Year 2000 - is your PC safe?

High-level rf mixers

The perfect If oscillator?

Neural nets, fuzzy logic

Rfi sources and solutions

Aluminium and tantalum caps

400Hz in 3-phases
The circuit design and analysis package which gives you a great deal more

- More Power
- More Functionality
- More Value for Money

Analogue, digital and mixed mode simulation
- Powerful analysis tools include AC, DC, transient, pole zero, Fourier (series & spectrum), noise, digital step-by-step and digital timing
- Monte Carlo and worst case analysis
- Enhanced symbolic analysis (providing closed form formulas)
- Temperature and parameter stepping, sweeping and optimisation
- Programmable input to circuits
- Component library contains 5,000+ components (user extensible)
- New models, including analogue control elements

Interactive components
- Faster algorithms for mixed-mode and large circuits
- Improved schematic entry
- Export to popular PCB packages
- Export/Import in Spice format
- Display results in sophisticated diagrams or on a range of Analogue and Digital Virtual Instruments, including function generator, multimeter, oscilloscope, frequency analyser and logic analyser
- Comprehensive DTP functions

Try TINA plus for yourself. For free demo disk, contact:
Tandem Technology Limited Breadbare Barns, Clay Lane, Chichester, West Sussex, PO18 8DJ
Telephone: 01243 576121 Fax: 01243 576119
E-mail: 101626.3234@compuserve.com Visit our website: www.tina.com

Special introductory offer. Just £199*
We challenge you to find a better circuit design and analysis package anywhere
*Price excludes VAT

Contents

451 COMMENT
Our life is littered away by detail... Simplify, simplify

453 NEWS
Internet through the three-pinned plug,
Virtual recruitment, Offender tagging costs, Hall to get ADSL.

458 YEAR 2000 DEBUGGED
Robert Harcourt looks at the year 2000 pc clock problem from a non-networked user's point of view.

464 HIGH LEVEL RF MIXERS
Darren Conway helps you choose the right mixer option for your receiver design.

470 HANDS-ON INTERNET
Among Cyril's findings this month is a dedicated modelling tool for optical links.

474 CIRCUIT IDEAS
- Heart p-wave detector
- Reducing valve psu ripple
- Low-noise, high-Z op-amp
- Testing digital recorders
- Quieter smps
- Wide-band isolated amplifier
- 1-bit keypad interface
- Enhanced current mirror
- Long-life flasher
- Brake for motors

485 A PERFECT VARIABLE OSCILLATOR?
Ian Hickman's latest invention is an oscillator scheme whereby all the harmonics are filtered, resulting in a near perfect sine wave.

490 BORN AGAIN
Richard Hall reports on how National's trusty old LM300 op-amp family has been given a complete overhaul.

495 UNDERSTANDING CAPACITORS
Aluminium and tantalum electrolytics are the subject of Cyril Baxeman's latest article in a series that examines all the popular capacitor types.

506 THE ROUTE TO PCB CAD
Thinking of buying a pcb design package? This month, Rod Cooper reviews Challenger and Ranger 2.

512 NEURAL NETWORKS AND FUZZY LOGIC
Chris MacLeod and Grant Maxwell ask what neural networks and fuzzy logic tell us about the future of digital electronics.

516 400Hz IN THREE-PHASES
Winner of the TRAC design competition Ben Sullivan describes his novel circuit for producing a three-phase 400Hz output that can be locked to an external signal.

519 NEW PRODUCTS
Four pages of product news, edited by Phil Darrington.

524 LETTERS
Modeling quartz in Spice, Are your ears flat? Assembler confusion.

526 RFI SOURCES AND SOLUTIONS
Alan Wood looks at potential sources of interference in telemetry applications.

JULY ISSUE ON SALE 29 MAY

TANDEM TECHNOLOGY
June 1998 ELECTRONICS WORLD
Our life is fluttered away by detail...

When Windows entered my consciousness years ago, I was terrified of it, because I thought I might disable the brain and not be able to recover. But there was no trouble; Windows 3.1 was robust, there was an enormous and well-written manual and the help line worked as promised. All well and good, but now I have to "upgrade" — a marketing expression meaning "to shell out for a new computer" — a 500MB hard disk, 33MHz 380 and 4MB of ram being a bit limiting. This new marvel was already loaded with Windows 95 and accompanied by a great tribe of cd-roms, many containing advertisements and games that anyone aged even nine has so far found totally incomprehensible. Telephone support — a major selling point — was promised but there were no manuals, since the "help" text was said to be enough, Ha!

I have had my sub rosa experience that Windows 95 is the flakiest system yet to be foisted on a receptive public. It is highly susceptible to wobbly mouse use. If your aim is at all uncertain, or the simple truth is that you don't really know what you are doing, the most entertaining thing can and do happen.

"Shortcuts" appear on the desktop utilities — they do on mine, at least — files turn up from nowhere, settings change without any intervention from the me and the machine has an infuriating habit of locking up. Then there is the apparent delight in performing "illegal" operations and implicitly blaming me for them; following the screen instructions after such a hiccup, doesn't work, so you have to reset the computer, which means another run of the disk-scanner before it will consent to do any more work, having lost any haven't saved. And the start-up menu: whoever decided to put Suspense next to Shut Down ought to be suspended and put down, prefaced possibly. You can, of course, hide it, but you have to find that out after the first stress-inducing episode of blankness. Curiously ringing the ambulantly named help-line did little towards postponing an inept seizure. I tried to speak to someone for three days, but was fixed with a recording of a silver-tongued lady every time, that is there were busy and wouldn't please hold on.

I tried a computer "expert", but found myself listening to Mozart, who is wonderful, but as a Windows consultant not particularly helpful. So I wrote to my supplier. That is many weeks ago and I haven't received a note to say I will shortly hear from them. I am becoming used to this prima donna of an operating system and the cynical way in which it competes are now mastered, but cannot help feeling a little resentful.

Windows 95 gives me the impression of being hopelessly over-engineered: providing endless different methods of doing it without anything. It appears that programmers were facilities it because they can be done, rather than because users need them. Maybe the programmers should be taught that simplicity is usually the winning approach in any branch of engineering. On-screen help facilities are good, but they cannot replace well produced manuals, particularly if there is nothing on the screen. An introductory booklet that came with the computer, a very slim volume indeed — is right as far as it goes, but it doesn't go anywhere near for enough. If the simpler Windows 3.1 needed a tone, why doesn't this one?

Most of the cd-roms had little to say about themselves apart from a bit on the cover and some fairly off-hand help on screen.

Cost is, I assume, the reason for a lack of manuals, but I do think an effort should be made to provide something a little more helpful than the booklet on Windows 95 that is currently sent out, particularly some help on how to recover from something outrageous like a blank screen after the boot-up (the F8 procedure at the first stress-inducing episode of blankness). Clearly, the computer seller's army of helpers is hard put to deal with the clamour for assistance and there is no reason why they should have to; it is the responsibility of people like Microsoft to ensure that there is enough printed instruction to enable customers trying to earn a living using Windows to do without getting themselves in a fix.

Maybe the next version of Windows will be a bit simpler, and a lot less vulnerable, but it seems unlikely.

Philip Darrington
**PROTEUS**

**The IVth Generation**

**Schematic Capture**
- Component Auto-Placer
- Pinswap/Gateswap Optimizer
- Background Regeneration of Power Planes
- Enhanced Autoreouting with Tidy Pass
- Full Control of Schematic Appearance
- Extensive New Component Libraries

Available in 5 levels - prices from £295 to £1875 + VAT. Call now for further information & upgrade prices.

**PCB Design**
- Automatic Component Placement
- Rip-Up & Relay
- Autocad and DXF imports
- Phosphor-Enhanced Glowing & Backannotation
- 32 bit high resolution database
- Full ERC and Connectivity Checking
- Shape list on all power planes
- Better and DfM report (optional)

New Features

**Simulation**
- Non-Linear & Linear Analogue Simulation
- Event driven Digital Simulation with modelling language
- Partial real simulation of large designs with infinite analogue & digital sections
- Graphs displayed directly on the schematic

**UP DATE**

Internet access via the three-pinned plug?

...said Mark Main, the project's marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.

New light on charging NiCd cells

...said John Hutchinson, engineering director at BayGen, the wind-up radio company.

...said John Laycock, head of the project at Nortel in Maidenhead. Commercial systems could be in place by September, he claimed.

A production version of the Digital PowerLine technology was announced by Nortel as C2BIT.

“Last year we announced a first generation product for verification and trials,” said Mark Main, the project’s marketing manager. This was based on a card in a pc, but restricted the technology to consumers privileged to own a computer, said Main.

The new unit is separate from other equipment and can be used with Web browsers and network computers as well as standard pcs.

Base-station units will be located at transformer substations, modulating data onto the mains.

Each base station handles a 1Mbit/s data stream. Houses or businesses that have a link onto the system share the bandwidth.
Offender tracking has a £100m tag

Electronic firms are being asked to tender for four major contracts, worth collectively over £100m, to extend electronic tagging of offenders throughout England and Wales. Home Office Ministers have decided that current tests in areas such as Greater Manchester, West Yorkshire, Berkshire, Midlands and Cambridgeshire have proved a success.

Despite teething troubles, Home Secretary Jack Straw has decided that the system—which has shown an 80 per cent failure rate for 1000 persistent petty offenders and people on bail—is ready to go nationwide. Now his Minister of State, Joyce Quinn, is to let four regional contracts from 1999 for systems of a virtual tagging tag and a receiver linked to the telephone system.

She said: "Companies from a wide range of relevant sectors including the security, telecommunications and electronics industries, are being encouraged to consider the business opportunities created by the increased use of tagging."

The tender details that the four regional contracts—which will let for five years with a two year extension option—will cover a minimum of 4500 offenders and be worth at least £100m.

The two firms involved in the existing trials—Societas and Geographics—are favourites for the contracts but a Whitbread source stressed that it was an open competition for any company with the necessary technical expertise.

Firms can bid for one, more or all of the regional contracts by the closing date of April 21.

Are 2000 solutions enough?

The DTI is stepping up its awareness campaign for the Millennium date change problem and calling on all sectors of the electronics industry to support its initiative.

"The electronics industry has a pivotal role to play," said Ian Edson, acting director of the DTI's Action 2000 programme. The focus for this activity, which will involve trade associations and institutions like the EEE, is the problem of finding and providing a fix for all embedded clocks.

"It is getting pretty close to the wire for many large companies," said Peter Williamson of Action 2000.

US skills crisis a myth?

US labour leaders have attacked high-tech companies' claims that there is a serious IT skills shortage in the US.

The Department for Professional Employees (DPE) has sent a letter of protest to the US Congress complaining that US technology firms' real motivation is not looking for workers but paying lower wages.

"There is no proven crisis regarding the demands for IT workers that justifies the drastic action of firing those jobs with foreign workers," said DPE chairman Morton Bahr. "We should be very careful about IT employers crying wolf just to enlarge the labour pool, depress salaries and benefits and undermine working conditions."
Ten sign up for mains Internet

T
en public utility companies in Europe and Asia have signed up to use the Internet-over-the-main technology.

Nortel and Norwek Communications, which is Norway’s own version of the American utility, are among the first. The three companies have installed the technology, which will allow users to access the Internet over the telephone lines. The companies say they will be able to provide Internet access to 2 million customers by the end of this year.

Intel outside?

C
hief executive of the joint venture company, said Nortel is looking to develop similar technology for Europe.

Hull to get fast DSL phone link

K
ington Communications plans to offer customers high-speed Internet access via its existing asymmetric digital subscriber line (ADSL) network.

The scheme, involving up to 170,000 customers in the Hull area, is a continuation of a successful pilot scheme.

Government reacts on low r&d spend

The government seems to have hit the panic button on the UK’s high technology investment. With r&d investment in the civil sector having fallen as a percentage of gross domestic product for three consecutive years, the Treasury has produced a consultative document to demonstrate its commitment to using tax incentives to promote r&d investment in UK firms.

According to the latest official figures, the UK’s r&d investment is a proportion of gross domestic product for three consecutive years, the Treasury has produced a consultative document to demonstrate its commitment to using tax incentives to promote r&d investment in UK firms.

Big brother back-off

The US government appears to be relaxing its position on the use of powerful encryption products.

Representatives of the FBI and the Department of Justice have been talking to the Senate committee saying they would not seek to stop encryption legislation which will allow the US government to read encrypted messages.

The Senate committee also heard from experts who said that encryption is the key to privacy on the Internet.

A recent survey by MCI Communications’ chief lawyer Tim Casey said, “Such privacy, in turn, is key to the realising the enormous potential of Internet and global electronic commerce.”

The Treasury has proposed a voluntary, industry-led approach to encryption policy rather than government controls or laws.

DSP like a microcontroller?

T
exan Instruments has announced a single-channel digital signal processor with microcontroller-like capabilities.

This is a dsp designed to perform well in areas where microcontrollers are currently found, such as home appliances and office automation.

The new device, called the 6x86MX/MD processors, is aimed at applications where performance and low power consumption are critical.

The 6x86MX and 6x86MD processors offer up to 60MIPS performance at 3V using a 6x86 architecture.

The processors are based on the 6x86 architecture, which was introduced by AMD in 1988.

Cyrix has yet to adopt the instructions. The two companies have first to agree whether to use the same set. "The plan is for Cyrix and Intel to use the same instructions as us," said Berglund. By early next year, AMD plans to release the K6-3D.

The "integrates the two latches on a chip which will operate at a clock speed similar to processor clock speed," said Berglund. He claimed the device will match the performance of Intel’s Kainat processor.

Cyrix meanwhile seems more concerned with pushing for cheaper devices, with its 6x86MX and 6x86MD processors.

According to the latest official figures, the UK’s r&d investment has fallen.

"We are planning to roll out by September, with up to 200 homes connected by the year end," said Davey.

Cyrix's fortunes may change. "Volumes are critical - on the basis of what we know so far," said Forrest Tobak, v-p of marketing at Cyrix.

Cyrix has yet to adopt the instructions. The two companies have first to agree whether to use the same set. "The plan is for Cyrix and Intel to use the same instructions as us," said Berglund. By early next year, AMD plans to release the K6-3D.

The "integrates the two latches on a chip which will operate at a clock speed similar to processor clock speed," said Berglund. He claimed the device will match the performance of Intel’s Kainat processor.

Cyrix meanwhile seems more concerned with pushing for cheaper devices, with its 6x86MX and 6x86MD processors.

The new device, called the 6x86MX/MD processors, is aimed at applications where performance and low power consumption are critical.

The 6x86MX and 6x86MD processors offer up to 60MIPS performance at 3V using a 6x86 architecture.

The processors are based on the 6x86 architecture, which was introduced by AMD in 1988.

Cyrix has yet to adopt the instructions. The two companies have first to agree whether to use the same set. "The plan is for Cyrix and Intel to use the same instructions as us," said Berglund. By early next year, AMD plans to release the K6-3D.

The "integrates the two latches on a chip which will operate at a clock speed similar to processor clock speed," said Berglund. He claimed the device will match the performance of Intel’s Kainat processor.

Cyrix meanwhile seems more concerned with pushing for cheaper devices, with its 6x86MX and 6x86MD processors.

According to the latest official figures, the UK’s r&d investment has fallen.

"We are planning to roll out by September, with up to 200 homes connected by the year end," said Davey.

Cyrix's fortunes may change. "Volumes are critical - on the basis of what we know so far," said Forrest Tobak, v-p of marketing at Cyrix.

Cyrix has yet to adopt the instructions. The two companies have first to agree whether to use the same set. "The plan is for Cyrix and Intel to use the same instructions as us," said Berglund. By early next year, AMD plans to release the K6-3D.

The "integrates the two latches on a chip which will operate at a clock speed similar to processor clock speed," said Berglund. He claimed the device will match the performance of Intel’s Kainat processor.

Cyrix meanwhile seems more concerned with pushing for cheaper devices, with its 6x86MX and 6x86MD processors.

The new device, called the 6x86MX/MD processors, is aimed at applications where performance and low power consumption are critical.

The 6x86MX and 6x86MD processors offer up to 60MIPS performance at 3V using a 6x86 architecture.

The processors are based on the 6x86 architecture, which was introduced by AMD in 1988.

Cyrix has yet to adopt the instructions. The two companies have first to agree whether to use the same set. "The plan is for Cyrix and Intel to use the same instructions as us," said Berglund. By early next year, AMD plans to release the K6-3D.

The "integrates the two latches on a chip which will operate at a clock speed similar to processor clock speed," said Berglund. He claimed the device will match the performance of Intel’s Kainat processor.

Cyrix meanwhile seems more concerned with pushing for cheaper devices, with its 6x86MX and 6x86MD processors.

According to the latest official figures, the UK’s r&d investment has fallen.

"We are planning to roll out by September, with up to 200 homes connected by the year end," said Davey.

Cyrix's fortunes may change. "Volumes are critical - on the basis of what we know so far," said Forrest Tobak, v-p of marketing at Cyrix.

Cyrix has yet to adopt the instructions. The two companies have first to agree whether to use the same set. "The plan is for Cyrix and Intel to use the same instructions as us," said Berglund. By early next year, AMD plans to release the K6-3D.

The "integrates the two latches on a chip which will operate at a clock speed similar to processor clock speed," said Berglund. He claimed the device will match the performance of Intel’s Kainat processor.

Cyrix meanwhile seems more concerned with pushing for cheaper devices, with its 6x86MX and 6x86MD processors.
Robert Harcourt looks at how the Year 2000 changeover will affect your pc - if at all.

First the good news. New Year's Five in 1999 falls on a Friday. This means that companies can shut down over the weekend to convert their pcs to cope with the year 2000. Another piece of good news is that pc real-time clocks usually implement the fact that the year 2000 is a leap year - although 1900 was not.

Apple Macintosh computers have not shown a problem with the year 2000 since at least Mac OS version 7. IBM pc compatibles on the other hand contain four or five system levels within which problems can occur with the date. At the lowest level is the real-time clock, which runs on a stand-by battery so that it does not stop running - in theory at least.

