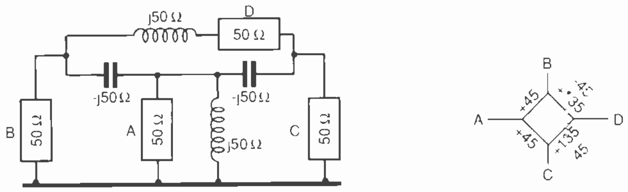
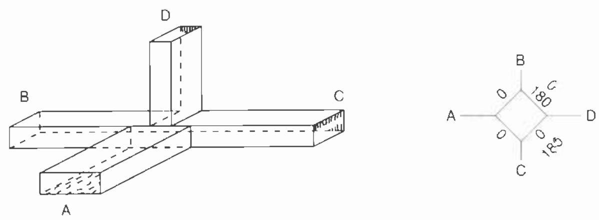


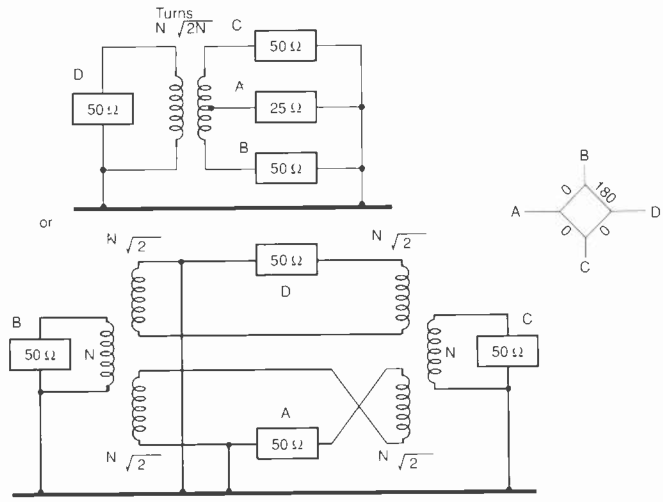
Fig. 6. Amplitude and phase variation using (a) quadrature type hybrids; (b) 0-180° type hybrids.



Wilkinson – 0 -180° type can be derived from the rat-race, but because cancellation of signals at port D does not rely on a half-wavelength of line, its bandwidth is greater. The disadvantage is that the load on port D needs to be 100Ω and balanced, but it is easy to fabricate and useful in the frequency range 30-3000MHz. (A 50Ω line version needs short-circuited transmission line stubs on ports B and C and a capacitor across load D.).



Transformer – 0-180 type is an excellent hybrid for frequencies up to 100MHz. It is degraded only by transformer performance. In its simpler version one load has to be 25Ω.



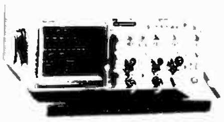
Waveguide magic T – 0-180 type has a theoretically perfect performance over the useable frequency range of the waveguide, although in practice it may be degraded by mode break-up at the junction.

RALFE · ELECTRONICS

36 EASTCOTE LANE, S. HARROW, MIDDLESEX HA2 8DB
TEL: 081-422 3593. FAX: 081-423 4009

EST 35 YEARS

SPECTRUM ANALYSERS



HP141T/8552B/8554B 1250MHz system	£1750
HP182C/8558B 0.1-1500MHz spectrum analyser	£1750
HP182T/8559A 21GHz system	£5000
HP35660A dynamic analyser 244μHz-102kHz	£3500
HP3580A 5Hz-50kHz opt 01. Digital readout model	£2000
As above but without option, mechanical readout	£1500
HP3582A dual-channel 25kHz analyser	£4000
HP3585A 40MHz analyser	£6000
MARCONI TF2370 110MHz analyser	£2250
TEKTRONIX 7L12 0.1MHz-1.5GHz in 7403N frame	£1350
ANRITSU MS62B 10kHz-1700MHz	£2000
ANRITSU MS68B 10kHz-4.4GHz	£4000
MARCONI 2380/2382 400MHz system	£5000

MARCONI INSTRUMENTS

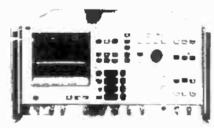
2019 synthesized signal generator 10kHz–1040MHz	£2000
2091C/2092C white noise receiver/transmitter, pair	£1000
2017 10kHz-1024MHz AM/FM signal generator	£2500
2356/2357 level oscillator/level meter	£500
2380/82 400MHz spectrum analyser	£5500
2388 1GHz active probe	£450
2347 100MHz timer/counter	£175
2501 RF power meter 0.3W DC-1GHz	£150
2503 RF power meter to 100W DC–1GHz	£200
2828A/2829 digital simulator/analyser	£1500
2830 multiplex tester	£1500
2833 digital in-line monitor	£250
2870 data communications tester	£1000
2955 mobile radio test set (75W version)	£3750
2956 NMT cellular adaptor, latest issue software	£1250
6460 microwave power meter with head 6421	£300
6700B sweep oscillator 8-12.4 GHz	£750
OA2805A PCM regenerator test set	£750
TF1245A Q-Meter with 1246 and 47 oscillators	£400
TF2006 FM signal generator 10–1000MHz	£350
TF2015/2171 signal generator AM/FM 10-520MHz	£400
TF2162 audio frequency attenuator	£100
TF2163S DC-1GHz attenuator	£350
TF2370 110MHz spectrum analyser	£2250
TF2910/4 non-linear distortion (video) analyser	£1000
TF2914A TV insertion signal analyser	£1250
TF2910 TV interval timer	£500

URGENTLY REQUIRED — 'HIGH-END' test Equipment by brand names. TOP prices paid for HP, TEK, MARCONI etc. PLEASE CALL.

TEST EQUIPMENT

AIM 501 low distortion oscillator GP1B/RS232	£500
ANRITSU MG98A/MH925A optical TDR	£1500
ANRITSU MS62B & 68B spectrum analysers-see above	
AVO CB154/5 electrolytic & tant' cap' bridge	£450
BRANDENBURG Alpha II 507R 0–5kV	£300
BRUEL & KJAER 2307 level recorder	£1000
FARNELL PSG520 signal generator AM/FM 10–520MHz	£750
FLUKE 8010A digital multi-meter	£175
HAMEG HM605 60MHz dual-trace oscilloscope	£295
KIKUSUI COS5040TM 40MHz dual-trace oscilloscope	£150
LING DYNAMICS LA500 (500W vibrator amplifier)	£275
MOTOROLA R-2010D Mobile radio test set	£2950
PHILIPS PM9355 current probe	£350
PHILIPS PM5190 synthesized function generator 2MHz	£950
PHILIPS PM5534 standard pattern generator NTSC	£2500
PHILIPS PM5545 colour encoder PAL	£500
PHILIPS PM5597 VHF modulators £250. PM5598 UHF	£500
PHILIPS PM5580 I.F. modulator	£1500
PHILIPS PM6652 1.5GHz timer/counter GPIB	£850
PHILIPS PM8202 recorder with 9874/01 temp' unit	£450
RACAL DANA 9008A automatic modulation meter	£400
RACAL 9081 signal generator 5-520MHz synthesized	£750
RACAL 9082 signal generator 1.5–520MHz synthesized	£850
RACAL 9105 RF micro-wattmeter 0.02μW–200mW	£250
RACAL 9300 RMS voltmeter −80dB to +50	£325
RACAL Store 4 4-channel tape recorder	£1000
RACAL 9341 LCR databridge component tester	£350
ROHDE & SCHWARZ CMT54 mobile radio test set GPIB	£4250
SCHAFFNER 200C/222/223 interference generator	£1250
SCHLUMBERGER 1250 frequency response analyser	£3250
SCHLUMBERGER 4010 mobile radio test set	£1500
TEKTRONIX 7L12 1.8GHz spec' an' plug-in	£1250
TEKTRONIX J16 digital photometer	£275
TEKTRONIX 1485R full spec' TV waveform monitor	£1500
TEKTRONIX 1503/03/04 TDR cable tester	£1750
TEKTRONIX 465 100MHz dual-trace oscilloscope	£400
TEKTRONIX 465B as above	£450
TEKTRONIX 7623A 100MHz storage main-frame	£750
TEKTRONIX 7613/7A19/7B10 storage scope system	£750
TEKTRONIX 7904/7A19/7A15A/7B70/7B71 500MHz o'scope	£1000
TEKTRONIX 7A13, 7B53A, 7A18, 7B85, 7B87, 7CT1N	£call
TEKTRONIX 475 200MHz dual-trace oscilloscope	£550
TEKTRONIX AFG5110 arbitrary function generator	£1750
THURLBY PL320T-GP 0-30V 2A twice psu. GPIB.	£350
YOKOGAWA 3061-21 6-channel chart recorder	£350

HEWLETT PACKARD



11602B transistor fixture for S-parameter test	£250
11710 frequency down-converter for 8640B	£500
1741A 100MHz storage (analogue) oscilloscope	£450
214B pulse generator high-power	£650
334A distortion meter	£450
3478A multi-meter	£550
35660A dynamic signal analyser 244μHz-102kHz	£3500
3580A audio spectrum analyser 15 Hz-50kHz LED version	£2000
3582A audio frequency specturm analyser	£4000
3585A 40MHz spectrum analyser	£6000
400FL MV-Meter 100μV–300V fs. 20Hz–4MHz	£325
4275/001 LCZ meter	£1750
5005B signature multi-meter, programmable	£1250
5328A 100MHz counter with DVM and HPIB options	£350
5328A 100MHz counter with High-performance DVM opt.	£350
5363B time-internal probes	£250
6516A power supply 0–3kV @ 6mA	£250
6825A bipolar power supply/amp −20 to +20vdc 0-1A	£350
70300A tracking generator plug-in unit	£3000
70907A external mixer	£2750
7015B analogue X-Y recorder with timebase	£650
8082A 250MHz pulse generator	£1500
8405A vector voltmeter, voltage & phase to 1000 MHz	£1250
8406A comb generator	£1000
8503A S-parameter test set	£1500
8505A network analyser including 5750A/8503A	£5000
8554B/141T/8552B spectrum analyser system to 1250MHz	£1750
8558B/182C 1500MHz spectrum analyser system	£2000
8559A/182T 21GHz spectrum analyser system	£5000
8590A 1500MHz spectrum analyser GPIB option	£3500
8600A digital marker generator for 8601A	£325
8614A signal generator 800MHz–2.4GHz	£1250
8640A signal generator 5-520MHz AM/FM	£750
8640B signal generator option 001/003	£1500
8656A AM/FM synthesized signal generator 0.1-990Mhz	£1500
8901B modulation analyser options 01/02/04	£4000
8903B audio analyser options 001/010/051	£2750
8954A transceiver interface	£500

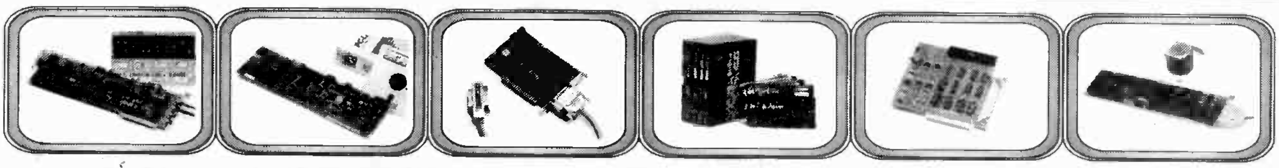
PLEASE NOTE: ALL OUR EQUIPMENT IS NOW CHECKED TO MANUFACTURERS' SPECIFICATIONS BY INDEPENDENT LABORATORY TO BS5750. Certificates of calibration to this standard can be supplied at very reasonable cost. All items guaranteed for 3 months (90 days) and 7-days 'return for full refund' warranty. URGENTLY REQUIRED FOR STOCK – 'high end' test equipment, cash waiting for first-quality second-user instruments. ALL PRICES SUBJECT TO ADDITIONAL VAT.

CIRCLE NO. 120 ON REPLY CARD

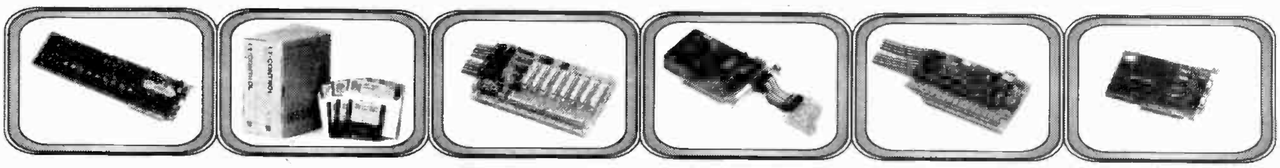
Total Solutions for PC based Applications

ENGINEERING & SCIENTIFIC PC

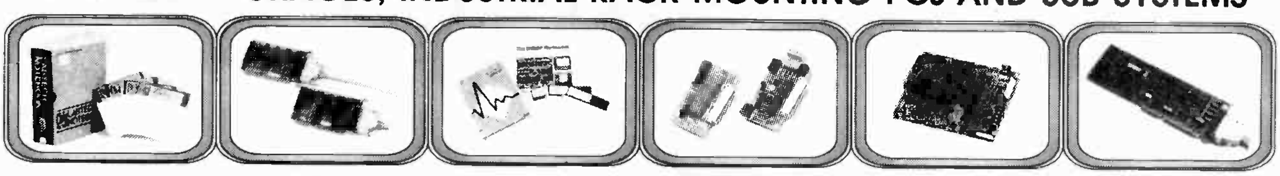
ENGINEERING & SCIENTIFIC PC



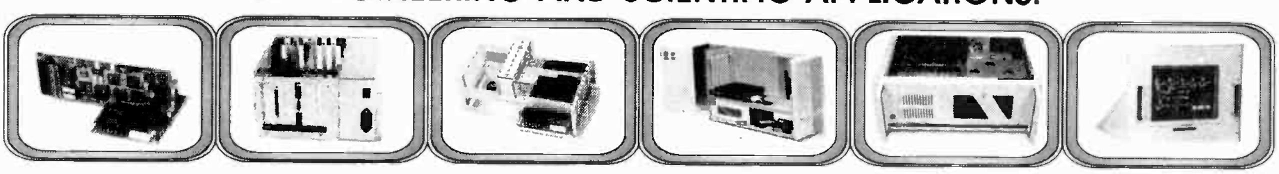
THE MOST COMPREHENSIVE RANGE OF PC BASED ADD-ON PRODUCTS



SOFTWARE PACKAGES, INDUSTRIAL RACK MOUNTING PCs AND SUB-SYSTEMS



FOR ENGINEERING AND SCIENTIFIC APPLICATIONS.



INTEGRATED MEASUREMENT SYSTEMS

Integrated Measurement Systems Ltd.
306 Solent Business Centre, Millbrook Rd West
Southampton SO1 0HW
Tel: (0703) 771143 Fax: (0703) 704301

Please call for a FREE copy of our Catalogue

Designers & Suppliers of Measurement, Test & Control Systems & Software

VISA

CIRCLE NO. 153 ON REPLY CARD

POPOV: Russia's Marconi?

If Popov had been less of a physicist, would he have beaten Marconi to the prize of long-distance wireless communication? Khatskel A Ioffe of the Popov Central Museum of Communications in St Petersburg reports.

A S Popov (1859-1906). A photo of the early 1900s. According to his contemporaries, Popov's broad Russian face with a thin, short beard and overhanging brows would suddenly light up with a smile and an attentive look at his questioner. He was an exceptionally hard-working, honest and sympathetic man[17].

Alexander Stepanovich Popov (1859-1906), born into a priest's family in an industrial settlement of the Northern Urals, was expected to enter the Church. But his passion for exact sciences instead took him to the Department of Physics and Mathematics at the University of St Petersburg. Later, in the 1890s, as an instructor at the Officers' Torpedo School at Kronstadt[1], he became a well-known name amongst the physicists in St Petersburg.

Since his student days, Popov had concentrated on the emerging subject of electrical engineering. But it was as a lecturer that Popov was able to demonstrate his particular gift for staging original experiments to clarify a point.

To demonstrate dynamo/motor convertibility, for example, he interconnected two moving-coil galvanometers. Giving the rectangular coil of one galvanometer a push caused that of the other to move in the opposite sense. Students could clearly see how moving the first galvanometer's coil induced a current in it to oppose the motion, while this current also flowed in the second galvanometer, connected in series, to produce the reverse effect.

Popov was also a passionate experimenter and spent nearly all his free time in the laboratory, closely following the latest developments in electricity and demonstrating them in his lectures. He was particularly impressed by Nikola Tesla's (1856-1943) experiments in transmitting electrical power into space using a high-frequency, high-voltage transformer and in 1891 manufactured a transformer from Tesla's diagrams to use in demonstrations. Brush discharge from the end of the transformer secondary attained a length of nearly a metre: the high-voltage field produced a glow in evacuated glass tubes distributed among the students, much to their delight.

Following publications by Galileo Ferraris (1847-1897) on rotating magnetic fields, Popov gave a public lecture on this theme in 1892, demonstrating devices in which two coils at right angles to each other and on a common centre had, at the centre, a magnetic needle on a pivot. When alternating currents with equal amplitudes and 90° phase shift were passed through the coils, the needle rotated.

In 1893, Popov built an original device to show the formation of a full AC cycle in slow motion, simulating the operation of an alternator by substituting for the magnetic field[2] an electric field applied to an electrolyte .

Investigating Hertz

After the publication in 1888-89 by Heinrich Rudolf Hertz (1857-1894) of his experiments with electromagnetic waves, Popov gave a

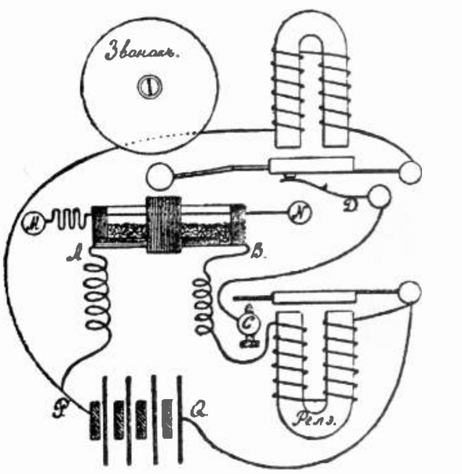


Fig. 1. Popov's receiver (1895) for "detection and registration of electrical oscillations."

series of public lectures in 1890 entitled: "The latest researches on the relations between optical and electrical phenomena", during which he demonstrated Hertz's experiments.

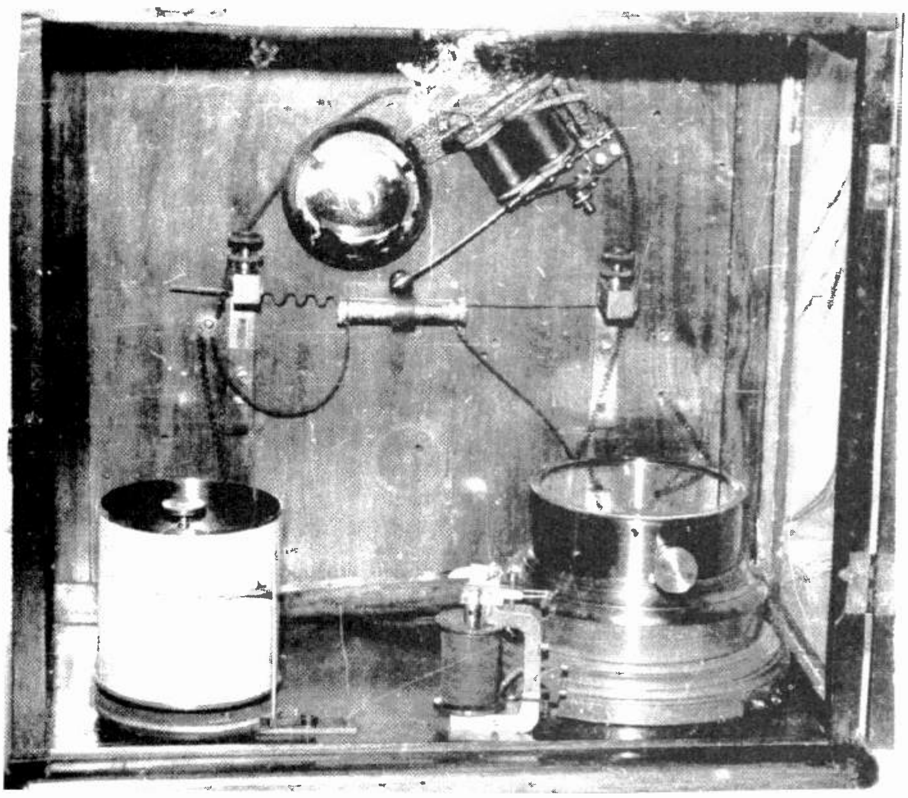
Even at that time, scientists were beginning to have ideas for the practical use of Hertzian waves. For example, O D Khvolson (1852-1934), professor at the University of St Petersburg and member of the Russian Physico-Chemical Society to which Popov also belonged, wrote: "Hertz's experiments are still on a laboratory scale only; however, it is impossible at the present time to determine what will develop from them further and whether they constitute the origins of new branches of electrical engineering"[3]. The editorial board added in a footnote: "For example, wireless telegraphy similar to optical". Also, the newly developed feasibility of wireless telegraphy was discussed in 1892 by W Crookes (1832-1919) and in 1893 by N Tesla.

All this was known to Popov who was searching for a more convenient and reliable way than Hertz's ring resonator of indicating the presence of electromagnetic waves. In the spring of 1893, he built a device he called a radiometer, whereby electrical oscillations brought into motion a lightweight spider with four platinum leaves at its ends. But he was not satisfied with the result. Fortunately, "The Work of Hertz"[4], a lecture published in 1894 by Oliver Joseph Lodge (1851-1940), came to his aid. His attention was attracted by Lodge's experiments with the coherer – a glass tube containing metal filings whose conduction dramatically increased under the action of electromagnetic waves and was returned to its initial value by shaking or tapping. The effect had been described by Edouard Branly (1846-1940) in 1890. When placed in a circuit comprising a battery and a galvanometer, the coherer enabled Lodge to detect Hertzian waves by deflection of the galvanometer.

Coherer detection

In repeating Lodge's experiments, Popov carried out, early in 1895, a series of investigations into various metal powders and coherer designs. Eventually, he decided in favour of a horizontally arranged glass tube, about 1cm in diameter and about 8cm long, almost half-filled with partially oxidised iron filings resting on two stripline platinum electrodes pasted to the inside of the tube and brought out at opposite ends. The ends were stopped with corks.

Fig. 2. Popov's lightning recorder. The unit was presumably presented at the 1900 Universal Exhibition in Paris, where Popov was awarded a gold medal for his instrument. Now in the keeping of the Popov Central Museum of Communications.



The coherer was sensitive and stable and, after achieving reliable detection of Hertzian waves using the technique, Popov was able to go further and set himself the goal of building a device to detect successive electromagnetic waves automatically. For this, he placed a telegraphic relay in the receiving circuit with an electric bell. The bell indicated the presence of a wave by ringing and, at the same time, tapped the coherer to prepare it for the next wave.

The result was a device which Popov termed an "instrument for detection and registration of electrical oscillations" (**Fig. 1**). A tube containing filings is mounted between terminals *M* and *N* with a light spring pressure. Above the tube is a bell which taps gently against the middle of the tube, the tube protected by a rubber ring. Direct current flows from a 4-5 V battery *PQ* through the tube *AB* and the winding of a relay and is normally insufficient to pull in the relay armature.

But if the tube is subjected to an electromagnetic wave, the powder resistance decreases and the current increases to activate the relay. This completes the circuit via the normally-open contact *C* and the bell rings. Tapping the tube decreases its conduction, with the result that the relay opens the bell circuit.

Each electromagnetic wave is thereby indicated by a short ringing signal, rhythmic signals being produced when waves arrive one after another. Inductance in the relay, bell windings and the spirally wound leads of the coherer eliminated the disturbing effect on the filings of possible sparks arising from breaking the circuit.

While testing the instrument, Popov found that when a vertical wire 2.5m long was connected at *A* or *B*, it responded in the open air to oscillations produced by a large Hertz vibrator with its spark gap in oil and provided with 40cm square sheets, 60-70m apart. Popov believed that the instrument was suitable for wireless communication; as he wrote: "With further improvements in my apparatus, it can be applied to signalling at a distance using fast electrical oscillations as soon as a source of such vibrations is found possessing sufficient energy"[5].

Popov noticed that his instrument responded, even at large distances, to electromagnetic disturbances in the atmosphere. This was best observed if one of the electrodes of the coherer was connected to a lightning rod or just a vertical wire and the other electrode to a conductor taken to earth. Atmospheric disturbances were not only signalled by the bell but also recorded by an electromagnetic marker of the Richard Bros system connected in parallel with the bell. This enabled Popov to use his instrument for both meteorology and lecture demonstrations.

He reported all this in 1895 to the Russian Physico-Chemical Society at St Petersburg[6] and then described his instrument in detail in his article entitled "An Instrument for the Detection and Registration of Electrical Oscillations"[5,7]. **Figure 2** shows the general view of an actual Popov instrument , adapted for meteorological observation.

Popov and Marconi

In Popov's experiments, we see many of the features needed for communication. There is a radiator – in the form of Hertz's vibrator fed from an induction coil and functioning as a transmitting aerial; the coherer-type indicator featured; aerial and earthing; signal amplification using a battery and a relay; an automatic tapper actuated by the received wave to prepare the coherer for the next one; signal indication by a bell and/or an electromagnetic recorder; and protection of the coherer against interference from sparks due to the circuit-breaker.

Taken as a whole, Popov's experiments constitute a fairly rough embodiment of signalling by means of electromagnetic waves. He did not take out a patent for his invention.

Popov's work soon came to be associated with that of Guglielmo Marconi (1874-1937) which was being made public in the press.

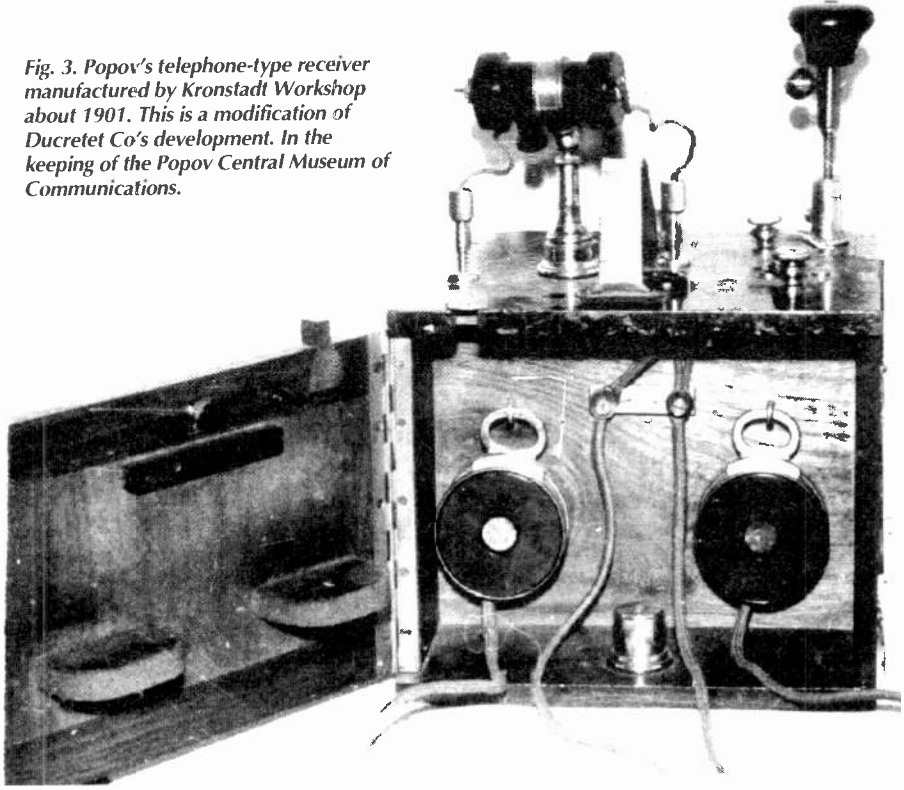
In the autumn of 1896, a short newspaper report from England described Marconi's work on signalling at a distance, but did not disclose details of the equipment.

Presuming that Marconi was working along the same lines as himself, Popov returned to his experiments, encouraged by the understanding by the Department of Navy of the paramount importance of signalling without wires for its operations. In March 1897, he gave a public lecture in Kronstadt "On the feasibility of wireless telegraphy" in the presence of the leaders of the Russian Navy, demonstrating his instruments in conjunction with the Morse telegraph.

For excitation, he used a Hertz vibrator with 30cm-diameter balls. Later, in April, Popov demonstrated experiments in the Kronstadt harbour. Thanks to an improvement in his coherer (fine steel beads instead of iron filings) and to the use of a more sensitive relay, he managed a range of about one kilometre.

June 1897 saw the publication by Sir William Henry Preece (1834-1913) of the details of Marconi's instruments. Popov could see that Marconi's receiver was essentially identical with his and pointed to this in *The Electrician*. At the same time, he noted that: "Marconi was the first to have the courage to take his stand on a practical ground and reached large distances in his experiments..."[10]. At a later date, Popov said "Whether my instrument had been known to Marconi or not, which seems to be more probable, it was, in any event, my combination of a relay, tube and electromagnetic tapper that served as the basis for his first patent for a new combination of already known devices. It is beyond all question that the first practical results in telegraphy over considerable distances have been reached by Marconi before others"[11].

Fig. 3. Popov's telephone-type receiver manufactured by Kronstadt Workshop about 1901. This is a modification of Ducretet Co's development. In the keeping of the Popov Central Museum of Communications.



Naval wireless

In the summer of 1897, Popov achieved a range of 5km between two ships, using a vertical receiving wire 16m long. The same year, Eugène Ducretet (1844-1915), a Parisian engineer and factory owner, initiated correspondence with Popov to discuss the design of equipment and, as a result, Ducretet started the manufacture of wireless stations of the Popov-Ducretet system[12]. Using this equipment, the first radio transmission from the Eiffel Tower took place in 1898, and in 1899 Popov carried out successful tests on the Black Sea Navy's warships. Later in 1899, Popov patented a telephone-type radio receiver for the reception of Morse telegraphic signals using a coherer requiring no concussion (**Fig. 3**)[13].

Early in 1900, Russia's first practical radio communication system was built and put into operation under Popov's leadership. With a range of 47km, it served reliably for three months during the rescue of the ironclad *Apraksin* which had run onto rocks in the Gulf of Finland and been holed. Transmissions between the islands of Kuutsalo and Hogland in the Gulf used Ducretet's transmitters and Popov's laboratory-made telephone-type receivers. Aerial masts at both ends of the line were 48m high, thus ensuring line-of-sight transmission[14].

In 1900, Popov started the training of wireless specialists for the Russian Navy, and in the same year, in Kronstadt, he organised Russia's first production of wireless equipment and was put in charge of installing wireless stations on Russian warships.

From 1883 to 1901, Popov stayed at the Officer's Torpedo School at Kronstadt where, at different times, he taught mathematics, physics, electricity, dynamos and electric motors and wireless telegraphy. But in 1901 he was invited to occupy the Chair of Physics at the Emperor Alexander III Electrotechnical Institute of St Petersburg.

Popov and the democratic movement

His career in the Electrotechnical Institute coincided with the growth of a democratic movement in Russia, which also involved his students. The government had to grant higher educational institutions the autonomy to elect their Director and in September 1905, Professor Popov became the first elected Director of the Electrotechnical Institute.

As the student movement grew, the government imposed repressive measures such as a ban on public meetings on the premises of educational institutions.

In response, Popov signed the following statement of the Council of his Institute: "In the opinion of the faculty of the Institute, the freedom of assembly constitutes a vital need and an inalienable right of the whole population, especially in the hard times we are going through. Therefore, the Council recognises that not only is it not in a position, but also it has no moral right, to prevent the arranging of public assemblies on the premises of the Institute by any means whatsoever, including the closing of the same. Any forced intrusion by authorities into the life of the Institute cannot give appeasement, rather it will only worsen the situation. Appeasement of educational institutions can only be attained by way of major political reforms capable of satisfying the public opinion of the whole country..."[15].

As a result, Popov was forced to carry out his duties as the Director of the Institute amidst persistent anxiety, experiencing serious trouble with the municipal bodies.

He was unable to endure the ordeals of those hard times and died suddenly of a brain haemorrhage on the last day 1905 (by the Julian calendar used in Russia until early in 1918, i.e., on the 13th January 1906), at the age of 46.

Popov the physicist

So why did Popov lag behind Marconi during their early wireless experiments?

It seems that, in the mind of Popov the physicist, the range of interaction of a source of waves (the transmitter) with an indicator of such waves (the receiver) was associated too closely with the laws of optics. For this reason, he could think of no other way of increasing range than by increasing the power of the wave generator.

Marconi was lucky to hit on the use of a transmitting aerial and an earth conductor connected to the generator, then tuning the receiving aerial to the transmitting aerial – a radical advance. There remained simpler problems to solve, such as the use of a telegraphic key to obtain a complete combination of devices for wireless telegraphy.

Confirming this view is a memoir by SM Aisenstein (1884-1962), a distinguished Russian radio engineer and businessman. Recollecting Popov's lecture given in December 1901 in Moscow at a Congress of Electrical Engineers, Aisenstein said: "After the lecture many members of the Congress asked questions. One of them asked Professor Popov what he thought about the latest news in the daily press that Marconi had succeeded in sending a message across the Atlantic. Professor Popov replied with a smile, saying that he had just explained to the audience that wireless communication uses electromagnetic waves which, as has been proved theoretically and experimentally, have the same propagation properties as light, and therefore such communication as across the Atlantic he found impossible to believe.

It would be necessary to erect masts or towers on both sides of the Atlantic, of such immense height that the top of one would be visible from the top of the other! He added also that as the letter "S" was only composed of three dots, he thought that it could be regarded as some stray atmospheric, and it would be very wise therefore to await the result of further experiments before drawing any conclusions from the very brief notice in the daily press[6].

Of course, at the dawn of wireless, no one knew about the propagation of radio waves at different ranges – and sometimes, those who were less fettered by knowledge tried anyway and were successful. ■

Translated from the Russian by L N Kryzhanovsky.