The real-time clock passes its date on to the basic input/output system, or BIOS, which only starts up at the moment the computer is switched on or re-booted. The real-time clock, and hence the BIOS, in many cases rolls over from mid-1959 to mid-1900, represented by 00:00:00.

At the third level is the operating system. Windows 3, Windows 95 and DOS, all interpret their version of the date from the date in the BIOS. However, they implement an algorithm so that no date before 1980 is possible. The RTC, BIOS and DOS clocks are shown in Table 1 as a normal time and date before the year 2000.

Table 1 shows these same clocks after being allowed to roll-over - when the computer is left switched on - on new years eve to 2000. You can see that the DOS clock shows correctly the year 2000 but the real-time and BIOS clocks 1900.

When the computer is switched on, BIOS startup and loads DOS. At this point it is possible to invoke the DATE command. The DOS date command forces the BIOS and RTC year, Table 3 into place if they are awry.

This is a complete solution for DOS, but it does not mean that the next level up - i.e. the application programs - will function correctly. If your computer runs under DOS, and automatically runs an application program at start up, you will not have the opportunity to change the date. If this is the case, please the simple statement DATE in the file AUTOEXEC.BAT, using a text editor such as EDIT. In this way, each time the computer is switched on, the current date will be displayed and you will have the opportunity to correct it.

The disk operating system asks:

Enter new date (mm-dd-yyyy)

Although the variable yy implies only two characters for the year, in fact the year input by the user will be accepted as four characters. If the date displays correctly, just press the return key.

This measure is thought to be necessary only once, as roll-over to 2001 a year later is usually correctly performed.

The fourth and fifth levels

The fourth level involving clock information is application software or Windows running application software. Windows 3 and, to an extent, '95 relies on the disk operating system, and uses the DOS date. The fifth level is application software which may or may not make use of the date supplied by DOS. For individual users of pcs, all that is required is to invoke the DATE command at the C prompt of DOS and correct any problems with the operating system DOS date.

With Windows '95 it is necessary to go to the Control Panel and enter a four-digit date. This is because whether the machine is left switched on or off overnight at the Millennium, the hardware real-time clock will fail to roll-over to the year 2000 and will set the date to the 1st of January 1900, while the operating system clock goes to the 4 January 1999 for what some older and not so old pcs. Table 4. Interestingly, if the pc is left switched on, the software in the DOS clock will in many cases roll-over correctly to 2000. Table 3. But at the first boot operation, it will revert to 1980, Table 4.

This is a potential trap for anyone trying to test for the problem, because although DOS initially has the correct date, the real-time clock and BIOS have 1900 as the date, and 'steal' the 2000 date from DOS at boot-up. This implies problems for servers or other machines which are left switched on all the time. They may appear to be working without bugs until their next re-boot.

Planning ahead

For those of you who are planning ahead because you foresee problems with the Millennium changeover, a free diagnostic test is available at the web site http://2000fixes.co.uk. The firm operating this site is Year 2000 Consultants Limited. The company has a second site at http://Y2KCP.com. Part of the free software is a program called ViewCMY. This package allows you to observe the real-time, BIOS and DOS clocks at the same time, and in real-time. The same company sells a fix program for those machines failing their test, called Y2KCPFix.

Other firms selling year 2000 software for pcs are Greenwich Mean Time Inc., Euromax Electronics Ltd, Decodle Technology Ltd, Nynry Nine 2000, and Computer Experts Ltd. Which magazine has carried out a review of the products from these firms in its November 1997 and January 1998 issues.

Are you Year-2000 compliant? So far I have considered only the hardware and operating system aspects of the Year 2000 changeover. Problems with the software are a different story - especially where networks are concerned.

Some firms are spending thousands of pounds and thousands of dollars on a software audit to ensure compliance. Others are spending millions on making sure that their mainframe systems are compliant.

The British Standards Institution has published "Definition of Year 2000 Conformity Requirements." It states that, "Year 2000 conformity shall mean that neither performance nor functionality is affected by date prior to, during and after the year 2000." There's more on this in the panel.

Table 4. All may be ok until you boot - at which point, the clock reverts to 1980.

Clock system

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Date</th>
<th>Clock system time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time hardware clock</td>
<td>01-01-1900</td>
<td>03:24:12</td>
</tr>
<tr>
<td>Basic input/output system clock</td>
<td>01-01-1900</td>
<td>03:24:12</td>
</tr>
<tr>
<td>Operating system clock</td>
<td>01-01-1900</td>
<td>03:24:12</td>
</tr>
</tbody>
</table>

Other requirements cover the prohition of the use of the date as an end-of-file marker. The sequence 99/99 is said to have been used by programmers as an end-of-file marker, or EOF, clearly limiting the life of the system.

The inference rule mentioned in the panel will not fit all situations: for example, if birth-dates are maintained in dates of the form 01-31-yy, this would fail.

Year 2000 defined

This is an extract from the BSI publication, "Definition of Year 2000 Conformity Requirements," document reference DISC PD2000-1, explaining what Year 2000 compliance means:

Rule 1 No value for current date will cause any interruption in operation.

Rule 2 Date-based functionality must behave consistently for dates prior to, during, and after year 2000.

Rule 3 In all interfaces and data storage, the century in any date must be specified explicitly or by unambiguous algorithms or inference rules. An example of an interesting rule is "e.g. two digits years after 2000 with a value greater than 5 imply 19xx, while those with a value equal to or less than 5 imply 20xx.

Rule 4 Year 2000 must be recognised as a leap year.
in a database, and a particular person was born in 1948, the inferring rule would change their birth date to 2048, which could mean they died before they were born.

Date files with dates in them must specify the century when there is any sorting applied to chronologically sequence the data, otherwise 2000 – appearing as 00 – would be sorted before 1999, which appears as 99. This could mean that a lot of re-writing of date-base or accounts software is required. DOS 6 and 6.22, Windows 3.1 and Windows 95 all carry the date of creation of files in the directory on a pc’s hard drive. These dates appear as only two digits, so the backup and archiving of files could become confused.

In summary, the date mechanism in pcs is not simple, and manual checks have to be meticulously carried out. In particular, it is necessary to check the date at switching on and on re-booting whilst switched on. It is necessary to do this at least twice to make sure the 21st century is not lost.

If you are using a pe that is not connected to a server, you will find it easy to correct any date problems with the DATE command.

References
1. Pitch, PO Box 66, Hertford SG14 3SH, November 1997 and January 1998 issues
Audio signal generator

AG2601 audio generator – specifications

General
Frequency range: 10Hz to 1MHz
Frequency stability: within ±2Hz
Output waveforms: sine, square
Output impedance: 600Ω
Accuracy: ±5%+2Hz, 10Hz-1MHz, ±3%+2Hz, 100Hz-100kHz
O/P floating voltage: within ±1.5dB

Sinewave characteristics
Distortion: <0.05%, 500Hz to 50kHz
Output voltage: 8V rms, max
Output flatness: ±1.5dB (1kHz)
Output impedance: 600Ω

Squarewave characteristics
Output voltage: 15V pk-pk, min
Rise time: 0.5µs

Synchronization input
Input impedances: 10kΩ
Maximum input: 10V rms

Supply
115/230V, 50/60Hz

Physical data
Dimensions: 150 by 250 by 130mm
Weight: 2.5kg

*Test leads supplied as standard

The AG2601 audio signal generator spans 10Hz to 1MHz in five overlapping decades. Sine wave distortion between 500Hz and 50GHz is just 0.05%.

The AG2601 audio signal generator spans 10Hz to 1MHz in five overlapping ranges and features floating output and low distortion. This stable sine and square-wave oscillator is being made available to Electronics World readers at the fully-inclusive special price of £129. Its normal selling price is £129 excluding VAT and delivery.

Use this coupon to order your AG2601

Make cheques payable to Vann Draper Electronics Ltd
Or, please debit my Master, Visa or Access card.


Expiration date

Please use this coupon to order your AG2601 audio generator, and address all correspondence relating to this order to Vann Draper Electronics at Unit 5, Premier Works, Canal Street, South Wigston, Leicester LE1 82PL, fax 0116 2773945 or tel. 0116 2771400.

Cool solutions

IN THE WHITE HOT LEADING EDGE OF TECHNOLOGY THINK WARTH

If your technology is heading up, or you need a cost effective cooling solution for your critical components, WARTH will provide you with innovative solutions to all your thermal management problems.

From sophisticated heat sinks to state of the art thermal interface pads we have the answer. Manufactured by WARTH in the UK to ISO9002.

WARTH Commitment to excellence is just the beginning.

Warth International Ltd, Birches Industrial Estate, East Grinstead, West Sussex RH19 1XH
Tel 01342 315944, fax 01342 312949, http://www.warth.co.uk

The Stereo Headphone Amplifier Box
Balanced or unbalanced line inputs to stereo headphone output
Professional portable units operating from an internal PP3 battery or external mains adaptor

Use this coupon to order your Stereo Headphone Amplifier Box

Make cheques payable to Surrey Electronics Ltd
Or, please debit my Master, Visa or Access card.


Expiration date

Please use this coupon to order your Stereo Headphone Amplifier Box, together with any other WARTH equipment you may require, and details with order on 01483 275997 or telephone 01483 2771402. Address all correspondence relating to this order to Surrey Electronics, The Forge, Lucks Green, Crowthorne, Berkshire RG10 8TG.

PPM5
20 PIN DUAL IN LINE

Consumption 3mA.

Fully meets BS5428-9

= PPM10 In-Vision PPM and Chart Recorder
= Advanced Active Aerial 4kHz-30MHz
= Stabalizer frequency shift units for howl reduction
= 10 Outlet Distribution Amplifier
= Stereo Variable Emphasis Limiter
= PPM9, PPM5 hybrid and PPM8 IEC/DIN-50/+6dB drives and movements
= Broadcast Stereo Coders
= Broadcast Monitor Receiver 150kHz-30MHz

SURREY ELECTRONICS LTD
The Forge, Lucks Green, Crowthorne GU8 7BG
Telephone: 01483 275997 Fax: 01483 276477

June 1998 ELECTRONICS WORLD

CIRCLE NO. 14 ON REPLY CARD

CIRCLE NO. 11 ON REPLY CARD
Darren Conway* helps you decide which is the right mixer option for your receiver design.

The vast majority of radio receivers are based on the super heterodyne principle, where incoming radio signals are mixed with a local oscillator to produce an intermediate frequency. In most cases a receiver uses two mixers to convert from rf to the desired base band signal.

One of the key design choices for a receiver is the selection of mixers – and in particular the first stage mixer. The development of rf mixers over the past forty years has been a process of evolutionary development and refinement. Although the basic principles and techniques have remained largely unchanged, the aim of this article is to review a representative sample of the current range of high level mixers and discuss the characteristics of each.

Discussion is limited to mixers used up to vhf and those that are readily available. You are encouraged to view the relevant data sheets and references in conjunction with this article as they contain a wealth of information that is not included here.

Although this discussion is limited to vhf, the basic principles and mixer characteristics are applicable at all frequencies. The purpose is to provide you with the information required to select the right mixer for the right application.

Why have a mixer?

The primary application of a mixer is to add an input frequency and a local oscillator frequency to obtain a single intermediate frequency, or IF, output. Ideally, a mixer output would only contain the desired output frequency, but in practice a product of the two input frequencies F1 - F2 and F2 - F1, where F2 is the received radio signal and F1 is the local oscillator input. But no such device exists.

In reality, mixers produce a whole range of frequency products ±nF2 ±nF1 (n=O ... \infty), at the IF output. The unwanted harmonics are filtered out.

The balance of mixers

There are effectively three types of mixers which may all be implemented as passive or active. The basic passive circuits are shown in Figs 1, 2 and 3. For active mixers, the diodes are replaced with fets, mosfets or transistors.

An unbalanced mixer shown in Fig. 1 has no isolation between the two input ports and the output port. They are rarely used because lack of isolation between the local oscillator and the rf input results in unwanted transmissions from the antenna at the local oscillator frequency. These transmissions may be strong enough to contravene emc regulations, and even if they are within legal limits, they are still undesirable.

Detection of local oscillator transmissions has been successfully used in the past to locate clandestine or illegal receivers. The main advantage with unbalanced mixers is that they can operate over a wide frequency range spanning greater than five decades. In certain applications, this may justify their use.

Single-balanced mixers go some way to solving the problem of unwanted transmissions by providing isolation between the local oscillator and the rf input as shown in Fig. 2. In addition, the local oscillator signal is suppressed at the intermediate-frequency output. However, like the unbalanced mixer, the rf input appears at the IF output port. If it is decided to fabricate a mixer from discrete components, then the single balanced mixer offers a reasonable compromise between the superior performance of the double balanced mixer, and the simplicity of the unbalanced mixer.

Double-balanced mixers ideally offer infinite suppression of signals between the three ports. The only output should be the intermediate-frequency signals (±nF2 ±nF1) with the rf and local oscillator inputs fully suppressed. In practice the local oscillator and the rf input are typically suppressed by about 50dB at the intermediate-frequency output. The ready availability of single package double balanced mixers often means that they are simpler to apply than either single balanced or unbalanced mixers.

In most applications, the double balanced mixer shown in Fig. 3 will provide the best performance.

What makes a good mixer?

Practical mixers are complex to analyse and their performance is defined by a number of characteristics. The following define the major specifications of a mixer in order of importance.

Frequency range. Mixers are usually required for all receivers operating from very low frequency to tens of gigahertz. Typical mass-produced mixers operate to maximum frequencies in the range of 100MHz to 2.5GHz. The operating frequency range is a fundamental design characteristic that will in part determine the final selection of mixer type.

Dynamic range. This is one of the most important specifications for a mixer. The massive proliferation of rf transmitters and other interference sources means that the modern radio receiver is usually operating in the presence of significant rf.

Even if the desired signal is always very weak – for example satellite transmissions – it is still important that a receiver has the ability to operate in the presence of strong signals so that the desired weak signal is not lost.

The lower limit of dynamic range is defined by the noise floor, while the upper limit is defined by the compression point, intermodulation products and burnout level.

Noise. Typically, mixers have noise figures ranging from 6dB to 20dB. The noise figure for passive mixers is about equal to the insertion loss. The noise figure for active mixers depends on the selected devices and circuit topology. It is usual but not essential in receiver design to include a low-noise if amplifier ahead of the first mixer in order to improve the noise figure of the receiver system.

Gain. The ready availability of amplifiers that cover the radio-frequency spectrum means that the mixer is not generally required to have any gain. Excess mixer gain can reduce the dynamic range of the receiver.

In most cases, insertion loss through a mixer is also undesirable particularly in the case of passive mixers. Active mixers provide gain in the range of –1dB to +17dB while passive mixers have a typical insertion loss of between 5.5dB and 8.5dB.

Local-oscillator drive. The ideal mixer would be insensitive to both local oscillator level and harmonic content but in reality, the local oscillator specifications need to match the requirements of the mixer.

Passive double-balanced diode mixers require local oscillator levels from +7dBm to +23dBm. Active mixers require local oscillator output levels ranging from –20dBm to +30dBm depending on the selected type. The design of the local oscillator is intimately related to the selected mixer type.

Isolation. Isolation is a measure of the mixer's ability to prevent a signal applied to a port, appearing at either of the other two ports. The only output should be the mixer products at the intermediate-frequency port. The degree of isolation depends on whether the mixer is unbalanced, single balanced or double balanced. Unbalanced mixers exhibit no isolation between ports. Double balanced mixers provide the best isolation between the three ports.

Impedance matching. The three ports of a mixer should be matched at each port. Mismatch in active mixers usually results in reduced mixer gain.

Passive mixers are particularly sensitive to mismatch at the intermediate-frequency output port which causes greater insertion loss and unwanted mixer products. Regardless of whether an active or passive mixer is used, care should always be taken to implement proper matching to maximise mixer performance.

Simplicity. An important characteristic of any circuit is the ease of design and implementation. Complex designs are often complex to build and difficult to set up. A lower parts

*Darren Conway, Lieutenant Commander, MIEE, MIPENZ, MIEC, C Eng, MIEE, RNZN

ELECTRONICS WORLD June 1998
Mixer selection guide

For applications that require high performance, no-tuned components, and a minimum of pcb real-estate, the AD831 is an excellent choice. The implications of the high noise figure need to be considered.

The SL6440 is an old device but for applications that require an average noise figure with a low level local oscillator it remains a good choice.

Despite the use of the same mixer in the high performance and gain are the key criteria, then the jet mixer would be selected. Most applications will require the matching transformers to be handcrafted.

For those after the ultimate in high-level mixers, the mosfet mixer is the choice. But as with the jet mixer, the effort required to implement the mixer and related circuits makes this choice difficult to justify except for the most demanding applications.

When good performance is applied, the diode double balanced passive mixer comprises the lowest noise figure with good high level performance. If low noise is important, and there is reasonable space and local oscillator power available, then a diode double balanced mixer is the right choice.

Almost all of the values shown in the Table are frequency dependent and can vary greatly depending on the exact operating conditions. Mixers should be chosen based on performance at the intended operating conditions. Performance should then be constructed and tested because it is highly unlikely that the test circuits in the data sheets will match exactly the applied circuit.

Table: mixer comparison between high-level mixers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Units</th>
<th>Active jet</th>
<th>Diode</th>
<th>Diode</th>
<th>Mosfet</th>
<th>Bipolar</th>
<th>Bipolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>MHz</td>
<td>-1dB</td>
<td>0.5-50</td>
<td>0.1-2500</td>
<td>0.2-500</td>
<td>0.1-400</td>
<td>0.1-1000</td>
</tr>
<tr>
<td>Isolation</td>
<td>dB</td>
<td>-1dB</td>
<td>35</td>
<td>45</td>
<td>30</td>
<td>65</td>
<td>45</td>
</tr>
<tr>
<td>Isolation local oscillator</td>
<td>dB</td>
<td>-1dB</td>
<td>45</td>
<td>40</td>
<td>20</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>Overall noise figure (1kHz)</td>
<td>dB</td>
<td>-1dB</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Local oscillator drive level</td>
<td>dB</td>
<td>-1dB</td>
<td>+7</td>
<td>+7</td>
<td>+23</td>
<td>+16</td>
<td>+10</td>
</tr>
<tr>
<td>Two-tone intermodulation</td>
<td>dB</td>
<td>-1dB</td>
<td>+16</td>
<td>+16</td>
<td>+25</td>
<td>+44</td>
<td>+30</td>
</tr>
<tr>
<td>Conversion gain</td>
<td>dB</td>
<td>-1dB</td>
<td>+44</td>
<td>+44</td>
<td>+44</td>
<td>+44</td>
<td>+44</td>
</tr>
<tr>
<td>1dB compression</td>
<td>dB</td>
<td>-1dB</td>
<td>+13</td>
<td>+13</td>
<td>+15</td>
<td>+15</td>
<td>+15</td>
</tr>
<tr>
<td>Min Circuit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The SL6440 is contained in a 16-pin DIP package. It fits into two input and two balanced signals but may also be configured for unbalanced signals. The SL6440 also includes an input pin to program the supply current which can be used for battery operation. It is possible to implement power management load by programming the supply current to a low value in the absence of a desired signal. When a signal is received, the supply current can be increased to improve the mixer performance. Such a feature would be relatively simple to include with the receiver squelch circuit.

Note that the supply current for most active mixers can be programmed by various means and this is not a unique feature of the SL6440. As a general guide for any mixer, either passive or active, intermediate frequency performance improves with increased supply current and voltage.

Like most active mixers, this device draws a significant current to achieve the best performance. The device requires two positive supply voltages. Rail Vcc1 is for the mixer while the on-chip oscillator buffer is supplied by Vcc2.

Typically the SL6440 draws 65mA and this may be increased with the use of a heat sink, or decreased to conserve power. The quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.

For maximum suppression of intermodulation products, the programming current I1 should be between 10mA and 12.5mA giving a supply current of about 40mA. The 

To achieve the best performance the quiescent current drawn by the mixer is determined by the value of Vcc2 and the programming current into I1 to pin 3. The absolute maximum power dissipation is specified at 1200mW.
Using junction and mos fets
J fet mixer. The junction-fet mixer appears to offer the potential for very good performance. Conversion gain and intermodulation distortion characteristics are superior to typical passive mixers. Junction fets have an inherent square law response which reduces third order intermodulation distortion. And, like passive mixers, jfet mixers have a high burn-out level. The main disadvantage is that there is no known source of ready-made units incorporating the fets and transformers. Also a high local-oscillator drive is required.

Unlike double balanced diode mixers, the jfet mixer has to be built up from individual components. Even commercialised produced receivers such as the ICOM R9500 uses a single balanced jfet mixer made from individual components.

The inability to obtain a single-package double-balanced mixer is a major disadvantage of the jfet mixer. Suitable transformers are difficult to obtain and for prototype work, hand-made coils are usually necessary. If optimum performance is to be achieved then the transformers need to be physically matched to high tolerances. It is possible to obtain good results with a combination of good construction techniques and a suitable balance adjustment. Optimum power gain and noise do not occur at the operating point. The bias currents, local oscillator drive level and matching transformers must be properly selected to ensure that the fets operate in the square law region and that distortion is minimised. The lowest achievable noise figure is 8dB.

For optimum performance of a double balanced fet mixer, the fets should be perfectly matched which is very difficult to achieve using discrete fets due to the difficulties in precisely controlling characteristics between batches. In practice matched characteristics can only be achieved if

Mosfet mixers. If there is a need for very high level performance, then the fets can be substituted for either monolithic chip fets or a combination of rf power mosfets. Suitable monolithic devices include Calogic SD9001 and the Siliconix SD6000 from which very good results have been obtained. Double balanced mixers may operate the mosfets as switches with no drain voltage applied resulting in an insertion loss of about -7dB. Alternatively, drain voltage supplied to the mosfets may be used to give a mixer gain of up to +17dB. One of the features of mosfets is that the gate drive voltages are roughly the same for all mosfet types. This makes the local oscillator power needed for a very high level mosfet mixer less than the power required for an equivalent diode mixer. A mosfet mixer giving very high level performance does not require an excessively high local oscillator drive.

While mosfet mixers provide excellent very high level performance, they suffer from the same problem as jfet mixers in that the transformers and surrounding circuitry result in a high parts count and the use of a significant area of circuit board. Such a mixer would only be useful for the very high level local oscillator with at least +7dBm output. Some very high level passive mixers require up to +25dBm local oscillator drive. The relationship between local oscillator power and the dB compression point is shown in Fig. 9 for a selection of mosfet mixers from Mini-Circuits. The local-oscillator level also affects conversion gain as shown in Fig. 10. It is important that harmonics from the local oscillator are adequately suppressed. Harmonics from the local oscillator mix with the rf input and produce unwanted mixer products. It can be difficult to design and build oscillators at the required output level combined with the desired spectral purity. This is particularly true for battery operated equipment where available power and voltage are relatively low. Some mixers are available that include a built-in amplifier either on the local oscillator input, or at the intermediate frequency output. These may ease the design problem in some situations. Local-oscillator power and purity has a major effect on the design and performance of the mixer stage and therefore the whole receiver system.

One of the main advantages of the diode double-balanced mixer is that being a passive device, it draws no quiescent current. This is somewhat offset by the high local oscillator drive requirements and the need to compensate for the conversion loss.

Circuits. It is cheap, compact and available, Mini-Circuits and other companies produce a wide range of passive mixers suitable for most mixer applications. Like the other mixers described, the performance of the diode double balanced mixer is dependant on a variety of factors including but not limited to frequency, local-oscillator power, matching and temperature. The graph of local-oscillator level to isolation shown in Fig. 8 is typical of the variations seen in performance.

Proper matching of the intermediate-frequency output is essential to gain optimum performance from a diode double balanced mixer. The intermediate-frequency filter should filter out mixer products except the desired intermediate-frequency. Reference to the design of an intermediate-frequency filter for a passive diode mixer is the subject of a future article.

Diode mixers require a high level local oscillator with at least +7dBm output. Some very high level passive mixers require up to +25dBm local oscillator drive. The relationship between local oscillator power and the dB compression point is shown in Fig. 9 for a selection of diode mixers from Mini-Circuits. The local-oscillator level also affects conversion gain as shown in Fig. 10. It is important that harmonics from the local oscillator are adequately suppressed. Harmonics from the local oscillator mix with the rf input and produce unwanted mixer products. It can be difficult to design and build oscillators at the required output level combined with the desired spectral purity. This is particularly true for battery operated equipment where available power and voltage are relatively low. Some mixers are available that include a built-in amplifier either on the local oscillator input, or at the intermediate frequency output. These may ease the design problem in some situations. Local-oscillator power and purity has a major effect on the design and performance of the mixer stage and therefore the whole receiver system.

One of the main advantages of the diode double-balanced mixer is that being a passive device, it draws no quiescent current. This is somewhat offset by the high local oscillator drive requirements and the need to compensate for the conversion loss.

Although diode mixers are available in very compact packages, the high level local oscillator and intermediate-frequency matching filter will normally require a significant circuit-board area. If high level and low noise are the prime requirements then the double balanced diode mixer remains the best choice.

Table of performance of a Passive mixer for a selection of diode mixers from Mini-Circuits. The values are representative of actual devices operating under typical conditions and in most instances these values will be different to those specified in data sheets.

References

1. 'The most from mixers,' Mini-Circuits
4. Olson, B, 'Active double-balanced mixers make easy work of r-f power,' Siliconix, Inc., EDM, 5 July 1975.
Hands-on Internet

The consolidation of processor programs discussed last month, Intel, is developing a series of CPU kits for PC makers, designed to speed the production of 'Intel Inside' PCs. These all-embracing kits will include the processor, chipset, motherboard, memory types, I/O interfaces and graphics buses. Fig. 1. Some PC vendors are reported to feel these kits will reduce their design options and may reduce their already small profit margins.

Other makers of compatible chip-sets however fear that "Intel Inside" might soon become "Only Intel Inside." As reported by ZDNet, the PC, or sixth generation, high-speed interface bus for Pentium II is proprietary to Intel so cannot be used without permission or licensing. Acer Laboratories, Silicon Integrated Systems and Via Technologies all have compatible chip-sets in customer evaluation, but these cannot be released for sale until legal problems have been resolved, leaving Intel as sole supplier.

Microsoft still under pressure

The Senate Judiciary Committee hearing on 'competition in the computer industry' debated the extent of Microsoft power to dominate desktop operating systems and Internet browsers. As reported by PCWeek, much discussion centred on Windows 95 and Explorer licensing.

The Senate Judiciary Committee oversees the DOJ. While the hearing produced no substantive result, it was apparent -- following the hearing -- that the DOJ continues to probe all aspects of Microsoft, to determine whether to proceed with a full-scale anti-trust assault. According to PC Week, the DOJ is conducting yet another round of depositions with computer vendors to find ammunition for its next actions. One particular question regards performance degradation should a different browser be installed on top of Windows 98 with Internet Explorer integrated into it.

Windows 98

Retail shipment of Windows 98 is now planned for June 25. Domestic users of Windows 95 in the USA and Canada can now purchase a pre-release version of Windows 98 for $99.50 as part of a beta preview programme for technically competent users. This offer is available in other countries, although the price differs. For UK and Ireland the price is £24.99, which includes an upgrade voucher to Internet Explorer Plus. You are already using Windows 95, have 125MB free available on your hard disk and have at least 16MB free with a 4GB/hour or faster processor.

It is claimed that Windows 98 speeds up system performance and its more efficient filing system releases some of the memory locked up by Windows 95. Windows 98 will also improve performance when running multiple applications at once. The new 'plug and play' feature also makes it easier to install new devices without having to reboot the system.

BROWSERS

Last month I mentioned the 'Opera' browser. At the moment, Windows versions are available, but I access Internet using Only OS/2 Warp or Merlin. I installed the 16-bit version of Opera 1.1 under Windows 98 (OS/2 with no problems. But I had difficulty linking the browser with my native OS/2 dialler since it required a Winsock dialler. A "proper" OS/2 version of Opera is apparently due shortly, so I have decided to await its arrival.

Many other companies are busy writing Net-based software. Browser.Com, part of CNet, gives a full listing. In its recent review of 'rebel' browsers, Opera was "editor's choice." This page is also worth visiting if you use Internet Explorer 4 and are troubled with the "No such interface supported" error. Apparently caused by installing over an older beta version, this problem can be cured by uninstalling and reinstalling completely. A simpler alternative correction is also possible, Fig. 2.

Junk mail

I recently mentioned that I receive far too much junk e-mail. If anything the problem has worsened lately. Not only has the quantity increased, but I frequently now get more than one copy of a mailing. Since I use an American-based service provider and my e-mail address is on my home Web page, it is possible I receive more than the average UK user. Junk e-mail or "spam" as it is called, is a pest until for both service providers and search engines. A service called Search Engine Watch recently ran some tests on search engines to check their spam content.

At one time Information had a particular problem with junk e-mail and as a result took preventative action. In these latest search engine tests, it was considered equal best with Lycos,9 but performed "equal best with Lycos." Apart from being annoying, junk e-mail can cause severe problems to Internet providers. In California, a bill giving legal recourse against 'spammers,' is now in hand. One vocal supporter of this bill - Pacific Bell Internet - was recently charged with spam e-mail, over a four day period. Having 17000 customers and a 50000 spare capacity, the system was under pressure of spamming. Since I use an American based service provider, I have installed yet another round of depositions with computer vendors to find ammunition for its next actions. One particular question regards performance degradation should a different browser be installed on top of Windows 98 with Internet Explorer integrated into it.

Fig. 1. Intel's new CPU kits add to PC overload

New Intel CPU kits add to PC overload

Intel Corp is developing a series of CPU kits for PC makers, designed to speed the production of everything from laptop notebooks to full-scale engineering workstations. The kits will include the processor, chipset, motherboard, memory types, I/O interfaces and graphics buses. Intel Ltd in its PCCentrum is also developing a lower-cost version. If you are interested you can find details in the latest Chips & Technology.

Fig. 2. Competing modelling optical systems

Apart from being annoying, junk e-mail can cause severe problems to Internet providers. In California, a bill giving legal recourse against 'spammers,' is now in hand. One vocal supporter of this bill - Pacific Bell Internet - was recently charged with spam e-mail, over a four day period. Having 17000 customers and a 50000 spare capacity, the system was under pressure of spamming. Since I use an American based service provider, I have installed yet another round of depositions with computer vendors to find ammunition for its next actions. One particular question regards performance degradation should a different browser be installed on top of Windows 98 with Internet Explorer integrated into it.

Fig. 3. Interested in modelling optical systems

With the hearing over, the DOJ continues to probe all aspects of Microsoft, to determine whether to proceed with a full-scale anti-trust assault. According to PC Week, the DOJ is conducting yet another round of depositions with computer vendors to find ammunition for its next actions. One particular question regards performance degradation should a different browser be installed on top of Windows 98 with Internet Explorer integrated into it.

Windows 98

Retail shipment of Windows 98 is now planned for June 25. Domestic users of Windows 95 in the USA and Canada can now purchase a pre-release version of Windows 98 for $99.50 as part of a beta preview programme for technically competent users. This offer is available in other countries, although the price differs. For UK and Ireland the price is £24.99, which includes an upgrade voucher to Internet Explorer Plus. You are already using Windows 95, have 125MB free available on your hard disk and have at least 16MB free with a 46/128XO or faster processor.

It is claimed that Windows 98 speeds up system performance and its more efficient filing system releases some of the memory locked up by Windows 95. Windows 98 will also improve performance when running multiple applications at once. The new 'plug and play' feature also makes it easier to install new devices without having to reboot the system.

BROWSERS

Last month I mentioned the 'Opera' browser. At the moment, Windows versions are available, but I access Internet using Only OS/2 Warp or Merlin. I installed the 16-bit version of Opera 1.1 under Windows 98 (OS/2 with no problems. But I had difficulty linking the browser with my native OS/2 dialler since it required a Winsock dialler. A "proper" OS/2 version of Opera is apparently due shortly, so I have decided to await its arrival.

Many other companies are busy writing Net-based software. Browser.Com, part of CNet, gives a full listing. In its recent review of 'rebel' browsers, Opera was "editor's choice." This page is also worth visiting if you use Internet Explorer 4 and are troubled with the "No such interface supported" error. Apparently caused by installing over an older beta version, this problem can be cured by uninstalling and reinstalling completely. A simpler alternative correction is also possible, Fig. 2.

Junk mail

I recently mentioned that I receive far too much junk e-mail. If anything the problem has worsened lately. Not only has the quantity increased, but I frequently now get more than one copy of a mailing. Since I use an American-based service provider and my e-mail address is on my home Web page, it is possible I receive more than the average UK user. Junk e-mail or "spam" as it is called, is a pest until for both service providers and search engines. A service called Search Engine Watch recently ran some tests on search engines to check their spam content.

At one time Information had a particular problem with junk e-mail and as a result took preventative action. In these latest search engine tests, it was considered equal best with Lycos,9 but performed "equal best with Lycos." Apart from being annoying, junk e-mail can cause severe problems to Internet providers. In California, a bill giving legal recourse against 'spammers,' is now in hand. One vocal supporter of this bill - Pacific Bell Internet - was recently charged with spam e-mail, over a four day period. Having 17000 customers and a 50000 spare capacity, the system was under pressure of spamming. Since I use an American based service provider, I have installed yet another round of depositions with computer vendors to find ammunition for its next actions. One particular question regards performance degradation should a different browser be installed on top of Windows 98 with Internet Explorer integrated into it.

Fig. 1. Intel's new CPU, motherboard, chip-set may make computer makers choices simpler, but will component costs increase for computer makers?
Where to surf

1. New Intel CPU hits add to PC makers overload.
2. Intel to shut out chip makers from Pentium II.
3. Rivals spur a Senate hearing.
4. DOJ ponder next move in Microsoft case.
5. OEMs might just get what they need with Windows98.
6. Preview Windows98.
7. Browsers.com
8. Sleuthing the IE 4.0 Windows bug.
10. GOLD Virtual Photonics.
12. Attack your design with a SHARC.

http://www.zdnet.com/zdnn/content/zdnews/0314/2947811.html
http://www.zdnet.com/zdnn/content/zdnews/0312/2947811.html
http://www.zdnet.com/zdnn/content/zdnews/0322/2947811.html
http://www.zdnet.com/zdnn/content/zdnews/0322/05ededt.html
http://www.zdnet.com/zdnn/content/zdnews/0399/11ewin98.html
http://www.eu.microsoft.com/uk/W98.htm
http://www.download.com/browsers/0,1452,0-2000000.html
http://www.microsoft.com/Content/Builder/Programming/Caldi/292119/index.html
http://www.searchenginewatch.com/reports/sspam.html
http://www.svt.com/ash/GOLD/GOLDCVI.htm
http://www.computer-design.com
http://www.svt.com/ash/GOLD/SHARC.htm

Australian Photonics Co-operative Research Centre. The demonstration disk is available, but you need to have either the base or development versions of LabVIEW installed, Fig. 3.

Computer Design Online is an on-line magazine and designers' meeting place. It is dedicated to all aspects of semiconductor circuit design. It includes a searchable database of its past publications and provides support for all computer aided design decisions. This magazine is sponsored in part by Analog Devices. When I visited it, the home page featured a flyer for Analog's new digital signal processor - a low-cost 240-pin 'Sharc' - and its evaluation kit, Fig. 4.

http://www.svt.com/ash/GOLD/GOOLDVI.htm
http://www.computer-design.com
http://www.svt.com/ash/GOLD/SHARC.htm

Electronics Workbench version 5 brings professional-level circuit simulation within the reach of every engineer!