References

1. Kronstadt is a port and fortress on the Isle of Kotlin in the Gulf of Finland, 29km west of St Petersburg.
2. The above-mentioned and some other of Popov's instruments of this kind are in the keeping of the Popov Central Museum of Communications in St Petersburg. See Kh.A. Ioffe, "AS Popov's Instruments", Artefacts of Science and Technology, 1984 (Nauka, Moscow, 1986), pp. 139-164.
3. OD Khvolson, "The Hertz Experiments and their Significance", *Elektrichestvo*, 1890, No 5, p.90.
4. OJ Lodge, "The Work of Hertz", *The Electrician*, 1894, Vol.33, pp.153, 186, 204.
5. AS Popov, "An Instrument for the Detection and Registration of Electrical Oscillations", *Journal of the Russian Physico-Chemical Society*, 1896, No 1, Physical Part, pp.1-14.
6. "Protocol of Sitting 151 (201) of the Physics Division of the Society, 25th April 1895", *Journal of the Russian Physico-Chemical Society*, 1895, No 8, Physical Part, p.259.
7. AS Popov, "An Instrument for the Detection and Registration of Electrical Oscillations: in the Atmosphere", *Elektrichestvo*, 1896, Nos 13-14, pp.177-180.
8 WH Preece, "Signalling through Space without Wires", *The Electrician*, 1897, June 11, pp.216-218.
9 AS Popoff (Popov), "An Application of the Coherer: To the Editor", *The Electrician*, 1897, December 10, p.235.
10 AS Popov, "To the Editor", *Novoye Vremya* (a St Petersburg newspaper), 1897, June 22, p.3.
11. AS Popov, The Paper "Wireless Telegraphy" presented at a Joint Conference of the 6th Division of the Russian Society of Technology and the 1st All-Russian Congress of Electrical Engineering held on 29 December 1899, *Physico-Mathematical Annual*, 1900, No 1, pp.100-121.
12. E Ducretet, "Sur la telegraphie hertzienne sans fil avec le radio-conducteur de M. Branly et les dispositifs de MM. A.Popoff et E.Ducretet", *Séances de la Société française de Physique*, Séance du 21 Janvier 1898, pp.51-61.
13. AS Popov, "(A Telephone Receiver of Telegrams sent by Means of a Source of Electromagnetic Waves by the Morse System", Russian Patent No.6060 issued 30 November 1901, applied 14 July 1899.
14. Verified by calculation at the suggestion of LN Kryzhanovsky to illustrate the memoir (ref. 16) of SM Aisenstein.
15. Minute-book of the Council of the Emperor Alexander III Electrotechnical Institute of St Petersburg. Protocol No 21 of 15th October 1905. In the keeping of the State Historical Archives, St Petersburg Region, F990-D2704, sheets 36-37.
16. AJ Young, "Obituary" (of SM Aisenstein), *The Marconi Review*, 1962, 4th Quarter, pp.243-249.
17. Alexander Stepanovich Popov in his Contemporaries' Characterisations and Reminiscences (USSR Academy of Sciences Press, Moscow and Leningrad, 1958), pp.86, 90, 191.

CIRCLE NO. 121 ON REPLY CARD

CIRCLE NO. 122 ON REPLY CARD

CIRCLE NO. 123 ON REPLY CARD

CUTTING ANTENNA TESTING DOWN TO SIZE

Reducing the size of antenna test ranges can cuts costs and save time. Mike Christieson shows how results can compare well with full-sized set-ups.

Accurate and repeatable antenna measurements are notoriously difficult to make. Of course, if facilities of a professional test range or anechoic chamber are available, testing is much easier and the comparative ease of measurement enables enough variability in parameters to reveal one or two surprises. For example, the gain of a yagi, its F:B ratio, best pattern and best match all happen at different frequencies; and the front-to-back ratio becomes negative above the director resonant frequency. But the cost of such facilities is high and their use must necessarily be limited to special projects.

Can useful measurements be made with more modest equipment operating in a less controlled environment?

The physical size of many antennas places a limit on test-range size reduction. Some of the most common types, referred to as "wire antennas" are structures made from linear elements, as opposed to apertures and lenses; monopoles, dipoles, yagis and the various types of long wires are examples of these. In many cases, the final design is large, even though the gains are modest, because the wavelengths are in the order of metres or tens of metres. It is these mid-frequency antennas that we will look at here.

Making the test range "bench sized" means it is not possible to operate at the final design frequency unless it happens to be above about 1GHz. This means that the antenna must be modelled at a higher frequency, the dimensions optimised and then scaled to the required frequency.

A convenient modelling frequency is about 1.5GHz (wavelength 20cm) because the elements are a handy size and the frequency is not so high that effects peculiar to the microwave bands become significant.

Feed point impedance

In essence the procedure is all very simple. An antenna under test transmits to or receives from a fixed antenna some distance away. Rotating the test antenna in two planes and plotting the signal strength at various frequencies produces a radiation pattern.

But even if an antenna has exactly the required radiating characteristics, it is very difficult to get power to or from it if the feed point impedance is unknown. So it is important to have a measure of the feed point impedance and it may be convenient to change some element dimensions to give a different impedance or improve constancy over a band of frequencies. Measurement of a complex impedance is difficult at any frequency without specialised equipment and at higher frequencies becomes a real limitation.

Simplest method of overcoming the problem is to connect a feeder, usually a coaxial cable, of known impedance and use a directional coupler to measure the return loss or VSWR. Of course, the result is not an absolute measurement of impedance. But it does give an idea of how near it is to the feeder impedance at a fraction of the cost and complexity of a network analyser.

Using these techniques, radiation patterns in both the E and H planes; forward gain over a

Interpreting polar diagrams

Polar diagrams are simply a way of representing the radiation pattern of an antenna. But choice of scales and resolutions can make the same antenna appear to have different characteristics.

Normally, the angular scale runs from 0 to 360°, although for antennas with a very narrow beam-width, like a dish, only a few degrees either side of zero are shown.

Angular resolution must be small enough that narrow lobes are not missed, and therefore depends on the antenna directivity.

The real opportunity for misleading plots is in the choice of radial scale representing power. If a linear scale is used, anything more than about 10dB below the main lobe disappears and the main lobe appears very sharp. Conversely, if a scale of, say, 70dB is used, most antennas appear to have significant side lobes. A scale of about 30dB or 40dB gives the best compromise between being able to see the side lobes but not those at an insignificant amplitude.

Another interesting fact is that, if an antenna has a significant back lobe of say -10dB, completely removing it would increase the forward gain by less than 1dB. Of course, if the application required good front-to-back ratio for interference suppression, this would be well worthwhile. As with all graphical results, the scales should be read carefully to see what is actually being shown before conclusions are drawn.

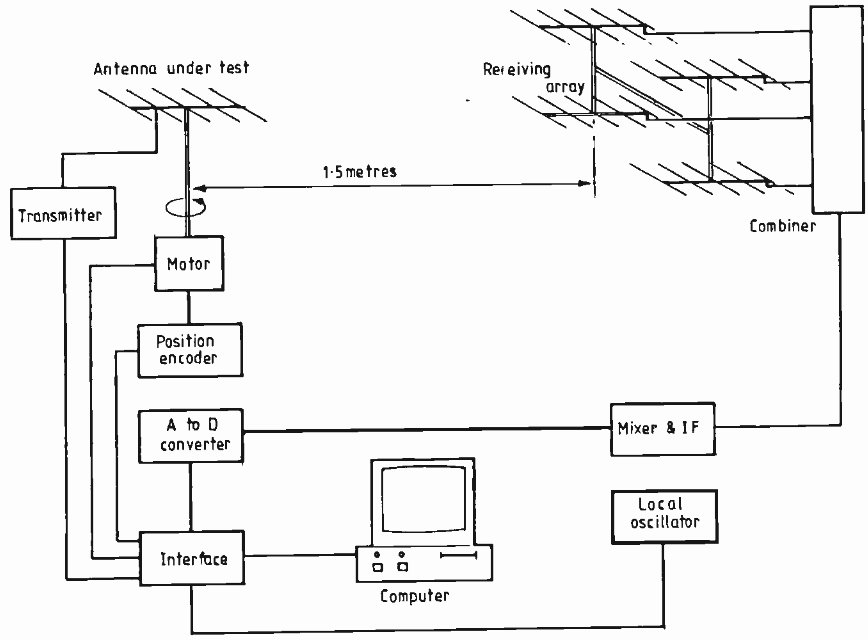


Fig. 1a. Basics of a practical modelling range. A computer controls all parameters and saves hours of work.

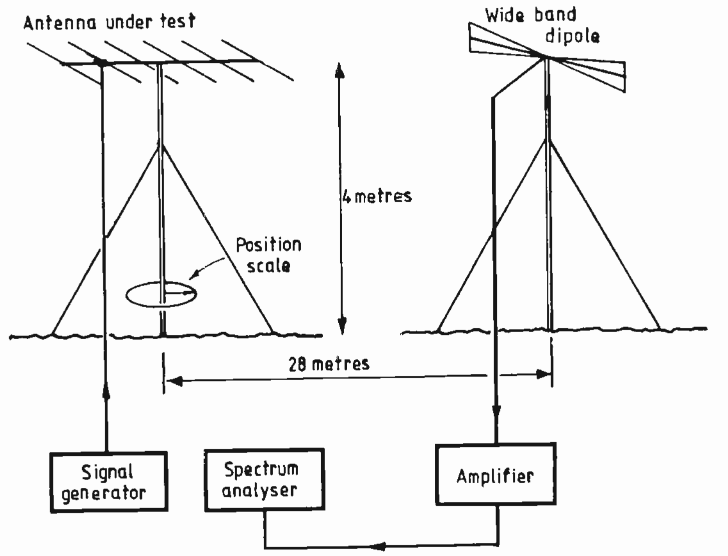


Fig. 1b. Full size testing can lead to big problems of time and cost.

band of frequencies: front-to-back ratio over a band of frequencies; and feed point return loss can all be measured.

Modelling range concepts.

An antenna modelling range consists of a low-power transmitter – with selectable frequency and with an output reasonably constant over the frequency band of interest; a receiver that can track the transmitter frequency and provide an output representing signal strength; a means of rotating the test antenna and measuring its angular position; and a system for collecting and displaying the results.

A suitable band is 1.2-1.8GHz (for the reasons already described) and this defines many of the system characteristics, the main one being range length, ie the distance between the two antennas.

It is well documented that, to give a good approximation to a plane wavefront, the minimum distance L must be $= 2D^2/\lambda$ where D is the apparent antenna aperture diameter.

The concept of aperture is obvious for some antennas. For example, D is the physical diameter of a dish or horn. But for a yagi it is not so clear and not directly related to any physical dimension, though it can be calculated from the gain of an antenna.

For any antenna, $G = 4\pi A/\lambda^2$, where A is the apparent aperture area and G is the isotropic gain (expressed as a numerical ratio).

Since $A = \pi D^2/4$, and substituting in the original equation:

$$L = \frac{2G\lambda}{\pi^2}$$

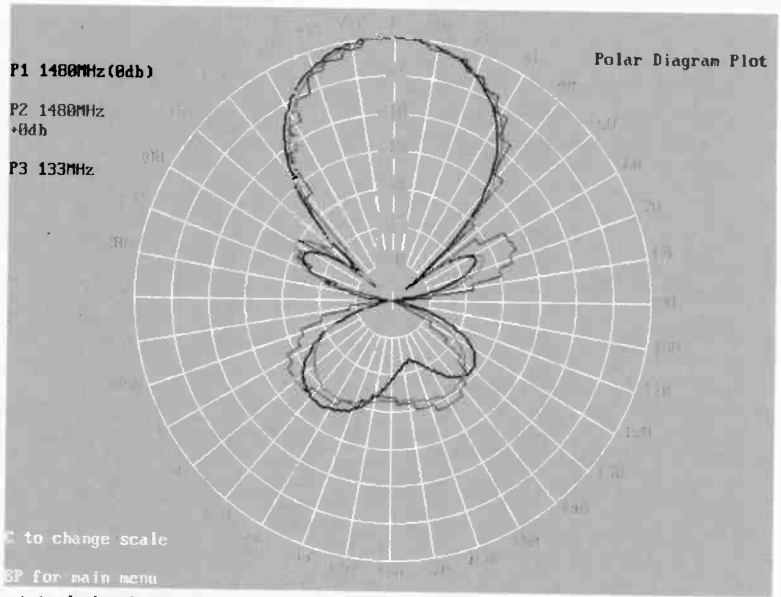
This means that the higher the gain of the antenna under test, the longer the range needs to be. In this investigation a maximum antenna gain of 13dB is likely, giving a range length of 2.5m at 1.5GHz, quite suitable for bench-top operation.

Reflections

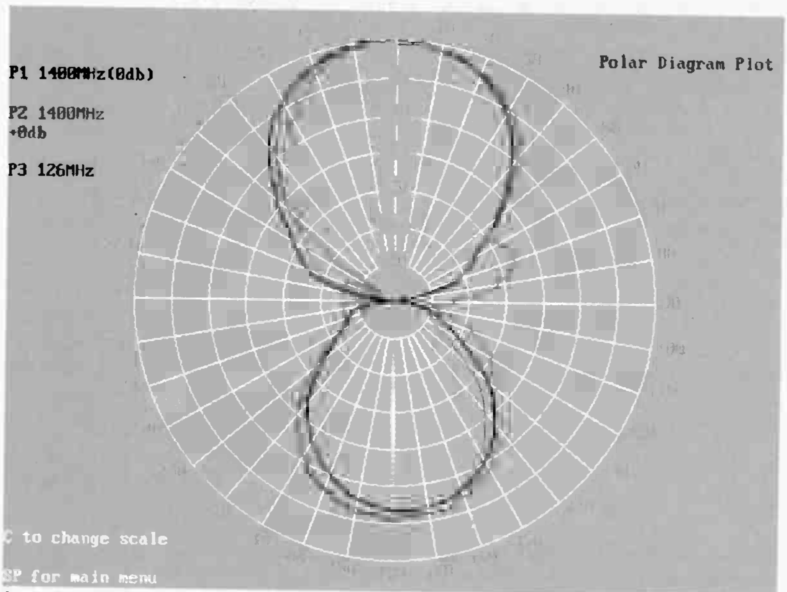
Reflection is the major problem that limits most radiation parameter measurements, both on model and real antennas. Most objects reflect radio signals – particularly those with high conductivity such as metal – meaning that the energy at the receiving antenna is the sum of the direct signal plus that reflected by the environment. If reflections are strong, they can completely change the apparent radiation pattern.

To reduce these effects, the range must be as far away from objects, particularly metal, as

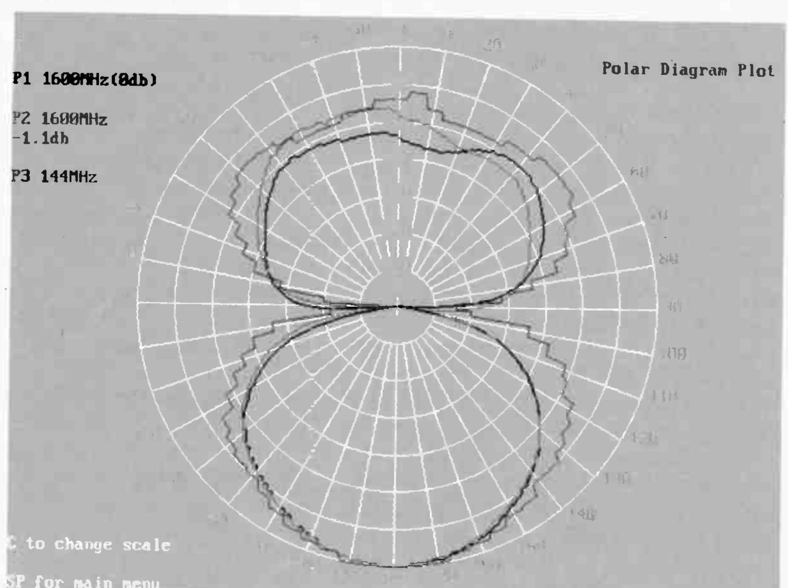
Fig. 2. Set of comparative results from the investigation, showing (black) a run with the model inside, (red) with the model outside and (blue) the 135MHz antenna. Plot at (a) shows the polar diagram at 1480MHz and 133MHz, at (b) the diagram for 1400MHz and 126MHz and at (c) that for 1600MHz and 144MHz. That at (c) indicates the negative front-to-back ratio caused by increasing the frequency beyond director resonance, turning them into reflectors – the effect seen at (d), which is power from the forward lobe for the three case; (e) shows power from the rear lobe and (f) is the return loss and VSWR. The plots show the remarkable coincidence between model and full-size antennas and the narrow band over which F:B ratio is maximum.



a) At design frequency



b) Below design frequency



c) Above design frequency

possible: range length must be short, if necessary slightly below the ideal minimum value; and the fixed antenna must have directivity so that only the antenna under test is within its beam-width. Reflections from behind the antenna under test should be limited, since these are also within the fixed antenna's beam-width.

Using a fixed antenna with directivity has one disadvantage: many directional antennas perform well only over a small frequency band and care must be taken that the results are only the characteristics of the antenna under test and not the sum of both antennas. One solution is to use a wide-band directional antenna such as a log-periodic dipole array.

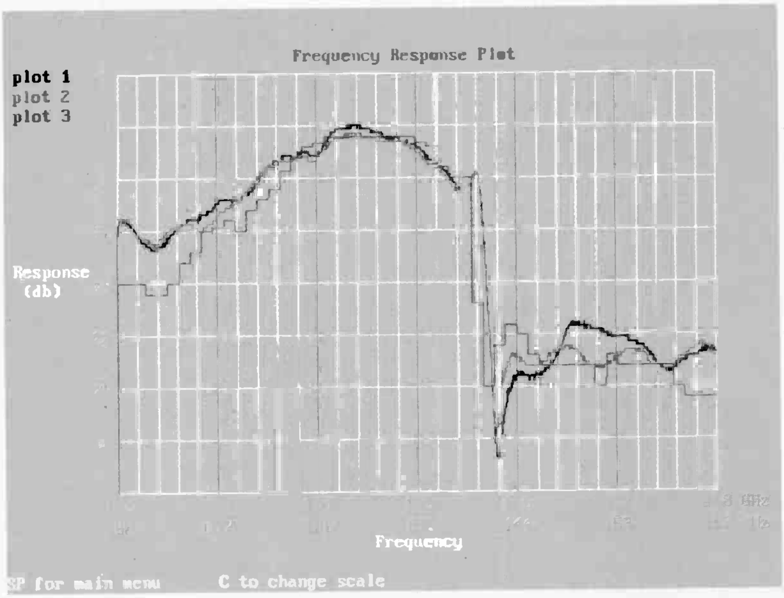
Practical modelling range

The range, outlined in **Fig.1a**, was designed to demonstrate and measure antenna characteristics as an aid to teaching in Universities and Technical Colleges. It consists of two free-standing towers about 1m high, made from plastic but with metal bases containing the system electronics. For various reasons, the antenna under test is the transmitter and the fixed antenna the receiver.

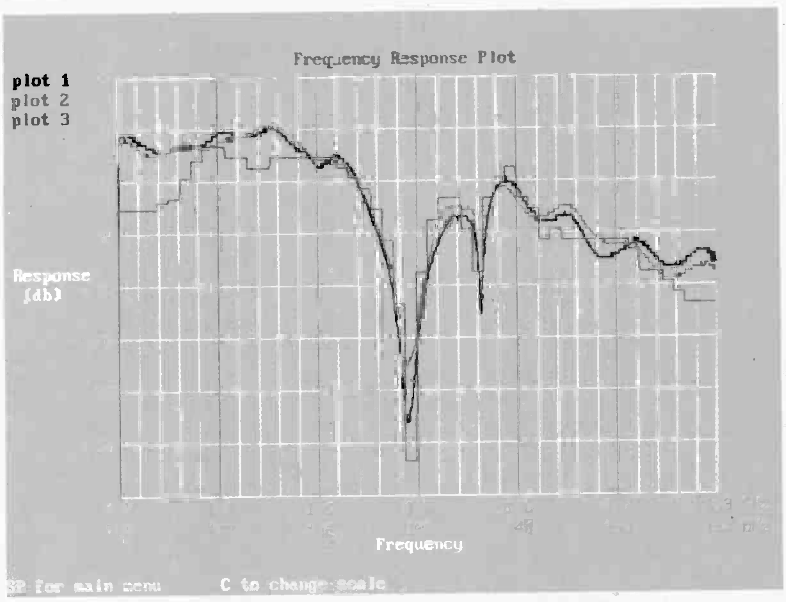
A desk-top computer controls the system, records the results and displays them as polar plots and frequency responses. The signal comes from an RF generator in the transmitter tower base which has a synthesizer with a step size of 125kHz. Output power is 1mW, fed via an internal fixed attenuator so that the source impedance is near to 50Ω.

The receiver in the other tower base is a single-conversion superhet with a synthesised local oscillator, but no RF selectivity, as there is no image response problem. Fixed attenuation gives an input impedance near to 50Ω. Logarithmic amplifiers in the 38MHz IF give a voltage output from the receiver proportional to the log of the input power, which is then digitised. System dynamic range is 70dB so that both transmitter and receiver must be fully screened to prevent signal leak-through.

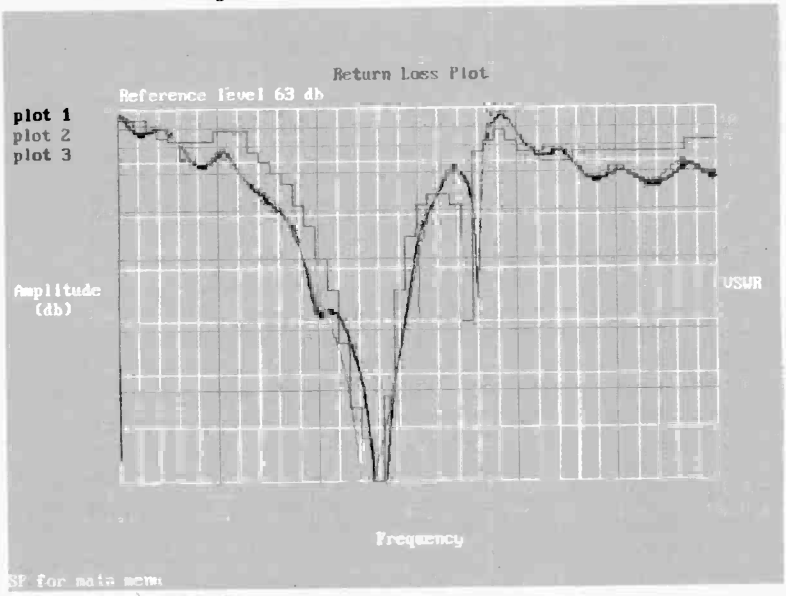
In the receiving antenna, an array of four five-element log-periodics have their outputs



d) Forward lobe gain



e) Rear lobe gain



f) Return loss and VSWR

connected to a microstrip combiner, and the array may be turned for either horizontal or vertical polarisation.

A computer controls, or has access to, transmitter frequency, receiver frequency, motor drive, antenna position and receiver output. Software automates the generation of polar and frequency plots over various scales and also allows data to be superimposed or recorded on disk. To plot return loss as a function of frequency, a microstrip directional coupler can be placed in the feeder to the test antenna. In this configuration, the receiver is connected directly to the coupler directional ports.

Case study test results

To evaluate accuracy of the modelling concept, a six-element yagi was designed and modelled on the system. A scaled version was then made, centred on 135MHz, and its performance measured in a field using a signal generator, a spectrum analyser and a large amount of patience.

Data was taken by hand from the 135MHz yagi and converted to the modelling system file format so that real and model data could be superimposed (from the modelling system in a typical laboratory environment with a clear area round the system; and a second set from the modelling system in the open air at least 5m from any other object and 2m off the ground). Range length in both cases was 1.2m, but one measurement was taken in the open air at a range of over 3m to investigate the effect of the rather short range length. There was little difference.

A fairly simple method-of-moments computer program assisted with initial yagi design and, for simplicity, all directors were the same length. The driven element was a half-wave folded dipole with a half-wave 4:1 impedance reduction balun. It appeared to operate best slightly low in frequency but, rather than trim the elements, the full sized version was built to the original dimensions. Computer predictions gave a forward gain of 10.7dBi and a feed impedance of 37Ω.

Measurements

A seven-acre field with the test antenna mounted on a 4m mast served as the range with the receiving antenna, a wide-band dipole, mounted at a similar height, at a distance of 28m (**Fig. 1b**). A signal generator provided the input and a spectrum analyser was connected to the receiving dipole via a wide-band amplifier located near to the dipole. Angular position came from a calibrated disc attached to the test antenna mast.

Due to the difficulty of fixing the antenna to a metal mast, only horizontal (E plane) patterns were plotted. Angular position intervals were 5°, the signal amplitude resolution 0.5dB and frequency plots were made at 1MHz steps. Equipment for this type of measurement is expensive and the measurements take about five hours. Had it been necessary to trim any elements and make more readings, the timescale could have run into days rather than hours.

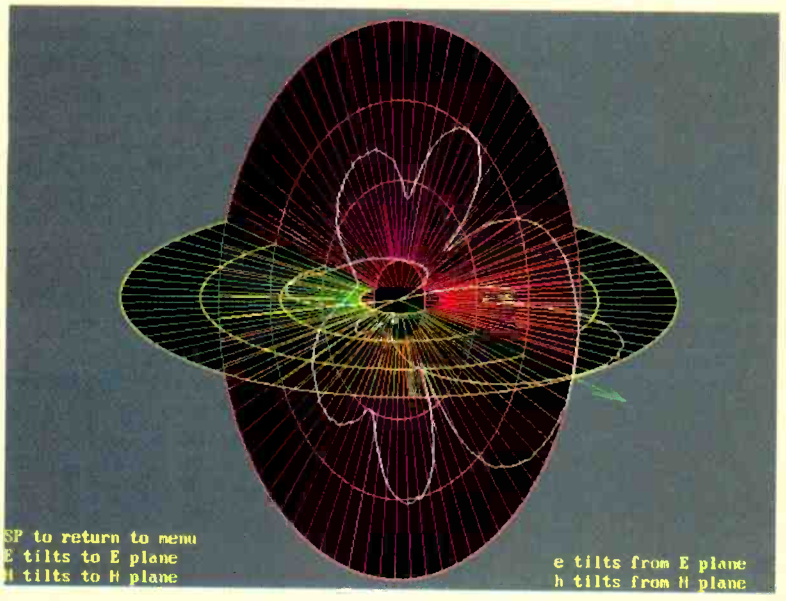


Fig. 3. Three-dimensional plot of model antenna at 1480MHz, showing E-plane and H-plane.

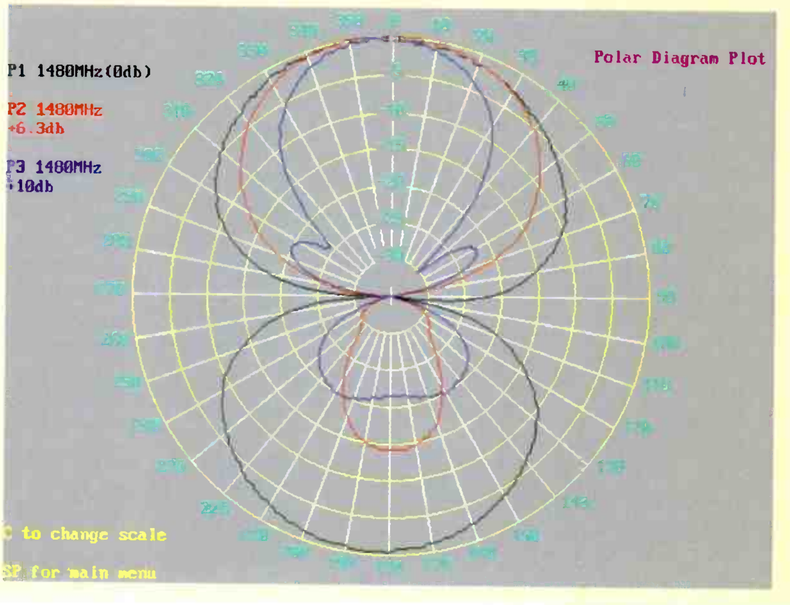


Fig. 4. Three different models at 1480MHz, the black being a dipole, the red a three-element yagi and the blue a six-element yagi. Gains shown are 0, 6.5dB and 10dB, against 0, 6dB and 9dB for the full-sized version.

Yet a similar set of measurements using the modelling range took less than 15 minutes.

Correlation between plots taken from model and full-size antennas is striking – there have been accusations of a "fix". But the results are genuine and show that the concept works providing that all dimensions, including element and boom diameters as well as lengths and spacing, are scaled.

Results show that antennas can be optimised on the modelling range and be expected to give the same performance when scaled to a lower frequency.

There are several limitations however: at low frequencies, it becomes difficult to scale thin-wire elements correctly; it is almost impossible to model lumped reactive elements such as coils, traps and capacitors; although a perfect ground plane can be simulated with a metal plate, a non-perfect ground is very difficult to make; and antennas such as co-linears, rhombics and long wires are still large and could present problems in a restricted environment.

Interpretation of results

It is interesting to see what the results say about the behaviour of yagi antennas. Close inspection of the plots reveals something about the compromises in yagi design; notice how the power in the forward beam (**Fig. 2d**) varies with frequency – a slow rise to maximum gain followed by a sharp drop, caused by the directors passing through resonance and becoming reflectors. This is emphasised by the polar diagram at 1600MHz (**Fig. 2c**) with a negative front-to-back ratio.

At 1480MHz, where the polar diagram has the cleanest pattern, the forward gain is not at its maximum – this occurs below the optimum pattern frequency, but here the front-to-back ratio is becoming poor. Increasing size of the back lobe characterises the antenna near to 1400MHz.

A plot of power from the rear of the antenna shows that the maximum front-to-back ratio occurs over a narrow frequency band. But front-to-back ratio does not tell the whole story as there may be a small back lobe with nulls either side.

The band over which the return loss is reasonable is also quite narrow, but more importantly, maximum gain, maximum front-to-back ratio, optimum pattern and best match are all at different frequencies!

To add a further complication, the E and H plots are different, partly because the antenna has no physical thickness in the H plane.

One conclusion from the investigation is that, with care, antenna modelling can give useful results without high cost or complexity. The other is that yagi design is not simply "tune for maximum forward gain." ■

Staying in control in an all-pass filter RC oscillator

Combine the purity of an all pass filter oscillator with the fast settling of a digital function generator. Impossible? No, says Dan Stiurca.

Automatic level control harmonic oscillators incorporate an ALC loop consisting of an active element with linear controlled gain. The DC input drive must have a very small ripple to avoid excessive distortion of the output waveform. Standard rectification and filtration of the output waveform used to generate this DC drive results in an amplitude settling time of several hundred cycles for a 0.1% distortion[1]. Moreover, in many cases, the ALC loop will become unstable.

To overcome the contradictory requirements of fast amplitude transients and small distortion, proposals include use of amplitude sampling[1,3], multiphase oscillators[4] and multiphase rectifiers[5]. But a new solution, where the amplitude is set by correction of the initial conditions at one of the oscillator's capacitors (proposed by Pahor *et al*[6] then improved by Vannai *et al*[7]) has been applied to Wien-bridge oscillators[8] and tried on twin-T bridge oscillators[9].

The circuit proposed here also controls amplitude by restoring initial conditions but for an all-pass filter RC oscillator. Since both the frequency selecting components are grounded, this circuit is more practical than Wien or twin-T networks. The conceptual circuit of **Fig. 1** can be used to realise the procedure of establishing and restoring the initial conditions. Assuming, for instance, an ideal resonator (infinite R) and supposing that, at the initial moment, switch S_1 is momentarily closed and switch S_2 is momentarily opened, undamped oscillations with the angular frequency

$$\omega_o = \frac{1}{LC} \qquad (1)$$

and the amplitude

$$V_{Cm} = \sqrt{V_{REF}^2 + \left(\frac{I_{REF}}{\omega_0 C}\right)^2} \qquad (2)$$

will occur.

But, any real resonator has losses (finite R) and a special control circuit, as in Fig. 1, is necessary to sustain the oscillations. Each period, this circuit, activated by the current I_R, interferes with the resonator for a short time. Closing S_1 and opening S_2 causes the control circuit to restore the initial conditions V_{REF} and I_{REF}. So, the circuit will have practically undamped sustained oscillations with the amplitude determined by equation[2]. If it measures the current in the inductor, the current source I_{REF} can be omitted and, at the moment of restoration, the capacitor voltage must be set in accordance with the results of measurement and the amplitude requirements. The full circuit of the fast amplitude control with all-pass filter RC oscillator is shown in **Fig. 2**. It includes an RC resonator, a control circuit and some buffer amplifiers (op amps A_4 to A_8). The resonator circuit is based on two first order all-pass filters (op amps A_1 and A_2) followed by an inverting stage with A_3. The transfer function of the filters is:

$$F(p) = \frac{-p + \omega_0}{p + \omega_0} \qquad (3)$$

where

$$\omega_0 = \frac{1}{R_0 C_0} \qquad (4)$$

The magnitude of this is always 1 and the phase angle is given by

$$\phi = -2\arctan\left(\frac{\omega}{\omega_0}\right) \qquad (5)$$

Hence, the phase shift equals 90° at the angular frequency ω_0; consequently this will be the oscillating frequency of the resonator. It may be observed that, at the frequency ω_0, the phase angle between V_{p1} and V_{p2} is 90°.

The fast amplitude control circuit includes a polarity comparator CM_1, a window comparator with CM_2 and CM_3, an analogue switch Sw and a source of reference voltage V_{REF} buffered by A_5. All the outputs of the comparators are open collector type. The resistors R_1, R_2 and P_1 set the small voltages $V\partial_1$

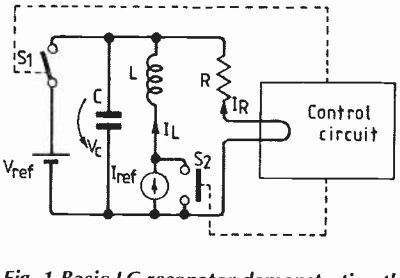


Fig. 1 Basic LC resonator demonstrating the ability to restore initial conditions.

and $V_{\delta 2}$ and thus the time duration of control circuit activation.

The waveforms illustrating the circuit operation are presented in **Fig 3**. When V_{p1} is between $V_{\delta 1}$ and $V_{\delta 2}$ and V_{p2} reaches its positive peaks, the control circuit interferes with the resonator for a short interval, t_w. Momentarily, it closes the switch Sw and the voltage V_{p2} equals V_{REF}; thus the oscillator starts every period with the same initial conditions, sustaining a practically constant amplitude:

$$V_{3m} = V_{REF}\sqrt{2} \qquad (6)$$

At the step change in V_{REF}, the dead time will be at most one cycle, until the condition

$$V_{P1} = 0 \qquad (7)$$

is achieved. This dead time is not essential in many applications, especially if the amplitude transient is absent.

The errors induced at the moment of control circuit activation by the op amp's offset voltages can be minimized by making some dc adjustments. First, without connecting frequency selecting capacitors, trim P_2 to nullify the dc voltage at the output of A_1. This ensures the zero offset for V_{p2}, and so the zeros of V_{p2} coincide with the positive peaks of V_{p1}. Then connect the capacitors and trim P_1 to centre the comparator's output voltage pulses around the moment when V_{p1} reaches its positive peaks.

The practical values for components and the type of ICs used in the oscillator are indicated in Fig. 2. The resistors are 1% metal film; the frequency selecting capacitors are 1% matched, polystyrene type and the supply voltage is ±15V, apart from *CD4066* (±7.5V).

Measured characteristics for the breadboard model, in the frequency range 5Hz-5kHz, for $V_0 > 1V_{rms}$ are:

level flatness: better than 0.8;

harmonic distortion: 0.13% at A_4 output; 0.24% at A_3 output.

At lower amplitudes, the harmonic distortion increases due to the increase in the relative width of the control pulse. The upper frequency limit is determined by the minimum practicable width of the control pulse.

The response at step changes in V_{REF} is given in **Fig.4**. V_{REF} is modulated between 1 and 7V and the time scale is 1ms/div. The response delay is not more than one period, and no amplitude transients appear. ■

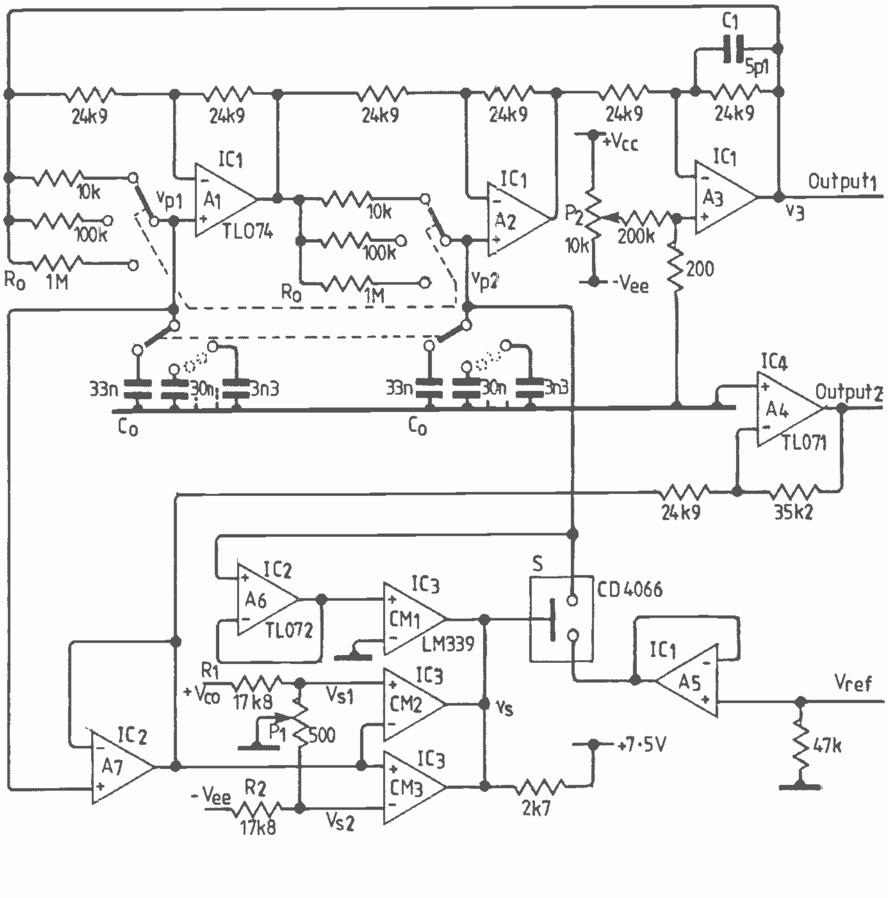


Fig. 2 All-pass filter RC oscillator with fast amplitude control. The resonator circuit consists of two first order all-pass (op amp) filters followed by an inverting stage with another amplifier. The circuit also contains a control circuit and some buffer amplifiers.

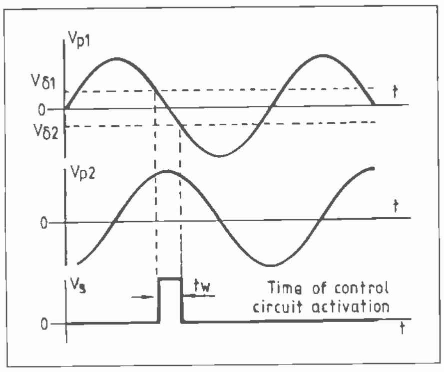


Fig. 3 Steady-state waveforms in the fast amplitude control circuit, illustrating circuit operation.

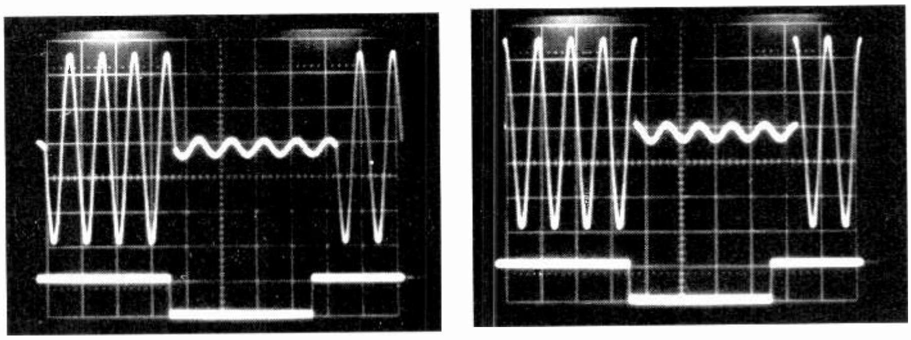


Fig. 4 Modulation of the reference voltage and a) the oscillator output 1 voltage; b) the V_{p2} voltage

References

1. Vannerson E., Smith K.J., A Low Distortion Oscillator with Fast Amplitude Stabilization. Int.J.Electronics, 1975, Vol.39, No.4, 465-472.
2. Meyer-Ebrecht D., Schnelle Amplitudenregelung harmonischer Oszillatorenn. Philips Res.rep.Suppl., 1974, No.6, 1-85.
3. Tong G.L., Audio Modulation Section for an RF Signal Generator. Hewlett-Packard Journal, Dec., 1985, 31-35.
4. Ryder A.D., Multiphase Low Distortion Oscillator. Wireless World, Jan.1981, 59-60.
5. Filanovsky I.M., Fast Amplitude Stabilization of an RC Oscillator. Wireless World, July 1982, 52-53.
6. Pahor J., Fettich J., Tavzes M., A Harmonic Oscillator with Low Harmonic Distortion and Stable Amplitude. Int.J.Electronics, 1974, Vol.37, No.6, 765-768.
7. Vannai N., Pap L., RC Oscillator with Extremely Low Harmonic Distortion. Periodica Polytechnica, (Hungary), Vol.24, No.1-2, 1980, 59-65.
8. Filanovsky I.M., Oscillators with Amplitude Control by Restoration of Capacitor Initial Conditions. IEE Proceedings, Vol.134, Pt.G, No.1, Feb.1987, 31-37.
9. Filanovsky I.M., Oscillators with Amplitude Control in a Twin-T Bridge RC-Oscillator. Proc 18th Midwest Symposium on Circuits and Systems, Louisville, KY, USA, Aug.1985, 429-432.

TRACY MARTIN

COMPUTER CONTROLLED SINE WAVE GENERATOR

With the price of PCs falling to the levels of commodity components, it becomes very attractive to harness their processing power to control applications. David Ryder outlines the design process behind a computer-driven 8-bit audio sinewave synthesiser.

The most important practical features of a general-purpose AF sine generator are speedy, accurate setting and constant amplitude. A computer add-on using digital synthesis from a standard rom offers a low-cost solution, and the keyboard can be set up as required to enter or recall frequencies directly, or vary current frequency in a chosen ratio. A rotary-encoder, which can be operated without looking, is a useful supplementary control.

Low harmonic content is of some importance when testing frequency-dependent circuits. While eight bit quantisation sets a limit on sampling accuracy, computation shows that some sets of sampling points are much better than others; optimum sampling allows THD to be kept generally below 0.05% by a simple alias-filter.

Digital interface

The *8086* IBM-compatible computer is loaded with a Chipboards *FPC-924* general purpose I/O counter card accessed by a simple program written in Basic. The present program uses only a few keys: the number keys enter target frequency while the actual output frequency, always within 0.05% of target, is continuously displayed.

The + and - keys increment or decrement the smallest available frequency step while F1 to F4 jump to programmed preset frequencies listed on screen. F9 captures current frequency to any one of F1-F4. F5 to F8 change current frequency by an octave or a semitone, up or down. F10, the amplitude-correction mode, enters corrections and/or make disk files.

The card was modified to use a 10MHz counter clock, by adding a Vero-mounted crystal package, and replacing the *8253* (socketed) triple counter by an *8254-2*. The present scheme uses only one counter section, and two I/O ports, here ports *B* and *C* of the 'number two' *8255* device on the card; byte *B0-B7*, and bits *C0-C3* are set as outputs, and bits *C4-C7* are set as inputs.

The synthesiser core

The circuit of **Fig. 1** accepts an input octave Fn of 5 to10kHz corresponding to a 10MHz divisor range of 1000-1999, allowing setting to ±0.05% or better. The input-stage PLL multiplies Fn by 128, to 640-1280kHz, from which all working octaves are derived.

The sine waveform is read from a 2048 byte rom, say a *2716*; the bytes to be stored, decimal integers 0-255, can be calculated in Basic by the expression

```
S(N)=128+INT(127.5*SIN(2*PI*N/2048)),
loop N=0 TO 2047                          (1)
```

The centre level 127.5 represents a DC component to be balanced out. The samples are symmetrical, and despite quantisation errors, even harmonics sum to zero over the cycle.

The memory addressing logic, basically a switchable binary divider, uses three small programmable logic devices. *PLD1* is a programmed as 7-bit synchronous counter for the PLL, combined with a

SPECIFICATION

Frequency range 11 octaves, 9.77Hz to 20kHz with setting to ±0.05%, using 1000 frequencies per octave.
Settling time 20ms.
Amplitude controlled to ±0.05% (±0.005 dB)
THD under 0.05% to 10kHz (under 0.1% to 20kHz)
Output 1V rms.

B0-B5 dec	oct no	KL/Fn (PLD1)	Fa out (PLD2)	optimum offsets	offset used	filter set at	THD Fmin	harmonics 3	5	7
7	7	128	KL/64	32n +/-6	26 (29-3)	7	0.06%	81	65	68
6	6	"	KL/128	16n +/-4	12 (15-3)	6	0.04%	79	69	72
5	5	"	KL/256	8n +/-4	4 (7-3)	5	0.02%	86	88	74
4	4	"	KL/512	4n +/-1	-3 (0-3)	4	0.03%	76	74	68
3	3	"	KL/1024	2n +/-1	-3 (0-3)	3	0.02%	76	75	73
2	2	"	KL/2048	N/A	-3	2	0.03%	74	77	71
1	1	64	"	"	"	1	0.03%	"	"	"
0	0	32	"	"	"	0	0.03%	"	"	"
8	-1	16	"	"	"	0	0.04%	"	"	"
16	-2	8	"	"	"	0	0.04%	"	"	"
24	-3	4	"	"	"	0	0.05%	"	"	"

Table 1. Frequency ratios, offsets, etc, for the 11 octaves. Output distortion figures are for the lowest frequency of each octave. The last three columns show pre-filter harmonic levels in dB below the fundamental. Calculations allow for measured D-TO-A errors.

selector switch; the control inputs *B0-B5* switch the separate output *KL* amongst divider stages, selecting 4 to 128 times the Fn frequency in octave steps.

PLD2 and *PLD3* together form an 11-bit synchronous counter, addressing the memory. *PLD3* is a straight 6-bit divider using a carry, *CY*, from *PLD2*. Another output inverts *KL* as an update for the 373 latch so that memory data lines have half a KL period, a minimum of 0.39µs, to settle before conversion. The eighth *PLD3* output, not shown, is used to buffer the signal Fn into the PLL.

Address-jumping and offsets

With only 1280kHz available, the maximum frequency using 2048 samples per cycle is 625Hz. The five highest output octaves therefore use address-jumping, to select only 1024, 512, 256, 128 or 64 of the 2048 samples per cycle. *PLD2* provides this function, controlled by *B0-B2*.

For example 20kHz is got as 1280/64, with addresses *A5-A10* only being read. The 64 samples must differ in address by 32, but need not start at address 0; a start offset can be set on the uncycled lines *A0-A4*, and the choice can significantly modify the spectrum of spurious (odd) harmonics which arise from quantisation. High order harmonics are suppressed by the filter, and output THD is minimised by choosing an offset which minimises low harmonics, especially the 3rd, 5th and 7th. For the filter described later, the best and worst choices for 64 samples per cycle give 0.05% and 0.20% THD (ignoring D-to-A errors). Similar variations occur for other values of reduced sampling per cycle.

Table 1 shows optimum offsets; a choice of sign is available since it is mathematically immaterial whether the memory is cycled backwards or forwards, and this allows *PLD2* to incorporate an optimum offset selection (as well as the jumping logic), with the aid of a fixed -3 offset in the rom, obtained by using 2*PI*(N-3) in the bracket of equation 1.

Specifying the converter

The 0.5 LSB errors of an 8-bit package D-to-A would cause the harmonic spectrum to depart unacceptably from that calculated; such packages also generate significant even harmonics, because the weights of low bits are slightly affected by switching high bits and the symmetry is lost. This situation can be remedied by using a much higher specification D-to-A converter and throwing away the lower order bits. Alternatively, a hand crafted version of an 8-bit converter can be made using combinations of precision high stability resistors.

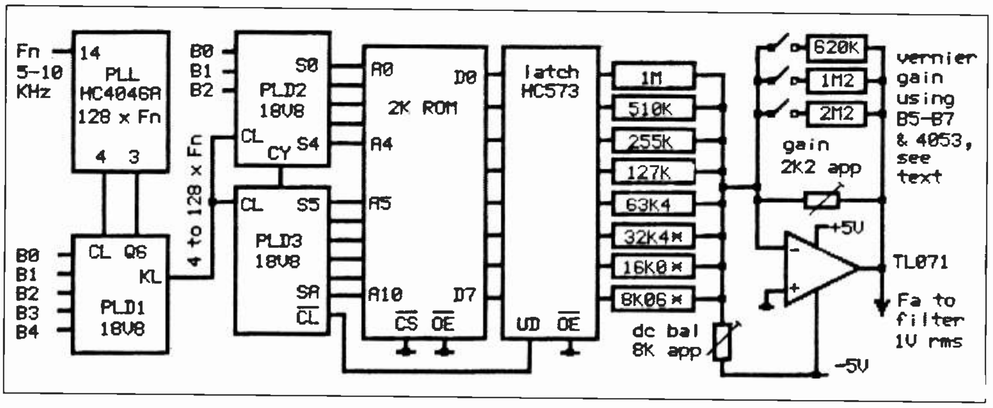


Fig 1. Digital circuits. Squarewave Fn and control-byte B0-B7 are from computer I/O card.

The resistor D-to-A of Fig. 1 can readily be set up to 0.1LSB. That is, if the total voltage-swing at F_a is defined as 0-255 units, intermediate sample-weights can be kept within ±0.1 of an integer. Also the contribution of each resistor is independent, so that bit-weight errors work symmetrically and even harmonics still cancel.

The calculated harmonic levels and output distortion of Table 1 allow for the measured errors of the dac used (+0.073 to –0.073); they are slightly worse than for exact integer weights, especially for the larger numbers of samples, but THD remains within 0.05%, except at the lower end of octave 7.

The D-to-A output level is set by the *74HC373* V_{dd}, pin 20; a separately stabilised +5V line could be used. To the op-amp the D-to-A appears as a 5V p-p source of internal resistance 4kΩ, and DC content +2.5V. The gain is adjusted to give 1V RMS at the filter output; the balance and gain-setting resistors can conveniently include 10-turn pre-sets, roughly 2% of the total required.

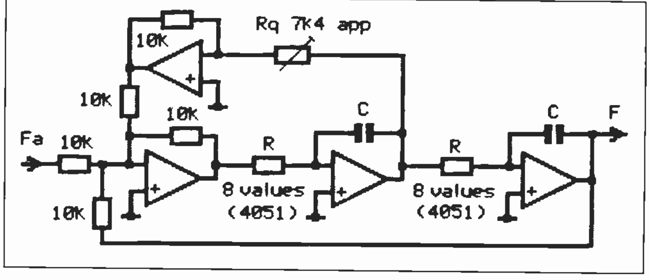


Fig 2. Filter. Op-amps are TL071-type, supply ±5V. R-values are switched by B0-B2 via 4051 devices.

Amplitude correction

The fundamental content of the quantised signal varies by about three parts in 10,000 according to number of samples and offset. Further variations arise from ripple in the analogue filter response over the working octave.

As shown in Fig. 1, bits *B5-B7* from the computer I/O card switch resistors for vernier gain-control in 0.1% steps with an accuracy of ±0.05%. A *4053* device, V_{ee} pin to -5V, provides the switching elements. This correction

PROGRAMMING THE PLDS

The Philips *18V8* PLD is a cmos sum-of-products device having 10 inputs, and eight output macrocells, which can be individually programmed as combinational or registered using D-type flip-flops. When any output is made a register, for example as a counter stage, input pin 1 is pre-empted as the clock, and input pin 11 is pre-empted as an active low output enable, here tied low on all PLD, along with unused inputs.

Each output has eight programmable AND terms: unprogrammed ANDs have no effect. Free inputs, and all outputs, are available in both senses as AND components. The clock input is not available, and for the *KL* inversion in *PLD3*, the *KL* signal is paralleled to a free input. For a registered output, the OR combination of the ANDs used is its data-bit, *DB*, determining the state it will take up on the next rising clock-edge.

Counter *DB* expressions basically use components fed back from outputs. For example if the outputs are *Q0, Q1*, etc, a counter can be set up by programming: *DB0 = /Q0 DB1 = /Q1*Q0 + Q1*/Q0 DB2 = /Q2*Q1*Q0 + Q2*/Q1 + Q2*/Q0* and so on; higher outputs use more terms. The carry output *CY* of *PLD2* is *S4*S3*S2*S1*S0*, so that */CY* serves for *(/S4 + /S3 + /S2 + /S1 + /S0)*, and *PLD3* can reach the 11th bit *SA* without running out of AND terms.

If a term *J0* (actually a combination of terms in *B0-B2*), is ORed: *DB0 = /Q0 + J0* then when *J0* is high, *Q0* is held high, and *DB1* becomes */Q1* merely; that is *Q1* switches on each rising clock-edge as *Q0* formerly did; *Q2, Q3* etc also switch twice as often, and each alternate memory address is jumped, i.e. only 1024 samples are read per output-cycle. *PLD2* includes a full set of J-terms, derived from *B0-B2*; in the highest octave *S0-S4* are all unswitched, and *CY* rests high.

Simply leaving *PLD2* unswitched outputs high would result in offsets 1,3,7,15,31 for the reduced sample-sets. However the *18V8* has enough room for the uncycled states of *S0* and *S1* to be set high or low. For example the 31 offset can be varied between 28 and 31. With a fixed offset of –3 in the rom, the choices are sufficient to program into *PLD2* an optimum selection of offsets, as shown in Table 1. The PLD programming equations are available on the disc from the author. See note, bottom right, this page..

can also cater for small DVM frequency errors, so that the DVM, at the output of a circuit under test, reads directly (to 0.01 dB) although the absolute signal level varies slightly. The software reads (or makes) a disk file of gain corrections; if more than one DVM is in use, each may have its own. Semitone intervals are convenient, 132 settings in all.

Filter

Although the alias components, even in octave 7, are remote and small, the low level spurious harmonics up to half KL sum typically to 0.28%, and for low THD, the filter must be to some extent programmable. It must also have small passband ripple. A switched-capacitor filter would add significant distortion, and inevitably some clock-breakthrough.

Figure. 2 shows one solution, an analogue state variable two-integrator loop. The fourth op-amp allows the use of inverting inputs only thus minimising distortion. The 10kΩ resistors are preferably selected to be equal, within say 0.1%. An output buffer and/or attenuator could be added.

The corner frequency F_c is programmable from 50kHz downwards in octaves, by switching resistors *R*, via two *4051* devices (V_{ee} pins to -5V), at the virtual earth side under control from bits *B0-B2* at the I/O board. The resistance values may be the same as those used for the digital to analogue converter.

The capacitors *C* will then be about 380pF, say 330pF polystyrene padded up, ideally to be equal but R_q, the trimmer pot in the filter feedback loop will compensate for small errors.

With F_c at 50kHz, octave 7, 10-20kHz, is located at 0.2 to $0.4F_c$, and the switched resistors with their binary relationships allow the same relationship down to octave 0, Table 1. The filter amplitude-ripple can then be kept within ±0.1% or so by setting *Q*, via R_q, at about 0.74. As Table 1 shows, the lowest four octaves use the same filter setting, and so distortion rises (though filter-ripple is less); calculated THD figures are for the lowest frequency of each octave, summed over odd harmonics up to about six times F_c. At the top of an octave they are roughly halved.

PLL multiplier

The circuit for this section (**Fig. 3**) uses information derived from Philips application note 9398 649 90011 which analyses loop stability. The shunt resistor R_p at pin 13, *PC2* output, discharges its parasitic capacitance. R_1, about 47k for the *HC4046A*, is chosen to set the 640-1280kHz octave within the allowed pin 9 range of 1.1 to 3.9V.

PLL jitter shows as excessive or unstable output harmonics, especially the 3rd. For low distortion, the starting-point was the rather large R_3, C_3 product, found experimentally, needed to filter *PC2* pulses adequately from the VCO, pin 9.

It turned out that an unconventionally small C_2/C_3 ratio could then be used without instability, limiting the settling-time penalty; the lead resistor R_4 is not critical.

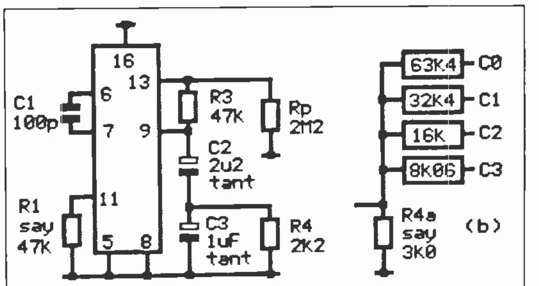


Fig 3. PLL components and fast settling circuit. Measured DC injection from the resistor ladders (b) settles the loop more quickly

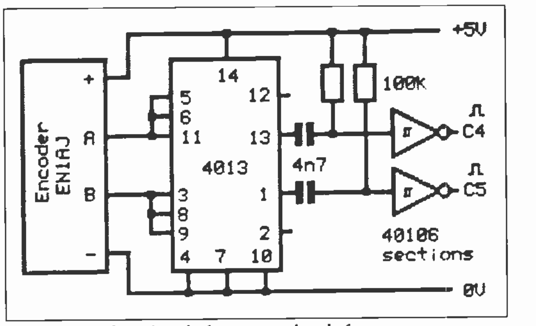


Fig 4. Encoder circuit for rotary knob frequency control.

The settling time for a near-octave jump is about 150ms. It can be reduced to about 20ms for any jump by step DC injection into the loop with an amplitude and sense which minimises C_2 voltage change. The additional circuitry shown to the right of the PLL loop detail in Fig. 3 replaces R_4. This is a 4-bit resistor D-to-A driven by 8255 I/O card outputs *C0-C3* gives 0-3.8V via 4.3k, divided by R_{4a} to the actual pin 9 range, say 1.6V.

The *C0-C3* nibble described in Basic is INT(30000/DIV-14.5) where DIV is the 10MHz divisor, 1000-1999.

Rotary encoder

A knob-operated rotary encoder, such as the Bourns *ENA1J* optical encoder, like an analogue potentiometer, can be used without looking and can also have a special law set by the software. For example, slow turning can give minimum frequency-steps and rapid turning large steps. The *EN* device gives 128 counts per revolution.

Figure. 4 shows cmos hardware to translate the *ENA1J* signals, two bit Gray code, to positive-going directional pulses on I/O card input lines *C4* and *C5*, clockwise and anti-clockwise unused inputs *C6, C7* are tied low. The *4013* pin 13 output is clocked low by encoder *B* high, but set again by the subsequent *A* high and vice versa for the pin 1 output. For consistent reading the *4013* output pulses need to be shortened to a fixed length; the 4n7/100kΩ combination give about 0.45ms at the Schmidt outputs.

A 5.25in IBM format disk with the Basic source-code, and some supplementary information can be supplied by the author. The fee is a £10 cheque, payable to Oxfam, sent to A.D. Ryder, Woodside Croft, Ladybridge Lane, Bolton BL1 5ED.

BASIC COMPUTER INTERFACE

Listing 1 is an extract from the Basic source code. Bits *C4* and *C5* are here read by the INP(438) statement (which ignores the *C0-C3* nibble); the IF clause saves the reading. Without the input loop 330-340, each main loop M-cycle takes about 0.39ms; the 11 N-cycles add about 0.21ms, total 0.60ms. To be seen, but only seen once, an input pulse should be longer than 0.39 but shorter than 0.60, e.g. 0.45 as above. The timings are for Qbasic-compiled code on an *8086* PC, and will vary for other systems. The INKEY$ in line 380 allows keyboard input for preset frequencies, etc.

The 10 M-cycles set 6ms normal response-time. A spin of the encoder will generate pulses, RTN<>0, over a series of 6ms intervals, and lines 630-640 then delay action until rotation has stopped (RTN=0); the accumulated count RAC, which can range from ±1 to ±70 or more, is passed to a subroutine.

Once read in, RAC can be used as required. For positive RAC, the present subroutine changes the current frequency in the ratio EXP(RAC^IND/1500). For a single step, RAC=1, the 1500 denominator gives the smallest available change; for RAC>1 the index variable, IND, sets the response to rapid rotation; for example, if IND is 1.5, an RAC of +70 gives a ratio of 1.4, half an octave. For negative RAC the ratio is inverted, as EXP(-ABS(RAC)^IND/1500). ■

Listing 1. Extract from Basic source-code for encoder

```
100 DEFINT K-R

300 'main loop; RB from encoder; K from keyboard
310 RTN=0: K=0 'reset at each main loop start
320 FOR M=0 TO 9
330 FOR N=0 TO 10: IF INP(438)>15 THEN RB=INP(438) 'INP(438)
reads encoder
340 NEXT N 'input loop ends, with any encoder step saved in RB
350 IF RB>31 THEN RTN=RTN-1: GOTO 370 'anti-clockwise, bit C5
360 IF RB>15 THEN RTN=RTN+1 'clockwise, bit C4
370 RB=0 'reset RB after contributing to RTN
380 K$=INKEY$: IF K$<>"" THEN K=ASC(K$) 'K saves any non-nul
value 390 NEXT M 'end of main loop

630 IF RTN<>0 THEN RAC=RAC+RTN 'accumulate + or - pulses in
RAC
640 IF RTN=0 AND RAC<>0 THEN GOSUB 800: RAC=0 'change
freq; reset RAC
650 ' (statements follow to use K<>0, keyboard input)

700 GOTO 300 'for a new main loop
```

Audio op amp with its head in the clouds?

Low distortion and high impedance make the OPA2604 audio op amp irresistible

By Ian Hickman.

Any reasonably priced plastic dual dil op-amp is worthy of further investigation if, like the Burr Brown *OPA2604*, it boasts a THD+N (total harmonic distortion plus noise) of 0.0003% typical at 3.5V_{RMS} output into a 1kΩ load at 1kHz.

Low distortion is in part due to the device's special distortion rejection circuit, **Fig. 1** – though details on this in the data sheet are sparse.

Audio buffs will know that if n% of distortion has to be accepted, second order rather than third order is preferred. Of course, if an amplifier has n% of pure second order distortion, it can be coupled push-pull with another identical amplifier to achieve a combined overall distortion of much less – say p%.

The p% will be all third order, but it should be so much lower than the n% of second that it will still be preferable. *OPA2604* is a single ended device, not push pull, so this distortion-reducing scheme is not applicable. But where selection can be made from a batch of devices, a distortion of well under 0.0002%, and probably under 0.00015% can be achieved.

Performance verification tests (see box) suggest that the dual op-amp output at pin seven has less distortion than the output at pin one. But with a sample size of just two specimens, this can only be conjecture.

High impedance in the clouds

High input impedance of the *OPA2604* (10^{12}Ω – 8pF differential and 10^{12}Ω – 10pF common mode) is another attractive feature.

Input bias current is 100pA, which is not a lot, and the offset current is ±4pA (all figures quoted are typical). So I speculated that perhaps the device could be used to measure the varying electrostatic potential induced in an elevated conductor, by vertical fields caused by clouds and other causes.

In practice, 10m of wire strung around the purlins in a loft proved to have a capacitance to ground of about 100pF. Induced voltages would appear in series with this, so that a 10MΩ path to ground would give a low frequency cut off of 160Hz – much too high to see the expected slow variations. Yet a DC path to ground is needed, for the input bias current.

To extend the LF cut-off downwards, circuit **Fig. 2a** was devised. The 20MΩ resistor at the non inverting input pin three is bootstrapped via the 10μF capacitor. This, with the other 20MΩ resistor gives an LF cut-off of 0.0008Hz.

Unfortunately, the circuit exhibits a huge response peak at a fraction of 1Hz. Redrawing the circuit with the op-amp's input capacitance included (**Fig. 2b**) shows it to be a Salen and Key second order lowpass circuit, the Q being 1/2X, where X is the square root of the ratio 10μF:(10pF plus circuit board strays).

Bootstrapping was therefore extended to DC, **Fig. 3a**, raising the effective resistance of the 20MΩ resistor at pin three to 20GΩ, giving an LF cut-off with a 100pF antenna of 0.08Hz.

Mains pick-up

Connecting the antenna revealed the next problem: op-amp output was a 50Hz waveform which would have exceeded ±15V but for clipping at the rails. The wire in the loft was obviously running too near mains wiring.

I reduced the problem by substituting a similar length of wire slung out of the upstairs front window of my laboratory, the far end supported on a step ladder.

There were still several volts peak to peak of 50Hz at the op-amp's output, but the level was reduced and the expected variations amplified by a factor of 10 (**Fig. 3b**). Lowpass SVF was as in Fig. 1b, except that the 1MΩ input resistor was changed to 100kΩ, *RQ* raised to 220kΩ and the capacitors changed to 1μF each, giving a 1Hz cut-off frequency. A further top cut circuit preceded the x10 gain stage, leaving just 20mV of residual 50Hz ripple at the output.

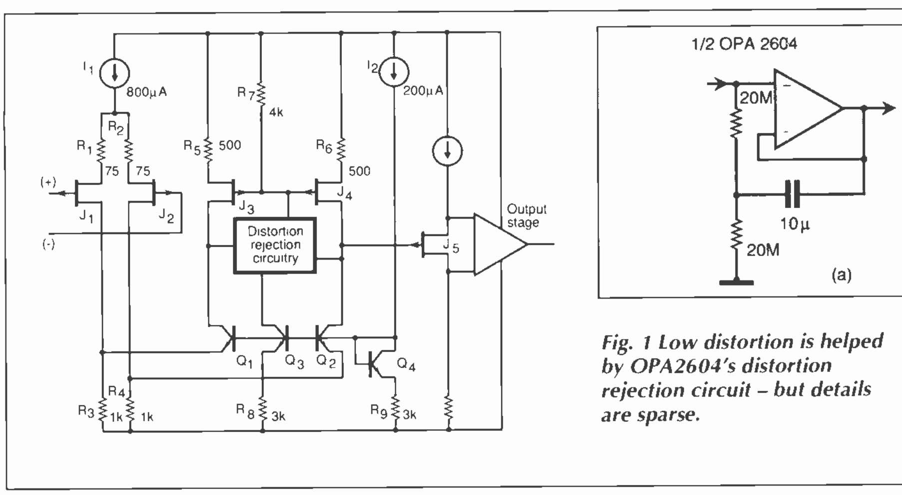


Fig. 1 Low distortion is helped by OPA2604's distortion rejection circuit – but details are sparse.

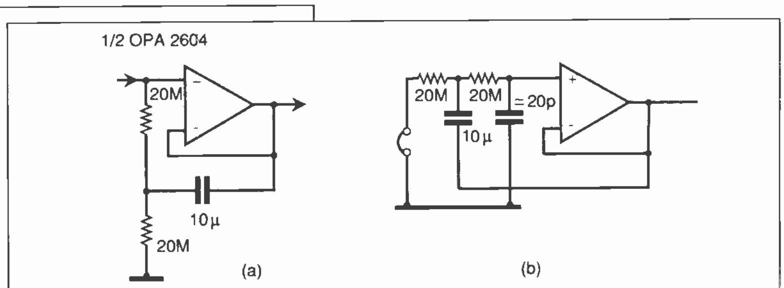


Fig. 2(a). Extending the LF cut-off downwards. 20MΩ resistor at the non inverting input pin three is bootstrapped via the 10μF capacitor. With the other 20MΩ resistor this gives an LF cut-off of 0.0008Hz. (b) Redrawing the circuit with the op-amp's input capacitance included shows it to be a Salen and Key second order lowpass circuit.

Verifying performance

Verifying performance of devices such as the *OPA2604* is an interesting task as good measurement practice demands a stimulus ten times better than the device under test.

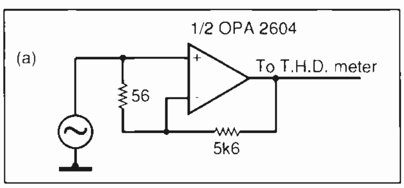
To verify that an oscillator's THD really is 0.00003% would require a distortion meter with inherent internal distortion of less than 0.000003% – well below noise.

But it is possible to test the *OPA2604* using an ingenious circuit given in the device's data sheet. The circuit is arranged (**Fig. Ia**) so that while the gain to the signal (both the fundamental and any harmonic components present) is just unity, the 40dB attenuation in the NFB path multiplies the device's internal distortion by a factor of 101. Measuring a distortion of 0.03% is certainly well within the capabilities of my THD meter, and all that is needed to be in business is to obtain a test signal with a THD well below this.

Two 10Hz to 10MHz video oscillators were available to me, with distortions (1kHz) of 0.08% and 0.05%. The first of these was used, as the short-term frequency stability (sideband phase noise) was better – an important consideration given the extreme narrowness of the THD meter's notch on the more sensitive ranges. The 0.08% distortion, nearly all third harmonic, was cleaned up using a high Q second order lowpass filter section based on the State variable filter, **Fig. Ib**. With unity gain at 0Hz, peak is 30.5dB at 1kHz, while at 3kHz the gain is about –18dB.

Resultant distortion at the filter's output should thus be 48.5dB lower than 0.08%, or about 0.0003% if the distortion in the *TL084* op-amp used to realise the SVF is zero. In fact, distortion measured on the 0.01% full scale deflection range of the THD meter was 0.0015% (with the 20kHz bandwidth limiting filter selected) and possibly lower.

Limit of measurement is set by the relatively poor short term frequency stability of the video oscillator, based on an RC oscillator circuit, making it difficult to hold the fundamental exactly in the notch.



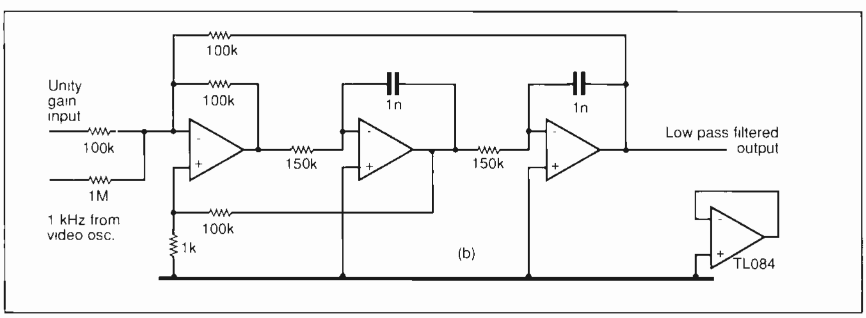


Fig. I(a). Ingenious circuit used to test the OPA2604, and (b) the sine wave clean-up circuit.

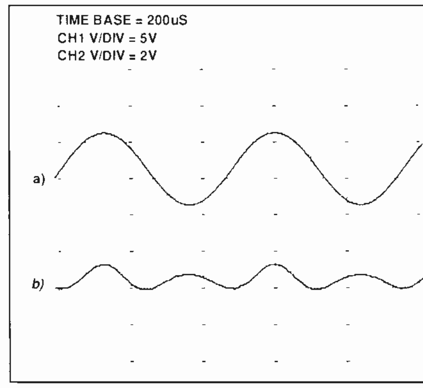


Fig. II(a). Using circuit Fig. 1a and the low distortion 1kHz test signal from Fig. I(b) the output at pin one was set to 10Vpk-pk (3.5V RMS). Residual distortion was measured as 0.035%, and its waveform is shown in (b).

Using the circuit of Fig. Ia and the low distortion 1kHz test signal from Fig. Ib, the output at pin one of the first sample was set to 10Vpk-pk (3.5V RMS), **Fig. II** upper trace. Residual distortion was measured as 0.035%, and its waveform is shown in the lower trace. Clearly, distortion is nearly all second harmonic, but with a trace of third, and translates to a figure for the *OPA2604* of 0.00035%, in good agreement with the claimed typical figure. The other op-amp in the dual, output at pin seven, gave an equivalent 0.00012%, while the corresponding sections in the second sample gave 0.0004% and 0.00027% respectively.