New Electronics Workbench version 5 combines schematic editing and mixed-mode SPICE simulation with a full set of test instruments, a comprehensive library of components and advanced analysis tools. Powerful enough for professional design engineers simple enough for first-year electronics engineering students to master, it's also surprisingly affordable.

Building a circuit couldn't be easier. Electronics Workbench uses the familiar Windows interface - you just grab the components you need with your mouse, and drop them in place. Connect them together: "smart" wiring automatically chooses the route. Fine tune your schematic when you need to move a component, Electronics Workbench will preserve all connections and re-route them as necessary.

With Electronics Workbench version 5, you can import and export SPICE netlists, choose components, devices and models from a huge, built-in "parts bin", perform analyses using virtual test instruments. Because it's all done in the software, your whole design process is faster, more flexible and a great deal easier to correlate - accurately. And you can easily export your design files to other programs, including PCB layout packages. In short, if you want to increase your productivity, there's no better way than Electronics Workbench.

Fill out the attached order form below and return it to us today!

or call 01462 480055

Adept Scientific plc 8 Business Centre West, Avenue One, Letchworth, Herts, SG6 2HS, UK
Telephone: 01462 480055 Fax: 01462 480213
Email: anew@adaptecscience.com http://www.adaptecscience.co.uk

I would like to pay by:

Credit card: Check

Credit Card: Credit Card No. Start Date

Please rush me Electronics Workbench version 5

I would like to pay by check (please use the appropriate box)

Cardholder's Signature:

Name on Card:

Address:

Delivery Address: Please let us know if the card billing address is different from the delivery address

Name:

Position:

Billing Telephone: Fax:

Company:

Postcode:

Copyright © 1997 Adept Scientific plc. All rights reserved. All trademarks registered.
CIRCUIT IDEAS

Over £600 for a circuit idea?

New awards scheme for circuit ideas

- Every circuit idea published in Electronics World receives £35.
- The pick of the month circuit idea receives a Pico Technology ADC42 – worth over £90 – in addition to £35.
- Once every six months, Pico Technology and Electronics World will select the best circuit idea published during the period and award the winner a Pico Technology ADC200-50 – worth £586.

How to submit your ideas

The best ideas are the ones that save readers time or money, or that solve a problem in a better or more elegant way than existing circuits. We will also consider the odd solution looking for a problem – if it has a degree of ingenuity. Your submission will be judged on its originality. This means that the idea should certainly not have been published before. Useful modifications to existing circuits will be considered though – provided that they are original. Don’t forget to say why you think your idea is worthy. We can accept anything from clear hand writing and hand-drawn circuits on the back of an envelope. Type written text is better. But it helps us if the idea is on disk in a popular pc or Mac format. Include an ascii drawing as a safety net and please label the disk with as much information as you can.

Turn your PC into a high-performance virtual instrument in return for a circuit idea.

The ADC200-50 is a dual-channel 50MHz digital storage oscilloscope, a 25MHz spectrum analyser and a multimeter. Interfacing to a pc via its parallel port, ADC200-50 also offers non-volatile storage and hard-copy facilities. Windows and DOS virtual instrument software is included.

ADC42 is a low-cost, high-resolution a-to-d converter sampling to 12 bits at 20kHz/sample/s. This single-channel converter benefits from all the instrumentation features of the ADC200-50.

Separating p-waves in cardiac waveforms

A n important part of cardiac analysis is the measurement of rate variability, the interval between appearances of the p-wave recently being of most interest. Since the p-wave is a relatively small part of the waveform, it is more difficult to separate it from the rest of the electrocardiogram than the r-wave; this circuit performs that function and measures the p-p time interval.

In the block diagram of Fig. 1, the input is the ECG which is amplified and compared with the threshold level $T_h$ to produce a reference pulse in time with the r-wave. The comparator triggers two monostables, the outputs of which are shown in Fig. 2 as (c) and (d). Added to produce the waveform at (e), which falls within the p-wave region. This pulse, which occurs, due to the timing of the monostables, during the p-region, programs the amplifier with a gain of 10; for the rest of the cycle, it is zero.

Only the p-wave, therefore, is amplified, the output (f) being compared with $T_h$ and the resulting pulse (h) triggering a further monostable to generate (k) and (l) by means of the two circuits shown in Figs 3 and 4. The pulse output (k) resets a 16-bit counter (four 7493s) and the one at (l) triggers a latch composed of four 7474s to hold the time count.

K Balasubramanian
NSS College of Engineering
Palakkad
India

Fig. 1. Block diagram of the p-wave separator for heart beat analysis. The p-region is the small, rounded part of a cardiac waveform.

Fig. 2. Timing diagram for circuit arrangement of Fig. 1.

Fig. 3. Edge deriving circuits for positive (a) and negative (b) edges of a positive-going square pulse.
Reducing power-supply mains-frequency ripple

If you have a centre-tapped mains transformer driving a full-wave rectifier, it is possible that 50Hz or 60Hz ripple is greater than it theoretically should be. This modification resolves the problem, producing a ripple reduction of about 20dB at mains frequency and odd harmonics.

With this modification, high voltages are present.

Because power transformers are normally wound serially, one side of the high-voltage winding is of higher resistance than the other. Although one expects the ripple to be primarily at even harmonics of the mains frequency, this effect inverts significantly at mains frequency and odd harmonics, since the output filter network, RC or LC, is relatively ineffective at the lower frequency.

The ripple does not occur in full bridge circuits and push-pull amplifiers are relatively immune, but single-ended amplifiers, particularly the triode type, are affected. Depending on loading, between 2/3 to 4/3 of the ripple is applied to the load in a true power stage and, since speakers have low-frequency resonances, the conditions are right for hum.

My own case is shown in Fig. 1, a power supply for a 1960 audio amplifier, the transformer being a 375V–875V model, the windings of which measure 38 and 40Ω. The 5V wending drives resistors R1,2,5 which apply ac in series with the dc from the rectifier in place of the direct connection at R1. Varying the potentialmeter, which is a wire-wound type, alters the polarity and aids or buck each half of the half. We can continue on this path.

The only other modification is R11, which is included for use during adjustment, which is done by observing current pulses across this resistor at point C. Fig. 2 shows properly adjusted pulses. If the 6V ac winding is used, the break should be at R11. Capacitors C14 must be ceramic type, safety rated for connection to the mains.

Both semiconductor and valve rectifiers have been tried, the valve type with varying results. The same process can be applied to a choke-input filter. The improvement at 60Hz at the output was, in my case, from 75mV to 8.5mV and at 180Hz from 2.5mV to 1mV.

If your power supply has a directly-heated rectifier, there may be no need for all this. Simply reverse the heater leads to get about 15dB improvement. There is a 50:50 chance that they were the wrong way round.

Fig. 2. Charging pulses should be equal at TP2.

Fig. 3. 20dB improvement in power supply ripple after adjustment of R1.

Fig. 4. Change of power frequency ripple when transformer heater leads to a directly-heated rectifier are reversed.

CIRCUIT IDEAS

Fig. 1. Modified power-supply scheme can give up to 20dB ripple reduction.
Low-noise, high input-impedance amplifier

Although this amplifier was developed for use with a guitar pickup, it may be used as a general-purpose circuit where small voltages may be amplified with very low noise and extremely high input impedance.

Input stage consists of a 6L30 matched jfet pair in a differential arrangement, the output op-amp having feedback to set the gain. Balance requires that $R_{g1}$ and $R_{g2}$ are equal, voltage gain being given by $G \approx \frac{R_f}{R_s}$, where $R_s$ is the jfet transconductance.

Input impedance is equal to $R_s$ which, with input bias current at 2nA, causes an input voltage of 20pV, negligible compared with the input offset of the jfet pair at 5mV. Bandwidth is 3MHz and is limited by the op-amp. Noise is about 2.5nV/√Hz. The input capacitor may be left out if the coupling is needed.

Peter Goodson
Bracknell
Berkshire (B16)

Economical testing for digital recorders

Output from DAT, cd and full solid-state recorders, when fed with a single frequency, should be a pure sine wave without distortion, sidebands, harmonics or beats; a single spectral line.

The output from the circuit contains a signal whose period is directly proportional to the frequency selected. Having selected the output frequency, the feedback to set the gain. Balance requires that

$$G = \frac{g_m R_s}{\text{where} \ g_m = \text{feedback}}$$

where $g_m$ limited to -6dB for operation at frequencies up to 478kHz respectively. These

$$12.345\text{kHz} \text{respectively. These}$$

$$\text{frequency have been selected and which system fault causes them, as in the Table. Weil adjusted systems have with 16-bit accuracy should have a noise floor below -86dB, with no spectral component other than the signal. In practice, tests on various systems, some of them professional equipment costing up to £50000, indicate that all systems suffer from one kind of trouble or another. Complex metronome generates a large number of spurious frequencies absent from the signal, it seems likely that this is part of an explanation for 'digital sound'.}

Gerd Schmidt
Frankfurt
Germany (B16)

Table. Fault examples.

<table>
<thead>
<tr>
<th>Fault</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A sample stage fault, possibly anti-aliasing filter,</td>
<td>Give a line at 34kHz (1.097kHz) or 0.827kHz</td>
</tr>
<tr>
<td>Errors in digital signal processing show at 32kHz (35.6kHz) or 11.1kHz</td>
<td></td>
</tr>
</tbody>
</table>

Simple circuit, switchable in frequency to cater for different types of digital equipment, produces input signal to help identify shortcomings in digital recording and replay devices.
**CIRCUIT IDEAS**

*Quietening switched-mode power supply rails*

Ripple and spikes from a switched-mode power supply can exceed the noise margin of logic gate inputs, make monostable flip-flops oscillate or misfire and possibly cause embarrassment in phase-locked loops. Low-impedance capacitors across the rails may effect a cure, but some form of inductive filter is often needed, although it must be damped to avoid making matters worse. This circuit, shown in Fig. 1(a), provides an economical solution.

Inductance takes the form of a MMB-Nosid ferrite window core, with a single wire through the two holes; capacitors are one good 220µF electrolytic and a number of ceramic types, which may be distributed around the board. This arrangement avoids excessive inductance and large capacitors, which would also be inductive. Used with a run-of-the-mill 5V, 2A supply, the filter reduced ripple and spikes from 100µVpp to 7µVpp. Figure 1(b) illustrates the method testing for the effect of other sources of trouble such as clock circuits; a square-wave generator producing a 5V output from 50Ω couples 5x5mA into the 5V rail. The worst effect was 20mVpp at 8kHz, with another of about the same amplitude at 20MHz, although the power-supply's feedback loop bandwidth is 5kHz, which makes for safe and overhauls.

If the circuit being supplied has its own ground connection, the arrangement of Fig. 1(c) may be used, this having the advantage of some common-mode rejection. With a multi-output power supply, where all rails share a common 0V, it may be necessary to bring the 0V directly and use heavy cable for the 5V, common-mode connection to the others. There is no easy method of overcoming dc errors without using properly isolated outputs.

Spikes have been found to cause more trouble than ripple and it is essential to attenuate anything that looks 'sharp' and this also means that spikes coming back from the load must be decoupled by low-impedance capacitors. Aluminium types, such as the Rubycam TWSS and, rather better, the same company's XFP are good, the technique having improved in recent times, while the Sanjo Cocon is even better; AVX MicroChip tantalums are very good.

> **Fig. 1.** Single turn on a ferrite window core, together with the right kind of capacitor, reduces ripple and noise from switches by over 90%. At (a) is the filter and (b) shows how to test the power source for noise coming from the load. For circuit boards having their own ground connections use the arrangement at (c).

---

*Interface between a 4-by-4 keypad and one microcomputer pin*

Used with a microcomputer having a 4-bit I/O pin that may be shared to ground while in the high state, such as one of the 8051 family, this circuit enables a 4-by-4 keypad to use only that pin, instead of the four or five normally needed.

Neglecting, for the moment, the effect of BC0, current through RB0 is small. Shorting COL and ROWx via the keypad, QB0 being low and QF0 high, causes current to flow ±5V through R6, D2 and D3 through RB0, the consequent voltage drop being detected by comparator A4. Most states of the counter give an unambiguous indication of the switch state. For example, if COL and ROWx are shorted by the keypad, the counter code is 000011100 and for COL and ROWy, 00111100. The process of testing a switch therefore requires the computer to advance the counter to the desired count and to monitor A4 output. LM339 OP-amps are open-circuit comparators; when on, the output is a short to ground and when off, open-circuit.

Initial conditions are such that point X1 is held low by the computer for 10µs or more, and A4 has switched off and C2 is charging to reset the counter. Current through RB0 drops a small voltage across R7 and the output of A4 and therefore the negative input of A5 are grounded and A5 in off.

When the computer takes X1 high, A4 discharges C1, A5 goes high and A4 pulls X1 low again. Switching delays allow C1 to discharge completely so that when A4 switches X1 off, it takes about 10µs for the voltage across C1 to swing A5 high again. For a count state and switch position causing the extra current to flow in RB0, A4 does not switch on and X1 stays high.

After driving X2 high, the computer monitors it to detect the presence or absence of current through the keypad and then forces X2 low again, notwithstanding the state of A5. After 14µs, the trailing edge of the pulse at A5 has incremented the counter, A4 has switched off and the computer drives X2 high to start the whole thing again until the counter holds the desired count for the switch under test.

SJ Kerry

Hoylake Wirral Merseyside

---

*Wide-band, dc-isolated amplifier*

In applications such as grounded-cathode photomultiplication, or scanning electron microscopy of dc-biased samples, it is necessary to use an isolation amplifier; wide bandwidth is also sometimes needed and not often found in such circuits. This design is useful when ac common-mode potentials are not involved and it provides a rise time of less than 100ns.

Input splits into two paths: an optically isolated amplifier, A1.2 and the optopair, and an ac coupling via C2 both driving A3.

By virtue of the ac coupling, provided that the time constant R3C3 equals R2C2 at 20µs here, frequency response is flat and limited by the bandwidth of A3, not by that of the optically coupled section.

Negative feedback using one diode in the 1K100 eliminates non-linearity in the optopair, and R3 allows bipolar input. Gain of the low-frequency path into the inverting input of the output amplifier is unity and that of the ac-coupled path is 2. Since R2=2R3, overall gain of the IF path is 2. Capacitors C3.4 preserve stability.

This is not a true isolation amplifier and the floating input and grounded output common rails must be well decoupled. In this case by C4. If an ungrounded power supply is used - power connections not shown here - R3 should be replaced by connection sources. Overall frequency response may be extended to over 50MHz by the use of a faster op-amp for A3: voltage op-amps should be used unless R2 and the under 1kHz and both the values and voltage ratings of C4 are increased. Minor adjustments in crossover frequency may be effected by replacing C1 with 100pF across a 20pF trimmer; crossover time constant of 20µs should not be reduced to become comparable with the optocoupler time constant of about 1.5µs.

> **Fig. 4.** Keyboard test and output circuit for a 4-by-4 keypad. Keyboards 1A, 2A and 3A are series-connected to the keypad. At each keyboard position, there is one count state giving an unambiguous indication of the switch state. For example, if COL and ROWx are shorted by the keypad, the counter code is 000011110 and for COL and ROWy, 00111100. The process of testing a switch therefore requires the computer to advance the counter to the desired count and to monitor A4 output. LM339 OP-amps are open-circuit comparators; when on, the output is a short to ground and when off, open-circuit.

Initial conditions are such that point X1 is held low by the computer for 10µs or more, and A4 has switched off and C2 is charging to reset the counter. Current through RB0 drops a small voltage across R7 and the output of A4 and therefore the negative input of A5 are grounded and A5 in off.

When the computer takes X1 high, A4 discharges C1, A5 goes high and A4 pulls X1 low again. Switching delays allow C1 to discharge completely so that when A4 switches X1 off, it takes about 10µs for the voltage across C1 to swing A5 high again. For a count state and switch position causing the extra current to flow in RB0, A4 does not switch on and X1 stays high.

After driving X2 high, the computer monitors it to detect the presence or absence of current through the keypad and then forces X2 low again, notwithstanding the state of A5. After 14µs, the trailing edge of the pulse at A5 has incremented the counter, A4 has switched off and the computer drives X2 high to start the whole thing again until the counter holds the desired count for the switch under test.

SJ Kerry

Hoylake Wirral Merseyside

---

*Wide-band, dc-isolated amplifier*

In applications such as grounded-cathode photomultiplication, or scanning electron microscopy of dc-biased samples, it is necessary to use an isolation amplifier; wide bandwidth is also sometimes needed and not often found in such circuits. This design is useful when ac common-mode potentials are not involved and it provides a rise time of less than 100ns.

Input splits into two paths: an optically isolated amplifier, A1.2 and the optopair, and an ac coupling via C2 both driving A3. By virtue of the ac coupling, provided that the time constant R3C3 equals R2C2 at 20µs here, frequency response is flat and limited by the bandwidth of A3, not by that of the optically coupled section.

Negative feedback using one diode in the 1K100 eliminates non-linearity in the optopair, and R3 allows bipolar input. Gain of the low-frequency path into the inverting input of the output amplifier is unity and that of the ac-coupled path is 2. Since R2=2R3, overall gain of the IF path is 2. Capacitors C3.4 preserve stability.

This is not a true isolation amplifier and the floating input and grounded output common rails must be well decoupled. In this case by C4. If an ungrounded power supply is used - power connections not shown here - R3 should be replaced by connection sources. Overall frequency response may be extended to over 50MHz by the use of a faster op-amp for A3: voltage op-amps should be used unless R2 and the
**Improved-accuracy current mirror**

Current mirrors of the form shown in Fig. 1 achieve increased accuracy by virtue of the emitter follower to reduce input base current. Assuming that all three $\beta$s are equal,

\[ A = \frac{1}{\beta(\beta + 1)} \]

To improve bandwidth, $T_1$ may be biased by an emitter resistor which, unfortunately, reduces mirror accuracy by the increased base current.