Interestingly, with these last three op-amp sections, the residual reduced to a pure sinewave, showing that the distortion was all second harmonic – as noted in the data sheet.

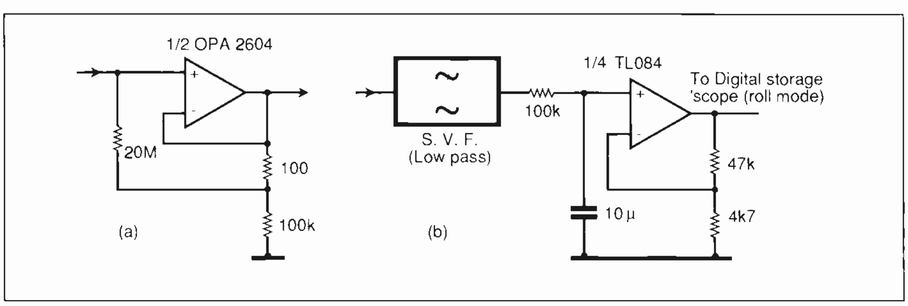


Fig. 3(a). Bootstrapping extended to DC, raising the effective resistance of the 20MΩ resistor at pin three to 20GΩ, giving an LF cut off with a 100pF antenna of 0.08Hz. (b) Following low pass filter and amplifier stages.

A typical 100s segment of the output is shown in **Fig. 4**, upper trace.

Some of the short term trace variations will be due to aliasing of the 50Hz due to the low sampling rate, but large slow variations are clearly evident. The sudden increase in noise at the right hand side of the trace is unexplained.

Intruder alarm

During the 100s taken to record the trace, the experimenter had to stand stock still, as any movements produced large deviations on the trace. For comparison, Fig. 4, lower trace, shows the output of the circuit under exactly the same conditions, except that the antenna had been disconnected. The arrangement would undoubtedly make an effective intruder alarm of the movement detector variety. For this purpose, a short antenna of about 0.5m is much more effective, since with a long wire out of the window, only the small part near the moving object is affected. ■

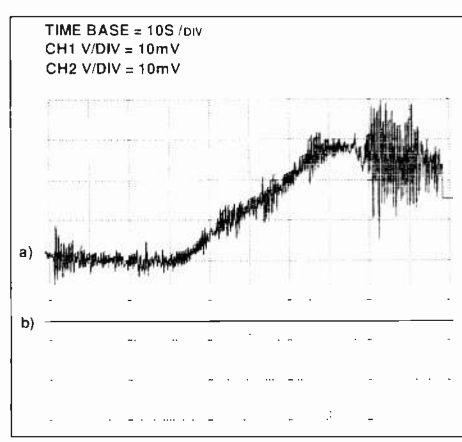


Fig. 4(a). Typical 100s segment of output and 4(b) with the antenna disconnected.

Circuits, Systems & Standards

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

Square-wave oscillator spans DC to 20MHz

Digitally controlled clock source

This circuit makes a useful digitally controlled clock for switched capacitor filters. Its spectral purity (close-in phase noise) will not be exceptionally good, but for this application that is not too important, though in other applications it could be a disadvantage.
IH

The digitally controlled oscillator of **Fig. 1** is useful as a clock source for switched-capacitor filters, and it costs less than $1 (OEM qty). During operation, the voltage at node *A* oscillates between the hysteresis thresholds at the input of IC_{2A}, a Schmitt-trigger inverter. The D-to-A converter, IC_1, sets the oscillation frequency by controlling the current into pin four (I_0), which sets the charge rate for capacitor C_1.

To understand how the circuit oscillates, first assume that C_1 is discharged (node *A* voltage is 5V). Node *B* is at 0V, so diode D_1 is reverse biased. The current into pin four of IC_1 determines the linear charge rate of C_1; this current ranges from 4µA to 4mA, depending on the D-to-A converter's input code *D* and reference current I_{REF}. C_1 charges until node *A*'s voltage ramps below the lower switching threshold (V_{TL}) of IC_{2A}.

The output of inverter IC_{2A} then switches high, although it clamps briefly at the voltage level of node *A* plus the diode's forward-voltage drop. The inverter can deliver more than 50mA in this state, overdriving the D-to-A converter's output current and rapidly discharging C_1. When node *A* rises to the inverter's upper threshold V_{TH}, node *B* returns to 0V and the cycle repeats.

Inverter IC_{2B} buffers the capacitor-discharge current and provides a negative-strobe output; IC_{2C} provides a positive strobe. Flip-flop IC_3 provides a square-wave output at one-half the strobe frequency (**Fig. 2**). The strobe period *T* equals T_1+T_2 (within the converter's 8-bit accuracy) for frequencies below 200kHz and for values of C_1 greater than 1000pF:

$$T \approx \frac{C_1\left(V_{TH}-V_{TL}\right)}{I_{REF}D}+60C_1\ln\left(\frac{5-V_{TL}}{5-V_{TH}}\right)$$

where *D*=(digital input)/256.

For C_1 values below 1000pF, you must account for stray capacitance. The following will add stray capacitance directly to C_1: converter output, 12pF; inverter input, 5 to 10pF; diode, 2pF. An IC socket will contribute additional capacitance. For strobe frequencies greater than 200kHz, effects of the inverter output's rise and fall times and its

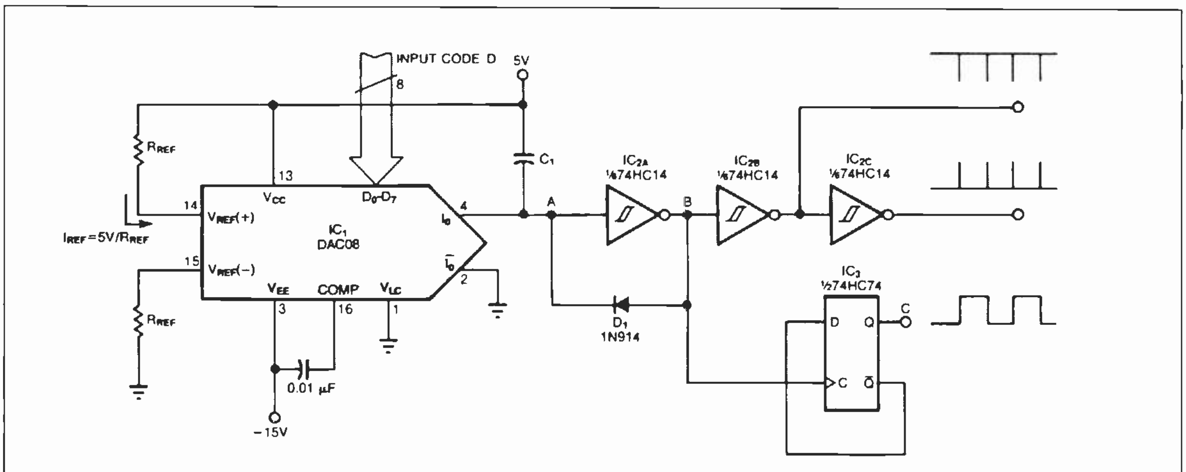


Fig. 1. This digitally controlled clock oscillator provides linear control below approximately 200kHz and has a maximum frequency higher than 20MHz.

propagation delay T_{PD} should be included:

$$T \approx (C_1 + C_{DAC} + C_{2A} + C_D)\left[\frac{V_{IH} - V_{TL}}{I_{REF}\,D} + 60\ln\left(\frac{5 - V_{IL}}{5 - V_{IH}}\right)\right] + T_{RISE} + T_{FALL} + T_{PD}$$

where C_{DAC} is the converter's output capacitance, C_{2A} is IC_{2A}'s input capacitance, and C_D is the diode's capacitance.

Figure 3 shows the oscillator operating at a strobe frequency of 20MHz. Capacitance at node *A* is 30pF (including 10pF from the oscilloscope probe). Notice that the fast-moving node *A* waveform overshoots both switching thresholds, producing an amplitude of 3.5V. Frequency vs input *D* becomes non-linear at higher frequencies because of propagation delays, rise times, and fall times in the inverter. At 20MHz, for example, the converter controls less than half of the waveform period at node *A*.

Although the oscillator is capable of high speed, its operation is more stable below 200kHz. You can set the converter's I_{REF} as low as 100μA and set C_I as high as you like – resulting in an operating frequency with no significant lower limit. For higher accuracy and greater dynamic range, you can replace the *DAC-08* with a 10 or 12-bit D-to-A converter.

Michael Jachowski, *Precision Monolithics Inc, Santa Clara, Ca*

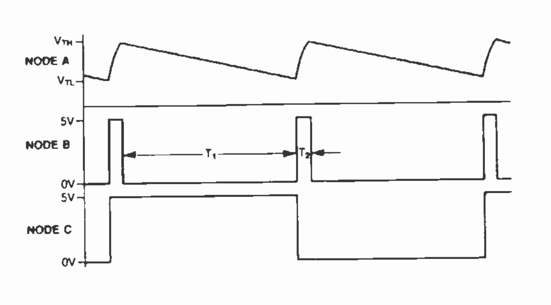
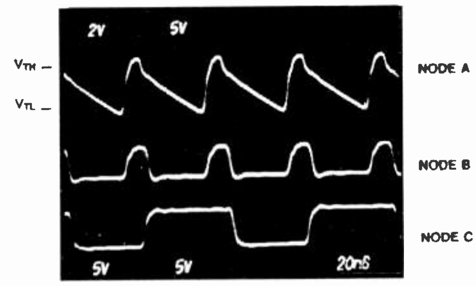


Fig. 2. Idealised waveforms from Fig. 1 illustrate the oscillator's operation for frequencies of 200kHz and below.



Trace	Vertical	Horizontal
Node A	2V/div	20ns/div
Node B	5V/div	20ns/div
Node C	5V/div	20ns/div

Fig. 3. Waveforms of Fig. 1's circuit operating at 20MHz. The strobe pulse width (node B) equals the sum of the rise time, fall time, and propagation delay for inverter IC_{2A}.

Multiple technologies produce fast clock

By combining saw, GaAs, and high-speed bipolar devices you can achieve an ECL-compatible clock oscillator (**Fig. 1**). Heart of the circuit is the saw-stabilised network that surrounds Q_I, the *DXL2401* GaAs fet from Gould Dexcel Div (Santa Clara, Ca). The *1143* saw oscillator from RF Monolithics (Dallas, Tx) has 180° of phase shift at resonance and couples the energy from Q_I's drain to its gate. L_I and C_I tune Q_I's drain to 1143MHz;

L band generator

Many RF-type ideas for designs tend to go to magazines specialising in RF and microwave, but *EDN* does get its fair share. This example shows a clock generator whose frequency is controlled by a surface acoustic wave device. Needless to say, at this frequency, extreme attention to the detailed layout will be essential to obtain the desired results. **IH**

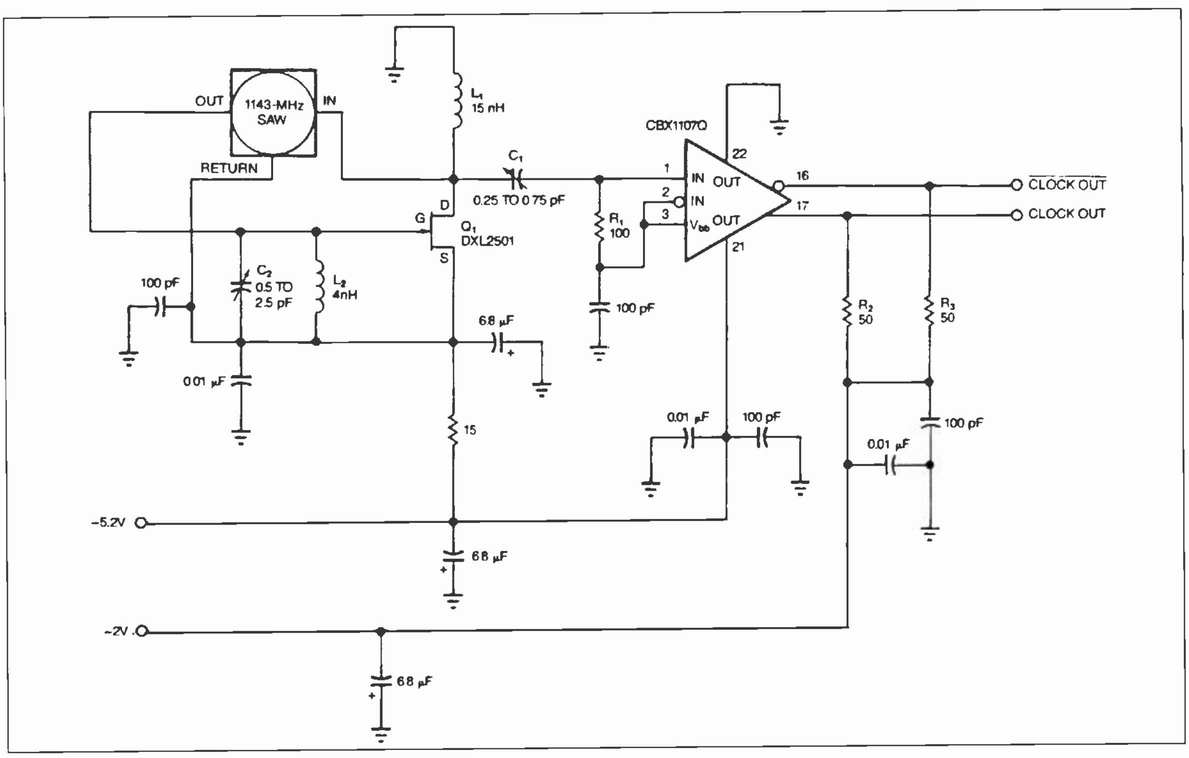


Fig. 1. Combining saw, GaAs and ECL devices, to implement a fast stable oscillator.

L_2 and C_2 tune Q_1's gate to 1143MHz. These networks also maintain proper phase relationships fbr oscillation at 1143MHz. The frequency of oscillation and temperature drifts are strictly determined by the saw characteristics. High quality saw devices typically have Qs in the neighbourhood of 6000 and frequency-drift rates as low as 1ppm/°C.

An ultra-high-speed bipolar ECL-compatible decision IC, the Sony *CBX1107Q*, functions as a comparator and ECL-level translator. C_1 couples Q_1's output to the *CBX1107Q*'s non-inverting data input. R_1 acts as a load resistor and supplies bias voltage to pin one of the decision IC. The inverting data input of the *CBX1107Q* is directly connected to the bias voltage, V_{BB}, which configures the IC as a high speed analogue comparator with input levels around V_{BB}. R_2, R_3 and –2V supply provide the proper termination and voltage level for ECL-compatible logic from the *CBX1107Q*'s data outputs.

***Michael A Wyatt**, SSAvD Honeywell Inc, Clearwater, Fl.*

Non-linear load extends PLL frequency range

Wide range PLL

The widely second-sourced *4046* PLL chip has a limited frequency range when used, as is usual, with a fixed timing resistor. This useful circuit removes that limitation.

A PLL chip such as the *74HC4046* in **Fig. 1** uses an external capacitor and resistor to set the frequency range for an internal voltage-controlled oscillator (VCO). By replacing the fixed resistor R_4 with a non-linear one, the VCO's frequency range can be extended by a factor of 50 or more. For the component values shown, when pin 11 connects to R_4, the range is 17 to 300kHz; in contrast, when the pin connects to the non-linear load, the range is 2kHz to 2MHz.

Capacitor C_1 and the current through pin 11 control the PLL's output frequency. Higher current produces a higher frequency. When V_{11} equals 0.5V, for example, the high-β transistor Q_1 is off and the resistance from pin 11 to ground is R_2+R_3. As V_{11} es, Q_1 turns on and draws more current from pin 11. Thus, the effective impedance, Z, is

$$Z = \frac{\dfrac{R_2 R_3}{\beta(R_2 + R_3)} + R_e}{\dfrac{R_3}{R_2 + R_3} - \dfrac{V_{BE}}{V_{11}}}$$

where β is the transistor's beta and V_{BE} equals 0.75V.

***Basel F Azzam and Christopher R Paul**, Coherent Communications, Hauppauge, NY.* ■

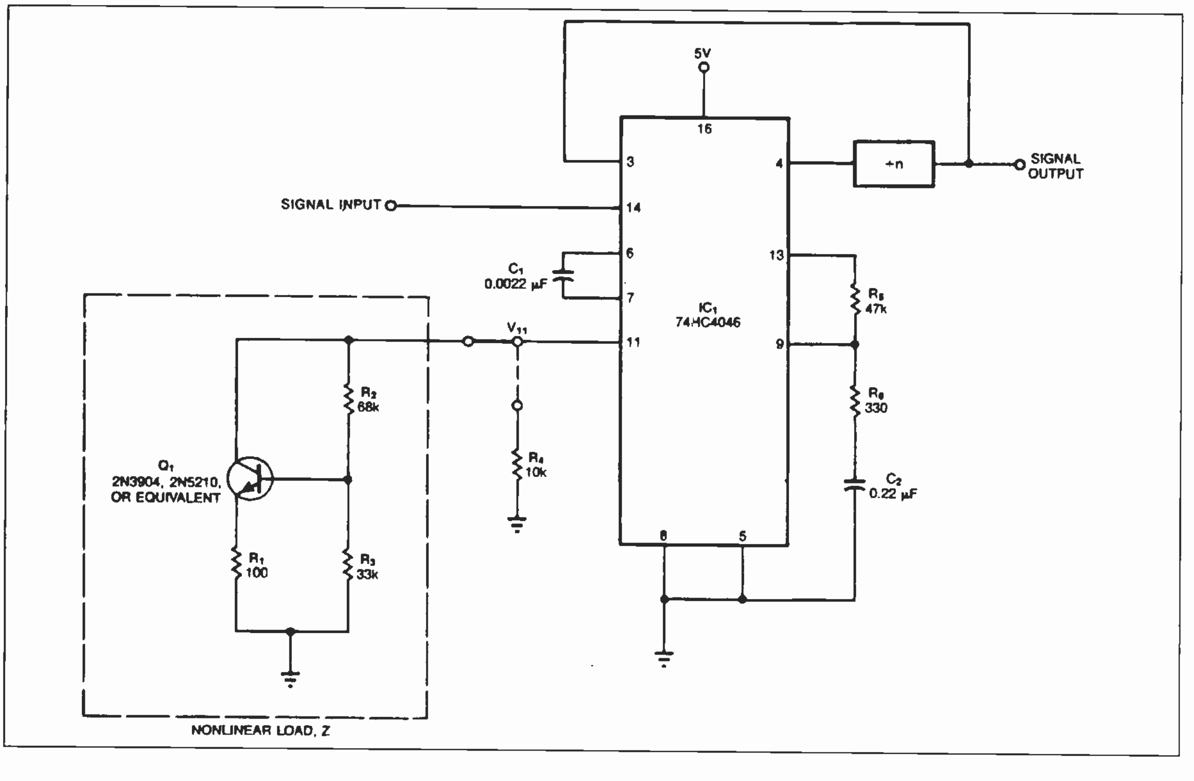


***Fig. 1.** By connecting the non-linear load Z to pin 11 of the PLL chip IC, the PLL's frequency range can be extended by a factor of 50, as compared with that possible by using a fixed resistor (R_4).*

Surplus always wanted for cash!

THE *ORIGINAL* SURPLUS WONDERLAND!

Surplus always wanted for cash!

BBC Model B APM Board

WIN £100 CASH!

£100 CASH FOR THE MOST NOVEL DEMONSTRATABLE APPLICATION!

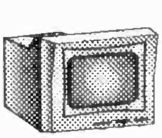
BBC Model B type computer on a board. A major purchase allows us to offer you the **PROFESSIONAL** version of the BBC computer at a parts only price. Used as a front end graphics system on large networked systems the architecture of the BBC board has so many similarities to the regular BBC model B that we are sure that with a bit of experimentation and ingenuity many useful applications will be found for this board!! It is supplied complete with a connector panel which brings all the I/O to 'D' and BNC type connectors - all you have to do is provide +5 and ± 12 v DC. The APM consists of a single PCB with most major ic's socketed. The ic's are too numerous to list but include a 6502, RAM and an SAA5050 teletext chip. Three 27128 EPROMS contain the custom operating system on which we have no data, On application of DC power the system boots and provides diagnostic information on the video output. On board DIP switches and jumpers select the ECONET address and enable the four extra EPROM sockets for user software. Appx. dims: main board 13" x 10". I/O board 14" x 3". Supplied tested with circuit diagram, data and competition entry form.

Only £29.95 or 2 for £53 (B)

MONITORS

MONOCHROME MONITORS

THIS MONTH'S SPECIAL!



There has never been a deal like this one! **Brand spanking new & boxed** monitors from NEC, normally selling at about £140! These are over-engineered for ultra reliability. 9" green screen composite input with etched non-glare screen plus switchable high/low impedance input and output for daisy-chaining. 3 front controls and 6 at rear. Standard BNC sockets. Beautiful high contrast screen and attractive case with carrying ledge. Perfect as a main or backup monitor and for quantity users! **£39.95 each** (D) **or 5 for £185**(G)

CALL FOR DISCOUNTS ON HIGHER QUANTITIES!

COLOUR MONITORS

Decca 16" 80 budget range colour monitor. Features a PIL tube, beautiful teak style case and guaranteed 80 column resolution, features usually seen only on colour monitors costing 3 times our price! Ready to connect to most computers or video outputs. 75Ω composite input with integral audio amp & speaker. Fully tested surplus, sold in little or hardly used condition with 90 day full RTB guarantee. Ideal for use with video recorder or our Telebox ST, and other audio visual uses. £99(E) 3/£275(G)

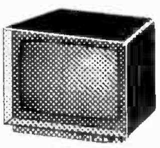
20", 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

CALL FOR PRICING ON NTSC VERSIONS!

HI-DEFINITION COLOUR MONITORS



Brand new 12" multiinput high definition colour monitors by Microvitek. Nice tight 0.31" dot pitch for superb clarity and modern metal black box styling. Operates from any 15.625 khz sync RGB video source, with either individual H & V syncs such as CGA IBM PC's or RGB analog with composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 14" x 12" square. Free data sheet including connection information. Will also function as quality TV with our RGB Telebox.

Only £145 (E)

Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubishi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case. Full 90 day guarantee. **Only £129** (E)

NEC CGA IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. A terrific purchase enables us to pass these on at only.... **£79** (E)

V22 1200 BAUD MODEMS

Master Systems 2/12 microprocessor controlled V22 full duplex 1200 baud modem. Fully **BT approved** unit, provides standard V22 high speed data comm, which at 120 cps, can save your phone bill and connect time by a staggering 75%! Ultra slim 45 mm high. Full featured with LED status indicators and remote error diagnostics. Sync or Async use; speech or data switching; built in 240v mains supply and 2 wire connection to BT. Units are in used but good condition. Fully tested prior despatch, with data and a full 90 day guarantee. What more can you ask for - and at this price!! **ONLY £69** (D)

IBM KEYBOARD DEALS

A replacement or backup keyboard, switchable for IBM PC, PC-XT or PC-AT. LED's for Caps, Scroll & Num Locks. Standard 84 keyboard layout. Made by NCR for the English & US markets. Absolutely standard. Brand new & boxed with manual and key template for user slogans on the function keys. Attractive beige, grey and cream finish, with the usual retractable legs underneath. A generous length of curly cord, terminating in the standard 5 pin DIN plug. A beautiful clean piece of manufacturers surplus. What a deal! £39 (B) 5/£175 (D)

Brand new and boxed 84 key PC/XT type keyboards in standard IBM grey with very attractive mottled finish and "clicky" solid feel keys. 10 function keys on side. English layout and £ sign. Green LEDs for Caps, Scroll & Num locks. £29.95 (B) 5/£135 (D)

CALL FOR DISCOUNTS ON HIGHER QUANTITIES!

FLOPPY DISK DRIVES BARGAINS GALORE !

NEW 5¼ inch from £29.95!

Massive purchases of standard 5¼" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from +5 & +12vdc, are of standard size and accept the standard 34 way connector.

TANDON TM100-2A IBM compatible DS	£39.95(C)
CANON,TEC etc.DS half height.State 40 or 80T	£79.00(C)
TEAC FD-55-F.40-80 DS half height. **BRAND NEW**	£79.00(C)

Specials!

TEAC FD-55 half height series in your choice of 40 track double sided 360k or 80 track double sided 720k. Ex-equipment fully tested in excellent condition with 90 day warranty. Order TE-36 for 360k £29.95(C) or TE-72 for 720k £39.95(C)

CHOOSE YOUR 8 INCH!

Shugart 800/801 SS refurbished & tested	£150.00(E)
Shugart 851 double sided refurbished & tested	£225.00(E)
Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW	£250.00(E)

SPECIAL OFFERS!!

Dual 8" drives with 2 megabyte capacity housed in a smart case with built in power supply! Ideal as exterior drives! **Only £499.00** (F)

End of line purchase scoop! Brand new **NEC D2246** 8" 85 megabyte of hard disk storage! Full CPU control and industry standard SMD interface. Ultra hi speed transfer and access time leaves the good old ST506 interface standing. In mint condition and comes complete with manual. Only.......................£399(E)

AFFORDABLE 10 Mb WINCHESTERS

A fantastic deal - 10mb (formatted) Winchester for £39.95! **Tandon TM502** full height ST506 interface. Use it as a second hard drive on your present driver card or as a starter into Winchester land - see the driver card listed below. In excellent used condition, guaranteed for 90 days.......................£39.95(C)

Hard disk driver card, complete with cables ready to plug into your PC or compatible. Supports two Winchesters......£29.95(A)

No Break Uninterruptable PSU's

Brand new and boxed 230 volts uninterruptable power supplies from **Densei**. Model MUK 0565-AUAF is 0.5 kva and MUD 1085-AHBH is 1 kva. Both have sealed lead acid batteries. MUK are internal, MUD has them in a matching case. Times from interrupt are 5 and 15 minutes respectively. Complete with full operation manuals.......**MUK**.....£249 (F) **MUD**.....£525 (G)

RECHARGEABLE BATTERIES

LEAD ACID

Maintenance free sealed long life. Type A300.

12 volts	12 volts 3 amp/hours	£13.95(A)
6 volts	6 volts3 amp/hours	£ 9.95(A)
12 volts	Centre tapped 1.8 amp hours. RFE.	£ 5.95(A)
12 volts	12 volts 38 amp hours.7-1/2"L x6"S.RFE	£35.00(B)

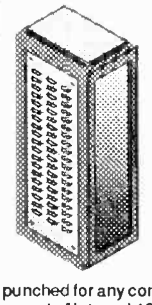
EXTRA HI-CAPACITY NICKEL CADMIUM

Super high capacity **Chloride Alcad** 12 volts refillable type XL1.5. Electrolyte is readily available Potassium Hydroxide. In banks of 10 cells per 8"H x 24"L x 5.5"D wooden case. Each cell measures 8"H x 1.75"L x 4"D. Can be easily separated. Ideal for all standby power applications. Ex MoD, like new..£49.95 (E)

SPECIAL INTEREST

Newton Derby frequency changer 3 phase 50hz to 3 phase 400hz. 15 kva output. As new.	£2900
Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator	£6500
Calcomp 1036 large drum 3 pen plotter	£ 650
Thurlby LA 160B logic analyser	£ 375
1.5kw 115v 60hz power source	£ 950
Tektronix R140 NTSC TV test signal standard.	£ 875
Sony KTX 1000 Videotex system - **brand new**	£ 650
ADDS 2020 VDU terminals - **brand new**	£ 225
Sekonic SD 150H 18 channel Hybrid recorder	£2000
Trend 1-9-1 Data transmission test set	£ 525
Kenwood DA-3501 CD tester, laser pickup simulator	£ 350

Superb Quality 6 foot 40u 19" Rack Cabinets



Massive Reductions Virtually New, Ultra Smart! *Less Than Half Price!*

Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels or stand singly. Overall dimensions are 77-1/2"H x 32-1/2"D x 22"W. Order as:

Rack 1 Complete with removable side panels......	£275.00 (G)
Rack 2 Less side panels	£145.00 (G)

POWER SUPPLIES

Power One SPL200-5200P 200 watt (250 w peak).Semi open frame giving +5v 35a, -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims13" x 5" x 2.5". Fully guaranteed RFE. £85.00 (B)

Power One SPL130. 130 watts. Selectable for 12v (4A) or 24 v (2A). 5v @ 20A. ± 12v @ 1.5A. Switch mode. New. £59.95(B)

Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4".New £19.95(B)

Greendale 19AB0E 60 watts switch mode.+5v @ 6a,±12v @ 1a,+15v @ 1a. RFE and fully tested.11 x 20 x5.5cms. £24.95(C)

Conver AC130. 130 watt hi-grade VDE spec.Switch mode.+5v @ 15a,-5v @ 1a,±12v @ 6a.27 x 12.5 x 6.5cms.New. £49.95(C)

Boshert 13090.Switch mode.Ideal for drives & system. +5v@ 6a, +12v @ 2.5a, -12v @ 0.5a, -5v @ 0.5a. £29.95(B)

Farnell G6/40A. Switch mode. 5v @ 40a.Encased £95.00(C)

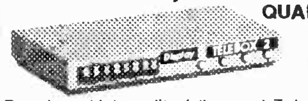
COOLING FANS

Please specify 110 or 240 volts for AC fans.

3 inch	AC. 1½" thick	£ 8.50(B)
3½ inch	AC ETRI slimline.Only 1" thick.	£ 9.95(B)
31/2 inch	AC 230 v 8 watts. Only 3/4" thick	£12.95(A)
4 inch	AC 110/240v 1½" thick.	£10.95(B)
10 inch	AC round. 3½ thick. Rotron 110v	£10.95(B)
10 inch	As above but 230 volts	£24.95(B)
60 mm	DC 1" thick.No.812 for 6/12v.814 24v.	£15.95(A)
80 mm	DC 5 v. Papst 8105G 4w. 38mm. RFE.	£19.95(A)
92 mm	DC 12v. 18 mm thick.	£14.95(A)
4 inch	DC 12v. 12w 1½" thick	£12.50(B)
4 inch	DC 24v 8w. 1" thick.	£14.50(B)

THE *AMAZING* TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER!

Brand new high quality, fully cased, 7 channel UHF PAL TV tuner system. Unit simply connects to your TV aerial socket and colour video monitor turning same into a fabulous colour TV. Dont worry if your monitor does'nt have sound, the TELEBOX even has an integral audio amp for driving a speaker plus an auxillary output for Headphones or Hi Fi system etc. Many other features: LED Status indicator, Smart moulded case, Mains powered, Built to BS safety specs. Many other uses for TV sound or video etc. Supplied BRAND NEW with full 1 year guarantee.

Telebox ST for composite video input monitors.........	£32.95(B)
Telebox STL as ST but with integral speaker...........	£36.50(B)
Telebox RGB for analogue RGB monitors................	£68.95(B)

RGB Telebox also suitable for IBM multisync monitors with RGB analog and composite sync. Overseas versions VHF & UHF call. SECAM / NTSC not available.

BRAND NEW PRINTERS

TEC Starwriter Model FP1500-25 daisywheel printer renowned for its reliability. Diablo type print mechanism gives superb registration and quality. On board microprocessor gives full Diablo/Qume command capability. Serial RS-232C with full handshake. Bidirectional 25 cps, switchable 10 or 12 pitch, 136 cpl in Pica, 163 in Elite. Friction or tractor feed. Full ASCII including £ sign. Font and ribbon Diablo compatible........£199(E)

DED DPG21 miniature ball point pen printer plotter mechanism with full 40 characters per line. Complete with data sheet which includes circuit diagrams for simple driver electronics......£49(B)

Centronics 150 series. Always known for their reliability in continuous use - real workhorses in any environment. Fast 150 cps with 4 fonts and choice of interfaces at a fantastic price!

159-4 Serial up to 9.5" paper, fan fold tractor...........	£ 99.00(E)
150-4 Serial up to 9.5" paper, tractor, roll or s/sheet.....	£129.00(E)
152-2 parallel up to 14.5" paper, tractor or s/sheet.....	£149.00(E)

CALL FOR THE MANY OTHERS IN STOCK.

VISIT OUR SHOP FOR BARGAINS

LARGE QUANTITIES OF OSCILLOSCOPES AND TEST GEAR ALWAYS AVAILABLE - CALL NOW!

DISPLAY -ELECTRONICS-

MAIL ORDER & OFFICES Open Mon-Fri 9.00-5.30 Dept WW, 32 Biggin Way, Upper Norwood, London SE19 3XF.

LONDON SHOP 100's of bargains! Open Mon-Sat 9-5.30 215 Whitehorse Lane, South Norwood, London, SE25.

DISTEL © The Original Free dial-up database! 1000's of items+info On Line V21, V22 & V22 bis 081-679-1888

ALL ENQUIRIES 081-679-4414 Fax- 081-679-1927 Telex- 894502

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. PO orders from Government, Universities, Schools & Local Authorities welcome-minimum account order £25. Carriage charges (A)=£2.00. (B)=£5.50. (C)=£8.50. (D)=£11.50. (E)=£14.00 (F)=£18.00 (G)=Call. All goods supplied subject to our standard Conditions of Sale and unless otherwise stated guaranteed for 90 days. All guarantees on a return to base basis. We reserve the right to change prices & specifications without prior notice. Orders accepted subject to stock. Quotations willingly given for higher quantities than those stated. Bulk surplus always required for cash.

REGULARS

CIRCUIT IDEAS

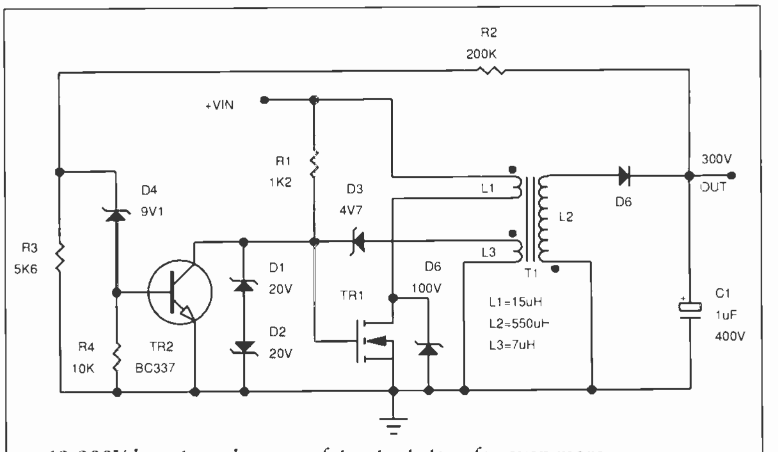
Ringing-choke inverter

Mosfets possess advantages over bipolars in the already simple and robust ringing-choke inverter, in that they confer even greater reliability and the possibility of higher frequency and therefore smaller inductive components. This one gives a regulated 300V output from an input of 12V and can easily be modified for other inputs and outputs.

At switch on, the mosfet is off. Its gate-source capacitance of about 1000pF charges through R_1, turning the mosfet on and causing an increase in L_1 current ($L_{1,2,3}$ are on the same ferrite core). When the gate voltage rises enough to turn D_3 on, the current in L_1 is limited, inducing a voltage in L_3 to turn the mosfet off; this is a positive-feedback action which gives a rapid turn-off to reduce losses. This generates a voltage across L_2 which is rectified and smoothed to give the 300V output. The gate-source capacitance now recharges and the whole thing starts again.