To regain accuracy, the circuit of Fig. 2 offers an alternative approach by deriving an extra base current and adding it to the output. Again, all $\beta$s are equal and gain is now,

\[ A = \frac{1 + \frac{2}{(\beta + 1)}}{1 + \frac{2}{\beta(\beta + 1)}} \]

Adding $T_7$ does have the effect of slightly lowering output impedance, but the improved accuracy and bandwidth normally outweigh the effect. Figure 3 shows the final circuit, in which $R_6$ helps to reduce errors caused by offset voltage and $R_9$ sets the quiescent current in $T_{1a}$. Reducing the value of $R_9$ does not affect the accuracy significantly, due to the effect of $T_{1a}$.

**Longer-life led flasher**

This 1.5V high-efficiency led flasher is an astable multivibrator with voltage doubler. The two transistor pairs are wired in Darlington mode to increase gain and reduce current consumption.

Values of $C_1$, $C_2$ can be changed to affect the flashing rate. The ultrabright led is obtainable from RS Components and Farnell Electronics. Ordinary leds can be used, but the flashing intensity is very much reduced since the circuit is trimmed for minimum current consumption.

An ordinary IN4148 type diode can be used instead of the IN5819 Schottky-barrier diodes but led intensity will be reduced due to the higher voltage drop. Little current of the circuit is 0.2mA and with the led on, the current goes up to 0.3mA. With such a low current consumption, a 1.5V cell lasts a long time.

The popular LM358N led flasher from National Semiconductor relies at typical 0.25mA and with the led active it drains 0.75mA. According to National's handbook the 358N will run for around 6 months continuously on a ordinary AA sized cell or for around 6 months on an alkaline type cell.

The circuit shown here should give you twice as much battery life.

Michael Clay Yong Kin
City Beach
Australia

**Circuit Ideas**

A reliable and cheap method of stopping a dc servo motor very quickly without recourse to electronic sensing.

When used in servos, dc motors usually need travel limit switches. This circuit arrangement stops a motor quickly when the switch is tripped.

When the servo reaches a limit, the bipolar drive circuit should be able to reverse the motor, $D_{12}$, across the limit switches perform this function.

Dc motors stop much more quickly if a short circuit is placed across the terminals, since the motor then behaves as a generator. Diodes $D_{12}$ provide a virtual short circuit in the direction in which the motor is moving when the limit is reached. This process is particularly suitable when moving high-inertia loads and does not rely on any exotic sensing devices; it is, therefore, more reliable when driving critical loads. It appears simple and somewhat obvious, but we have not seen it published before.

An emitter resistor and diode must be suitably rated.

B Volfoci and RG Newman
OzLab Laboratory Cancer Research Trust
Mount Vernon Hospital
Northwood
Middlesex

(B15)
Thupe introduces the HANDYSOC2
A powerful 12 bit virtual measuring instrument for the PC

The HANDYSOC 2, connected to the parallel printer port of the PC and controlled by very user-friendly software under Windows or DOS, gives everybody the possibility to measure within a few minutes. The HANDYSOC 2 is the best PC controlled measuring instrument in its category.

The HANDYSOC 2 is suitable for Windows 3.1 and Windows 95. There is also software available for DOS 3.1 and higher.

The four integrated virtual instruments give lots of possibilities for performing good measurements and making clear documentation. The software for the HANDYSOC 2 is also software available for DOS 3.1 and higher.

The HANDYSOC 2 is connected to the parallel printer port of the PC and controlled by very user-friendly software under Windows or DOS, giving everybody the possibility to measure within a few minutes. The HANDYSOC 2 is the best PC controlled measuring instrument in its category.

The HANDYSOC 2 introduces the HANDYSOC 2, a powerful 12 bit virtual measuring instrument for the PC.

The HANDYSOC 2 is a fully configurable virtual instrument with a choice of measurement types and units. It can be configured to your own demands.

The HANDYSOC 2 has a built-in printer that can be used to print results in a variety of formats, including ASCII, HTML, and PDF. It can also be configured to send results to a network or a printer.

The HANDYSOC 2 has a choice of measurement types, including voltage, current, resistance, and temperature. It can be configured to measure any combination of these types of measurements.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.

The HANDYSOC 2 can be configured to perform a wide range of calculations, including statistical analysis, Fourier analysis, and spectral analysis.
filter was larger than the output of the second integrator. The feedback resistor was therefore raised by 3kΩ, giving roughly equal amplitude non-limiting outputs at the bandpass output.

The spectrum was now as shown in Fig. 2, lower trace. For clarity, this has been recorded at a narrower IF bandwidth. The signal was first raised by 12kΩ, giving roughly equal amplitude non-limiting outputs at the bandpass output nodes.

For such a simple circuit, the diode noise figure of 0.03% is not at all bad, and it is a very useful and economical arrangement for a fixed frequency oscillator. For a wide range of audio oscillator circuit it is less suitable, since the excess phase shift in the integrators will increase with frequency, leading to a much worse distortion figure at 10kHz and above. So my thoughts turned to the type of oscillator described in reference 4.

Diodes for stabilisation

This circuit incorporated negative feedback of such a value that the output was 24 kHz. Positive feedback was applied from the bandpass output, BP, of a value exceeding the negative feedback, effectively providing the filter with an input derived from itself. However, as the amplitude of the oscillation builds up, diodes start to limit the positive feedback, so that the fundamental component of the output increases, or decreases only marginally. As the negative feedback continues to increase proportionally with the amplitude of the oscillation, an equilibrium point is reached, where the net loop gain at the fundamental just equals infinity. The circuit was arranged so that this condition was always maintained below the maximum possible swing set by the supply rails, with the result that the second harmonic distortion was negligible.

An advantage of an oscillator in this, based upon the state variable filter, is that the circuit then used as both an oscillator, and a bandpass filter. The feedback resistor was therefore raised by 3kΩ, giving roughly equal amplitude non-limiting outputs at the bandpass output nodes.

Furthermore, as each integrator provides a 90° phase shift relative to its input, the third harmonic present at the high-pass output is antiphase to that at the bandpass output. So by using an additional anti-symmetric filter to combine one ninth of the highpass output with the full lowpass output, the third harmonic sits in a notch.

This results in a signal entirely free of any third harmonic, an arrangement used in reference 4. Meanwhile, the fundamental output is of course also reduced, but by only a ninth. Handy though this arrangement is, there is a downside to it. While the third harmonic is outphased completely, the fifth harmonic is actually made 5dB worse. But there is still a reduction in this, since, due to the soft limiting action of the diodes, the amplitudes of the harmonics at the high-pass output drop off much more rapidly than in an ideal wave.

Outphasing the fifth harmonic

It occurred to me that if I could arrange that the amplitude limiting method inherently did not produce third harmonic, then the fifth harmonic would be eliminated by adding a 90° phase shift negative feedback pulse to the high-pass output.

Reduction of selected harmonics by waveform shaping is a technique well known in power engineering. Here, it can be used to minimise the effect of harmonics at the output of an inverter, as in for example reference 7. So I experimented with a circuit designed to avoid producing third harmonic in the stability of distortion, by permitting outphasing of the fifth harmonic.

This is shown in Fig. 3. Oscillation commences since there is positive feedback from the bandpass output via IC2 to the inverting input of the op-amp amplifier. Initially, there is no negative feedback via IC4 to the non-inverting input, as it is blocked by the diodes.

As the amplitude increases, their forward voltage is overcome, and therefore the stronger feedback effect is achieved more rapidly than the positive feedback. This leads to outphasing at a double rate as shown by the 4.5kHz phase inverter. The 22MΩ potentiometer can then be adjusted to feed narrow additional positive feedback pulses at the top of the wave by the diode at the non-inverting input, as it is blocked by the diodes.

Following careful setting up, the output was as shown in Fig. 4. The third harmonic at the low-pass output is -69dB, about as low as the diode-free circuit of Fig. 1. It is also lower – without the benefit of outphasing – than achieved by the circuit of reference 4 with diodes.

But setting up was fairly critical, and performance with tuning and with change of ambient temperature would clearly have been unsatisfactory. Nevertheless, the low level of fifth harmonic was encouraging, so the circuit was arranged to provide low third harmonic output by means of outphasing.

Why not outphase all the harmonics?

This circuit is shown in Fig. 5, and its performance in Fig. 6. The third harmonic is outphased completely, while compared with Fig. 4, the fifth harmonic has increased by the expected 5dB.

It would be fine, thought, that both the third and the fifth harmonics could be outphased, and why not the seventh and the others as well? This led to the experimental arrangement of Fig. 7.

However, the amount of positive feedback is fixed by the 3.3MΩ resistor, the desired amplitude of oscillation being set by the maximum negative feedback via the diodes. Having constructed the circuit as shown, with the 100kΩ potentiometer at mid-travel, on switching on, the spectrum which met my unbelieving gaze is shown in Fig. 8. Where had all the harmonics gone? The following day, they were back again, but now just above the –40dB noise floor of the spectrum analyser. Successive adjustments of the two potentiometers merely reproduced the previous day’s astounding results, but the settings were critical, and the amplitude of the oscillation very unstable. So it was time to think the whole thing through.

The intention had been to use op-amp IC3 as a difference amplifier to pick off the harmonics generated by the diodes. These were then fed into the inverting input of IC4. With the inverting amplifier fed into the non-inverting input as part of the negative feedback signal, the harmonic distortion should be rejected by IC4, as a common mode signal. The result is good, but not the harmonics, and only the harmonics, be fed back to the inverting input of IC4. For this to be the case, the in-phase waveform appearing across the diodes be fed back as well, the amplitude stabilisation mechanism is defeated. It is the 'dead space' created in the negative feedback signal by the diodes that ensures oscillator start-up.

Thereafter, when the signal becomes large enough for the diodes to start working, the negative feedback increases with the amplitude of oscillation, faster than the positive feedback increases. If the fundamental component of the diode drop is now fed back along with the harmonics, via the difference amplifier, to the inverting terminal of IC4, then regardless of level, the ratio of positive to negative feedback becomes independent of level, and amplitude stabilisation is lost.

So the circuit was modified to make IC4 a true difference amplifier, as shown in Fig. 9. Note that the ratio of the two resistors at the inverting input of IC4 is equal to the ratio of the resistors at the output – although these in fact also do double duty as the input divider chain for the negative feedback resistance.

With the diode IR at the top of its travel – point B in Fig. 10 – IC4 is a classic difference amplifier, with a near squarewave output representing the volotage waveform across the diodes. However, this is not quite what is wanted; it contains the mains fundamental component of the negative feedback as well as the harmonics, as shown in the upper trace in Fig. 10.

The waveform input to the diodes is shown in the upper trace of Fig. 11, and note that the upper trace in Fig. 10 is in antiphase to this. Thus the voltage applied via the diodes and resistors, as negative feedback to IC4, is as shown in Fig. 11, lower trace. Note the dead-space, rather like an underbiased class B output stage.

This illustrates an important point. When any mechanism introduces harmonic distortion onto a pure sinewave, the amplitude of the fundamental component of the distorted waveform will differ from that of the original.

To ensure outphasing the harmonics by common mode.
the experiments were carried out
as the
contains
560k
waveform appearing
DP
Figure 8 shows this to be adjusted to equal the amplitude of the fundamental component of the negative feedback signal shown in the lower trace of Fig. 8. The result is that the output of the difference amplifier \( \text{IC}_4 \) then contains the harmonic components only, as shown in Fig. 10, lower trace.

This adjustment is very easily carried out, by displaying the spectrum of the waveform at the distortion products measuring point DP in Fig. 8, on a spectrum analyser, and adjusting \( R_5 \) to minimise the fundamental component displayed.

Measuring the results
Output of the circuit of Fig. 9, measured at the point LP, displayed a third harmonic component just visible above the spectrum analyser's noise floor, with higher harmonics not visible at all.

To increase the measurement range, a twin-tee network was made up, using four 15k \( \Omega \), 1% metal film resistors and four 100 \( \mu \)F, 2% polypropylene capacitors. Figure 9 used 2.2\( \mu \)F polypropylene capacitors, and 1% metal film resistors throughout the way.

Response of the twin-tee was plotted, using the spectrum analyser's internal tracking generator, and is shown as the upper trace in Fig. 12. With no adjustment, the twin-tee notch reduced the fundamental of the oscillator by 45dB, permitting the input level to the spectrum analyser to be increased by 45dB without overloading.

The measurement noise floor was now about 120dB below the oscillator output, as can be seen in Fig. 12, lower trace. Allowing for the residual attenuation of the notch, the third harmonic is seen to be a -85dBc, and the fifth at -104dBc, while the second and fourth are lost in the oscillator's phase noise sidebands.

Some practical extensions
While the circuit has not to date been developed into a complete 20kHz to 200kHz audio oscillator, some initial tests were carried out to see if this would be practicable.

To test the performance with change in ambient temperature, an electronic thermometer was used in conjunction with a hair-dryer. The thermometer probe was placed adjacent to the diodes, and the hairdryer at a fair distance, so that the whole circuit was bathed in the same air stream, and left to reach equilibrium.

The temperatures were thus raised from 20°C to 30°C. The oscillator's output level rose by roughly 2dB, but the distortion figure remained unchanged.

Next, the circuit was modified to operate at 1kHz by changing the two integrators 150k \( \Omega \) resistors to 15k \( \Omega \). As expected, amplitude control was lost, due to the increased residual phase shift in the integrators. This was largely corrected by fitting three 1.5 \( \mu \)F capacitors, shown as C in Fig. 9. Some re-adjustments of \( R_5 \) of the harmonics other than the distortion was, as far as could be determined without another (win-tee) filter, similar to that measured previously.

The exact value required for the compensating capacitors \( C \) will depend upon layout, and may well be 1.5 \( \mu \)F or even less with a good pcb design — the experiments were carried out using, for space, Experimentor prototyping plug-board. This exhibits a fairly high stray capacitance between adjacent points, rendering it completely unsuitable for rf work.

Even at audio, the stray can, as here, pose a problem. Bandwidth-limited and low frequency control, to cover 20Hz to 20kHz, can be implemented as in reference 4.

Fig. 10 shows some simple additions which could be accommodated with an additional quad op-amp. In theory, \( \text{IC}_3 \) should operate, even the residual third harmonic distortion visible in Fig. 12 - but don't expect perfection. After all, the typical 3dB of the 7200 used in all the circuits illus-

Fig. 11. Upper trace, the waveform at point B in Fig. 9. Lower trace, the waveform at point C in Fig. 9. Both traces, 2V/division vertical, 500µA/division horizontal.

References
Richard Ball reports on how LM300 family op-amps — which are now a quarter of a century old — have been relaunched with a familiar feel but a new set of specs.

A quarter of a century after its introduction, the company has redesigned the LM300 family of op-amps using a relatively advanced 0.8µm BiCMOS manufacturing process. For designers of modern equipment, the most important outcome is that supply voltage ranges from 2.7 to 5.5V. Other parameters have been improved, and because of the huge numbers of die per wafer, cost is actually reduced.

Cyrille Claustres, National’s European marketing manager, explained the company’s reasons for the redesign. “Many op-amps were introduced up to 25 years ago. They cannot meet today’s voltage and packaging requirements,” he said.

Devices that can do the job are available, but as Claustres said: “Specialised low power, small products cannot meet the requirement of low cost.”

The redesigned family includes the LM324, arguably the most popular device used today.

In order to get 6000 die from a wafer, National reduced the size of the pads from four to three millimetres (75µm). The scribe street — the gap between each die removed when the wafer is cut with a diamond saw — was also reduced to 35µm. National got its supplier to redesign the saw to get this narrow cut.

Continued over...
Both op-amps and comparators have been announced in single, dual and quad form. Part numbers are LM231, 758, 224 for op-amps and LM3041, 393 and 339 for comparators. These devices are drop-in replacements for their LM ancestors. “Very often when we introduce a new product, designers have to learn to use it – not the LMVM,” said Clauser.

Prices range from 28c for single and dual devices in SOIC packages to 80c for a quad LM324 or 339 device in a TSOP.

In order to obtain, and in some cases exceed, the specification of the LM300 devices, some caution was required. The major change is of course the use of a BiCMOS process. This has both advantages and disadvantages. Because the process is less than a rupee, thousands of die are available from a wafer, reducing cost even as there are four times as many transistors than the original design’s 13.

If CMOS devices are available, then power consumption can be reduced. Bipolar transistor characters are well known, and driving capabilities. The main downside of BICMOS is that it is essentially a digital process, modified for analogue devices. “We had to come up with a completely new architecture,” admitted Clauser.

Just to make the redesign even more difficult, the designers set themselves the task of enhancing, as far as possible, the crossover distortion in the LM300 op-amps. “LM324s are not stable in some applications due to crossover distortion,” said Clauser.

The new design, with a class A output amplifier, has built-in rail-to-rail inputs with little distortion. Tied in a typical audio configuration, the device had a signal-to-noise ratio of 71dB and total-harmonic-distortion plus noise figure of 0.02%.

On the other hand, CMOS transistors made to rail-to-rail output easier to implement and maintained a 3MHz gain bandwidth product with up to 200GHz of power capacity. At low values of output capacitance, the rail-to-rail bandwidth product increases to 3MHz.

National is being defensively secretive about the actual design of the output stage. Chief designer Repp Dietz would only say, “I’ll tell you now that the output stage has an extra gain stage sourcing current and 2nF of feedback and a PMOS for sourcing.”

Another problem with the original design is the input common mode voltage range. The input cannot go further than 1.5V to the supply. With a 15 or 30V supply this is fine, but at 27V, this does not leave much room for manoeuvre.

National solved this by changing the front end to a bipolar differential pair with a folded cascade configuration. The original design also used a differential pair, but needed a darlington pair on the inputs.

CMOS power management also allows the input common mode voltage range to extend to ground and to within 0.8V of the positive supply. Using bipolar transistors rather than MOS types on the input improves noise and matching characteristics.

The majority of the remaining circuit uses CMOS which brings the benefit of reduced power consumption.

More modern and stringent electromagnetic interference (EMI) laws have been taken into consideration. Electromagnetic discharge protection of the package allows the device to be increased to 900V on the LM324 and 1200V on the quad devices.