Voltage divider $R_{2,3}$ and the offset zener D_4 provide the regulator input; if D_4 and therefore Tr_2 conduct, the mosfet stays off. Zeners $D_{1,2}$ limit the mosfet's gate-source voltage and D_3 determines L_1 peak current.

D F Conway *Browns Bay Auckland New Zealand*



12-300V inverter using a mosfet output stage for even more reliability. Bipolar transistor regulates output.

Programmable-window comparator

A dual buffered D-to-A converter and a dual four-input cmos comparator can be configured to form a comparator having independently, digitally programmed window centre voltage and width. Three outputs indicate whether the input is inside, above or below the window

The *8222* and the three op-amps generate V_x, which is the window centre voltage, and V_y, half of the window width, from data in the *8222* latches, *DAC A* working in a bipolar manner and *DAC B* in unipolar mode. Signals $\overline{\text{DAC-A/DAC-B}}$, $\overline{\text{LDAC}}$ and $\overline{\text{WR}}$ come from, for example, a microprocessor address bus.

Sampling comparators in the *LTC-1040* drive outputs $\text{OUT}_{1,2,3}$. If the algebraic sum of the signals at $\text{A}_{\text{IN}1\text{-}4}$ is positive, OUT_1 goes high:

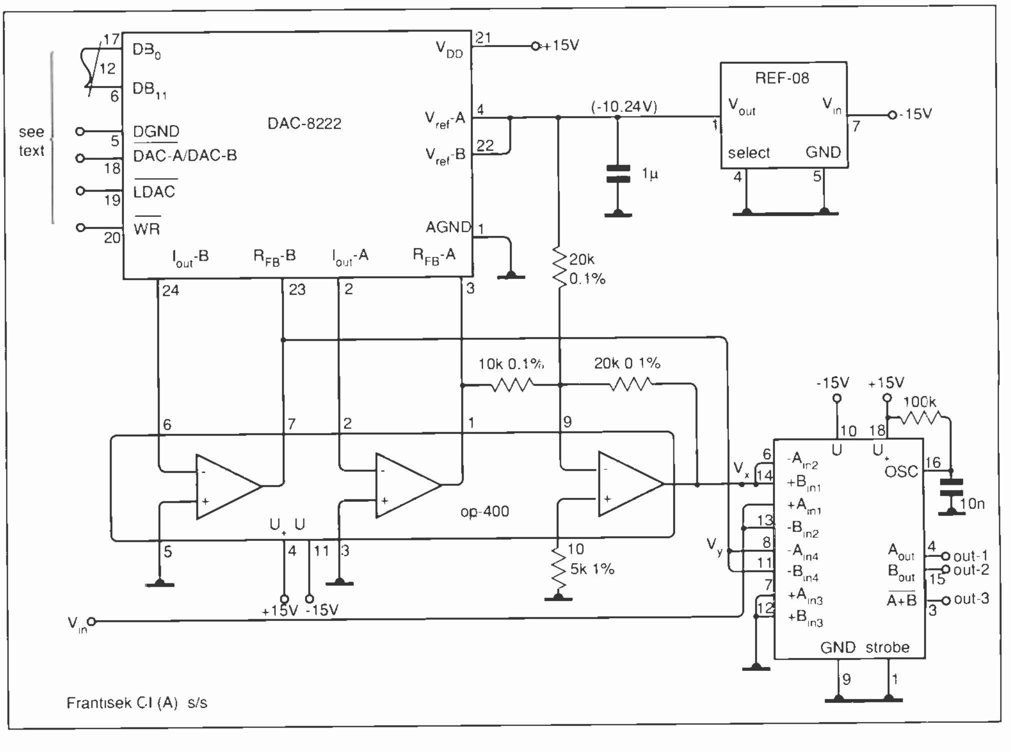
$$V_{IN} - V_X - V_Y > 0$$

$$V_{IN} > V_X + V_Y$$

OUT1 is therefore high if V_{IN} is higher than the upper window limit. In a similar way, OUT_2 goes high if V_{IN} is lower than the lower window limit and out_3 is high when OUT_1 and OUT_2 are low, ie when V_{IN} is higher than the lower limit and lower than the upper limit. With the RC components on pin 16 of the *1040*, sampling takes place at 1000s/s.

Without using the manufacturer's DAC calibration method, accuracy is within ±0.1V over a range of ±10V.

Frantisek Michele
Brno
Czechoslovakia



Comparator with digitally programmed window upper and lower limits, giving an accuracy over ±10V input of within 0.01%.

Measuring transfer functions

In a frequency-swept transfer-function analyser for use with an oscilloscope, it is necessary to maintain the level of the swept oscillator constant at all relevant frequencies – a problem that often exercises designers. In my design, the problem is largely eliminated

Since a square wave is composed of an infinite series of harmonics, the fundamental being predominant, the LF response of a circuit to a square wave indicates its response to the fundamental. As **Fig.1** shows, if *A* is fed with a square wave, its LF response V_{OL}, which is the flat part, accounts for the transfer function at that frequency. If, therefore, a series of period-modulated square waves is applied to a circuit, the relative amplitudes of the flat parts of the response gives the frequency response to all the fundamental frequencies of the input series.

This the core of my transfer-function scanner. It produces a series of square waves that are frequency-modulated in steps, rather than continuously. **Figure 2** shows the essentials. A 555 timer provides the clock, which drives the 4017B decade counter. This, via the *4066B* analogue switches, connects $C_{1\text{-}n}$ in the second 555 timer (*Z*). The output is therefore a number of stepped frequency changes, the step duration being fixed by the clock and the square-wave frequency in each step by R_iC. **Figure 3** is a more detailed diagram, in which values may be chosen for any particular application. In the circuit described, the frequencies inside the steps varied in a 1-2-4 sequence from 100Hz to 12kHz and the capacitors $C_{1\text{-}8}$ from 100nF to 800pF. Resistor R_c is 72k and R_d is 30.5k.

Figure 4 shows some results. At (a) is a screen shot of a high-pass filter circuit, showing a clear representation of the effect, with the measured response on the right. At (b) is a low-pass response and the output of the transfer-function scanner itself at (c).

T C Liao
Beijing Peoples's Republic of China

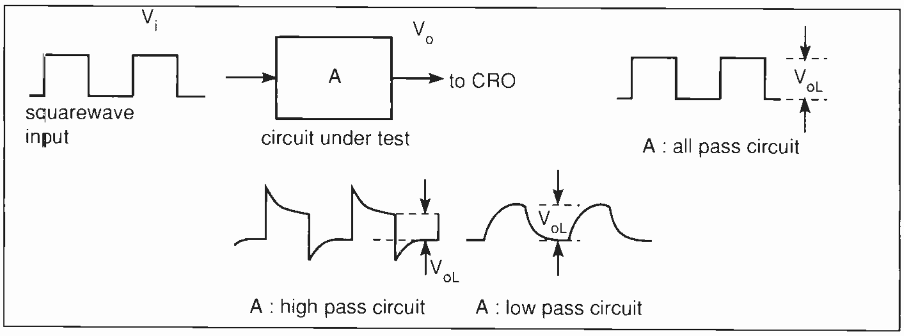


Fig.1. The shape of a squarewave after passing through a filter is determined by the filter characteristics. This provides the basis for a simple audio network analyser

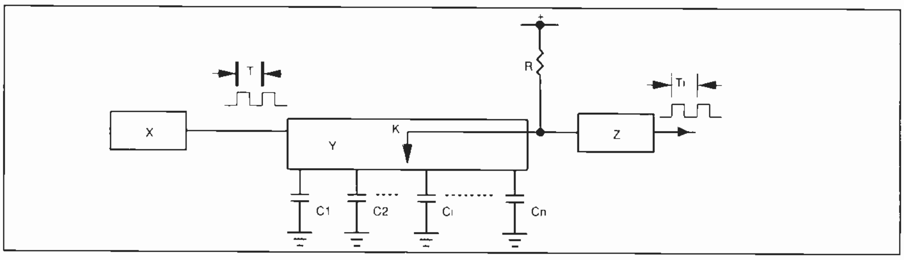


Fig. 2. Essentials of the transfer-function scanner.

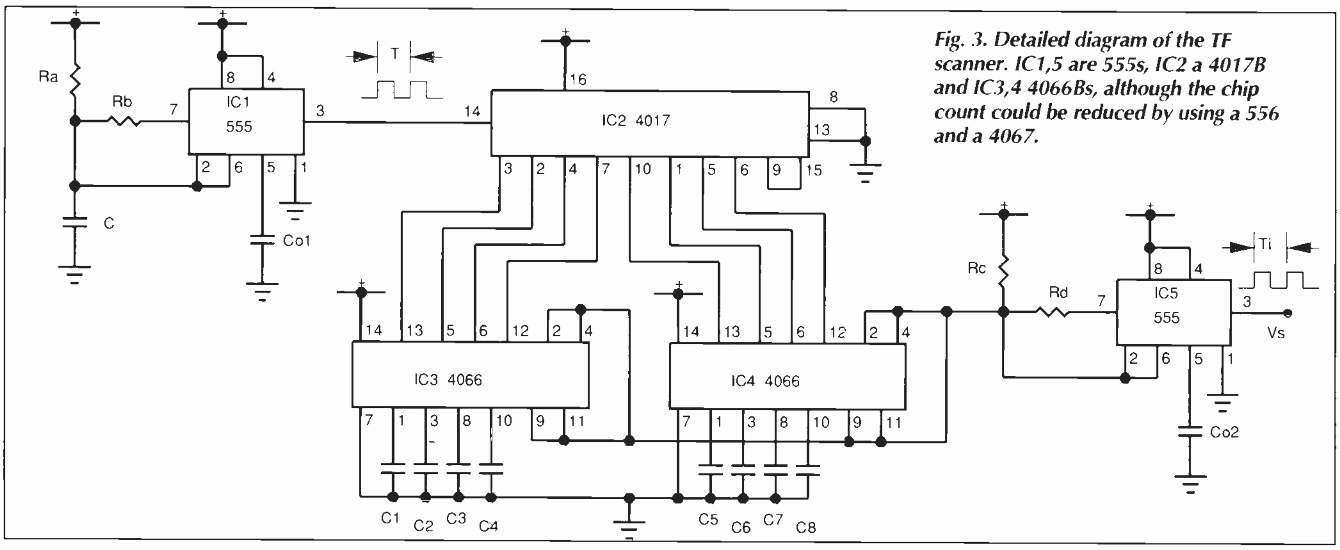
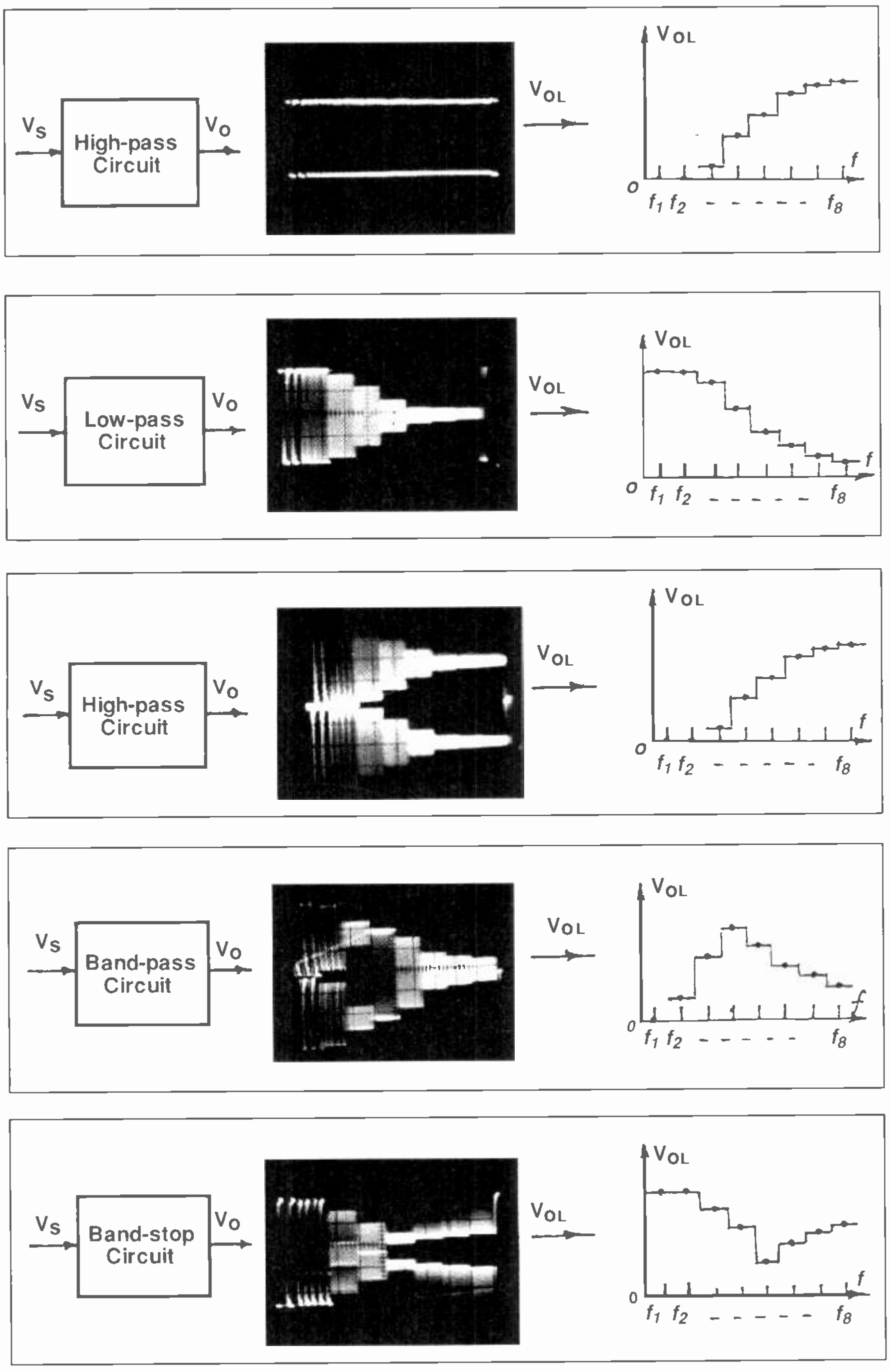


Fig. 3. Detailed diagram of the TF scanner. IC1,5 are 555s, IC2 a 4017B and IC3,4 4066Bs, although the chip count could be reduced by using a 556 and a 4067.

Fig. 4. The results from various filter types. The circuit in Fig. 3 produces a step-frequency mdoulated squarewave output which, when applied to a filter input, produces output voltages and waveforms of the types shown below. The swept frequency oscillogram requires a degree of interpretation – the RMS voltage output does not correspond to external envelope shape.

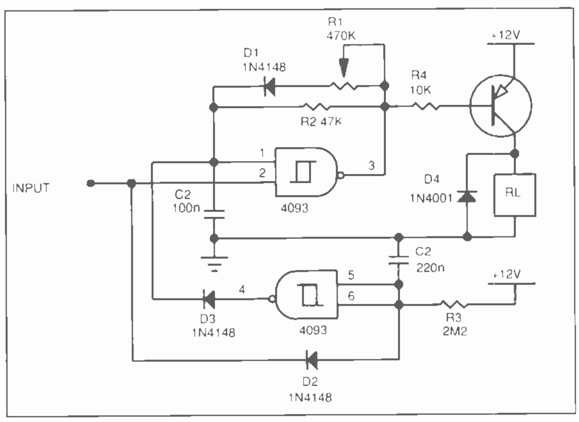


Chopper saves relay power

Relays need more power to turn on than they do to stay on. That being so, you can save about 40% in drive power by chopping the drive.

With a low input, the output of IC_A is high, Tr_1 is off and the relay de-energised; capacitor C_2 is discharged via D_2 and the output of IC_B is high. On a high input IC_A goes low, switching on Tr_1 and the relay at full power, but only until C_2 charges through R_3. At this point, IC_B output goes low, cutting off D_3 and enabling the oscillator formed by IC_A, $R_{1,2}$, D_1 and C_1. This chops the drive to Tr_1 and the relay at a mark:space ratio and therefore average power set by R_1 and C_1. The transistor dissipates very little power, since it acts almost purely as a switch.

Yongping Xia
Torrance
California
USA



When the relay is solidly on, the oscillator chops the drive to apply greatly reduced holding power, saving battery life.

FRESH IDEAS
While we are not short of Circuit Ideas to publish, it would be agreeable to see some fresh input from the vast, untapped bank of talent that our readers represent. We pay a useful fee for all ideas published. So send them to Circuit Ideas, Room L333, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS.

ACTIVE

Asic

GaAs asic evaluator. Fujitsu's GaAs *MB53* asic gate arrays now have their evaluator kit. It comes with a test chip that contains all available circuit functions. The *MB53* range is in five master sizes with from 3000 to 30000 gates, with or without ram. Gate delay is 80ps, gate power 1.1µW and working frequency up to 1GHz. Fujitsu Microelectronics Ltd, 0628 76100.

3V gate array. The *CLA70000* asic gate array family is now fully characterised for 3V operation, with a view to its use in hand-held battery-powered equipment. Gate density is now over 150,000 usable gates. GEC Plessey Semiconductors, 0793 518000.

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

Data converters for digital radio. *AD7001* and *AD7002* from Analog are data converters to go between audio and IF/RF stages of the new generation of digital mobile radios (DMRs), in which voice is digitised and encoded at source so that channels can be interleaved in the pan-European GSM cellular system. The devices are similar, but the *7001* uses a successive-approximation A-to-D converter, whereas the *7002* has a sigma-delta type, a pulse-shaping rom and further D-to-A converters for frequency and gain control and signal shaping. Analog Devices, 0932 232222.

Multiplexed sample/hold. A four-channel simultaneous sample-and-hold with output multiplexer, the *MSH-840* from Datel, will recognise a 10V step to within 0.01% in 775ns, input to multiplexer output. Simultaneous or single-channel sampling is available and there is provision for a channel to be digitised or put on hold and then digitised. Input impedance is 100MΩ, harmonic distortion -70dB at 500kHz and slew rate 45V/µs. Datel (UK) Ltd, 0256 880444.

Discrete active devices

HF transistor. Philips's *BFG25AX* n-p-n transistor has a transition frequency of 5GHz. It is meant mainly for use in battery-powered, low-power amplifiers. DC current gain is 200 and noise at 1GHz is 2.5dB maximum. Gothic Crellon Ltd, 0734 788878.

HF power transistors. Philips's *BLF547/548* mos transistors have been hotted up to give 100W/150W output power at 500MHz. These devices are both n-channel enhancement-mode units, working with a 28V supply at over 50% efficiency. There are no internal matching networks, so that they cover application from VHF to UHF. The increased power is intended to reduce the number of stages needed in a transmitter. Philips Semiconductors Ltd, 071 580 6633

Low-resistance mosfet. Combined with a drain-source breakdown of 100V and fast switching, the 1.5Ω on resistance of Zetex's *ZVN4210A* n-channel mosfet makes it well suited to medium-power switching applications. Current is 0.45A continuous, 6A pulsed, and maximum power is 700mW. At 1MHz and 25V on the drain, input C is 100pF maximum and transconductance is 250ms at 1.5A. Turn-on and turn-off delays are 4ns and 20ns. Zetex plc, 061 627 4963.

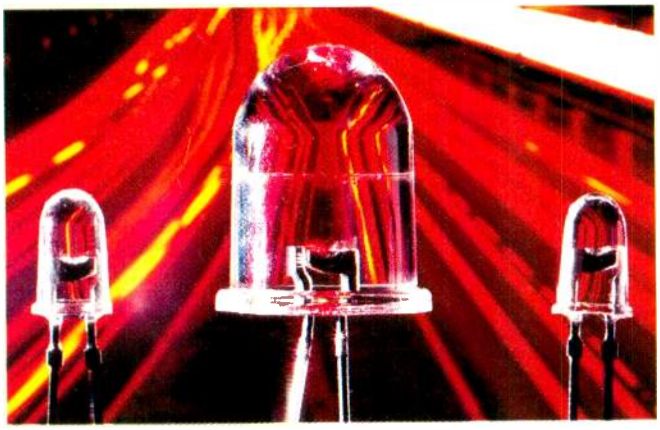
Digital signal processor

DCT processing. *ZR36020* in the Zoran range of processors used in image compression is a high-speed device meant to perform 2-D forward and inverse discrete cosine transforms. In combination with an image coder/decoder, the *ZR36020* forms a DCT-based image compression system to the JPEG standard. A host system controls transform direction and data format and, when initialised, runs continuously at up to 15Msample/s. It will process 8 by 8 data blocks in 4.2µs. Amega Electronics Ltd 0256 843166.

Linear integrated circuits

Fast NiCad charging. Able to charge NiCad batteries in 20min, the *ICS1700* from Integrated Circuit Systems also increases battery life, restores lost capacity, increases charging efficiency and acceptance and minimises memory effects. Its integral risc microprocessor institutes several different methods of stopping the charge to ensure internal pressure and temperature are safe. There is provision for indication of charge status and a safety timer is included. Amega Electronics Ltd, 0256 843166.

MAC chipset. *DMA2281* and *DMA2286*, decoder and descrambler respectively, will handle any of the new MAC television standards coming via satellite. The devices, from ITT, are usable with the company's *DIGIT2000* digital TV system or in other systems. *DMA2281* processes D2mac, Dmac and Cmac signals at baseband, once they have been digitised by the *VCU2133* video codec unit. For sound, duobimary signal is filtered and sliced to obtain low bit errors. All 16 configurations can be coped with to give up to four channels in parallel. ITT Semiconductors, 0932 336116.



Bright leds. Leds from Hewlett-Packard in a material whimsically called transparent-substrate aluminium gallium arsenide (TSAlGaAs, for not very short) are much brighter than the average, putting out up to 15 candela at 20mA and at a very narrow viewing angle. They are red (637nm), are compatible with cmos/mos and dissipate 130mW. Jermyn Distribution, 0732 740100.

2GHz amplifier. From Elantec, the EL2075 is a voltage-feedback amplifier with a gain.bandwidth product of 2GHz, 13ns settling time to 0.1% and 50mA output over temperature. It is stable at a gain of 10, the -3dB bandwidth being 400MHz. Input offset is 200µV, it has a 2µA input bias and symmetrical differential input. Microelectronics Technology, 0844 278781.

Battery management. Sequoia says its bq2001 energy management unit (EMU for short) is the first BiCMOS IC designed to look after the batteries in portable equipment. It measures battery capacity, monitors rate of discharge, controls fast charging in minutes and battery conditioning. Programmable control registers allow for adaptive operation under microprocessor control, but default settings enable stand-alone operation. Six outputs are usable for led driving, state indication, switch control etc. Sequoia Technology Ltd, 0734311822.

Logic building blocks

Fast comparator. Linear Technology's *LT1116* is a 12ns comparator that will sense signals at ground, although using a single +5V supply. Input common-mode range is from zero to 2.5V below the positive rail and offset voltage is typically 1mV. There is active drive in both directions at the output with little cross-conduction current and the device is stable on slow transitions. An output latch is included. Micro Call Ltd, 0844 261939.

3.3V logic. With high speed and application to notebook and lap-top computers in mind, Performance have announced a 3.3V logic family, *54/74FCT3XXX*, which is in CMOS and compatible in all but pinout with TTL. Full rail-voltage swings are produced and two grades give propagation delays of 4-5ns or 3-4ns. Power consumption is much below that for 5V families and the devices include circuitry to reduce ground bounce and noise. Supply pins are now in the package centre, with multiple ground pins and a more practical location of signal pins. Translators to interface this family with 5V logic are included in the range. Performance Semiconductor Ltd, 0256 59585.

Mixed-signal ICs.

Speech synthesiser. Oki's *MSM63P74* is a single-chip speech synthesiser with a built-in 512kbyte one-time-programmable rom for

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

storage. It uses an analogue/digital-conversion PCM data conversion technique for high quality. The chip is meant for short runs where many different messages are needed, speech analysis and data programming being carried out on the Oki development tool, which is offered for demonstration. Highland Electronics Ltd, 0444 245021.

Fax/modems for portables. Rockwell have two chipsets intended for high-end data/fax modems destined for personal computers. RC96AC-W is a full-featured modem with enhanced PC AT commands, operating at up to 9600b/s, data compression allowing throughput of 38.4kb/s. *RC144AC-W* is compatible with it , working at up to 14,400b/s, or 57.6kb/s effectively with compression. Both sets consist of a modem datapump and microcontroller, and firmware on disk. RCS Microsystems Ltd, 081 979 2204.

Teletext decoder. TI's new Multipage teletext decoder captures and stores 1000 pages in one transmission cycle and holds them in external dram for instant access. Instead of using blocks for graphics, a 260 by 480 bit map can provide higher-resolution graphics, a process which is accelerated by Multipage development software. TI says the system is simple to design into receivers: programming for fastext and TOP modes needs only about 3kbyte. Texas Instruments, 0234 223252.

Optical devices

Light sensor. Light-to-frequency conversion is used in the *TSL220* Bicmos device to give greater precision and to allow direct connection to a microprocessor or digital control circuit, noise being less of a problem than is usually the case. Dynamic range is 118dB, "dark" output is 1Hz and in ordinary room lighting over 100kHz. One of these devices replaces a photodiode, an amplifier and A-to-D converter. Texas Instruments Ltd, 0234 223252.

LCD backlights. The Visualux range of backlighting for liquid-crystal displays uses numbers of leds bonded to a "step" on the edges of an acrylic block, their light being reflected from opposite and adjacent edges of the block to illuminate the viewing area. Edges are white to increase reflection. Service life is claimed to be up to 100,000 hours, several times the life of cold-cathode or electroluminescent devices. A variety of colours is available. Visualtec Ltd, 0268 288173.

Oscillators

SM oscillator. For surface mounting, this oscillator is epoxy-encapsulated to relieve problems of differential expansion commonly found in ceramic packages. Resulting stability is ±15ppm from 0°C to 70°C and ±50ppm from -55°C to 125°C. Gas contamination from the epoxy is overcome by hermetic sealing. Ageing is guaranteed at 1-2ppm for the first year. Frequency ranges from 1-50MHz, current requirement being 10-30mA. McKnight Fordahl Ltd, 0703 848961.

Programmable logic arrays

10ns PLD. The *PLD610* from Cypress Semiconductor is a 10ns version of the *EP610* programmable logic device. It is made in 0.8micron BiCMOS and is fast enough to make a 100MHz counter. The *PLD610* is pin and function-compatible with *EP600/610/63, 85C060* and *PALCE610*s, and possesses 60% more registers and more inputs than the *22V10*. It is supported by Abel, PLD designer, Log/ic and Cupl Ambar Components Ltd, 0844 261144.

10,000-gate FPGA. Xilinx's *XC4010* is claimed to be the largest field-programmable gate array, with 10,000 usable gates. It is now possible to implement an FPGA-based 32-bit microprocessor peripheral control system, this being made faster and easier by new software. Three-state buses, fast carry logic and wide edge decoders are all incorporated, all being needed for 32-bit systems. Design changes are taken care of by a reprogramming facility, resulting in cheaper and faster development. Micro Call Ltd, 0844 261939.

Power semiconductors

No power for mosfet driver. Harris's new mosfet driver, the *HV400*, needs no external power supply, taking its power and control signals from the system's floating PWM circuit. It is a bipolar, dielectric isolation IC, sourcing 6A, sinking 30A and driving capacitive loads of up to 0.1µF at up to 300kHz; rise and fall times are 70ns and 30ns and can be controlled by separate pins. Harris Semiconductor (UK), 0276 686886.

Fast power mosfets. Silicon n-channel mosfets from Hitachi for motor control and power conversion switch in 90ns for a 250V device. DIII-HF devices are for use at voltages up to 600V and at 30A, all of them possessing low drive-current needs. On resistances lie between 0.075Ω and 0.35Ω. Hitachi Europe Ltd, 0628 585000.

70A IGBT. Ixys says its new insulated-gate bipolar transistor,the *IXSH35N100*, is the highest current discrete IGBT with short-term short-circuit capability. Maximum collector current is 70A, minimum blocking voltage 1000V, maximum saturation voltage 3.5V and fall time 700ns. Short-circuit withstand time is 10µs. Ixys Corporation, Fax: 010 1 408-435-0670.

SMPS controller. Unitrode's *UC3875* family combine resonant and pulse-width modulation for efficiency at high frequencies and, therefore, reduction in size. To control a bridge power stage, one half is shifted in phase relative to the other, allowing the use of constant 1MHz PWM combined with resonant, zero-voltage switching in either voltage or current modes of operation. Duty-cycle control is 0-100%; there are four 1A totem-pole outputs; a 10MHz error amplifier; and soft start, with all the usual protection circuitry. Macro, 0628 604383.

5V regulator. *MAX639* is claimed by Maxim to be the industry's most efficient step-down switching regulator. Quiescent current is 20µA, which confers efficiencies of more than 94% for output currents of 2mA to 225mA. Preset output is 5V±4%, but is adjustable by two resistors, input being between 4V and 11.5V. Short-circuit and logic-level protection are included, as is a low-battery monitor. Maxim Integrated Products Ltd, 0734 845255.

PASSIVE

Passive components

Trimmer pot. Bourns's new trimmer, Model *3319*, is meant for high-volume commercial and consumer use. Its single-turn carbon-on-ceramic track has a range of 100Ω-1MΩ with a tolerance of ±25% at 0.2W. Temperature coefficient is 1000ppm/°C. Bourns Electronics Ltd, 0276692392.

Mains toroids. Toroidal mains transformers made by ILP can now be obtained from Cirkit. The transformers come in ratings from 15VA to 500VA, with dual primaries for 120V or 240V, 50 or 60Hz, and dual secondaries for the required voltage or current provision. Each is provided with its mounting kit. Should none of the stocked range fit one's needs, specials can be wound. Cirkit Distribution Ltd, 0992 444111.

Connectors and cabling

Filter headers. Murata's new EMI-suppressed header connectors, the *CUH* series, incorporate miniature feedthrough capacitors to eliminate noise from cables, the only changes to existing PCB layouts being the need for ground planes. Capacitance values from 47pF to 2200pF are available with ground pins at each end of the connector. Murata Electronics (UK) Ltd, 0252 811666.

Optical modem. Acapella, part of the ES2 organisation, has introduced *ACS100*, which is an asic designed to enable the replacement of dual fibre links with single ones. It allows full duplex serial transmission over the one cable at up to 38.4kb/s over a distance of 2.5km. The trick is to use

Time/frequency analysis. TimeView is a software package designed for use with the Philips *PM6680* timer/counter in time and frequency analysis in conjunction with a PC AT with 640K of memory, Dos 3.30 and VGA/EGA mono or colour. The system takes thousands of counter/timer measurements and displays them graphically against time. It will also perform statistical analysis and FFTs. Data capture modes are free-running, repetitive and waveform-capture, and data can be stored on disk for analysis, off-line if necessary. Philips Test & Measurement, 0923 240511.

one led for both transmission and reception, with a controller to tell it which. Data is compressed by the modem before being TDMed and the incoming data is accordingly expanded. ES2, 0344 525252.

Displays

Digital panel meters. LCD and led panel meters from Amplicon Liveline provide BCD and autoranging options. There are 3 1/2 and 4 1/2-digit instruments giving multiplexed BCD signals and optional parallel tri-state outputs for voltage measurement and 4-20mA current loop two-wire process measurement with temperature display and dummy zero. Self-powered meters measure the signal from which they derive their power. Amplicon Liveline Ltd, 0273 570220.

Filters

Dual FIR filter. To confer a flexibility not found in asic designs of finite impulse-response filter, Harris introduce the *HSP43168* dual filter, which contains two 8-tap FIR filters, used singly or in cascade, configuration control and storage of up to 256 programmable coefficients. Modes of operation include high-/low-/band-pass and complex filtering, 2-D convolution, interpolation and decimation. Decimation filters for each tap effectively increase the number of taps by 16 times, allowing the design of a 256-tap low-pass filter with very sharp transition. Thame Components Ltd, 0844 261188.

Instrumentation

Satellite level meter. The *MS-450B* satellite level meter made by Promaxis is intended to check for possible interference between the number of television satellites in, or soon to be in, operation. Frequency range is 950 to 1750MHz, indicated digitally, and the level meter is calibrated for a 30dB range, though the actual range is -60dB to -10dB for measurement of cross-polarisation. C/N figure and possibly side lobes assist with dish alignment. Alban Marketing Ltd, 0727 832266.

Electric field meter. Four sensitivity ranges from 1kV/m to 1000kV/m are available in the IDB model *107* hand-held electric field strength and polarity meter from Bristol Industrial & Research Associates Ltd. The unit is complete with case and battery charger. Biral, 0275 847787.

Fast DSO. Gould claims its new digital storage oscilloscope to be the fastest available at less than £10,000. The *4096* digitises at 1.6Gsamples/s, repetitive signals being captured at up to 5Gsamples/s; time resolution for transient signals is 625ps. Transients can be seen with eight points per cycle, and then analysed by a waveform processor. There is a built-in colour plotter and IEEE-488 and RS423 interfaces allow control by and transfer to a computer. Gould Electronics Ltd, 081-500 1000

40MHz oscilloscope. At a remarkably low price, Maplin have available the *7046* 40MHz, delayed-sweep oscilloscope, with a 40ns delay line. Cost is £499.95, which includes vat. Maplin Electronics, 0702 554155.

1.3GHz counter. For low-frequency accuracy, where long gate times would normally be needed, the *TF830* counter/frequency meter measures multiple periodic times and takes the reciprocal to display the frequency to a resolution of seven digits per second of measurement time, or 0.001ms. *TF830* measures frequency to 1.3GHz, frequency ratio and pulse width, and counts events. An RS232 interface option is offered. Thurlby-Thandar Ltd, 0480 412451.

Literature

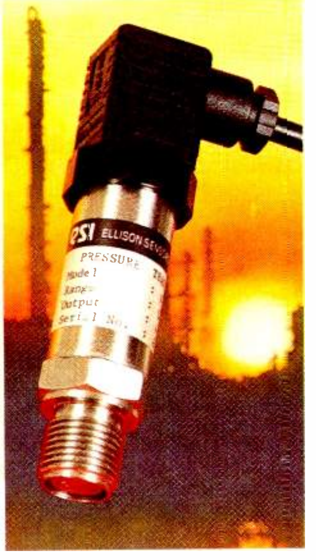
IC selector on disk. Harris has put all salient data on its ICs on a floppy disk, covering analogue and digital signal processing, data acquisition, power processing, general microprocessor, peripherals and telecomms. There is also a list of application notes and some other useful stuff. You can select devices in several ways, for example by A-to-D conversion time, to see a display of all the devices meeting the requirement, with specifications. It is free from Harris.Harris Semiconductor (UK), 0276 686886.

Radio answering machine. To avoid mobile radio users missing messages when away from their sets, Midland LMR have introduced a built-in message storage/relay facility, described in a new brochure. In one mode, the device behaves as an answering machine and in the other as a repeater to extend talk-back range. Midland LMR (USA)1-800/643-5263.

Power supplies

30kV bench supply. This new unit provides 30kV at 100µA, the output being controllable from zero to full scale by a ten-turn potentiometer and indicated to a resolution of 100V by a led panel meter. Current is displayed by a two-range meter with a resolution of 0.1µA on the top range and 0.01µA up to 20µA. Stability is 300ppm/°C, with stabilisation and regulation of 0.1%; ripple is 0.02%pk-pk. Applied Kilovolts Ltd, 0273 439440.

Medical SMPS. 40W and 110W switching power supplies with universal input, *NFS40/110* by Computer Products, are now available with approval to UL544, IEC601 and CSA 22.2-125 standards, which means that they are usable in non-patient-connected applications under IEC601 and for patient-connected use under the other two. Since the units accept 85-264V AC input, this means that one model with international approval will suffice worldwide. Computer Products, 0234 273838.