National is taking the opportunity to design a range of devices on its new BICMOS process. “The problem with this process is it’s pad limited,” said National’s Steve Cline. So the company is looking for further integration. “We will put a three-op-amp instrument amplifier onto one IC,” he said. This combines four op amps and eight resistors on a single die. The die could easily be sieved into four SOIC-8 packages.

There are many other building blocks that could be integrated. “We also have an 8-to-d converter in this process,” Cline said.
NEW Unused Test Equipment
from one of the UK's Leading Manufacturers

Automatic Modulation Meter
Model AMM255. 1.5MHz - 2.4GHz
Fitted IEEE488. LCD Display
ONLY £495 + vat **

Automatic Modulation Meter
Model AMM5200. 10Hz - 2.4GHz
32 chr alphanumeric display
Fitted GPIB and RS322
ONLY £995 + vat **

Synthesised Clock Generator
Model SG2515 10MHz - 50MHz
LED Display
ONLY £125 + vat **

Transmitter Test Set
Model TTS520. RF power, mod,
AF up to 520MHz 1KRI. 50ohms
ONLY £750 + vat

Porta ble Appliance Tester
Model PAT1000. LCD Display
ONLY £350 + vat **

Programmable Signal Generator Model PSG1000. 10Hz-1GHz fitted GPIB. ONLY £995+vat**
Black Star Meteor 100 Frequency Counters with TXO option. To 100MHz, ONLY £75+vat**
Black Star Meteor 1000 Frequency Counters with TXO option. To 1000MHz, ONLY £150+vat**
NOTE: All items marked "**" are supplied Complete WITH MANUALS

SPECIAL OFFER..."PROBE-ABLY the Best Offer you will see this YEAR"
Brand New x1 x10 Switchable Oscilloscope Probes, OK to 100MHz, Supplied with adaptors etc Quality German made. NOT Rubbish. blister packed. (see picture above) ONLY £9.95 + vat

ANCHOR SUPPLIES LTD
The Cattle Market, Nottingham NG2 3GY. UK
Tel: (0115) 986 4902 Fax: (0115) 868 4667
Mail Order Most Welcome
Open 8 Days a week (Closed Sunday)
WEB Site: http://www.anchor-supplies.ltd.uk e-mail: hitek@anchor-supplies.ltd.uk
All Prices are plus VAT. Courier Delivery to UK mainland addresses £7.95 + vat

Understanding capacitors
Aluminium and tantalum options

Aluminium and tantalum electrolytic capacitors uniquely balance CV product against physical size. While film or ceramic capacitors are readily available up to 10µF, higher capacitance values are physically large and very expensive. Very large value electrolytic capacitors are available at low cost, and in physically small packages.

The possibility of forming an insulating film on the surface of aluminium was first observed by Wheatstone in 1854. In 1908 a rolled type aluminium capacitor was produced in USA and a vacuum electrolyte of aluminium terephthalate and glycine was developed in Germany. 1 These two essential discoveries resulting ultimately in the modern electrolytic capacitor.

Regardless of construction or dielectric used, every capacitor is composed essentially of two conducting surfaces, called electrodes, separated by an insulator. Insulation materials produce differing capacitance values for the same area and thickness, according to their dielectric constant, or K value.

The permittivity of free space is used as the base unit since all other materials — including air — exhibit increased capacitance. These K values, which range from 1.00059 for air to greater than 12000 for high-K ceramics, significantly influence the capacitance achieved.

Electrolytic capacitors are manufactured using so-called 'Valve metals', the most common being aluminium and tantalum. Valve metals have the ability to form an insulating, non-conducting and protective surface oxide film. Aluminium oxide has a K value of 9, while that for tantalum pentoxide is 27.6, approximately.

Aluminium oxide and tantalum pentoxide films grown on the highest purity metals provide very high-quality, low-loss insulators. Aluminium oxide has a dielectric strength approaching the theoretical strength8 as predicted by theionic theory of crystals.

Capacity value depends on the product of the electrode area and the K value of the insulating dielectric. It is inversely proportional to the distance separating the electrodes. For any chosen dielectric, the capacitance attained depends totally on the insulators thickness and surface area.

When a flexible electrode system that conforms precisely with the insulator’s surface is used, the effective or apparent area can then be increased by roughening or abrading, increasing capacitance without increase of physical size. This effect is called surface gain.

Frequently, electrolytic capacitors have been described as having an extremely high dielectric constant. This is wrong, the K values of 9 and 27.6 are correct, so how can such high capacitance values be attained?

Compared to metalised-plastic film capacitors, which use dielectric film thickness of a micron and above, electrolytic capacitor dielectric films are only five times thinner.

This extremely thin dielectric results in electrolytics being the most highly voltage stressed of all capacitors. However this combination of a very thin dielectric having a K value of 9 or, even 27.6, still does not explain how much large capacitance values can be attained.

Surface gain — aluminium

I mentioned roughening or abrading the insulators surface to increase its apparent area. You can see an example of this by closely examining a piece of aluminium kitchen foil. Usually, one side is smooth and shiny, the other matt. Under a times-ten magnifying glass, this matt surface is visibly embossed, providing some surface gain.

The earliest electrolytic capacitors attained usable surface gains by spraying molten aluminium onto a carrier. Known
Compartment - 496

Highly conductive electrolyte and paper

Figured sketch of an aluminium capacitor.

Electrolyte and paper form the dielectric, as illustrated in Fig. 2. This view of a partially wound element shows a large multiple tab for the leaded capacitor. An alternative arrangement using a single anode and cathode tab is more common. Also shown is an extended cathode foil, which improves heat dissipation. With its turns swaged to connect each other, this extended cathode foil can substantially reduce capacitor equivalent series resistance.

Fig. 3. A view of a partially wound element shows a large multiple tab for the leaded capacitor. An alternative arrangement using a single anode and cathode tab is more common. Also shown is an extended cathode foil, which improves heat dissipation. With its turns swaged to connect each other, this extended cathode foil can substantially reduce capacitor equivalent series resistance.

Aluminium - winding methods

Aluminium is non-conductive, but in order to be used, it is chemically treated to form an aluminium oxide layer on the surface. This oxide layer serves as an excellent insulator to the aluminum itself. When the aluminium foil is subjected to an electric field, the aluminum oxide layer will grow in thickness, forming a thin film of aluminium oxide on the surface. This oxide layer is highly conductive, and it can be used as a dielectric in capacitors.

As shown in Fig. 5, the oxide layer on the aluminium foil can be grown to a thickness of 0.02 microns. The oxide layer thickness can be controlled by adjusting the electrical field strength and the duration of the oxide growth process.

When the oxide layer thickness is increased, the capacitor exhibits higher self-inductance, which is typically much less than 200µH.

Forming aluminium oxide

The oxide layer on the aluminium foil is grown using anodic oxidation. The process involves an electrochemical etching, in which a voltage is applied to the foil, and the oxide layer on the surface is grown. The oxide layer thickness can be controlled by adjusting the voltage and the duration of the oxide growth process.

A non-aggressive electrolyte is used, such as a non-aggressive electrolyte, to prevent the oxide layer from growing too thick.

Using a non-aggressive electrolyte, a slowly growing, impervious and continuous oxide film is obtained. This non-porous, hard oxide film grown on pure aluminium is an excellent insulator that can be formed to withstand at least 600 volts. It is highly insulating, and it is used in electrolytic capacitors.

I mentioned earlier that the dielectric oxide is very thin. Its thickness is self-limiting. Oxide growth at any one voltage slows and almost ceases with time, ultimately attaining some 0.1A thickness for each volt applied.

Fig. 4. One common construction used for the smallest axial leaded capacitors. Disadvantages are the increased voltage between cathode tab and case and increased self-inductance due to foil connections being at extreme opposite winding ends. But with small windings, self-inductance remains acceptable.

Forming aluminium oxide on the foil is a complex process that requires careful control to ensure the formation of a thin, uniform oxide layer. A non-aggressive electrolyte is used, such as a non-aggressive electrolyte, to prevent the oxide layer from growing too thick.

Using a non-aggressive electrolyte, a slowly growing, impervious and continuous oxide film is obtained. This non-porous, hard oxide film grown on pure aluminium is an excellent insulator that can be formed to withstand at least 600 volts. It is highly insulating, and it is used in electrolytic capacitors.

I mentioned earlier that the dielectric oxide is very thin. Its thickness is self-limiting. Oxide growth at any one voltage slows and almost ceases with time, ultimately attaining some 0.1A thickness for each volt applied.

Fig. 4. One common construction used for the smallest axial leaded capacitors. Disadvantages are the increased voltage between cathode tab and case and increased self-inductance due to foil connections being at extreme opposite winding ends. But with small windings, self-inductance remains acceptable.

Aluminium oxide is a non-conductive material, but it can be made conductive by applying an electric field. This is done by applying a voltage to the aluminium foil, and the oxide layer on the surface is grown. The oxide layer thickness can be controlled by adjusting the voltage and the duration of the oxide growth process.

As shown in Fig. 5, the oxide layer on the aluminium foil can be grown to a thickness of 0.02 microns. The oxide layer thickness can be controlled by adjusting the voltage and the duration of the oxide growth process.

When the oxide layer thickness is increased, the capacitor exhibits higher self-inductance, which is typically much less than 200µH. The major contribution to this is from the connecting tabs and the capacitors lead ends.

Axial leaded capacitors exhibit more inductance. While larger sizes may be centre tabbed, connecting the cathode to the case, requires a longer tab. This tab is folded and offset when inserting the capacitor winding into the case.

Inevitably, an axial capacitor exhibits higher self-inductance compared with the same sized radial leaded version, as illustrated in Fig. 6.

To demonstrate the effects constructional differences of small aluminium electrolytic capacitors have in practice, I used the application test circuit and phase meter. When possible, I selected 50V rated bi-polar radial and polar axial aluminium electrolytic capacitor constructions. Since 10µF 35V tantalum head capacitors were readily available, I used these components. I measured four capacitor from 10µF to 100µF. These values are frequently used in audio amplifier coupling circuits.

Rearranging the phase meter connections to the capacitor winding, I measured four capacitor from 10µF to 100µF. These values are frequently used in audio amplifier coupling circuits.

Rearranging the phase meter connections to the capacitor winding, I measured four capacitor from 10µF to 100µF. These values are frequently used in audio amplifier coupling circuits.

The un-satisfised measured plots, Fig. 7-10, show departures from ideal or theoretical behaviour starting at well below 1kHz. The ear curves are almost constant with frequency, resulting in capacitor phase angles approaching 45° at the critical mid-audio frequencies. The bi-polar capacitor clearly out-performs the other aluminium types.

Regardless of these differences in construction, to ensure a long life service, the electrolytic unit must provide the oxygen needed to re-grow any damaged oxide film. It must also be chemically inert to both aluminium and its oxides. Due to electro-chemical potential effects, no other metal can be permitted to contact the electrolyte. Being in contact with the cathode, the anode becomes a conductor of a non-metal.

Any two pieces of aluminium in contact with electrolyte and subjected to a voltage differential will grow aluminium oxide. So pressure contacts, as used in foil and paper capacitors, are not suitable.
Fig. 8. As for Fig. 7 aluminium types but 22pF values. Where possible, 50V ratings or nearest possible were used for these comparisons. At this value the bi-polar capacitor is the best choice.

Fig. 9. As for Fig. 8 but this time using 470pF values. Due to the larger size and fill area, the Panasonic bi-polar style easily outperforms the smaller alternatives.

Fig. 10. With 10pF values the Panasonic bi-polar remains a notably better performing capacitor for these tests.

Aluminium 'forming'

Placed in a bath of suitable electrolyte and with a positive voltage applied to the foil, aluminium oxide, Al₂O₃, grows on the foil surfaces to a thickness of 14Å (Angstroms) for each volt.

As mentioned in the main text, two forms of aluminium oxide can be produced, one porous and another non-porous and hard.

The hard oxide film is an excellent insulator that can be produced to withstand 600V using super-purity aluminium. Aluminium and electrolyte purity are important, since impurities result in weakness in this insulating oxide film, increasing leakage current.

Pure aluminium can be attacked by pure water at modest elevated temperatures, unless this oxide film has first been hydrated by boiling in water, or is chemically inhibited.

The oxidation process is self-regulating, initially most forming current passes through visible and exposed surfaces. With continued oxide growth, current at these exposed surfaces reduces, slowing local growth and diverting current to less accessible areas. Current flow and oxide growth almost cease when all metal surfaces are insulated.

The aluminium oxide dielectric formed is highly amorphous, except for the outermost surface layer, which may be porous when formed at high voltages. Boiling in very pure water hydrates the oxide sealing this porosity, resulting in very low leakage current capacitors.

Aluminium oxide is visually transparent, but the etched foil surfaces are covered with minute seeds and tunnels which absorb light, hence the dark appearance, Fig. 11.

In general, foils are etched and formed from wide rolls of aluminium, then slit to the desired widths for capacitor manufacture. Each width has its own processing history, with the thickest foil taking the longest time to allow the metal from the electrode and tab foils to reappear, forming a molecular bond. A as with a conventional hot weld, the two joined metals cannot be separated. This excellent joint results from the tool pattern used. By compressing and displacing metal, the pattern removes the oxide layers, allowing direct metal to metal bonds. Cold welds are easily identified by the press tool's outline and inner patterns. No burning through as for a stitched connection can be seen, Fig. 11.

Welding, using either cold pressure or laser, is the preferred method for all aluminium electrolytic capacitor internal connections. However a riveted connection between connecting tabs and the external solder tags, can be satisfactory alternative especially for smaller capacitors.

Aluminium-dielectric systems

The anode electrode foil of an aluminium electrolytic also allows the dielectric oxide which is in intimate contact with the electrolyte -- the true second electrode. Electrical connection to this electrolyte is provided by a second foil, or cathode electrode, which is also covered with dielectric oxide. In other words two foils comprise two distinctly separate capacitances in series, inner connected by the conductive electrolyte.

A polarised aluminium electrolytic possesses two capacitances, the desired one in series with a much larger 'cathode' capacitance. This cathode capacitance has a lower voltage withstand, typically 1.5V and is of opposing polarity to the anode capacitor, Fig. 2.

A non-polarised, or bi-polar capacitor is usually made using two identical anode foils. This provides two equal voltage and equal voltage capacitances in series, each double the required capacitance and again of opposing polarity.

Being a semi-conductor, aluminium oxide withstands its formed voltage in one direction only, passing a small 'leakage' current. As for a semi-conductor diode, with reversed polarity it conducts at a low voltage, typically 0.4 to 0.5V while passing a high current.

Regardless of level, this current dissolves water in the electrolyte, depositing oxygen at the positive electrode, hydrogen at the negative electrode. The oxygen decomposes to generate aluminium oxide.

Many electrolytes contain a hydrogen absorber, so absorb the hydrogen released by normal leakage currents. Even so, with reversed polarity much of the hydrogen must be allowed to escape.

With the above information, it is now possible to develop an equivalent circuit model of an aluminium electrolytic capacitor, Fig. 12.

Reverse bias effects

In a polarised capacitor the 'cathode' foil capacitance, being in series with that of the anode foil, reduces the net or measured capacitance. It also contributes two advantages not present with the tantalum slug styles.

The withstand voltage of the cathode foil's dielectric oxide allows the capacitor to accept small reverse voltages for a significant time, both in service and in approval testing.

This cathode foil's ESR product, if equal or greater than that of the anode foil, enables charge displacement from anode foil to cathode foil. The cathode foil in a capacitor subjected to normal charge and discharge-currents, does not then become reverse biased with respect to the electrolyte. Such capacitors are described as being charge-discharge proof, Fig. 12.

Many quality aluminium electrolytic capacitors are subjected to a million charge-discharge cycles with rise and fall times of 100ms as part of their approvals testing. For IEC 384-4 charge-discharge approval, capacitance change in this test must be less than 10%.

Note, though, that capacitors that are repeatedly 'crash' charged and discharged, as in flashlights or smoke equipment, require special construction. Commercial capacitors used for these duties -- regardless of their voltage rating -- have quickly and very dramatically failed.

The current that flows when polarity is reversed can generate sufficient gas to drive electrolyte out of the winding. Pressure builds up in the capacitor case, resulting ultimately in a capacitor failure.

Direct-current polarity reversal at the capacitor terminals is of course easily measured and avoided. A less obvious problem occurs when the capacitor is used to couple irregular or pulse waveforms, a repetitive charge
Aluminium electrolytes

The manganese dioxide used in solid aluminium electrolytics has already been discussed, but for wet or non-solid aluminium electrolytic capacitors, many different formulations exist. These usually comprise a neutralised weak acid in a suitable solvent. The solvent used must not freeze or boil at the extremes of the capacitor’s working temperature range, nor must they attack pure aluminium.

One old but still usable electrolyte is a mixture of ammonium hydroxide and boric acid dissolved in pure ethylene glycol. Most older electrolytes contained small quantities of water. Prepared using solid ammonium, they were boiled to reduce water content.

This water content combined with lesser purity resulted in a much higher and continued deterioration in storage. They needed re-forming before use.

For the past 30 years, this water attack could easily be inhibited by a chemical additive in the electrolyte, in much the same way that steel is passivated to prevent rust, using phosphoric acid. This, and the use of super purity aluminium foils, has effectively minimised the need to re-form capacitors.

As an experiment, I recently measured the leakage current of three unused manganese dioxide electrolytic capacitors, made almost 30 years ago and stored since then in a box in my garage. All three easily passed their catalogue leakage claims without reforming.

Modern electrolytes use many different acid formulations and solvents. These range from simple solutions of ammonium borate or ammonium saccharinate in glycol to organic acids and solvents such as ethylene diethylene glycol. In principle, many weak acids or their ammonium salts can be used, leading to a wide choice.

A byproduct, able to cope with hydrogen released by normal leakage current, is provided in many modern electrolytes.

While very conductive electrolytes are used in the lowest voltage capacitors, such electrolytes cannot be used at high voltages. Low voltage capacitors must not be used in the separating tissue paper, because of their conductivity. Thin low-density paper can be used in high voltages, while for high voltage, higher densities are used. Even multiple tissues may be needed.

While most aluminium capacitor electrolytes are innocuous, it is as well to check the results given by the manufacturer when buying a capacitor to investigate its construction. In any case, you are well advised to wear suitable rubber or plastic gloves, and use eye protection, though aluminium paper becomes highly conductive when wet.

Formic acid for example stings the eyes and any broken skin. It may also trigger an allergic reaction in hay fever suffers, as I can well testify from past experience.

Tantalum and aluminium solid electrolyte capacitors behave quite differently. Fault repair and leakage current reduction does not depend on oxide regrowth, but rather in a similar fashion to metallised film capacitor self-healing, by isolating the faulty area.

The increased current due to a minor fault locally heats the manganese dioxide, which spontaneously degenerates to low resistances. These exhibit much increased capacitance compared to manganese dioxide, effectively isolating this faulty area.

Should a major fault occur in a bead tantalum capacitor used in a low source impedance circuit, excess heat is generated. This excess may be sufficient to locally crystallise the surrounding area of tantalum pentoxide. Energy available from the capacitor can then be sufficient to promote an avalanche failure condition, the capacitor failing short circuit. Given sufficient externally supplied power, the capacitor can burn.

In the early days of bead tantalums in order to prevent this avalanche failure mode, a common recommendation was that they should only be used on power rails via a current limiting fuse. While this may have been correct at the time, it does not prevent low-voltage burn in and even fuse protected tantalum capacitors. However the advice in MIL-STD-181 is best adhered to.

It says you should ensure a 10V source impedance minimum together with substantial capacitor voltage derating for high reliability.

One hybrid capacitor combining the best aspects of the two aluminium-foil construction with the long shelf and service life characteristics of tantalum is the solid aluminium wound foil capacitor. These characteristics provide reliable service in automotive applications, surviving vibration, temperature extremes and voltage surges. Unfortunately this excellent capacitor style is not usually stocked by mainstream distributors.

Temperature effects

Some capacitance variation with temperature is exhibited both by aluminium oxide and tantalum pentoxide. Their leakage currents will follow the Arrhenius law, roughly doubling for each 10°C change of temperature.

by far the most noticeable effect of temperature is the way the voltage anode foil is etched deliberately to provide much larger tapers which will not block with oxide, usually on a thinner foil base. Fig. 13. Various cathode foil etchings, forming and connecting cathode electrode.

Aluminium etching

The surface gain of modern aluminium electrolytic capacitor foils is attained by electrochemical etching, as a hard etch into the electrolyte. The foil is etched into a highly conductive bath, usually in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath, in a highly conductive bath.
Impedance of wet aluminium electrolytic capacitors changes versus frequency with change of temperature. The wet electrolyte and separating papers used in aluminium electrolytic capacitors, combined with the minute and tortuous paths into the inner recesses of the anode foils, contributes much of the capacitors series resistance. At 85°C, resistivity of the electrolyte/paper combination is typically half its room temperature value. At lower temperatures — and especially with higher voltage capacitors — electrolyte viscosity increases more rapidly. By 0°C, resistivity of the electrolyte/paper combination is typically double its room temperature value. At the lowest temperatures the normal impedance frequency curve becomes a nearly constant resistance plot. This low temperature behaviour fortunately is of no importance for most decoupling applications, which only require the capacitor to be a low impedance path. Fig. 13. The conductivity of solid electrolytes is also temperature dependent. But at very low temperatures, increase of impedance is modest, compared to that of the wet aluminium electrolytic capacitor.

Ripple ratings
These temperature and frequency effects on capacitor eesr reflect directly into the capacitors ripple ratings above room temperature. At lower temperatures, any ripple current generated heat serves to warm up the capacitor.
Every capacitor has an internal hot-spot maximum temperature that should not be exceeded. Frequently this cannot be measured, except by manufacturing test capacitors. A more practical method with aluminium electrolytics is to measure the surface temperature at the aluminium case end, under no plastic insulating material, using a 0.2mm wire, naked-bead thermocouple with PTFE insulation. Especially with wet aluminium electrolytic capacitors, hot-spot temperature directly influences the rate at which electrolyte evaporates through the end seals and thus capacitors life. End-seal materials are chosen to minimise electrolyte losses while allowing excess hydrogen to diffuse out, avoiding undue pressure build up.

Makers’ ripple current ratings are usually determined in practice by using 100Hz sinuosoidal waveforms. Consequently, other frequencies and non-sinusoidal voltage and current waveform requirements must be related to these 100Hz catalogue ratings, using appropriate methods.
Frequency this requires the current for each harmonic component be determined using Fourier transforms. Each harmonic’s current is determined from the capacitor’s actual eesr at that frequency and ambient temperature. The total capacitor power is calculated as the rms sum of these all powers. Designers interested in a step by step description of this process for calculating capacitor power dissipation for any repetitive waveform will find details in my April 1995 capacitor article. Alternatively, having calculated the rms current for each frequency, some makers specify suitable frequency correction multiplying factors. The rms sum of these corrected currents is then related to the 100Hz catalogue figures.
In many instances, the waveform may not be sufficiently repetitive, so these methods may not be possible. In that case, a conservative and long-standing rule of thumb is to assume any case temperature rise of less than 5°C should be acceptable. This is subject to the proviso that the case operating temperature at the maximum expected ambient temperature does not exceed the maximum service temperature of the capacitor.

Readers interested in this simplistic approach are referred to the IEC 834-4 or IEC 30 300 specifications. These provide tables of permissible case temperature rises for differing ambient temperature. Ripple-voltage peaks superimposed on any applied dc level must not exceed the capacitor’s rated voltage. The resulting current must not exceed the permitted ripple current at that frequency and with polar capacitors, no polarity reversal is allowed.

While capacitors generally have a small permitted surge voltage level, this is intended to cover equipment switch on conditions. It should not be used when calculating permitted ripple voltages. Should it become necessary to bank capacitors in series or parallel to provide the needed ratings, voltage and current sharing arrangements are essential to avoid premature capacitor failure. Whenever possible capacitors should be used de-rated from the permitted catalogue values. This extends service life. All capacitors — and especially electrolytics — provide a much improved service life if operated at a reduced operating voltage, and exhibit no adverse side effects.

Washing
Aluminium electrolytic capacitor end seals need to be taken into account when choosing a flux removal fluid so check the capacitor maker’s literature. In principle, any seal designed to allow hydrogen to escape might also permit ingress of chlorinated hydrocarbon solvents. Once inside the case, these could supply free chlorides, causing internal capacitor corrosion and leading to failure. Chlorinated hydrocarbon solvents, used to clean light metals like copper and aluminium quickly become scented unless frequently replenished. Acidified solvents cause considerable damage to many components, so must be avoided.

Capacitor mounting
It is common practice to conveniently mount large aluminium electrolytic capacitors, terminals in laps. In many constructions the hydrogen venting seal will then be mounted as the lowest point of the capacitor.
If the capacitor is used well within its voltage and ripple current ratings, having the vent at the bottom should not present a problem. If the device is used incorrectly though, excess gas build up can force electrolyte to exude — probably forcibly — from this venting seal. This usually results in corrosion damage to surrounding areas.

Capacitors designed to mount terminals down usually have a vent at the opposite end of the case from the terminals. For satisfactory service life, again the capacitor maker’s mounting instructions, voltage and ripple ratings should be observed.

References
5. Engineering Bulletin F-26093, Kenlon, PD Box 9928, Greenwich, CT06830, USA.
10. Technical Summary & Application Guidelines, AVX Tantalum
11. Capacitor Data CD rom.
12. Engineering Bulletin F-26093, Kenlon, PD Box 9928, Greenwich, CT06830, USA.
16. Technical Summary & Application Guidelines, AVX Tantalum
17. Capacitor Data CD rom.
18. Engineering Bulletin F-26093, Kenlon, PD Box 9928, Greenwich, CT06830, USA.
22. Technical Summary & Application Guidelines, AVX Tantalum
23. Capacitor Data CD rom.
24. Engineering Bulletin F-26093, Kenlon, PD Box 9928, Greenwich, CT06830, USA.
28. Technical Summary & Application Guidelines, AVX Tantalum
29. Capacitor Data CD rom.
30. Engineering Bulletin F-26093, Kenlon, PD Box 9928, Greenwich, CT06830, USA.
32. Data Handbook — Electrolytic Capacitors, pub. Philips
34. Technical Summary & Application Guidelines, AVX Tantalum
35. Capacitor Data CD rom.
36. Engineering Bulletin F-26093, Kenlon, PD Box 9928, Greenwich, CT06830, USA.
40. Technical Summary & Application Guidelines, AVX Tantalum
41. Capacitor Data CD rom.
42. Engineering Bulletin F-26093, Kenlon, PD Box 9928, Greenwich, CT06830, USA.
44. Data Handbook — Electrolytic Capacitors, pub. Philips
46. Technical Summary & Application Guidelines, AVX Tantalum
47. Capacitor Data CD rom.
48. Engineering Bulletin F-26093, Kenlon, PD Box 9928, Greenwich, CT06830, USA.
52. Technical Summary & Application Guidelines, AVX Tantalum
53. Capacitor Data CD rom.
The Low Cost Controller
That's Easy to Use

The K-307 Module provides the features required for most embedded applications:

**Analog**
- 4 Channels in 1 Channel out
- 36 Digital in or out & Timers

**Display**
- LCD both text and graphics
- Upto 2Mbytes available on board

**Memory**
- Many modes to choose from

**Development**
The PC Starter Pack provides the quickest method to get your application up & running.

**Languages**
- 'C', Modula-2 and Assembler

**Expansion**
- Easy to expand on a wide range of peripheral cards

**Other Features**
- Real Time Calendar Clock, Battery Back Up, Watch Dog, Power Fail Detect, STE I/O Box, 8051 interface, 68000 and PC Interface

Cambridge Microprocessor Systems Limited

---

**M&B RADIO (LEEDS)**
THE NORTH'S LEADING USED TEST EQUIPMENT DEALER

---

**Subscribe today!**
Guarantee your own personal copy each month

Save on a 2 year subscription

---

**Subscribe today!**
Guarantee your own personal copy each month

Save on a 2 year subscription

---

**ELECTRONICS WORLD**
June 1998
Challenger is a schematic capture and layout program with two autorouters. Versions with both larger and smaller restrictions than those shown in the availability information panel are available at various prices. At present, the schematic drawing and capture section, called ULTicap, is only available for dos, but the pcb layout section, ULTibord, is available in both dos and Windows. The external rip-up-and-try autorouter provided for the Challenger, ULTibord GXR, is designed for Windows. A dos shell, called naturally enough ULTishell, connects the various parts. For a product having sub-programs in dos and Windows, a shell is a good method of linking them.

Find out the facts about the new Windows versions of Ranger 2, and Ultimate's Challenger dos/Windows package in Rod Cooper's latest set of reviews.

Challenger

UK supplier; Ultimate Technology, Unit 1, Lodges Barn, Coxbury Lane, St. Brives, Gloucester GL15 6GJ. Tel. 01539 810100, fax 01539 810200.
Prices are £195 for 700 pin limit, £275 for 1400 pin limit.

ULTibord if you are using the autorouter.

There is no recommended hardware set-up, but both ULTicap and ULTibord are 32-bit, so this would indicate a 386DX minimum. Although I used a 386DX and it worked well.

The extra GKS graphics in Windows is an external add-on. Net-list files have to be transferred via a translator, GXR is again a 32-bit program.

Comprehensive literature is provided with the package in the form of four manuals, covering schematic capture, board design, a tutorial and a library reference for pcb footprints.

The books are not a native English translation but, given a few errors in grammar and spelling, are understandable.

Some versions of Ultimate software are protected by registration number, but some higher versions have a dongle. For more on dongles, see my first review in the October 1996 issue.

Schematic drawing

ULTicap is a typical menu-driven dos program. There is no GUI to temper the dos aspect as there is, for example, in Ranger 2 for dos. One positive result of this is that it gives a good screen drawing area. On a typical 14in monitor you can expect 9.5in by 6.5in of drawing space.

Figure 2 shows a typical screen during the compilation of the same test circuit used in the earlier review. Note a large cross-hair pointer replaces the more usual mouse arrow.

The package revolves around a central database. Whereas EDWin calls this plainly "the database," Ranger 2 calls it "the job," and in Ultimate it is referred to as "the project." It is important to realise this before starting off on a design.

The program has autosave, autosave, a 15-level zoom system, and a good electrical miles checker. All these work with typical dos speed and efficiency. The system is simple and logical - ie left-hand button starts an action, right-hand button escapes or terminates. The system can be set for metric or imperial units.

Initially, symbols are selected from the external database, although this is recommended as a text form. Library accessibility is only fair. For things like resistors and capacitors, there is no immediate way of knowing what the associated footprint is. This is found by cross-checking with the library editor.

The selection of symbols is good. There is also a good selection of pcb footprints to match. Although there is no parts bin, a "local" library system like that in EDWin performs a similar duty. Moving symbols around was easy, but rotating them less so. The method is to crank them round a fixed point using F2 on the keyboard. Again, this is very similar to EDWin. Text rotates with the symbol and rotating the text back to readability is cumbersome and takes time.

This is an area where things could be improved. Text is fully manipulable, but the circuit can be tidied up afterwards to make the circuit look good.

Wiring symbols is easy, and to make it even easier there is an straightforward auto-wire. Positive confirmation of connectivity is given when you make connections with component pins. However, I still managed somehow to produce a few "bad" nets using this system. It is possible to draw lines in space and these mistakes have to be deleted manually. Pressing the screen redraw does not clear them up. Moreover, they have to be deleted in segments, which is slow. There is a good connectivity checker which you can

PREVIOUS REVIEW SUBJECTS

PCB Designer: Nichi Software Ltd, tel 01432 355414 - reviewed September 1996.

PDAW Software Ltd, Germany tel +49 89 601592 - reviewed September 1996.

Labvolt, tel 01480 300695

MicroCode Engineering USA, UK agent - reviewed September 1996.

Number One Systems, tel 01480 461778

Software Ltd, Germany tel +49 89 6915352 - reviewed September 1996.

Labvolt, tel 01480 300695 - reviewed September 1996.

Electronic Workbench: Interactive Image Technologies Ltd Canada, tel. 00141 69 772 550 - reviewed October 1996.


Quickroute 3.5 Pro: Quickroute Systems Ltd, tel 0161 449 7101 - reviewed December 1996.

Prolab: Labcenter Electronics, tel 01756 753440 - reviewed December 1996.

Proteus: Labcenter Electronics, Schematic capture and pcb design - reviewed January 1997.


Fig. 1. The Ultra shell which ties in all the modules, including the parts in Windows as well as dos.

Fig. 2. Schematic of test circuit showing an ULTicap menu. Note good available screen area for drawing.

Fig. 3. Typical linear rat's nest produced from schematic capture.
Fig. 4. Ultimate Rat's nest of test circuit after manual sorting and transfer to Windows. Note the lace vectors which can aid component placement.

Fig. 5. The above rat's nest of Fig. 4 after routing with the GXR autorouter.

In my first set of reviews, Ranger 2 for dos was recommended for its good graphical user interface, overall competence, good pricing, and for offering a choice of autorouters. The subject of this review, Ranger 2 for Windows, has retained much of the character of the previous version, but the appearance has changed all recognition. One is the full-screen menus, the buttons labelled addpoint, libvol etc.

This approach to conversion to Windows contracts with Labcenter's Proves, which retained its dos format in Windows to the extent that dos users could convert immediately. Nevertheless, previous users of Ranger 2 will still recognize the characteristic style of Spectra products so conversion to the Windows version should not be a problem. Ranger 2 contrasts sharply with programs such as EDWin in use of icons. While EDWin uses a lot of icons, Ranger 2 uses relatively few. The main access to functions in Windows is via the full-screen menus. The screen of Fig. 1 shows a typical Ranger 2 screen and menus. I found the bias towards menus worked very well and was a refreshing change from over-screened programs.

This new version is intended for use with Windows 95 or NT. It comes on two 3.5M disks and you will need about 5Mbyte to install it.

The operator's manual is in the same style as the original, but much shorter and with a slightly better subject order. Of course, in a Windows program there is often a shorter manual because much more assistance is available in the Help menu. But in the version I tested the Help menu was empty. I am told that the Help text is being prepared and will be available.

The new Ranger 2 is still formulated around Spectra's...
the need to go back and delete, although it was not always perfect in operation. The command is not as well thought out in the Windows version.

Capture of the schematic is very much as before, with a parts list and wiring lists being created. The lists are in plain text - i.e. easily readable. You can export a PSpice list if you want to connect to a simulator, and import a Futurelist list.

Laying out a pcb

Having generated parts and wiring lists, the next step in Ranger 2 is to draw a pcb board outline and this is done with a simple sub-program in the artwork section. Both metric and imperial units are supported. Parts are interactively positioned inside this area, and the method is to place the components by hand as they appear simultaneously in one by one.

You will see from Fig. 2 that the current component being placed is listed in a box next to the icon. This remains a superior system to having component lists cramped in a line or in a heap. However, Ranger 2 is oriented towards being an automated system so Seetrax should be considering adoption of an automation system in the near future, to keep pace with the competition like Proteus, EDWin, TrakMaker. Force vectors should be considered as well.

A useful feature of Ranger 2 is that the power nets are shown in a different colour from signal nets - see Fig. 2. You might choose to route the power nets manually, as these often take routing precedence over signal routes, and having them shown separately makes this task easier. You could of course automate them on your own as well, particularly if there are a lot of them. Having them separated also helps to decide which method to use.

Manual routing of unplotted nets is done by the rubberbanding method. This is still not easy in the Windows version, and an attractive feature is the track placement is not given much priority in the Ranger 2 scheme. If you want to draw a board entirely using manual methods, I would recommend using a simpler program, such as PTA.