Lithium cells. Two additions to the *LS* range of primary lithium bobbin cells from Saft Nife are the C-type *LS26500* and the D-type *LS33600*, both with a voltage of 3.3V. D cells have what is believed to be the highest capacity for this size of lithium thionyl chloride cell at 14.5Ah, the C cell being of 6.4Ah capacity. Singles or battery packs are available, with various types of protection circuitry. Saft Nife Ltd, 081 979 7755.

Pressure transmitter. A British-designed and manufactured pressure transmitter from Ellison, the *PR3100* is said to be so versatile that it meets virtually all requirements in industry and science, also meeting European standards. It is a strain-gauge instrument with a two-wire 4-20mA output and is built in stainless steel with temperature compensation from -20°C to 80°C. Pressure range is from 250mbar to 1000mbar. Ellison Sensors International, 0978 846434.

Radio communications products

Dual LNB. New from Cambridge, the Gemini low-noise block down-converter has dual outputs to allow the operation of two satellite receivers from one offset or prime-focus dish. Working in Ku-band, the LNB is Astra-compatible and has a polarisation system to select vertical or horizontal polarisation. Typical noise figure is 1.2dB and cross polar rejection figure 20dB minimum. Cambridge Computer Ltd, 0294 222100.

Superregen kits. Superregenerative RF receivers have not always had a good press, and are often guilty of over-wide front-end bandwidth, drift, an enthusiasm for picking up noise and sometimes generating it themselves. Quantelec have a design kit for receivers in the paging system market, using a delay line in the oscillator feedback, which apparently helps with most of these problems The kit contains the delay line, a list of components, a working board and artwork to make more. The receiver has a sensitivity of -105dBmwith a front-end bandwidth of 600kHz and draws only 430µA from 5V. Quantelec Ltd, 0993 776488.

RF modem. *DP240* high-speed universal modem has a 2400baud data rate and is miniaturised, being supplied in the form of a printed board. It provides TTL/cmos/RS232C i/o with a 25mA current requirement. Fixings are provided on board for a radio unit from the company's series of low-power transmitter/receiver telemetry modules, or the *TCV450* UHF transceiver. Wood and Douglas, 0734 811444.

Switches and relays

High-temp relays. *DX* relays from Matsushita can be used at temperatures up to 200°C. These hermetically sealed units are available in monostable or latching versions, with two 30W changeover contacts, the thermal EMF of 1µV making them usable in hostile surroundings such as furnaces and engine monitoring. Matsushita Automation Controls, 0908 23155.

Keyboard switches. Eight switching functions are offered by the Unimec *1500* series by Quiller, in alternate and momentary-action versions. The switches fit standard 15mm keyboard matrices and ordinarily possess two normally-open and two normally-closed contacts, so that the switching function is determined by board layout. Momentary-action types have a 1.5 million-cycle lifetime, with a travel of 1.8mm and actuating force of 2N. DC load rating is 6W (9W AC) and maxima are 250mA and 120V. Quiller Switches Ltd, 0202 417744.

No charge for toggle switches. Types E and EK sealed miniature toggle switches by C&K are fitted with plastic actuator bushes to dissipate up to 20kV of charge. There are 18 PCB-mounting types of terminal in miniature and sub-miniature styles, *Please quote "Electronics World + Wireless World" when seeking further information*

eight switching functions and 1,2 or 3 poles. Ratings are up to 7.5A/125V AC/28V DC or 3A/250V AC. Roxburgh Electronics Ltd, 0274 281770.

Transducers and sensors

Doppler alarm modules. Microwave doppler modules for motion detection in alarm systems, door openers, speed measurement and any amount of other uses are made by Alpha Industries. They are said to offer advantages over ultrasonics and infrared in that they have a greater rangs, are smaller and do not waken the entire population every five minutes with false alarms. Sensitivity is 30Hz for a 1mile/h speed. Several types are offered: *DRO2980* for 3-5m range and Gunn oscillator. tuned cavity types for 10 and 24GHz working with horns for increased range. Cirkit Distribution Ltd, 0992 444111.

Miniature load cell. Very small load cells from Control Transducers come with full-scale ranges of from 1lb to 100lb, with 50% overload. Output is 1-2mV/V and bridge resistance is 350Ω. Temperature compensation is effective from -25°C to 650°C; combined non-linearity, repeatability and hysteresis are within ±0.5% of full scale. Some idea of the size is given by the practice of inserting these devices into finger joints to measure fatigue. Control Transducers, 0234 217704.

Carbon monoxide sensor. NAP-11A by Nemoto is a semiconductor CO sensor designed to operate at concentrations of 50-1000ppm and is "virtually insensitive" to other gases such as hydrogen and alcohol vapour. Operation is stable at -10°C and 50°C and up to 95% relative humidity. Quantelec Ltd. 0993 776488.

COMPUTER

Computer board level products

386SX card. Fairchild's *PCA-6133* AT-compatible 386SX half-length card can be used in conventional passive backplane systems or as a single-board computer on its own without a backplane, for building into OEM equipment where there isn't much room. There are two serial ports, a printer port, a keyboard connector, floppy and IDE hard-disk interfaces, and the 25MHz processor can access up to 16Mb of on-board dynamic ram. It will boot from a floppy or hard disk or from an optional silicon disk, which emulates two floppies. Fairchild Ltd, 0703 559090.

PC data acquisition. *DAS-1600* from Metrabyte is the successor to the established *DAS-16* analogue i/o board for PC XT/386/486 computers. The new board offers advantages in speed, i/o capability, analogue output ranges,better software and a lower price. Sixteen single-ended or eight differential analogue inputs are provided. Resolution is 12 bits and sampling rate up to 100kHz, with programmable input range. No external timing signals or software are needed and built-in 16-bit counters can be used to count events or measure frequency.

25Mflops for PC AT. NCS have a maths co-processor for the PC AT that increases its speed of execution by more than 100 times. The *DSP32C* co-processor handles 25Mflops and turns a PC into a workstation for engineering tasks. It is based on a 50MHz version of the AT&T *DSP32C* digital signal processing CPU and the package includes a maths library of C and Fortran routines and examples, including FFTs, matrices, IIR and FIR convolutional filters. Also supplied is a monitor program, the AT&T assembler and DSPASM, an assembler for source files up to 64K. The buffered, 32-bit port runs at 12.5MHz. Neural Computer Sciences, 0703 667775

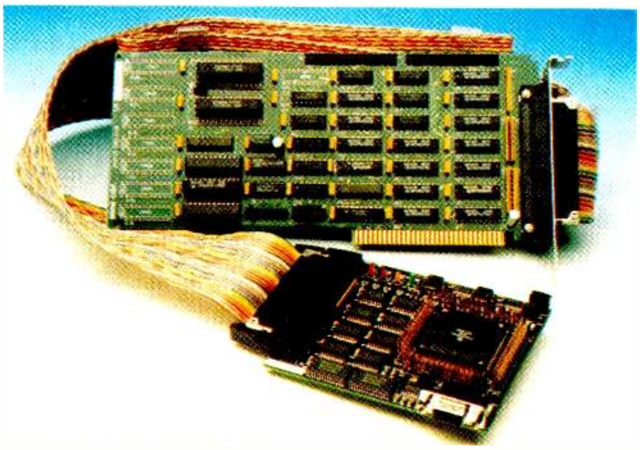
330kHz A-to-D interface for PCs. ComputerBoards's *CIO-AD16Jr-AT* 12-bit 300kHz A-to-D interface for PC XT/ATs is fully compatible with earlier boards from this company, but with unlimited sample set sizes and the higher speed. It offers a 16-bit data bus, 1024-sample FIFO buffer, pre/post trigger counters and DT-Connect interface. Labtech and Snapshot software support the enhancements, but earlier software is usable with reduced rates of data. Talisman Electronics, 0491 671914.

Computer systems

Tough Mac. BVM says that its ruggedised Macintosh computer is the first for industrial 19in rack mounting. A typical unit in the RackMac range of five machines is the *IIci*, which has a 13in hi-res RGB monitor, processor and full-sized keyboard, all in separate, dust-proof, steel enclosures slide-mounted anywhere in the rack. The motherboard is on shock absorbers, as is the 170Mbyte hard disk, and the cast-aluminium front panel holds the 3.5in floppy drive and switches, so that everything is dust-proof when closed. A touch-screen is available. BVM Ltd, 0703 270770.

Development and evaluation

83C528 development system. *CT83C528* from Ashling affords real-time in-circuit emulation for the Philips microcontroller series in rom (*83C528*), eprom (*87...*) and romless (*80...*) modes, to provide source-level debugging, automatic software test, performance analysis and prom programming. It has 32k of rom, 512byte of ram, an IIC bus controller and a watchdog. In addition to the usual 8051 languages, the system allows assembly-language source-level debugging. Ashling Microsystems Ltd, +353-61-334466.



ICE for Windows. Nohau's EMUL 16/300-PC is an in-circuit emulator for the Motorola 68HC16 and 68300 families of microcontrollers. It is PC-based, running under Windows 3.0, the control boards fitting straight into the PC chassis and using the PC bus for high speed. Real-time emulation up to 16.78MHz is offered — higher when it becomes necessary — and the unit has 1Mbyte of both breakpoint ram and shadow ram. Nohau UK Ltd, 0962 733140.

TMS370 development. Jermyn have available a low-cost development tool for the Texas Instruments *TMS370* family of 8-bit microcontrollers, which includes the field-programmable types. It takes the form of one emulator board, plugged into the expansion bus of a PC XT/AT, running under dos, or an RS232-C serial interface. An interactive, windowed debugger, real-time emulation and an integrated eprom programmer are all in the one package. Jermyn Distribution, 0732 740100.

Software

Saber 3.1. Version 3.1 of Analogy's Saber simulation system offers new and enhanced features such as a bigger component library, better simulation, Fourier and inverse Fourier analysis and extended template library. The Fourier facility now includes an FFT command that gives a continuous spectrum, produces a time-domain display from the spectrum and offers user-definable windowing. Analogy Europe, 0793 432286.

C++ for proms. C++toPROM is a new software package from Borland which takes the PC's .EXE files from Borland C or C++ and converts them to .BIN form for loading into prom emulators or programmers. Users have control over code placement in the target and can use memory-mapped i/o at absolute addresses. The package includes all code needed to initialise the system and segment registers. Computer Solutions Ltd, 0932 352744.

C clarifier. XRAY Source Explorer is a CASE product that analyses a C program and reveals its nature by providing a graphical display of its structure. The package is intended for use with embedded processors, in particular when the code has come from another source, its starting place being obscure. The result is similar to the type of diagram that is sometimes sketched after the flow chart. Sun workstations running MWM or OLWM handle the software. Microtec Research Ltd, 0256 57551.

Fuzzy logic. The Fuzzy Inference Development Environment (FIDE for short) is a set of software from Aptronix that will impart fuzzy logic capability to perfectly ordinary microprocessors — the first ones to be so honoured being the Motorola *68HC05* and *68HC11* devices. Fide allows an entire system to be designed and simulated, including the MCU-specific hardware. Fuzzy Inference Language is used and a real-time code generator makes efficient object code and assembler source code and an analyser gives a 3-D surface view of the response function. The two companies have made the data structure by which fuzzy logic systems are represented an open, freely available standard. It is all said to be user-friendly. Motorola Ltd, 0908 614614. ■

Switching audio amplifier uses power mosfets

In the early 1960s, there was a surge of interest in switching-audio-amplifiers as designers speculated that transistors might work where valves had failed. But they reckoned without the high frequencies at which the devices would have to switch and the losses involved. Complementary mosfets avoid these problems. They are more efficient, faster switching and need none of the base-drive current applied to bipolar types. Motorola's tmos power mosfets fulfil the function successfully. (The "T" denotes the shape of the almost vertical current path in the device.)

Application Note AN1042 describes the design of class D amplifiers in general, and a 70W version in detail. **Figure 1** shows the effect of the switching process and **Fig. 2** the means of achieving it in broad outline.

A change-over switch connects the loudspeaker to +44V and –44V in turn at a high frequency – many times the highest audio frequency. Output to the speaker is an 88V square wave.

Under the influence of the input signal, the mark:space ratio of the waveform is modified to produce a net DC level proportional to the input, as in Fig. 1. A low-pass filter blocks the high-frequency square, leaving the audio.

Feedback is needed, but not from the output, since its phase shift varies widely over the range of DC-120kHz, the switching frequency. It is taken instead from the switching output, which is the square wave.

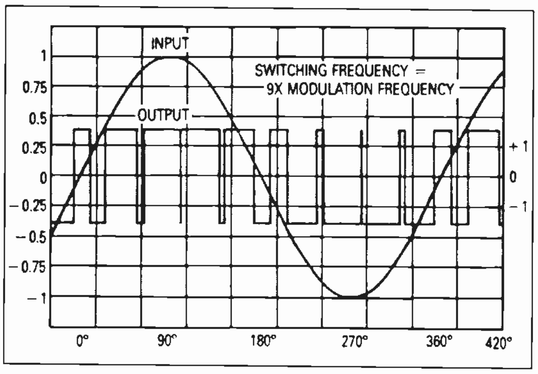


Fig. 1. Net DC level of a square wave, varying its M:S ratio in proportion to the audio input, forms the output voltage of a class D amplifier, with high efficiency and no output stage crossover distortion.

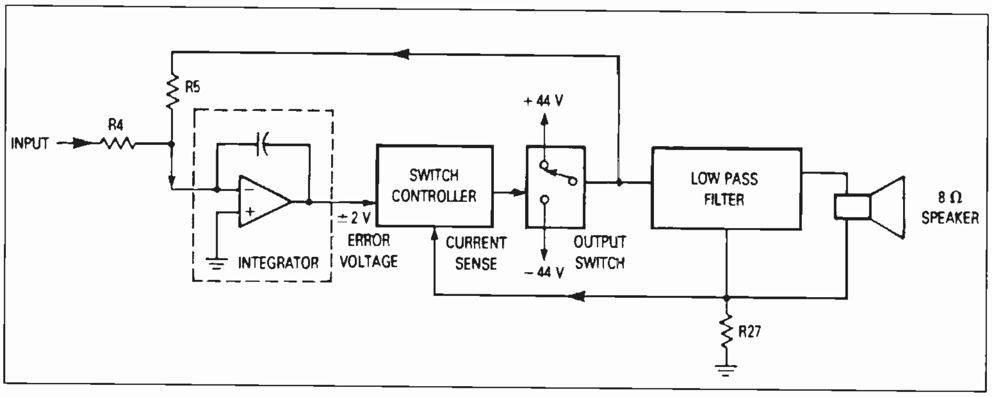


Fig. 2. Achieving the waveforms of Fig. 1. Resistor R_{27} is a current sense component for current limiting.

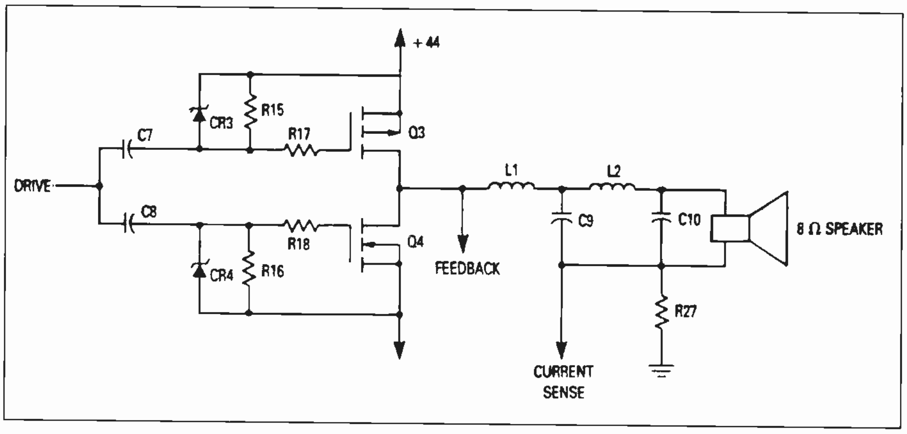


Fig. 3. Tmos complementary mosfet output stage with DC restorers feeding a low-pass filter to eliminate switching waveform, leaving the audio component.

Input signal, via R_4, is mixed with the fed-back wave, via R_5. It is then taken to an integrator whose output is zero when the switcher output is an accurate simulation of the input, otherwise generating an error voltage. The switch controller corrects the error. A four-pole Butterworth LP filter chosen for the job is maximally flat to 20kHz, its resonances causing no trouble with the average speaker and crossover.

The mosfet output stage, **Fig. 3**, puts out the ±44V 120kHz square wave – with a duty cycle between 5% and 95% – to the low-pass filter feeding the speaker. Full turn-on is given by a 10V pk-pk drive on the gates, supplied by a buffer working from ±5V rails. Series gate resistors prevent HF oscillation and the zeners act as clamps to restore the DC lost in the capacitive coupling and protect the devices against the effects of static discharge.

Output transition times are about 30ns and current is ±5A down to 0.1Hz, below which thermal runaway may be a problem.

Switching control is handled by the duty cycle controller shown in **Fig. 4**. A 120kHz square wave is taken to U_{1B} – an integrator in which R_1 and C_1 are the timing components – the output being a ±2V triangle with a better than 1% linearity, fed

to the non-inverting input of comparator U_{1D}.

Input signals go to the inverting input of U_{2C} via R_4 and the square wave output to the LP filter also goes to this point via R_5, which is 20 times the value of R_4. U_{2C} integrator has a gain of 20 to put the output of U_{2C} at ground potential. The output is the error voltage and goes to the inverting input of U_{1D}. C_4 preventing spikes on the error bus.

The result at U_{1D} output is a 120kHz "square" wave with a 0%-100% duty cycle varying with the error voltage. To prevent the amplifier clipping and causing the error voltage to exceed limits, causing distortion, a duty cycle limiter restricts the duty cycle to within 5-95%. There is also a current-limiter to protect the output mosfets, reducing output voltage to zero if the current exceeds 5A.

Total harmonic distortion at 10Hz is 0.08%; at 100Hz, 0.08%; at 1kHz, 0.19%; and at 10kHz, 0.31% with an output of ±30V into 8Ω. Signal:noise ratio is 100dB below full power, power bandwidth is 20kHz and efficiency is 92% at 72W.

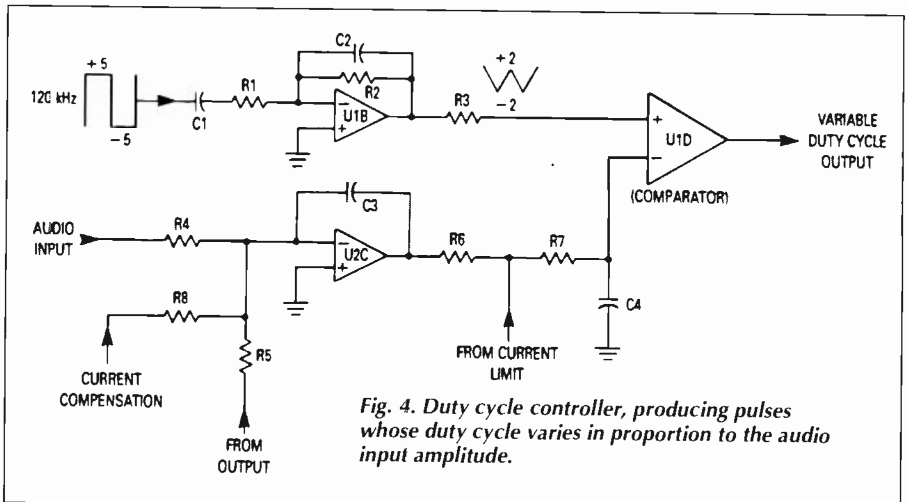


Fig. 4. Duty cycle controller, producing pulses whose duty cycle varies in proportion to the audio input amplitude.

Motorola Ltd, European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP. Telephone 0908 614614.

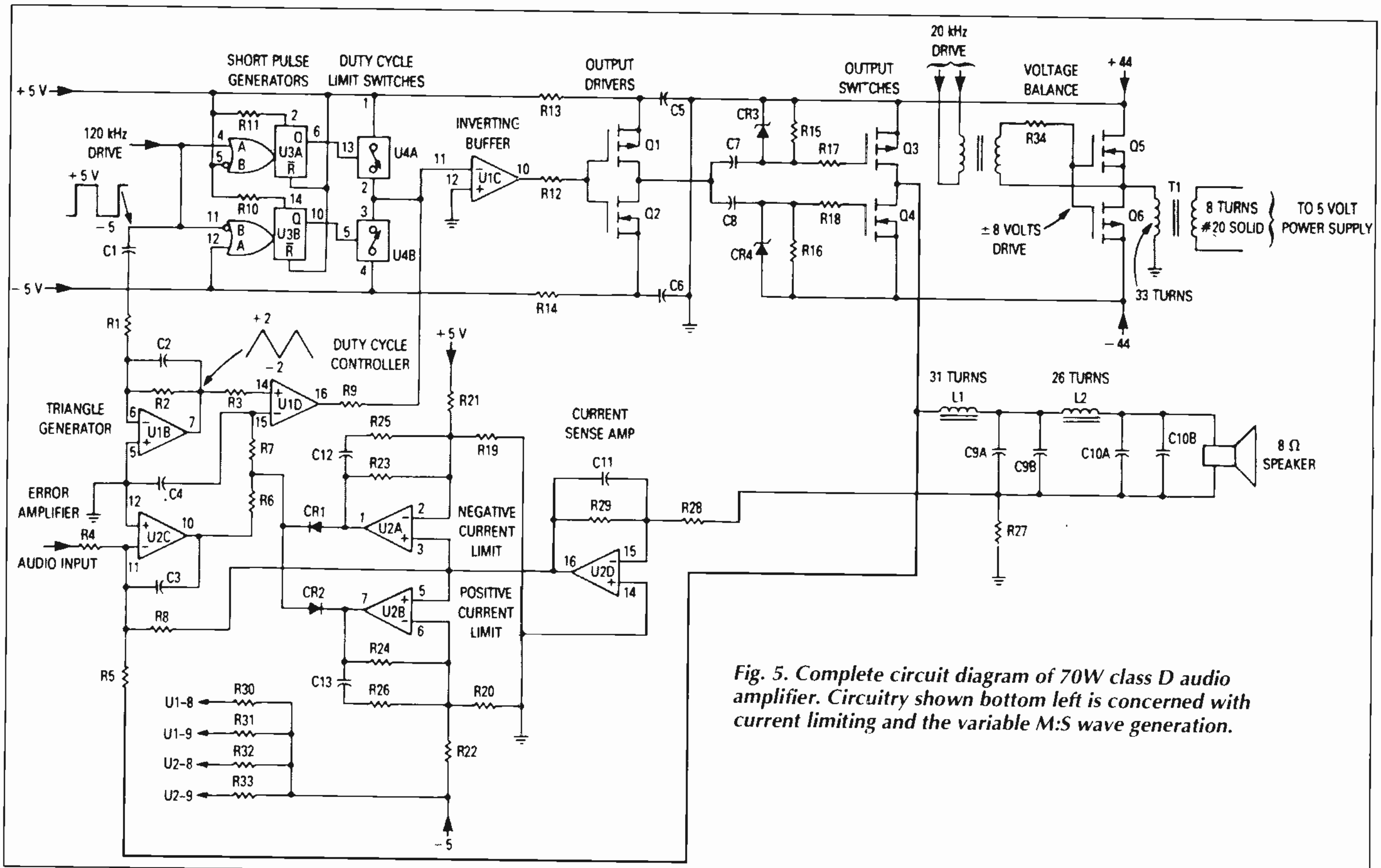


Fig. 5. Complete circuit diagram of 70W class D audio amplifier. Circuitry shown bottom left is concerned with current limiting and the variable M:S wave generation.

Precise, +10V to –10V adjustable voltage

An ordinary laboratory power supply is ill-suited to measurements requiring a continuous sweep of voltage from positive to negative, including a true 0V setting. One must reduce the input to zero, change leads round and readjust for the opposite polarity, probably finding true zero elusive.

For a precision bipolar source providing a range of +10V to –10V in one sweep of a potentiometer, this circuit by Burr-Brown needs two chips: a *REF102* 10V reference and an *INA105* differencing amplifier. In **Fig.1**, with the wiper of the potentiometer at the top, the circuit is a voltage follower with a gain of 1 ±0.001% and the output is the same as the input. With the slider at the bottom, the circuit takes the form of a unity-gain amplifier and the output is $-V_{in}$ ±0.001%. Setting the slider to mid-travel makes the amplifier net gain zero and the output is 0V. Control linearity depends on the potentiometer and a precision 10-turn type would normally be used.

Should it be necessary to drive high-capacitance loads up to about 1μF, use the circuit in **Fig. 2**. In this case, the inverting input of the op-amp must be accessible, so

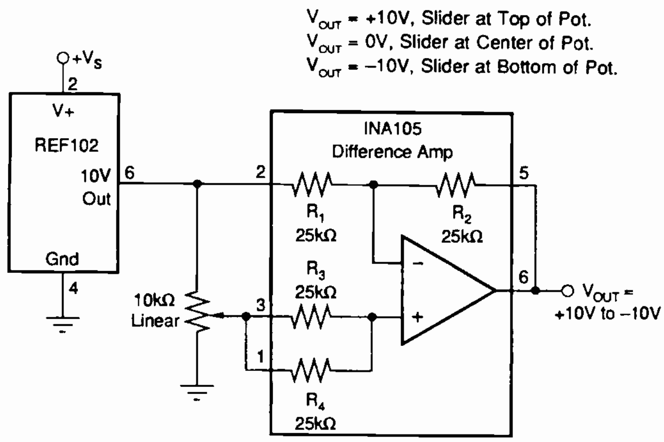


Fig. 1. Two Burr-Brown ICs make a voltage source capable of swinging from +10V to -10V in one travel of a potentiometer. Accuracy is such that precision of voltage output is limited only by quality of the potentiometer.

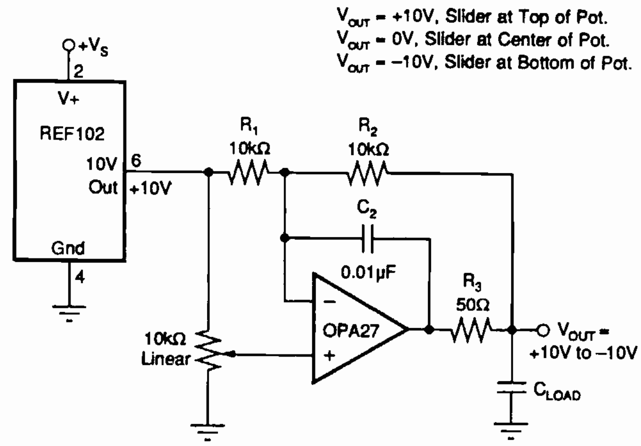


Fig. 2. This circuit is on the same lines as that in Fig.1, but drives high-capacitance loads. Since the INA105 does not allow access to its non-inverting input, an OPA27 is used in its place.

an *OPA27* is used (a special version of the *INA105* with this feature – the *2A660* – is available for high-volume production). Resistors $R_{1,2}$ should be well matched for precision and, since output current flows in R_3, the op-amp output is increased for a given V_{out}, so the voltage across R_3 should be less than 1V to prevent the amplifier output approaching the supply rail. Application Bulletin 6, 1991.

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

Halogen lamp converter

Low voltage halogen lamps are increasing in popularity because of their high efficiency and better light when compared with standard incandescent-filament bulbs. But there is a need for 220/12V converters. A new range of bipolar power transistors from Motorola, the *BulXXX* series, handle the unexpectedly high powers needed for the job. See Application Note EB407.

The diagram shows the basic circuit, which is effectively a standard half-bridge self-oscillating converter with a chopper frequency in the 25-40kHz range, depending on the core used in the transformer. No smoothing electrolytics are needed, since the lamp has a high thermal inertia.

Operating frequency is dependent on the saturable transformer T_1:

$f = (V_p \times 10^4)/(4 \times B_s \times A \times N)$,

in which f is the chopper frequency (Hz), V_p is the output transformer primary voltage, B_s is T_1 core saturation flux in Tesla and A is T_1 core CSA in cm^2. Efficiency depends on keeping f constant for a given output transformer and maintaining a 50% duty cycle, so that either the transistors should be matched or the circuit tuned during final test. Or, of course, use the *BulXXX* series, which are tightly controlled for H_{fe}, storage and fall times, and are designed for this application.

Resistor R_1, C_1 and the 32V diac D_4 with R_4 start the circuit. Diode D_1 eliminates imbalance between the transistor drives in steady state. Diodes $D_{2,3}$ avoid uncontrolled transistor conduction during transients and must withstand 400V V_{cc} (for a 200V line) and give a fast turn-on.

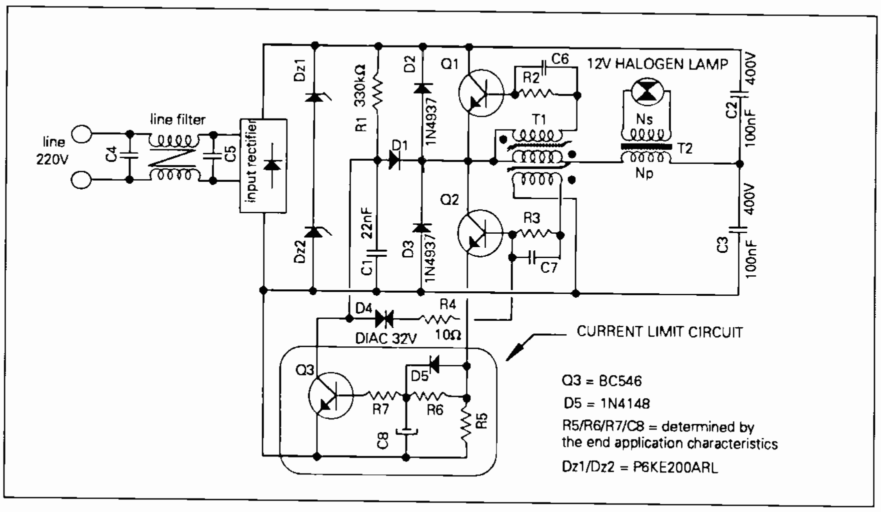
Since the lamps constitute a short when cold, the transistors have to cope with a large forward-bias safe operating area (FBSOA) for a short time. The application note points out that the basic circuit is not proof against shorts, a protection circuit being given.

Output transformer T_2 is a non-saturable type with a ferrite core for 25-45kHz working. Self-oscillation depends on the saturable-cored oscillator transformer T_1, which also has a ferrite core with a squarish B/H curve for reliable saturation. Motorola says a toroid with high permeability factor is best. Details of transformer design are all in the note.

A Mac disk "SMPSanalysis", part number *DK401/D*, can be obtained from Motorola.

Motorola Ltd, *European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP. Telephone 0908 614614.*

Circuit of Motorola's 220/12V converter for low-voltage halogen lamps, using the new BULXXX series of high-power, closely controlled transistors. The input protection components $Dz_{1,2}$ are for transient protection and the line filter prevents RFI from the converter getting back to the line. The lower part of the circuit is the short-circuit protector; R_5 senses current and turns on Q_3 if it exceeds its limit, thereby grounding the starting network. Capacitor C_8 delays this action to allow the lamp time to warm up.



Scalar analyser gives measured returns

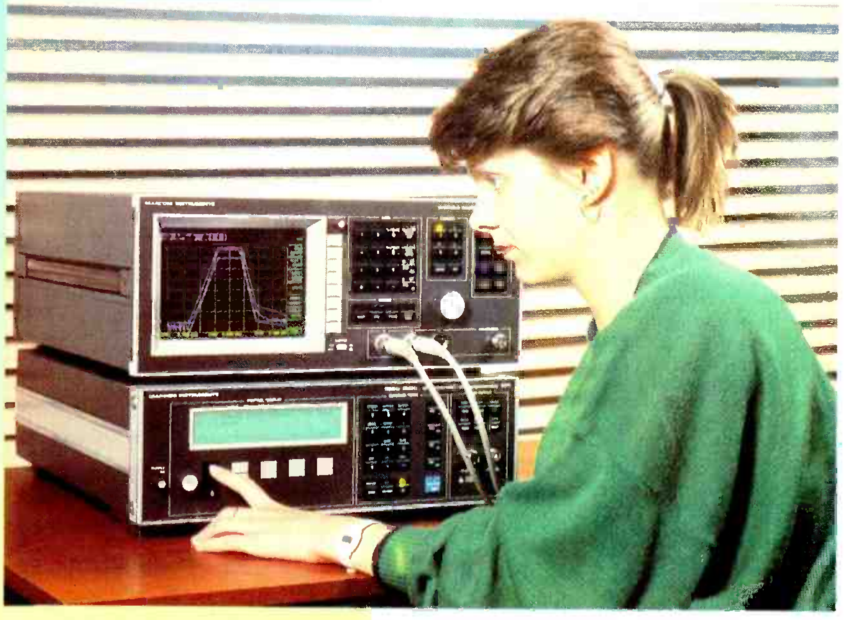


Fig. 1 Combining a sweeper and scalar analyser into a swept frequency measurement system.

Stephen Gledhill explains how sweep oscillators built around scalar analysers provide a powerful system for analysis of microwave devices.

Evaluation of microwave components and sub systems such as filters, amplifiers, mixers, attenuators, limiters, cables and waveguides often requires measurement of frequency response.

Measurements can be made with just a signal generator and a power meter, where signal generator output is set to a number of different frequencies and the power meter reading is noted at each point.

But fine details such as a dip in the passband of a filter might be missed if the filter frequency response is only measured at a small number of discrete points. Increasing the resolution and measuring the response at many more points captures the fine detail but measurement takes a long time.

The sweep generator, or sweep oscillator, was developed to overcome this problem, automatically changing the output frequency so that frequency response and return loss could be rapidly measured at many points across the frequency band.

Its old CRT-based X-Y display of response was simple but had a number of drawbacks. Accurate calibration of either level or frequency was difficult to achieve and the single or dual input limited the range of measurements that could be addressed.

More inputs were subsequently added to the signal processing and display systems, and processing power was used to help with operation and calibration... and the scalar analyser was born.

Now, with ingenuity and extra software for signal processing and analysis, the scalar analyser is a powerful analytical tool. Modern scalar analysers have marker facilities and a colour display to ensure ease of use. Measurements are speeded up by directly controlling the associated sweeper so that settings need only need be entered on one instrument keyboard (**Fig. 1**).

Insertion loss or gain measurements

The most obvious way to measure insertion loss or gain of a device under test (DUT) is simply to connect it between the output of the sweeper and a detector. Before inserting the DUT, a zero reference must be established by connecting the detector directly to the sweeper, removing effects of system frequency response errors. But the method is not very elegant, and amplitude changes in output of the sweep generator and mismatch errors caused by the sweep generator, cables and connectors affect measurement accuracy. Two detectors, used to measure both incident and

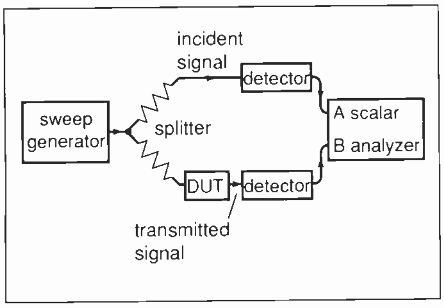


Fig. 2. Two detectors are used to measure incident and transmitted power.

transmitted power, will overcome these problems.

A power splitter divides the sweep generator signal between the DUT input and the detector – known as the reference detector. The signal from the detector is connected to one input of the scalar analyser (input A, **Fig. 2**) and the signal from the second detector, measuring the transmitted power, is connected to another input (input B). The "A-B" arithmetic function in the scalar analyser gives a true display of insertion loss against frequency since it shows the ratio between incident and transmitted power.

The problem with this technique is that the dynamic range of the measurement is reduced by 6dB because of the power lost in the splitter. But source match is significantly improved, minimising effects of mismatch uncertainty where the DUT has a poor match. For measurements in waveguide systems, directional couplers with lower insertion loss can be used but directional couplers can be limited in bandwidth.

Principle of operation

A scalar analyser system comprises a sweep generator, detector and scalar analyser.

RF and microwave sweep generators generally incorporate three basic blocks of a voltage tuned oscillator, ramp generator and linearising circuit.

The voltage tuned oscillator is the heart of a sweep generator and the generated frequency changes according to the voltage applied.

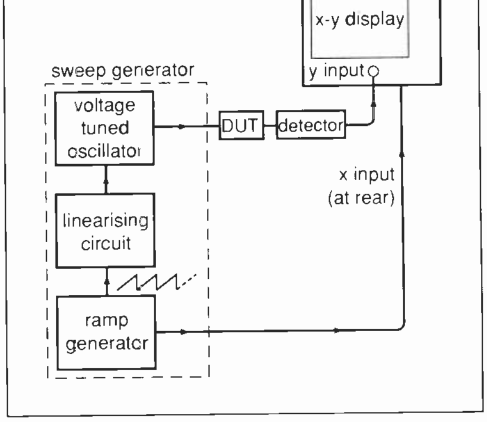
A ramp generator sweeps the frequency of the voltage controlled oscillator through a linearising circuit. As the ramp voltage increases so the output frequency from the voltage controlled oscillator also increases.

The linearising circuit modifies the voltage/frequency law of the voltage controlled oscillator so that linear frequency increments are obtained. In modern instruments the linearising and sweeping is carried out using digital techniques.

Scalar analysers essentially consist of detectors, an X-Y display and signal processing. The detectors used are crucial to accuracy of a system. Many advances have been made in their design – flatter frequency response, higher sensitivity and a better input return loss have been the chief enhancements. Other improvements include detectors with a very wide frequency range, a wider dynamic range and improved linearity. Temperature drift effects have also been reduced in modern detectors by employing temperature correction.

The detector converts the signal at the output of the device under test to a DC voltage which can be applied to the Y- or vertical-deflection input of the X-Y display used to display the response. The same ramp generator that controls the voltage controlled oscillator in the sweep generator is also fed to the X- or horizontal-deflection input of the X-Y display so that the spot on the display sweeps in synchronism with change in frequency.

A simplified sweep generator.



Return loss measurement

Return loss is a measure of the quality of a termination in terms of power reflected back compared to power absorbed by the termination. It is a very important measurement because power is wasted if source and load are not matched.

To determine return-loss, the incident and reflected signals must be measured; the ratio of the two signals, expressed in dB, is the return loss of the DUT.

Source match can also be expressed in other terms such as voltage standing wave ratio (VSWR) or reflection coefficient (ρ). These units are just different ways of expressing source match and there is a direct mathematical relationship between them. Charts are available to convert between units[1].

The arithmetic mode of the scalar analyser is used when measuring return loss so that the display shows the true ratio of incident to reflected power irrespective of any changes of sweeper output power with frequency. Reflected power from the input of the DUT can be routed to the third detector of the scalar analyser (input C) by using a directional coupler which (theoretically) outputs signals flowing in one direction and ignores signals in the opposite direction.

An alternative to using a directional coupler is to use a return loss bridge or "autotester" (**Fig. 3**). The bridge is comparable to a Wheatstone bridge; if the termination of the device being measured is exactly 50Ω then it is balanced and there is no difference signal across the arms of the bridge. A detector in the autotester gives a DC signal proportional to the deviation from 50Ω – a large detected signal indicates a poor match.

To carry out a return loss measurement, a zero return loss reference point must be established. The calibration reference is produced by first connecting a short-circuit then an open-circuit in place of the device under test. When a short-circuit or open-circuit is presented, in theory, all the incident power is reflected back. The detected value of the reflected power is routed to the scalar analyser and data representing the level of reflected signal vs frequency is held in the store as a calibration reference.

With the calibration reference established, the DUT is connected and a second plot of reflected signal against frequency is then obtained. The difference (in dBs) between the calibration reference data and the reflected

Fig. 3. In a return loss measurement set-up, three detectors are used to measure incident, transmitted and reflected power.

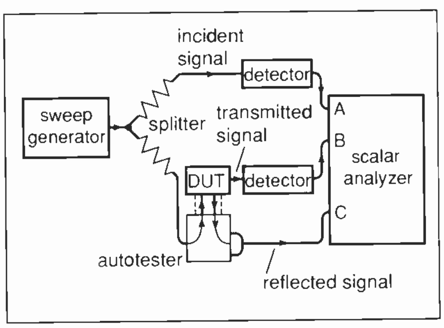
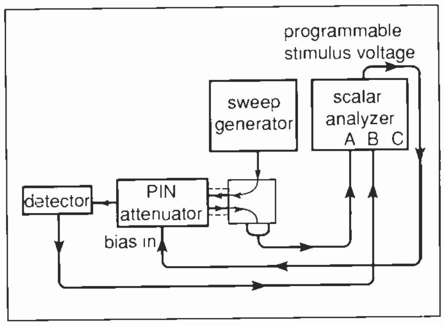


Fig. 4. Pin diode attenuator characterisation. A programmable stimulus port changes attenuation so that frequency response and return loss can be measured automatically at different attenuator values.



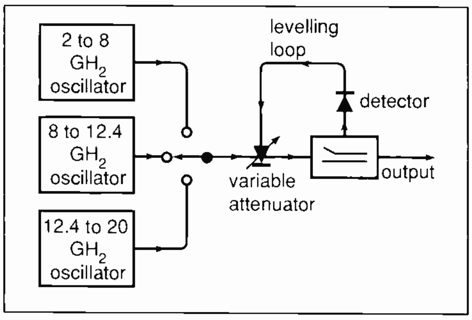
Microwave sweeper implementation

Special techniques are needed to design a swept microwave oscillator able to cover a frequency range of greater than one octave; ie a ratio of 2:1 between the high frequency and low frequency ends. Wide frequency coverage is an increasingly important requirement for many measurement applications, and several techniques have been used to provide coverage. This has given rise to different types though all systems are based around yig (yttrium iron garnett) technology.

Heterodyne sweepers: A swept frequency oscillator is mixed with a fixed frequency oscillator to increase the overall coverage. A 2-4GHz oscillator can be mixed with a 2GHz signal to cover from 10MHz to 2GHz for example.

Harmonic multiplier sweepers: A swept oscillator drives a switched multiplier in synchronism with a tracking band-pass filter. Higher order harmonics of the basic oscillator are thus used to generate the higher frequencies. The tracking filter reduces sub-harmonic and unwanted harmonic signals.

A third way of extending the frequency range of a microwave sweeper is to use more than one swept oscillator. The figure shows a sweeper with three separate yig oscillators which are switched in sequentially. Signal purity is high as there are no sub-harmonics and harmonics can be kept to a very low level.



Multiple oscillator sweeper, the technique used in the instrument in Fig. 1.

Some broadband sweepers cannot carry out narrowband sweeps on high Q devices because their drift and inherent FM may be large in comparison to the narrow bandwidth of the narrowband device under test. Synthesised sweepers are used for such applications.

Sweepers have improved dramatically in recent years, in terms of both specification improvements and facilities available. They used to rely on the technique of a mainframe plus different frequency plug-ins – plug-ins were used because a wide frequency range could not be encompassed with a single unit and coverage was generally confined to one waveguide band.

Advances in oscillator design and development of high frequency connectors has meant that modern sweepers can cover from 10MHz to 26.5GHz or even 10MHz to 40GHz in one unit and in a single sweep. The advances have signalled the end of plug-in sweepers.

Modern scalar analysers can be programmed to set the stimulus voltages to a device under test so that an automatic plot of return loss and attenuation can be made for a variety of stimulus voltages (**Fig. 4**). Plotting the frequency response at a particular applied voltage (**Fig. 5**) clearly shows the attenuation values and reveals any frequency response differences.

Power sweep

Many sweeper and scalar analyser systems incorporate a power sweep for evaluation of level-sensitive devices – analysis of gain linearity and gain compression of an amplifier for example.

Output power of the device under test will stop increasing linearly as the input power is raised above a certain level. To quantify this overload or "saturation" effect a 1dB gain compression point is used, the point at which the gain drops by 1dB from its nominal value.

Power sweeps are traditionally made at a fixed frequency, with the output power of the sweeper swept over a specified range and the detector showing how the output of the DUT changes. Such systems are useful but, ideally, gain compression needs to be measured at frequencies across the full range of the DUT.

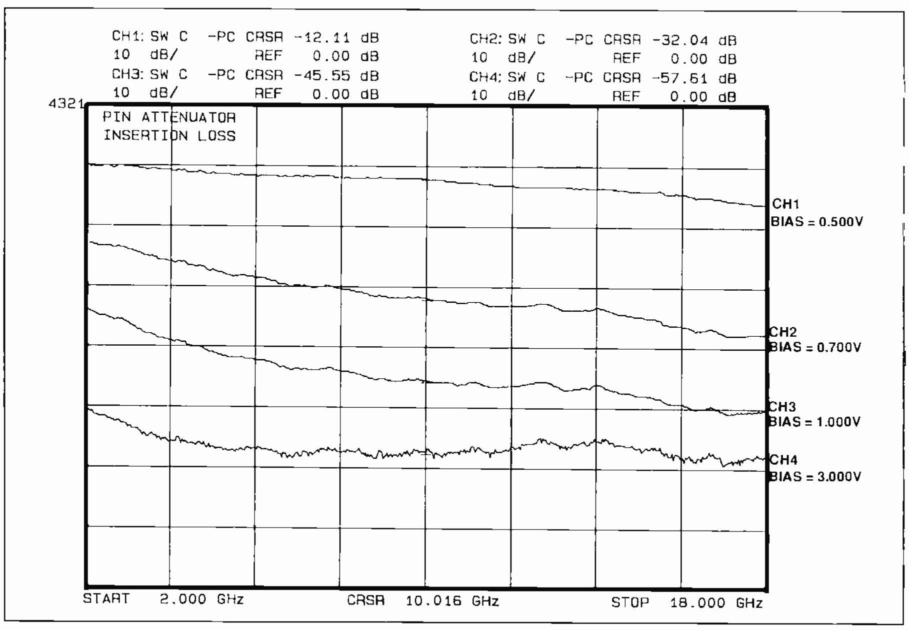
Making the required number of measurements can be a laborious task. But many hours of manual measurements can be saved by using a computer program which controls the level of the sweeper across the band of interest and makes automatic gain compression mea-

data is the return loss. Insertion loss and return loss measurements can thus be made simultaneously.

Fig. 5. Four traces show how the frequency response and attenuation vary – the programmable stimulus port automatically sets four attenuation settings.

Component characterisation

Frequency response often changes depending on the operational mode of a device. At high output levels an amplifier may have a different frequency response to that at low levels. Similarly, with a pin diode attenuator, the attenuation changes according to the stimulus voltage applied to its control port.



Scalar or vector network analysers

Scalar network analysers (SNAs) are sometimes confused with vector network analysers (VNAs) because although they both display the swept frequency responses of devices they do so in a different way.

A scalar network analyser measures amplitude only, while a network analyser measures and displays both amplitude and phase.

Determination of the phase response of devices is an essential measurement for certain applications. Group delay also needs to be determined – important to ensure the integrity of video and data signals through communications systems.

Network analysers are considerably more expensive than comparable scalar analyser systems and require use of precision calibration kits which can be cumbersome.Temperature changes can degrade measurement accuracy so limiting the environments and applications where a traditional network analyser can be used.

Unless phase information is essential a scalar network analyser is therefore the ideal measurement tool.

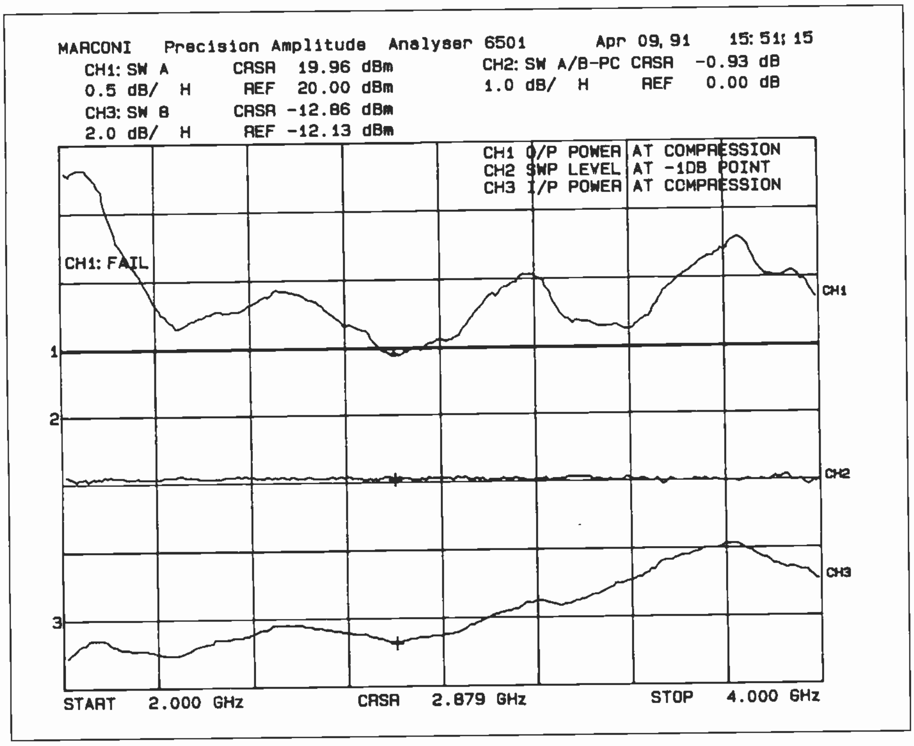


Fig. 6. For automatic gain compression measurement the 1dB gain compression point is measured at a number of discrete frequency points and is plotted as a function of frequency.

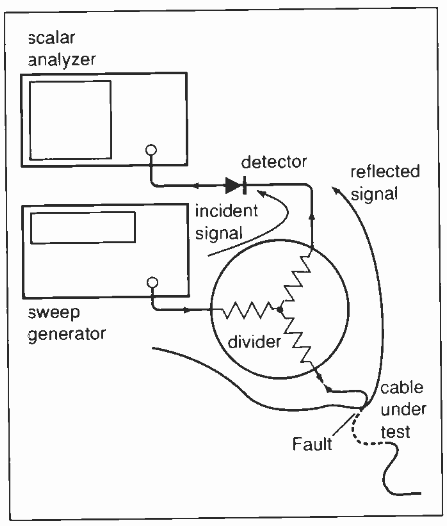
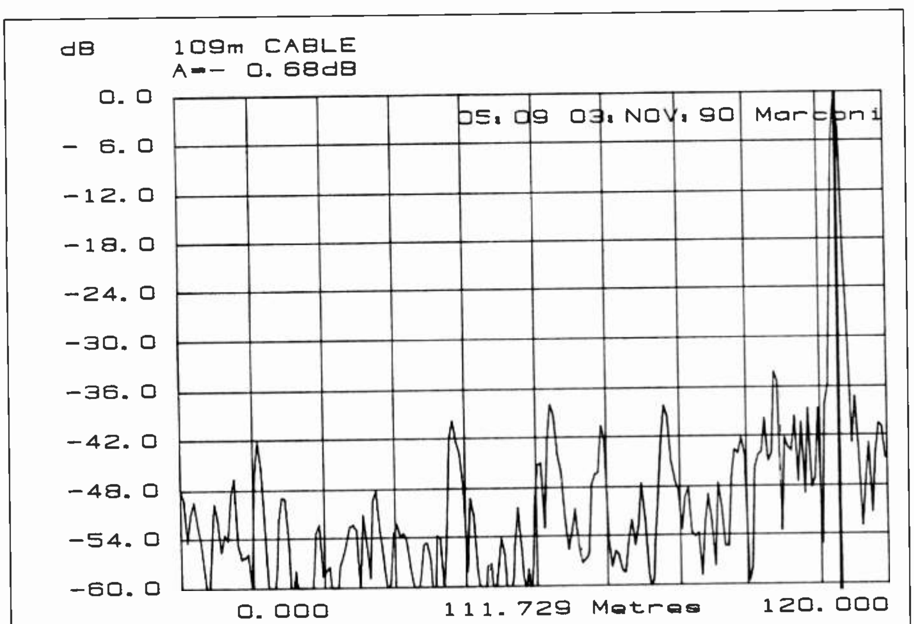


Fig. 7. Time domain measurements are made by analysing the signal reflected back from a discontinuity.

Fig. 8. Typical time domain measurement display of return loss versus distance. Discontinuities are shown as a rapid deterioration of return loss.



surements at up to 512 points. A comprehensive display of gain compression (**Fig. 6**) is a valuable asset to the designer of wideband microwave amplifiers.

Time domain measurement

Faults in a component or cable (ie a transmission line) cause a poor return loss because incident signals are reflected. Fortunately, modern scalar analysers have much improved diagnostics, and by using additional integral computing power, characteristics of the reflected signal can be analysed, and the physical distance of the fault deduced.

In measurement of distance to a fault (**Fig. 7**) a symmetrical power divider directs the signal from the sweep generator to both the cable under test and an amplitude detector.

If there is no fault in the cable under test then no signal will be reflected back to the detector. The scalar analyser will display a flat response if perfectly terminated by an ideal cable.

A fault – an impedance discontinuity – causes a signal to be reflected back to the detector. The reflected signal will have travelled from the divider, along the cable and back again, through the divider and to the detector. So two signals are received at the detector with a phase delay between them – the delay related to the distance to the fault and propagation velocity.

As the frequency is swept, a ripple pattern would be displayed by the scalar analyser which must be decoded to reveal the information incorporated in it. The fault location information (**Fig. 8**) is derived by fast Fourier transform (FFT). ■

References

1. "Datamate", Marconi Instruments Limited, St Albans.

Acknowledgements

Thanks to my many colleagues who have given advice and assistance, especially Tim Pegg and Bryan Harber of Marconi Instruments, and Stuart Fox of Wavetek.

REGULARS

LETTERS

Dangerous idea

R N Misra's Circuit Idea "Use a printer port for general i/o" (*EW + WW*, May 1992) is dangerous.

Standard printer ports for PCs do not use the 8255 PPI. Instead, they use a mix of LS240 and LS244 ICs in a hard-wired configuration.

To be fair, some early design attempts of PC compatibles did use the 8255 but this was often because machines were a rehash of CP/M computers, introduced to get into the market quickly.

Problems lie with software writers who regularly bypass bios routines to improve performance. If bios rules were always followed then printer ports could be anything required – the whole idea of bios in the first place.

To sell PCs in the real world, compatibility on both the hardware and software levels is a must – just ask owners of DEC Rainbow or other early PCs if you have any doubts.

Unlike the 8255 PPI, the PC printer's interface is not programmable in any way. Try to force data into a printer port and you will most likely damage it.

A PC printer port has inputs and 12 outputs. Many people believe you can input data into ports using a port read facility. This facility is often used as part of a start-up diagnostic and printer port detection. In reality a read path (LS244) is connected to the output path (LS240) for use as a wrap-test. The problem is that output chips are always enabled and any attempt to force data into the port will have to force an LSTTL output to change level – not recommended!

Now for the good news. It is possible to read data into a parallel printer port. Some years ago I sold a real-time clock that was plugged into a printer port and transferred data one bit at a time. Currently, my company markets two products, a weather satellite decoder and an analogue interface that transfer 4, 8, 12 or 16 bit data through printer ports for consumers who don't want, or are unable, to modify host PCs.

David V Goadby
Pixel-Plus Developments
Nuneaton

Dreaming of Western work

In 1977 I graduated from Kiev Polytechnic Institute and have since devoted all my spare time to the design of electronic equipment. I indulge in this work on my own because there are no electronic enterprises, design offices or competent specialists in my town.

Books and magazines are my only contact with the wide world of electronics.

Over the last two years I have designed an audio universal meter which I believe offers a unique possibility for comprehensive testing of professional electronic audio equipment.

But I have now arrived at the notion that all I have done will be useless if nobody has access to it. My dream is that my design will be manufactured for the benefit of all electronic investigators.

Are there any manufacturers out there that might be interested in my design?

Katkov Vladimir
Ukraine

Not pursuing a lost course

I have read with interest Phillip Darrington's article "Pursuing A Lost Course" (*EW + WW*, May 1992) in which he describes Heinz Lipschutz's proposal for a radio navigational aid for use by aircraft. Darrington suggests that had it been adopted when proposed in 1939 it would have had a major impact on Bomber Command's wartime operations and might indeed have affected the course of the war.

But, the article contains a number of misconceptions which I feel should be corrected.

Firstly, while in 1940 and 1941 Bomber Command certainly lacked accurate means of navigating to and finding its targets, this problem was solved by Robert Dippy's Gee and Alec Reeves' Oboe inventions, both of TRE and based at Swanage. These remarkable systems came into service in 1942 and were followed in 1943 by H2S, developed by Dee and Lovell, again at TRE. Later GH, was to join the armoury of navigational aids used by Bomber Command.

When the main bombing offensive commenced from 1942, these aids gave the Commander in Chief a good means of locating his targets with precision.

It is incorrect that Gee and Oboe were jammed after a some months and, as implied, of no further operational use.

True they were jammed, but various measures were rapidly developed to counter the jamming. Bomber Command and many American bomber groups were still using Gee as their main navigational aid at the end of the war and mobile Gee stations were sited far into Europe to provide cover over the battle areas.

Oboe operating from UK and Continental stations also continued to meet precision bombing needs of No 8 Pathfinder Group and American 9th Bomber Command.

GH was being employed against special industrial targets such as oil refineries and H2S was in full use for targets beyond Oboe range. From early 1942 until the and of the war Gee in addition to its primary task of *en route* navigation provided an outstanding aid for return to base and indeed saved the lives of many hundreds of air crews returning in crippled planes under bad weather conditions.

As to whether the interesting proposal of Lipschutz would have provided a navigational aid equal to Gee one can only express doubt. It would have been subject to several errors common to D/F systems and very susceptible to jamming. Nevertheless it was, for its day, an ingenious invention of a young man working very much on his own. Whether Lipschutz, had he been encouraged, could have gone on to develop his further concept of inertial navigation to an engineered product in time to be used operationally during the war, is hard to judge. Bearing in mind problems that have had to be overcome in developing effective inertial systems it would have been a very formidable task with available technology of 1940.

Sir Edward Fennessy
Guildford

Egyptian CFA update

Following MC Hately, FM Kabbary and BG Stewart's crossed field antenna (CFA) article "CFA: working assumption?" (*EW + WW*, December 1990) I would like to inform your readers of our progress with using the CFA.

Experiments have continued since December 1990 and our CFA has been developed to withstand 60kW RF power at medium frequency (a success presented at the IEE Icap Conference in April 1991).

Further developments in structure, phasing unit and matching unit have all been carried out, satisfying the need for 250Ω matching the transmitter and 37Ω matching the CFA. Equal power sharing of 30kW through each feeder to E and D plates of the CFA has been achieved, obtained at in-circuit pure real resistance measured directly at the input of each E and D plate.

Progress has also continued on evaluation of coupling and

Station engineer Ihab Hammouda with the Tanta CFA.

equivalent circuit impedance – adding more proof to the CFA theory.

Our 60kW CFA is now being used successfully to transmit a regional radio service to the Middle Nile Delta and serves a population of 15million within a 50km radius around Tanta City. The CFA has delivered a much wider bandwidth than a 0.25 wavelength mast radiator, with equal or better field strength (63dB at 90km distance).

Application to long-wave broadcast at high power up to 250kW is now under way to create a new LW transmission for upper Egypt.

We believe our work is part of the new age of antennas which will lead to a major change in configuration of broadcast transmitting centres, especially in the medium and long wave range.

Mahmoud Khattab
Egyptian Radio and Television Union Cairo

DIY pollution

I would like to raise the issue of dusk to dawn dimmer lamps now available at DIY and hardware stores.

Engineers are aware of all the serious electromagnetic pollution that results from use of unsuppressed, no-zero AC switching. Yet here we have a product available to the untrained that is capable of transmitting horrendous, spark-like, wide band interference.

The devices are not large enough to contain the suppression necessary for connection to long lengths of outdoor cable, and untrained people installing them are unlikely to be aware of switching transients. Nor will they realise the necessity of live plus neutral wire runs, to prevent radiating electromagnetic field loop development.

The problem is, potentially, even more serious.

Suppose that the dimmer is incorrectly installed, then we end up with interacting noises on the domestic mains.

It is already too late for me, I'm surrounded by active DIYers. My mains receivers buzz all night, and portables will pull weaker stations only when away from all electrical wiring. My entire home is full of other people's RF pollution; the worst appears between 40-50kHz and 400-500kHz, but also through the broadcast band and I have even observed it at up to 4MHz.

I do not blame the purchasers, shops, manufacturers, electricity companies, but simply ask who is responsible for testing the goods prior to sale, and what can I do about the EMP now permeating my home?

I fear the situation will only worsen as sales increase.

Graham Maynard
Newtownabbey
N. Ireland

Coherer anomaly

In my article "The Coherer: preparing the way for wireless" (*EW + WW*, March 1992) I, like most historians, restricted myself to saying that coherer technology is still not quite clear.

But some important acts relating to this issue were established as early as the 1890s by Popov and Marconi themselves. Both inventors found that their receivers acted even when placed in a "perfectly closed metallic box"[1] (Popov's receiver was housed in a case of galvanised iron[2]).

Preece called this an "apparent anomaly". In both Popov's and Marconi's receivers, one coherer's lead extended outward from the metal case to allow connection to an aerial.

Thus, like any other detector type (diode or transistor), coherers respond to electrical signals. So it is essentially a varistor, its quiescent point being set in the vicinity of the kink in current-voltage characteristic, at about threshold voltage.

The figure shows an idealised *I* vs *U* curve of coherer (and varistor), illustrating the detection process.

As a typically SiC- or Zn-based ceramic component used chiefly for protection of electrical and electronic equipment against overvoltages, the varistor is a favourite object of study for physicists since its disordered structure features the interesting conduction mechanism involving electronic tunnelling across grain boundaries, and percolation. Research results obtained are valid for both varistor and coherer.

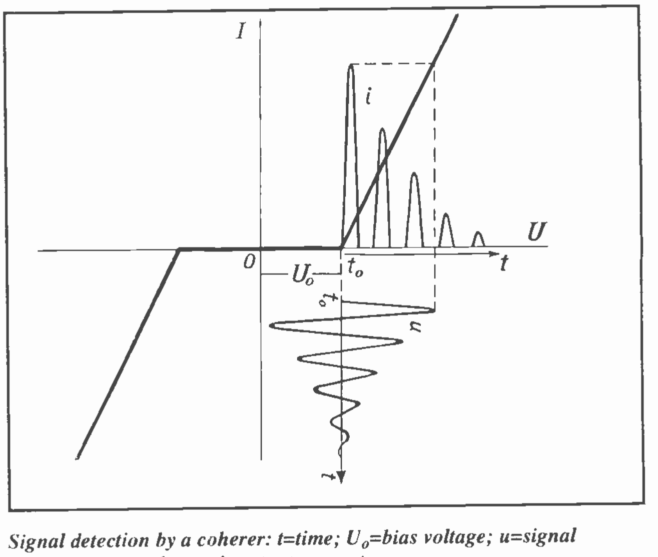
The necessity to give the coherer a light concussion upon its response to a wave means too strong a signal results in device degradation, concussion restoring initial, non-degraded structure of the powder material.

But questions still remain open and perhaps it is time a modern study on coherers is made.

Leonid N Kryzhanovsky
Popov Central Museum of Communications
St Petersburg

References

1. Preece, Signalling through space without wires, *The Electrician*, June 11, 1897, Vol.39, pp.216-218.
2. AS Popov, An instrument for the detection and registration of electrical oscillations, *Journal of the Russia Physico-Chemical Society*, 1896, Vol.28, o.1 Physics Part, pp.1-14.



Signal detection by a coherer: t=time; U_o=bias voltage; u=signal voltage across coherer; i=output current

Einstein's suspect theories

Paul Dunnet's letter (*EW + WW*, December 1991) points out that conclusions from Mickelson and Morley's ether drift measurements of 1887 are debatable, but are often quoted as proof of Einstein's speed-of-light postulate.

Contradictory results obtained by these scientists and Miller in 1924, are not even mentioned in most text-books.

Sagnac's 1913 paper "Experimental proof of the reality of the ether" is rarely mentioned but, some books do admit his results are in accordance with non-relativistic theory.

The same sad story of mis-reporting applies to 1919 measurements of star-light deflection by the Sun. Described as a crucial test of GR theory, results appear to be "cooked", to support Einstein's rather than Newton's theory of gravitation.

Surely, it is imperative that engineering students are not misled by suspect theories supported by falsified experiment results carried out half a century ago.I sometimes wonder if research funds presently used to bolster up Einstein's theories, by searching for gravity waves, black holes, exotic particles and evolving galaxies, would be better spent repeating suspect experiments with modern electronic equipment.

Validity of Einstein's postulates could be checked using state-of-the-art pulsed lasers and electronic counters which permit accurate speed-of-light experiments, suggested by Ove Tedenstig's letter (*EW + WW*, November 1991).

Unfortunately, the deafening silence of Academia on such matters suggests they prefer to conserve, rather than expand, the existing Body of Knowledge.

I could be wrong, of course!

John Ferguson
Camberley

Class-A push-pull amplifier changes

You published my circuit idea "Class-A push-pull amplifier" (*EW + WW*, October 1991).

The design aim was to provide a circuit with a performance comparable to a pure class-A amplifier, but with better efficiency.

Upon return to the circuit diagram, I realise that two changes could be made to the amplifier's output stage and there were a few (forgivable) typography errors.

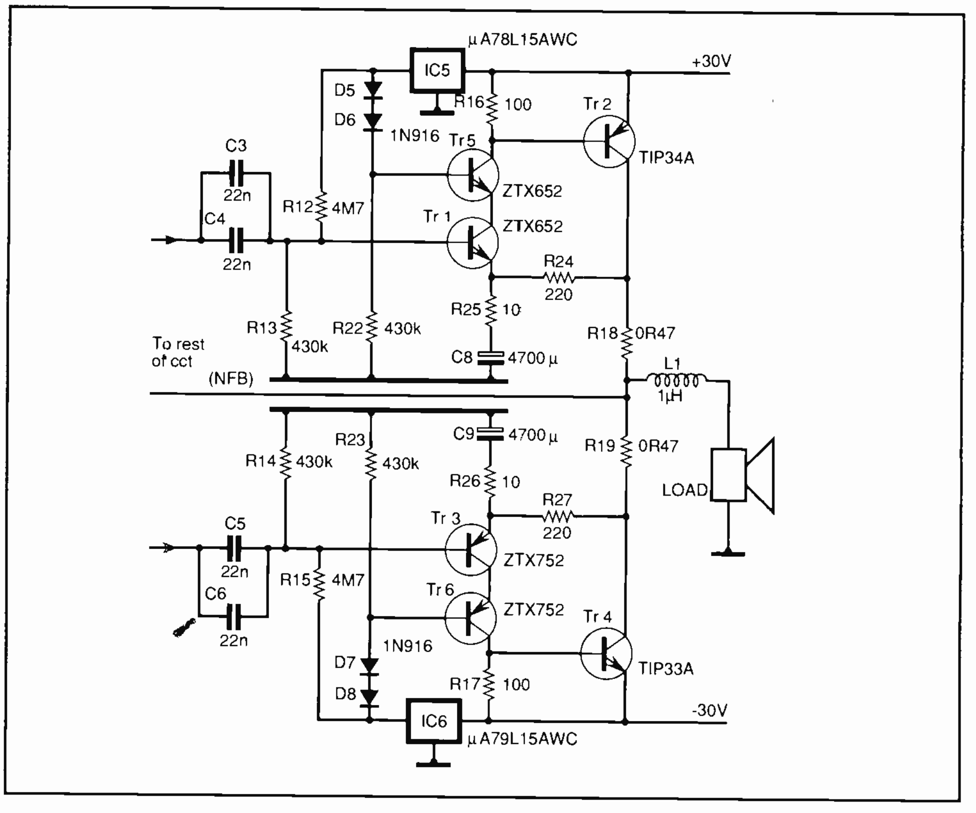
The output stage involves an addition of six components (R_{24}, R_{25}, R_{26}, R_{27}, C_8 and C_9) to the circuit, as this will give the output stage some voltage gain, providing a lager output voltage swing. C_8 and C_9 reduce DC voltage gain to unity.

Cascode connecting Tr_1 to Tr_2 and Tr_3 to Tr_4 may improve high frequency circuit performance.

The figure shows revised circuit output stages. All other circuit details remain unchanged.

Circuit performance is unknown to me. I haven't actually built it yet due to lack of time and resources. Others are invited to build and test the circuit (with or without modified output stage) if they wish to do so.

W O Richards
London



Relative clarification

Some points in John Ferguson's letter "Ether or no" (*EW + WW*, December 1991), and other such letters require clarification.

Firstly, general relativity does not require photons to have mass to interact with a gravitational field. General relativity predicts that light rays should be deviated by traversing curved space caused by a nearby mass. Relativity, therefore, is consistent in this regard.

Secondly, one does not have to assume photons have mass to apply laws of conservation of linear momentum, merely that they have an intrinsic momentum. Also, it transpires it is not merely ordinary momentum which is conserved in relativistic collisions, but four-momentum (E/c, p1, p2, p3), as confirmed regularly at establishments such as Cern.

With regard to recent submissions on Doppler shifting of light frequency, perhaps after agreeing with Frank La Tella's statement (*EW + WW*, June 1991), that common sense is not based on situations where relativistic correction is noticeable, it is unwise to say that additions of velocities of incoming wave-fronts and observer is consistent with common sense.

Addition of an observer's velocity to that of the radiation is not consistent with Maxwell's theory. This theory explicitly states that velocity of electromagnetic radiation in vacuo is given by $c = 1/\sqrt{\mu_0 \varepsilon_0}$ which is constant and independent of observer velocity. Maxwell's theory is consistent with Einstein's theory of relativity but not common sense Galilean relativity which allows us to add velocities to that of light. (This inconsistency prompted Einstein to formulate his theory of relativity).

Details of experimental confirmations of this first postulate of Special Relativity (velocity of light is the same in all frames of reference) are given in most basic physics texts; eg. Halliday and Resnick.

Correctness of Special Relativity hinges only on this postulate and second postulate which states there are no privileged inertial frames of reference – all observers have possibly different, but equally valid, views of the universe.

Absolute validity of relativity is not certain. Inconsistencies between aspects of quantum physics and

relativity may have to be resolved by adjustment to either or both theories. But, it is certain Newtonian mechanics is not an adequate description of the physical universe. There are experiments which unequivocally show Newtonian mechanics are inadequate at high speeds and energies, whereas no experiments as yet have invalidated relativity.
A Myles and C Higgs
Edinburgh

Filter questions ...and answers

Prof Grundy's idea for a zero-phase-shift low-pass filter is fatally flawed. Grundy states that his filter's response of the form $1/(1+\omega^2)^N$ has no phase shift associated with it.

The received wisdom is that any realisable filter must inevitably cause a phase shift; so is the received wisdom at fault or has prof Grundy missed something? The answer lies in the time domain response of a filter with the proposed response, and the easiest way to get there is via the s plane.

Take the simplest case, where N = 1. To get into the s plane from the frequency domain, make $\omega = s/j$:

$$\frac{1}{1+\omega^2}=\frac{1}{1-s^2}=\frac{-1}{(s+1)(s-1)}$$
$$=\frac{1}{2}\left[\frac{1}{s+1}-\frac{1}{s-1}\right]$$

Now look up a table of Laplace transform pairs – impulse response of the above = $0.5(e^{-t}-e^{t})$. So the circuit is unstable and the response goes to infinity as time t goes to infinity.

This highlights the comment about *realisable* filter responses. Theoretically, prof Grundy's response can be synthesised. But practically it is simultaneously an unobtainable and useless response, because it means an impulse would cause the filter output to rise indefinitely.

There is a further difficulty associated with the, admittedly ingenious, proposed method of analogue processing (assuming it is utilised to produce realisable responses). The synthesis involves raising analogue signals to a power; the means of carrying out this procedure involves taking the log of an AC signal. However AC signals keep going through zero, and so taking logs is a process that can only be approximated since the log of zero is minus infinity.

The result of this approximation will be some sort of crossover distortion. Also, since the log-antilog processing is carried out continuously, then any non-linearities in the process will show up as waveform distortion.

Commercially available log converters can manage a linearity of about ±0.2dB and this represents a waveform envelope error of 2% – hardly acceptable for audio. No doubt this could be improved , but even so, dynamic range would be a problem.

Since it does appear that this scheme could be used to synthesise realisable filters, perhaps Grundy could be persuaded to comment on how the waveform distortion problems might be addressed, and any practical results obtained.
Brian Pollard
Watford

Prof David Grundy appears to have misunderstood the basic principles of filtering.

It is impossible to produce real time filters exhibiting zero phase shift, whether implemented digitally, by analogue techniques, or by any other means. The problem lies not with the implementation but with basic mathematics.

Impulse response for a zero phase shift low pass filter can be shown to be a sync function ($\sin x/x$) centred on $t = 0$. This is convolved across the input waveform to produce the filtered output waveform. Since part of the impulse response occurs before $t = 0$, it follows that part of the filter output must also precede the input – clearly impossible for any filter operating in the time domain. Such a filter is neither causal, nor can be physically realised. Similar arguments also apply to bandpass and highpass filters.

It *is* possible to produce FIR (finite impulse response) filters with a true, linear-phase constant-delay characteristic. It is also possible to produce analogue approximations to linear phase filters; eg Bessel maximally flat delay types, equi-ripple linear phase types, or even finite time averaging filters which are not only linear phase but also FIR approximations..

It is also possible to produce true zero phase shift filters when all the information is available simultaneously, as in image processing. Such filters do not operate in the time domain, and so do not violate causality.

Should prof Grundy prove me wrong by producing a practical circuit with oscilloscope traces showing it predicting its own input (as well as taking the log of a negative quantity as in Figs. 1 and 3 of his article) I shall be the first to offer an apology, and use his circuits for compensating infinitely accurate control loops with none of the nasty destabilising phase shifts which have plagued control engineers for the last century.

Alternatively I shall give up electronics altogether, and use his circuit to predict the Stock Market.
John D Yewen
Beds

May I be the first to congratulate David Grundy on his ingenious April Fool article "Structured analogue design builds perfect filters" (*EW + WW*, May 1992)

Firstly the logarithm of a negative number does not exist, so only positive half-cycles can be processed. Any attempt to take logarithms of positive and negative half-cycles separately may work on some simple waveforms but will not work in the general case.

Secondly, replacement of log-antilog by a divider circuit will not work for AC inputs because division by 0 will be encountered. The topology is also prone to component tolerance problems.

Stability and noise problems mean nobody in their right mind designs a circuit or system that includes a differentiation function.

Replacement of differentiators by integrators yields DC operating condition problems – but these may be overcome in filters containing damping terms.
Mike Rogers
Cheltenham Spa

David Grundy responds..
First of all I should say that my interest in filters is for audio applications and all my work has been involved in considering sinusoidal signals. So my interest in zero phase shift is concerned largely with the facility this gives of combining, for example, the output of a low pass filter and its input to produce a high pass, and if needed cascading this with a low pass to produce a band pass (Fig. 3 in my article).

Zero phase shift: I have looked at the output from this type of filter and compared it with its input on an oscilloscope, and I can assure readers that there is no discernible phase shift. Indeed if there were, the calculation simply would not work.

The reason there is no phase shift is that all input frequencies are shifted through 360°. My preoccupation is with collections of sine waves and moving 360° along a sine wave is getting back to where you started. I recognise that this is a feature of a periodic signal, but that is my interest.

Impulse testing: I cannot comment on the impulse testing point since I have not undertaken this type of measurement. The limited square-wave testing that I have carried out shows the output to be square with obviously "rounded" edges and no discernible overshoot.

Raising signals to a power: the log of zero is minus infinity as stated. But since real silicon junctions are involved the current never goes to zero due to presence of the saturation current which although small is finite.

The logarithm of a negative quality does not present any problem because the logarithmic circuitry is designed to operate in all the quadrants required – clearly a design detail.

Distortion: the distortion acceptable for audio is dependent on the application. The largest market for speech filtering is, of course, communication where demands on distortion are obviously not as great as for high fidelity. In my experience I feel that the 2% envelope distortion mentioned is pessimistic and there are obviously techniques for improving this. In the particular system under discussion, since the log and antilog procedures are carried out by the same junction construction, the absolute performance of either is not so significant in this context.

Realisable filters: though still early days I have produced filters of this type of 9th order and measured them on the bench with sinusoidal input (including two separate sources). I have found them to behave as per the mathematics in the article. The problems I have experienced have been more to do with aspects such as limited slew rates of available amplifiers, rather than fundamentals.

Practical circuits: these have already been built and for sinusoidal inputs behave in line with the mathematics outlines.

In conclusion I would once again state that the applications I envisaged for this type of filter were primarily for continuous periodic signals, as in communications, and not for control systems.
David Grundy

NO WALKOVER FOR RADIO AT WARC 92

As Warcs go, the 92 world administrative radio conference had a fairly restricted agenda. It was mainly concerned with wresting spectrum for emerging technologies away from existing users. But as Pat Hawker and Peter Willis report, the debate was far from battle-free.

The World Administrative Radio Conference 1992 (Warc-92) ended after four weeks of protracted, confused and often heated debate in Malaga. But the feeling is that for the UK the outcome was good – though the many complex footnotes added to the ITU's Radio Regulations may take a decade to interpret and assimilate.

The UK made no specific proposals of its own but prepared its stance in close co-operation with the European Cept, with additional support from EBU, ESA, etc. Cept's main proposals were accepted, though with modifications made to the suggested frequency allocations and some reservations over the form of large numbers of additional footnotes.

A last-minute all-night meeting was required before the final acts were agreed by the national delegations, which at one stage comprised some 1400 delegates from over 125 countries.

Unlike Warc-79, at which the entire international table of frequency allocations was reviewed, Warc-92 revolved around a limited agenda, though this covered important aspects of the broadcast, mobile-satellite and mobile-terrestrial services, all of which have been seeking additional spectrum.

Decisions taken at Warc open the way for several important new radio services. These include allocations for wideband HDTV and digital audio broadcasting (dab) from space, providing, for the first time, frequencies for non-geostationary and low earth orbiting satellites.

For digital audio broadcasting, the 1452-1492MHz band was allocated – against the wishes of the UK and Europe which were pressing for the 2.6GHz area. But the service will be restricted to secondary status – meaning existing services will have priority – until 2007.

For more than a decade, there has been demand for significant additional frequencies for HF broadcasting, sought primarily at the expense of the fixed (point-to-point) services transferred to satellite. This demand continued to be strongly resisted by the developing countries for whom HF is still regarded as an essential low-cost service under national control.

In the event, 790kHz has been added to the broadcast service: 590kHz between 10 and 30MHz but only 200kHz below 10MHz (the most congested part of the HF spectrum).

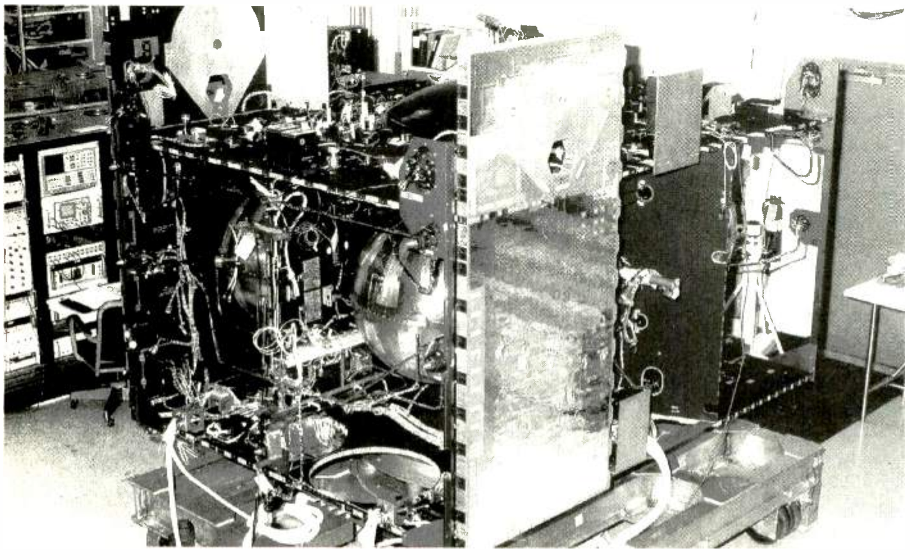
Single sideband reservations

Restrictions on the use of the tropical bands have been maintained. The additional frequencies will not become available until 1 April 2007 and then only for the SSB (reduced carrier) mode.

A recommendation has been made that all HF broadcasting should be changed from double to single sideband before the present mandatory date of 31 December 2015. It is no secret that some major broadcasters, including the BBC, are concerned at the high cost – and possible loss of audience – of converting to SSB unless and until assured that really low-cost SSB receivers are available. To date, consumer receivers suitable for SSB are priced well beyond mass audiences in many developing countries.

Although UK/Cept proposed an allocation for the broadcast satellite service (BSS) around 2.6GHz, Warc-92 finally gave BSS 50MHz of spectrum between 1452 and 1492MHz, with a planning conference to be held not later than 1998. In the UK, this allocation clashes with a considerable number of private fixed links and BSS will have only secondary (non-interfering) status until 2007. The USA and several other countries have footnotes providing for a BSS allocation around 2.6GHz. The

Astra 1B under construction: Warc 92 looked at future operation of satellite broadcasting



1.45GHz band will also be available for complementary terrestrial broadcasting.

A number of European countries, including the UK, have become concerned at the cost of digital audio broadcasting from a non-geostationary satellite and are increasingly anxious to initiate muscam/cofdm digital broadcasting as a terrestrial system at a relatively low VHF frequency. They are currently seeking a "parking" allocation, with a future objective of digital-audio replacing FM in Band II.

As a result of proposals by Germany and Spain, Warc-92 decided to request the Administrative Council of the ITU to include VHF terrestrial digital sound broadcasting in the agenda of a future radio administrative conference for Region 1 (and interested countries in Region 2). When the suggestion that it would be possible for the UK to utilise some part of either Band I or Band III for terrestrial dab was put to Michael Goddard (Radiocommunications Agency and leader of the 40-strong UK delegation) he pointed to ministerial commitment to use the whole of these "broadcast" bands for mobile communications and ancillary services. But ministerial commitment is far from Holy Writ, and not all of Bands I and III have yet been handed over to the mobile services.

The low-end of Band I could provide national dab networks, not only for the UK but also for most European countries. It would then be possible to launch CD-quality digital sound broadcasting at an early date, at least in some areas and at relatively low cost.

Although it proved impossible at Warc-92 to reach agreement on a unique worldwide allocation for wideband HDTV, Region 1 (Europe/Africa) and Region 3 (Asia/Australasia) have opted for 21.4-22GHz from 1 April 2007 (HDTV services may be implemented in this band before then on the basis of non-interference to existing services).

In compensation, FSS will gain access to 24.25 to 25.25GHz, with satellite feeder links in the range 27.5 to 30GHz. Additionally, the 1977 Region 1 plans for 11.7 to 12.5GHz BSS will be reviewed at a future administrative radio conference with the objective of improving spectrum use, maintaining existing services and providing for the needs of new countries.

This will not directly affect Astra and Eutelsat, where the proximity of satellites has created a potential for interference, since they are both on the adjacent FSS band. However, Astra has called for a similar review of orbital allocation, and the passing of this resolution could strengthen its case.

Mobile satellite issues, according to Mr Goddard, dominated much of the conference debate. The only European proposals were for a modest expansion of the existing mobile-satellite allocations in the short-term and for a substantial new allocation for beyond 2005.

Low earth orbit proposals

Australia, Canada and the USA wanted significant provisions to be made for mobile-satellite services in the shorter term. In addition, the USA came to Warc-92 with an extensive list of proposals to accommodate low earth orbiting (leo) satellite systems for both below and above 1GHz. It proved extremely difficult to reach agreement and the results are an inevitable compromise, representing some of the most complex regulations to have been produced by an ITU conference. The safeguards built-in to protect existing users (fixed links, mobile services, radio astronomy) may prove difficult, even impossible to surmount.

Civil leo systems are seen as offering scope for new services in the VHF/UHF band, including basic message communications and data on a store-and-forward basis or in real-time for emergency operations, paging, position location, etc. in conjunction with lightweight (portable) terminals in areas unserved or underserved by more conventional telecommunications systems.

A problem, however, is that a significant number of developing countries, which could benefit from the introduction of such systems, fear loss of national control over their internal and external communications.

Over 50 countries have subscribed to footnotes that appear to restrict severely the use of leo systems during satellite passes over their countries.

Leos operating below 1GHz have been dubbed "little leos" and above 1GHz "big leos", which would be suitable for mobile communications. Primary allocations, subject to the many footnotes, include 137-137.025MHz, 137.175-137.825MHz and 148-149.9MHz with secondary-status allocations at 137.025-137.175MHz and 137.825-138MHz.

A new worldwide primary allocation for the mobile satellite service (MSS) is 1610-1626.5 MHz (earth-to-space) paired with 2483.5-2500MHz, subject to the coordination procedure developed for non-GSO systems. Above 2GHz, new worldwide primary allocations for MSS, in effect from 1 January 2005, are 1980-2010MHz, 2170-2200MHz, 2500-2520MHz and 2670-2690MHz.

For terrestrial mobile services, an upgrading to primary status will permit worldwide allocations suitable for FPLMTS (the future public land mobile telecommunications systems often referred to as the 3rd generation cellular service) in the band 1700-2690MHz – one of the main objectives sought by UK/Cept. 1885-2025MHz and 2110-2200MHz will be available for the terrestrial components of FPLMTS, with sub-bands 1980-2010MHz and 2170-2200MHz allocated also to MSS and thus able to accommodate both terrestrial and space components of the FTS.

Due at the beginning of the next century, they are expected to provide voice and non-voice services, with global roaming capabilities, of especial use to areas with underdeveloped communications systems.

Flying phones

Telephoning while travelling on a commercial airline will at last become possible following agreement on frequencies that will allow the introduction of APC services (aeronautical public correspondence for aircraft passengers) in the bands 1670-1675 MHz (aeronautical) and 1800-1805 MHz (aircraft). Region 2 (Americas) will have APC initially in the bands 849-851 MHz and 894-896 MHz, meaning that some aircraft may have to carry two sets of equipment.

Generally, it seems to be recognised that with the continuing development of broadband fibre-optic international cable systems, the fixed satellite service (FSS) is likely to be used primarily for spur and mobile services with the bulk of traffic carried between the main hubs by fibre optics. Satellites remain the first choice for multi-point distribution.

With the design-life of satellites now in the order of 15 years, there is less scope for new generations of the established satellite systems, although the advantages and disadvantages of the transparent transponder concept versus on board processing (OBP) continue to attract attention.

Users stress the need to reduce further the cost of satellite communications, in both the earth and the space segments. This calls for improvement in spacecraft EIRP, power amplifier efficiency (both with travelling-wave tubes and solid state), transponder linearity, and also antenna beam-shaping technology and polarisation-isolation performance.

Mr Goddard, although clearly concerned at some aspects of this major conference, believes that although the overall results of Warc-92 are complex and far from perfect, they represent a major step forward in making provision for the number of new and expanding radio services, with the ground work laid for future planning: "Given the problems, complexities and threats, there is every reason to consider Warc-92 a success". ■

TRACY MARTIN

WHITE NOISE

by Hot Carrier

A nation of project managers

I have recently watched the complete closure of two sites near me belonging to large electronics companies, with many redundancies and transfers to other locations.

Job losses have extended across the board. Except, that is, in one department which seems to have escaped the cuts almost entirely – the project office.

What goes on in project offices? – it seems to be mainly massaging estimates and pert charts, and writing progress reports and attending meetings. Their existence is down to the exigencies of *matrix management*, where everyone reports to at least two different managers, one for technical matters and one for progress.

The drawback is that when things go wrong, most of the managers survive, with technical management being the usual scapegoat. The result is a company staffed almost entirely by project managers who long ago moved out of practical engineering, or who were never even in it.

Come the upturn, who will do the real engineering when the firm has been restructured to nothing?

Developing an inadequacy

Electronics companies continue to complain that they are having difficulty recruiting good engineers, especially in analogue and RF techniques.

Shortage of RF engineers in particular is mainly due to the large demand from GSM/Dect/CT2/etc development and if it poses a problem now, this can only get worse. The root causes are twofold.

Universities, polys and technical colleges are no longer teaching much analogue electronics. They are lured by the glamour (and comparative ease) of teaching digital, and avoid the difficulty and inconvenience of organising worthwhile practical analogue circuit lab experience.

In the past even where lab work was minimal, the shortcoming was more than made up for by students having an active hobby interest (and hence practical experience) in making circuits work. Even if they weren't into transmitting, they still aspired to make the ultimate communications receiver. Now they are likely simply to go out and buy a Japanese 2m handheld. In less affluent days, building home-brew equipment was the only way to get on the air

The shortage of RF engineers is good news for students: keep yourself technically up to date and be prepared to move house as desperate employers improve their offers.

But for the UK it is bad news. If products cannot be developed here then they will be developed overseas. Manufacturing is more likely to take place where the development is carried out rather than be transferred back to the UK.

We need a scheme where experienced development engineers are encouraged to spend a day a week at the local university electronics department or technical college passing on their invaluable experience – practical experience which many lecturers often lack.

The government must step into fund such a scheme – *in all our interests.*

Simple approach to advanced business efficiency

Spectrum, the Journal of the IEEE, contains a regular advertisement by GM Hughes Electronics detailing various notable advances made by the company. These are usually significant and well worth reading about, especially where they refer to technical developments in communications, aircraft or space technology.

But sometimes the "advances" seem less impressive, especially where they do not relate to technical matters.

For instance, we learn that on a communications satellite programme, substantial savings were achieved by replacing detailed inspection of incoming parts by verification of the critical parameters only. Also, determining which departments needed to sign off individual engineering drawings, eliminated unnecessary reviews by unaffected departments. As a development engineer, I was never responsible for organising such procedures in the companies where I worked. But the measures mentioned seem so obvious that doubtless all British companies have operated them since the earliest times... haven't they?

CLASSIFIED

TEL 081 652 8339 **FAX 081 652 8931**

ARTICLES FOR SALE

PRODUCTION/A.T.E.
SECOND USER EQUIPMENT
HUGE SAVINGS ON NEW PRICES

PCB ASSEMBLY

AMBOTECH ROBIN Axial/DIP Inserter	£5,000
DYNAPERT 118 Pick and Place Machine	£6,750
DYNAPERT 318HR Pick and Place Machine	£29,975
DYNAPERT 500 Pick and Place Machine	£16,500
UNIVERSAL 6241A Sequencer/Axial Inserter.	£48,000
UNIVERSAL 6241B Sequencer/Axial Inserter.	£72,000
UNIVERSAL 6348A Sequencer/Radial Inserter	call
UNIVERSAL 6772 Multimod .3".6"	£20.000
DEK 255 Pass Thru'. Brand New/unused	£28,000
UNIVERSAL 6348A 40 stn. Radial Inserter	£82,500
ROYONIC Light guided assembly benches	£call
HELLER 715 Axial Lead former	£2,800

Many more makes/models of Production, ATE, Semiconductor Fabrication, Environmental Test, T&M, Soldering and Cleaning Equipment available. Call for full listing.
See latest issue of Buyers News for full listing and Terms & Conditions. Prices exclude VAT. Buyer's Premium not included.

SPECIAL OFFERS

ACE 350-litre Burn-in Oven	£995
ACE −20 to +150°C Chamber	£2,900
BLAKELL LS210 c/w LS34 Assembly Station	£895
DEK 245 (New in Box) Screen Printer	£6,000
DEXION Automated Horizontal Warehouse Storage System	£1,190
EUBANKS 2700-04 Cable cut & strip C/W 6215 04	£5,550
FISCHER Betascope 870C With Z5NGB2 Platform	£2,995
ICI SCREENKLENE A0 Solder screen cleaner	£1,450
ICI 1214 Vapour Phase Reflow Tank	£2,550
ICI 2818 UV 28 Ultrasonic cleaning plant	£1,995
PHILIPS 3320 250Ms/s Digital Storage Oscilloscope	£2,995
PLANER GB7 Gas bonder	£175
TEKTRONIX 2445 150MHz Oscilloscope	£1,350
TEKTRONIX 2465 300MHz Oscilloscope	£1,995
TRESTON PA-60 Paternoster Assembly Aid	£495
BLUNDELL Cropmatic/Vacuclamp Package	£5,500
MARCONI 2019 Sig. Generator	£2,000
HP 3325A Function generator	£2,650

HUGE SAVINGS ON Second User Manufacturing Equipment for the Electronics Industry
The Buyers News Offer List

BUYERS NEWS Tel: 071-284 4074 (UK)
Fax: 071-267 7363 (UK)
146 Camden Street, London NW1 9PF

VISA

COOKE INTERNATIONAL

NEW EX DEMONSTRATION EQUIPMENT

Marconi 2871 Data Communication Analyser	£1850.00
Kane May Infratrace 1000	300.00
Kane May MK1202 Printer (Goes with Infratrace)	150.00
Norma D4155 Digital Wattmeter	500.00

CLEARANCE SALE

Ailtech 446 10/50 Watt Power Signal Source with 196 & 197 Plug Ins 200-1000MHz	£1200.00
Philips PM8131 X-YT Recorder with PM 9884 T/Base	£250.00
Bradley Oscilloscope Calibrator Type 192	£350.00

SPECIAL OFFER

Telequipment D83 Oscilloscope DC-50MHz with FREE Weir Minireg PSU 0-30V 0-1.5 Amps inclusive VAT and CARRIAGE — £250.00

All equipment is used unless stated and prices unless marked exclude VAT and carriage
MUCH MORE AVAILABLE, VISIT, PHONE OR S.A.E. FOR LISTS

COOKE INTERNATIONAL
Unit 4 Fordingbridge Site, Main Road, Barnham, Bognor Regis, West Sussex PO22 0EB
TEL: 0243 545111 **FAX 0243 542457**
We are always looking to purchase good S/H stock

TO MANUFACTURERS, WHOLESALERS, BULK BUYERS, ETC.

LARGE QUANTITIES OF RADIO, TV AND ELECTRONIC COMPONENTS FOR DISPOSAL

SEMICONDUCTORS, all types, INTEGRATED CIRCUITS, TRANSISTORS, DIODES, RECTIFIERS, THYRISTORS, etc. RESISTORS, C/F, M/F, W/W, etc. CAPACITORS, SILVER MICA, POLYSTYRENE, C280, C296, DISC CERAMICS, PLATE CERAMICS, etc. ELECTROLYTIC CONDENSERS, SPEAKERS, CONNECTING WIRE, CABLES SCREENED WIRE, SCREWS, NUTS, CHOKES, TRANSFORMERS, ETC **ALL AT KNOCKOUT PRICES**
– Come and pay us a visit ALADDIN'S CAVE

TELEPHONE 081 445 0749/445 2713
R. HENSON LTD
21 Lodge Lane, North Finchley, London N12 8JG.
(5 minutes from Tally Ho Corner)

TURN YOUR SURPLUS TRANSISTORS, ICS ETC, INTO CASH
Immediate settlement.
We also welcome the opportunity to quote for complete factory clearance.
Contact:
COLES-HARDING & CO.
103 South Brink
Wisbech, Cambs PE14 0RJ.
ESTABLISHED OVER 15 YEARS
Buyers of Surplus Inventory
Tel: 0945 584188 Fax 0945 475216

GOLLEDGE
ELECTRONICS

CRYSTALS . OSCILLATORS FILTERS

Comprehensive stocks of standard items. Over 650 stock lines. Specials made to order
OEM support: design advice, prototype quantities, production schedules.
Personal and export orders welcome.
SAE for our latest product information sheets
GOLLEDGE ELECTRONICS LTD **Tel: 0460 73718**
Merriott, Somerset, TA16 5NS **Fax: 0460 76340**

CLASSIFIED ADVERTISEMENT ORDER FORM

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30

Place a lineage advertisement in next months issue and it will cost, for a single insertion, only £2.50 per word

Lineage advertisements under £50 have to be pre-paid by credit card or cheque.

Special rates:

6 insertion £2.15 per word/issue. (Advertisement can appear every month or every other month only) 12 insertions £1.80 per word/issue. (Advertisement to run every month only).

WHY NOT PLACE A BOXED ADVERTISEMENT TO GIVE MAXIMUM IMPACT? →

EXAMPLE SIZE
3 cm x 1 column
For 1 insertion cost is: £60.00
For 6 insertions costs are: £51.00 per issue
For 12 insertions costs are: £42.00 per issue

Extras:

Spot Colour 20%

Box number service £22.00

ALL RATES QUOTED ARE EXCLUSIVE OF VAT: All major credit cards accepted
Please debit my__________________card a total of £__________________

Expiry Date:__________________
Please ensure that address given is where your credit card statement goes to.

NAME..

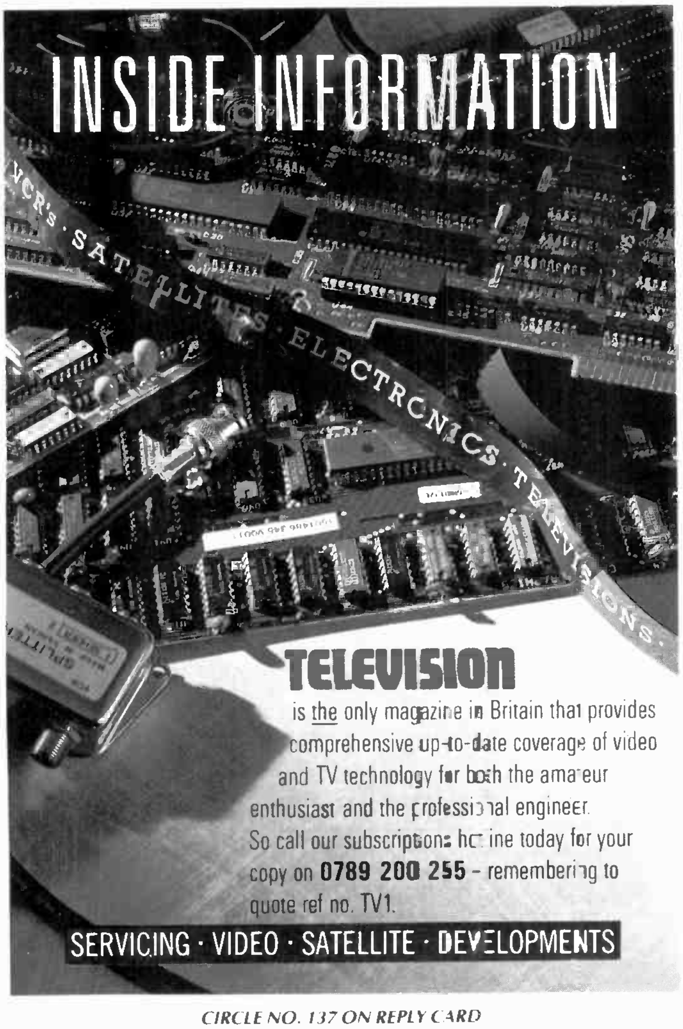
ADDRESS..

....

TEL NO .... SIGNATURE ....

All advertisements must be received 5 weeks prior to publication date.
All cancellations must be received by 8 weeks prior to publication date after that. No advertisement can be cancelled.
Please send to Electronics World & Wireless World, Classified, Room L329, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Tel: Pat Bunce on 081-652 8339.

ARTICLES FOR SALE



CIRCLE NO. 137 ON REPLY CARD

ARTICLES WANTED

SERVICES

BOOKS/ PUBLICATIONS

FREE PRIVATE CLASSIFIED

RACAL RA17L. Excellent Condition, Cased, Spare set of valves. Full Manual. £230 Tel: 0530-62565

COMPLETE SET OF WIRELESS/ ELECTRONICS WORLD since 1953. 1953-1969 in Bound Volumes. Mint Condition. Offers for Set. Tel: 0235-850724

GRAPHICS DIGITISER. CURSOR. TYPE TDS HR48. Size AO. Links to any CAD System. Immaculate. Motorised Raise/Lower Stand. Expensive New. £ Offers. Tel: 0272-741918

HI-FI ENGINEER RETIRING 1ST JULY. Workshop Contents For Sale Instruments including Ferrograph RTS. Spares, Manuals, Filing Cabinets, etc. £1,000 Tel: 0256-461923

HAMEG PORTABLE SCOPE HM207-3 8 Meg 70mm £60 Tel: 0702-522929

ELECTROHOME ECM1311 MONITOR. Source of Replacement CRT Required. Please phone Mr Briggs on 0543-491867

SCHLUMBERGER 2721 Universal Counter, 200MHz, Wide range of measurements and processing. CRT display. GPIB interface, excellent condition. AOC. Jim (0252) 518538

This offer only applies to private sales of electrical and electronic equipment. All adverts will be placed as soon as possible. However, we are unable to guarantee insertion dates. We regret that we are unable to enter into correspondence with readers using this service. We also reserve the right to reject adverts which do not fulfil the terms of this offer.

INDEX TO ADVERTISERS

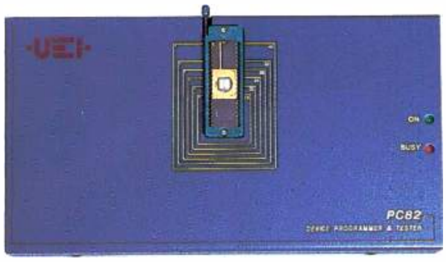
OVERSEAS ADVERTISEMENT AGENTS

France and Belgium: Pierre Mussard, 18–20 Place de la Madeleine, Paris 75008.

United States of America: Jay Fenman, Reed Business Ltd., 205 East 42nd Street, New York, NY 10017 – Telephone (212) 867 2080 – Telex 23827.

Printed in Great Britain by Riverside Press, Gillingham, Kent, and typeset by Marlin Graphics, Sidcup, Kent DA14 5DT, for the proprietors, Reed Business Publishing Ltd, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. © Reed Publishing Ltd 1992. *Electronics and Wireless World* can be obtained from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd, INDIA: A.H. Wheeler & Co, CANADA: The Wm Dawson Subscription Service Ltd.; Gordon & Gotch Ltd., SOUTH AFRICA: Central News Agency Ltd.; William Dawson & Sons (S.A.) Ltd.; UNITED STATES: Worldwide Media Services Inc., 115 East 23rd Street, NEW YORK, N.Y. 10010. USA. *Electronics & Wireless World* $5.95 (74513).

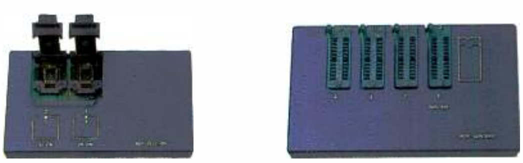
TOTAL PROGRAMMING SOLUTIONS FROM CITADEL



PC82 UNIVERSAL PROGRAMMER £395.00



- Universal programmer – the complete designers kit.
- Over 1,500 devices – call for list on FREE disk.
- EPROM, EEPROM, Flash, BPROM, GAL, PAL, MPU etc.
- Serial EEPROM, EPLD, MACH, MAX, MAPL, CMOS EPAL.
- Device testing – 74XX, 40XX, 45XX, DRAM, SRAM.
- PAL vector test.
- Clear menu driven software
- Text mode only, suits any video card.
- 40 pin Zero insertion force socket.
- Device testing – 74XX, 40XX, 45XX, DRAM, SRAM.
- Small half card to install in PC may be left in place.
- Secure round cable and locking D connectors.
- Proven reliability – over 100,000 units sold.
- Programmer pod size – 260×140×38mm.



ADAPTERS FOR THE PC82 From £85.00

- Extend programming facility for special devices.
- Allows alternative socket types eg PLCC.
- Multi-gang adapters for fast programming of EPROMS, GAL, PAL and popular CPU types.

FEATURES ALL PROGRAMMERS

For the IBM PC, install the interface card and programming socket, load the menu-driven software and you have a complete design system at your fingertips. The programmers will run on any compatible IBM machines such as XT, AT, '286, '386 or '486. Whether it be an Amstrad or Compaq the system will work. All features are software-driven and supplied on 5¼" disks, these may be copied onto your hard disk using the DOS copy command. All control of the programmer, programme voltages etc are menu-driven by selecting manufacture, type number, and selection of a suitable speed algorithm. Blank check, read & modify, verify, programme, auto programme, security blow etc.
FREE SOFTWARE UPDATES as new devices become available.

FILE CONVERSION FACILITIES

- HEX to BIN File conversions for Intel, Motorola and Tektronics.
- 2 way/4 way Bin file splitter for 16/32 bit data.
- Dump file to Console, modify and re-programme.

M25 BULK FAST ERASER £199·00

- Same advanced UV source as the M1 but 4 lamps.
- Very large capacity 64×32 pin chips or one double Eurocard.
- All other features as M1.
- Low profile steel case finished in powder coat.
- Size 365×240×65mm high.

M1 FAST ERASER £99·00

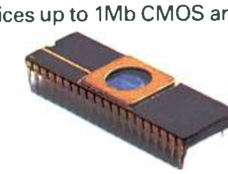
- Advanced UV source.
- Typical erase time three minutes.
- LED display of set time and countdown.
- End of time indicated by beep and display.
- Large capacity 13×28 pin devices.
- Sturdy construction, plated steel & aluminium
- Small footprint only 65×225×100mm high.

PC86 HANDY POCKET DEVICE TESTER £99·00

- Tests and identifies virtually all TTL & CMOS.
- Test many DRAM and SRAM memory chips.
- LCD display of type number and results.
- Battery operated (PP3) and completely self-contained.
- Zero insertion force test socket.
- Dimensions 90×140×30mm.

PC84-1 to -8 ROM PROGRAMMERS From £139·00

- Low cost EPROM programmer – devices up to 1Mb CMOS and NMOS.
- One to eight gang versions.
- To program 2716 to 271000.
- 32 pin Zero insertion force sockets.



ORDER INFORMATION

Please include £7 for carriage by overnight courier (£20 for exports) and VAT on all UK orders. ACCESS, VISA or CWO. Official orders welcome from Government bodies and local authorities.

For further information and your **FREE PC82** Simulation and device disk

PHONE SAMANTHA NOW ON:
081 951 1848
081 951 1849

FREE DEMO DISK

CITADEL PRODUCTS LTD
DEPT WW
50 HIGH STREET
MIDDLESEX HA8 7EP