The rat's nest automatically optimises as the components are moved round. When a satisfactory placement has been achieved, you have to digitise before going on to the autorouter. If you want to simply route any tracks left unplotted by the autorouter after it has finished, it is necessary to de-digitise first to the "Undigitise" function. These extra steps of digitising and de-digitising remain over from the dos version and are not found in other programs.

Autorouter options

Ranger 2 for Windows has three autorouter options. The standard autorouter is a windowised version of the one provided in the dos version of Ranger 2 and will route double-sided boards. It will attempt single-sided boards but the test results put it into category C. The advantage of the standard autorouter is that it is easy to set up and quick to run.

The second autorouter is a Windows version of Seetrax's former 386 rip-up-and-retry autorouter. This is now referred to as the "Ripper" autorouter in the Windows program menus. With suitable configuration this could route the test boards, as shown in Fig. 3, putting it in category A - this router is capable of routing a single-sided board, or from two to six layers, and it can animate. Like the Dos version of this autorouter, setting up is comprehensive. A continuous system is used to keep track of the autorouter as it runs away from the direct route, making a change of direction, putting in vias etc.

Fig. 4. Typical set of menus for configuring the rip-up-and-retry autorouter. Setting up for optimum results takes some time.

well-grounded concept of "the job" so previous dos users will quickly pick up the threads of operation from this.

Schematic drawing

Figure 1 shows that although the screen layout has changed completely, the symbols and drawing style have not. Note the lack of scroll-bars. Planning is done by selecting this function on the edit menu and pointing with the mouse. Alternatively, you can use the space bar combined with the mouse pointer. Both methods work well. Multi-sheet schematics are supported.

There is no map showing where your circuit is on the page so if you want to get lost, but you can recover the circuit with the "view, full" from the view menu. There is no autosave facility yet: this is said to be under development.

Accessing the libraries is done by menus and is straightforward. Symbols are in text only, but if you want to see exactly what you are getting in graphical form before you use it, it is now possible to open library volumes and check. You can also check the associated pcb footprint with this method.

Library volumes are numbered, so if you want to know what they contain without going to the trouble of opening them, you have to refer to the manual. This could be improved. For example, the resistor volume could be labelled "vol 40 - resistors" instead of the cryptic "defaul.vol". The size and content of the libraries appear to be about the same as the former version, so are adequate for general purpose use.

Placing symbols is done via a parts bin - or tray in Seetrax language - and is smooth and well controlled. The tray can be toggled off to increase drawing area, which is a good idea. In fact, with no scroll bars, no map and the off-load parts tray, the screen's drawing area is good for a Windows program, at approximately 9.5 by 5.0 in on the 14in screen.

This router is capable of routing a single-sided board, or from two to six layers, and it can animate. Like the Dos version of this autorouter, setting up is comprehensive. A continuous system is used to keep track of the autorouter as it runs away from the direct route, making a change of direction, putting in vias etc.

Symbol text stays upright when symbols are rotated but is non-normative. Other text, such as power and signal references, can be moved.

Wiring symbols up is easy due to a strong "snap-to" function, combined with a good orthogonal system. Dragnet is in space is inhibited, but it is possible to draw "illegal" lines i.e. lines not connecting two component pins. This was prevented automatically in the dos version of Ranger 2 without

Technical drawing

Fig. 2 shows that although the screen layout has changed completely, the symbols and drawing style have not. Note the lack of scroll-bars. Planning is done by selecting this function on the edit menu and pointing with the mouse. Alternatively, you can use the space bar combined with the mouse pointer. Both methods work well. Multi-sheet schematics are supported.

There is no map showing where your circuit is on the page so if you want to get lost, but you can recover the circuit with the "view, full" from the view menu. There is no autosave facility yet: this is said to be under development.

Accessing the libraries is done by menus and is straightforward. Symbols are in text only, but if you want to see exactly what you are getting in graphical form before you use it, it is now possible to open library volumes and check. You can also check the associated pcb footprint with this method.

Library volumes are numbered, so if you want to know what they contain without going to the trouble of opening them, you have to refer to the manual. This could be improved. For example, the resistor volume could be labelled "vol 40 - resistors" instead of the cryptic "default.vol". The size and content of the libraries appear to be about the same as the former version, so are adequate for general purpose use.

Placing symbols is done via a parts bin - or tray in Seetrax language - and is smooth and well controlled. The tray can be toggled off to increase drawing area, which is a good idea. In fact, with no scroll bars, no map and the off-load parts tray, the screen's drawing area is good for a Windows program, at approximately 9.5 by 5.0 in on the 14in screen.

This router is capable of routing a single-sided board, or from two to six layers, and it can animate. Like the Dos version of this autorouter, setting up is comprehensive. A continuous system is used to keep track of the autorouter as it runs away from the direct route, making a change of direction, putting in vias etc.

Symbol text stays upright when symbols are rotated but is non-normative. Other text, such as power and signal references, can be moved.

Wiring symbols up is easy due to a strong "snap-to" function, combined with a good orthogonal system. Dragnet is in space is inhibited, but it is possible to draw "illegal" lines i.e. lines not connecting two component pins. This was prevented automatically in the dos version of Ranger 2 without

uous forms for each of the strategies listed 1 to 8 in this score sheet. Setting up may take longer than other autorouters, but to outweigh that, you have more control over the way that the autorouter functions.

Some abstract ideas such as axis overshoot, bend, and gravity strength and distance, are used in the strategy set-up. These are best read about in the manual, they take a little time to get accustomed to.

The third autorouter is Cooper & Clyde's Spectra SP2 for Windows. This is the most capable of the three and is also in category A. All the comments already made in my first review about this autorouter apply, and it should be noted that the track-spread option is included, and is no longer an extra. However, the security system for this autorouter still uses a dongle, and in addition, you need a password.

Seetrax has provided another of its excellent short-form interfaces with Spectra, so it is not really necessary to enter the Spectra program fully unless you especially want to. With this interface you can avoid learning another, very different program.

However, if you want master the intricacies of Spectra, you can run it separately. Three chunky Symbol operators manuals are provided should you wish to learn how to do this. I expect that most users will go for the soft option and stick to the Ranger 2 interface. This highlights the difference between the Spectra and the Seetrax Rip/retry autorouter.

The latter needs considerable input from the operator to configure it, whereas the Spectra is easy and quick to set up with the Ranger 2 interface and can still produce neat, very well routed boards.

Hard copy of a routed board is obtained via the Windows printer drivers or from Seetrax's own plotter driver. It is now possible to mirror the output from either. In the dos version this had to be done by means of Gerber input/output files. The plotter driver is suitable for HP or compatible and Household machines. There is no way to manipulate the plotter but a text file is produced for sending to the plotter. Output is done from the dos prompt but this is not made clear in the manual and there are no specific instructions for doing this. For those of you who are rusty on dos, I used the following command to get the plotter to run:

\C\SPECTRA \RSDPNT /D :LP0T A \SPECTRA.CRT

The plotter in this instance was LPT1, which is normally the printer port, and I copied the plotter file \SPECTRA.CRT in advance to a floppy drive, drive A, to avoid a long path entry.

This is a roundabout method of achieving plotting but it works. Spectra could improve this aspect, and should include extra advice in their manual about it. The results of using this plotter driver were good.

Printing out the artwork using the Windows Laser printer drivers also gave good results. The position and size of the artwork in relation to the page is shown on-screen before printing, so adjustment is particularly easy.

In summary

As most users are following the inevitable Windows trend, this version of Ranger 2 will undoubtedly attract buyers who would otherwise have passed by the dos version. No major new features over the dos version have been added. Seetrax has simply brought the dos version 2 into the Windows era and incorporated several items that were optional extras in the dos version into one package. The attractions are obvious; this is the lowest-priced unrestricted Windows program that offers a user-friendly schematic drawing program and a capa-
Neural networks and fuzzy logic

"What can neural networks and fuzzy logic tell us about the future of digital electronics?" asks Chris Macleod and Grant Maxwell.

Artificial neural networks and fuzzy logic are two popular modern technologies used to improve the performance of intelligent electronic systems. At first sight, the two appear quite different from each other, and also from standard digital electronics. This article explains why the technologies are actually very similar, but complementary to each other. It also looks at the possible future of intelligent electronics as a combination of the best of these existing techniques.

Artificial neural networks

Artificial neural networks achieved some early successes in fields such as pattern recognition, but it was quickly realized that they did not live up to the initial promise of real intelligence. During the early eighties, interest revived, and again neural nets are a popular subject of research. However, they have consistently failed to find their way into domestic or consumer products, and most design engineers are not aware of their possibilities.

Fuzzy logic was proposed in a paper by Lofti Zadeh in 1965. It was received with scepticism by the engineering control community, typical comments being that it was common sense and 'just' statistics.

Fuzzy logic

Fuzzy logic is most often applied to control systems. The term 'fuzzy' arises from the fact that the system uses continuous as opposed to discrete inputs.

The fuzzy logic system is basically an expert system, in which a continuous input is assigned a membership of several sets. These values are then operated on by inference engine and the result, which is also continuous, is used to control the system.

Fuzzy logic systems show several advantages over conventional control systems. These include ease of design, and better performance in many systems such as speed controllers in lifts and vehicles. In a speed controller, the continuous nature of Fuzzy logic causes the motor to speed up and slow down more smoothly.

Neural nets, fuzzy logic and digital electronics

These systems all appear quite different from one another, but are actually very similar. In the case of combinational digital electronics, the binary inputs are mapped onto binary outputs, but Fuzzy logic maps a continuous input to a continuous output, Fig. 5. The system accepts a continuous input rather than a discrete input - as in the case of 'normal' digital electronics. First, consider the functions of normal logic represented as Venn diagrams, Fig. 6.

In terms of normalised voltage levels these represent MAX, MIN, and COMPLEMENT functions, Fig. 7. These functions are actually used within the fuzzy logic inference engine. Such a simple system, operating on continuous voltage levels, has important advantages:

- it decomposes to normal logic if the inputs are 1 and 0.
- Consider the Boolean expression A+B(A+B) which reduces using normal methods to A+B, then take a look at Table 1. You can see that the continuous logic gives the same answer as the standard discrete logic; this can be shown in every case.
- It may be arithmetically manipulated in the same way as normal logic.
that systems designed using fuzzy digital electronics behave in a very similar way to neural networks or fuzzy logic, and further that 'hard' digital logic is a special case of 'fuzzy' digital logic.

The other main difference between standard logic and neural networks is that neural networks learn mappings through a training cycle; the other two systems have a designed structure. However, it is possible to design fuzzy digital logic systems that can learn.

One way this can be achieved is by implementing a training algorithm that adjusts the threshold of the MAX and MIN functions of the gates to minimise the output error. You can therefore envisage a compound system neuro-fuzzy digital electronics. This would have all the advantages of Boolean logic — for example, easy mathematical manipulation — but have continuous outputs and be trainable in the manner of a artificial neural network.

Looking even further ahead, the design of the neural processing elements is based somewhat loosely on the structure of biological neurons. This association has caused many workers to only consider models which are biologically feasible and this may have hamstrung researchers somewhat — in fact it has almost become an ideology. Future networks may take a much more rigorous view of neural units, and allow them to have designed or evolved processing capabilities. The end result may be a general technology — a new electronics, one stage beyond neuro-fuzzy digital electronics — which has all the advantages of the previous examples without any of the disadvantages.

The example above shows that the continuous logic reduces discrete logic if the levels are forced to their maximum and minimum values, in general:

\[ A \lor B = A \lor B \]

\[ A \wedge B = A \wedge B \]

and they may be manipulated as such.

- It degrades gently. Consider the case \( A \lor B \), where a high input to a continuous logic gate is 0.7 and low 0.2

\[
\begin{align*}
A &= 0.2 \\
B &= 0.2 \\
A \lor B &= 0.7 \\
A \wedge B &= 0.2 \\
A' &= 0.7 \\
B' &= 0.3
\end{align*}
\]

- Mathematical logic circuits continue to fulfil their functions. Consider the half adder in Fig. 8. The XOR is implemented as \( A \lor B \).

\[
\begin{align*}
A &= 0.2 \\
B &= 0.2 \\
A \lor B &= 0.7 \\
A \wedge B &= 0.2 \\
A' &= 0.7 \\
B' &= 0.3
\end{align*}
\]

- The final advantage is that such a system interfaces naturally with the analogue world.

This type of system has the advantages already pointed out for fuzzy logic; because it produces intermediate outputs. When used as a controller, it allows outputs to change gradually.

- In summary

Looking at the modern techniques, neural networks and fuzzy logic, these technologies give two important advantages over traditional Boolean logic gates.

One advantage is that neural networks can learning from example, so no detailed design is involved. Secondly, neural networks and fuzzy logic operate with continuous signals. As we pointed out earlier, the continuous nature of signals gives the system certain useful properties. It causes the system to degrade gently in the presence of noise. It means that systems such as lifts slow down and speed up gently — it interfaces better with the natural world. The continuous nature of the signal also makes the system somewhat more fault tolerant.

As you have seen, standard digital logic is a special case of fuzzy digital logic. This means...
Trac competition winner

Ben Sullivan's winning entry from the Fast Analog Solutions TRAC design competition is a synchronisable 400Hz three-phase generator with an out-of-lock indicator for testing aircraft equipment.

400Hz in three phases

In the main, modern aircraft electrical systems are 200V three phase supplies running at 400Hz. When designing, testing and repairing of such instruments, there is a need to power them on the bench, away from their normal supply.

In the early days, a 400Hz alternator, driven by a main electric motor was used. But electronic supplies have long been preferred on various grounds. These include Drivability, reliability, the option of synchronising the source with an external 400Hz pilot signal, and of course, the absence of acoustic noise.

An electronic 400Hz three phase supply consists of a bank of three high power audio amplifiers plus their associated dc supplies, driven by a suitable exciter. This note describes the implementation of a 400Hz three phase exciter, using the TRAC device.

Circuit description

The exciter uses a state-variable filter as the basis of a 400Hz oscillator. The filter section consists of auxiliary elements at pins 9, 13 and 17, providing high, low and band-pass outputs HP, LP and BP respectively, Fig 1.

The band-pass output is attenuated by 20dB – i.e. a change in its actual amplitude. The result is a low-distortion sinewave at the band-pass filtered output, due to the operating Q of the circuit.

The Q enhances the fundamental component of the positive feedback signal by 20dB, while the action of the integrator Exc 13 attenuates the third harmonic component by 9dB. As the third harmonic content of the positive feedback signal is in any case only one third the amplitude of the fundamental, the harmonic content of the filtered sinewave at the BP output is only around 1%, the harmonic content at the LP output being of course lower still.

Exc 25 scales the BP output down by 50%, while Exc 31 produces an output of 86.6% of the LP output. Combining these in 39 40K
do produces an output at 120° to the BP output. Similarly, combining a negative version of the output at 31 with the output of Exc 25 provides the third harmonic component. The outputs at pins 12, 37 and 41 – scaled to an appropriate level if necessary – drive the inputs of the three high power audio amplifiers.

In hardware, the three-phase oscillator runs as described. In simulation, a small input applied to pin 1 is necessary to start oscillation. The amplitude of the positive feedback signal stabilises within a few cycles of start-up, due to the large gain in the limiting amplifier Aux 26.

The three-phase outputs, however, build up more slowly, at a rate determined by the Q of the filter. In hardware, pin 1 may also be used to inject a low-level locking signal, either sine or square wave, to be used to synchronise the three phase output with other equipment in use at the same time. Provided the frequency difference is not excessive, the state variable filter oscillator will pull in, or be driven off, the injected external frequency.

Increasing the amplitude of the injected signal increases the frequency range over which lock can be maintained. Designing the oscillator to operate at a lower Q will also increase the frequency range over which lock can be maintained, but at the expense of an increase in harmonic content.

Locked, or not?

When operating with the supply synchronised with an external signal, it is important to know whether the circuit is properly synchronised, or whether lock has been lost. This is achieved in conjunction with a dual retriggerable monostable, not shown.

The external sync signal is applied to log stage 45, which produces a squared up version, approximately independent of its actual amplitude. This is attenuated by 36dB by Aux 49, differentiating by Aux 53 and the positive spikes selected by Rec 55.

The BP signal is processed similarly by items 40-50, and the two sets of spikes appear combined at pin 5. The characteristics of this pulse train produce a means of detecting the "out-of-lock" condition as described below.

When the frequency of the external signal equals the free running frequency of the oscillator, the BP output will be in phase with the external input. When there is a small difference, lock will be maintained, but with a standing phase shift between the two. As the frequency difference increases, so does the standing phase shift, up to a maximum of 90°. With a larger frequency difference, lock is lost, and a beat frequency appears.

The period of the 400Hz waveform is 2.5ms. When the oscillator is in lock, the phase shift between its BP output and the locking signal cannot exceed 90°. There will therefore be "pulsing" of the pulses at pin 5, the gap between peaks being at least 1.875ms – i.e. 75% of 2.5ms.

Positive going spikes at pin 63 are applied to a retriggerable monostable with a period of 1.6ms. As a result, it

ELECTRONICS WORLD June 1998
TRACE TEKTRONIX

**ACTIVE**

Discrete active devices

Power transistors, shown in curves at least 13dB at up to 30W and is line driven at up to 1GHz. It is designed for a 28V supply and has a maximum dissipation of 1300W. The device has an advantage over bipolar types in that it can be directly driven from a logic gate output. It is suitable for use in all frequencies above 1GHz. The device is available in the TO-99 package.

**Memory chips**

BiMOS and BiMOS-370: Two new memory chips from Micron Technology. Micron's M77524K12A7V.G7 device has a new, fast 3.3V CMOS input/output interface that allows it to be driven by 5V CMOS logic. The device is available in a 32-pin quad flat pack and has a maximum operating frequency of 200MHz. The device is available in a 32-pin quad flat pack and has a maximum operating frequency of 200MHz.

**Linear integrated circuits**

Power op-amps. The M8500-series of monolithic power op-amps is available in a wide range of packages, including the M8501, M8502, M8503, and M8504.

**Microprocessors and controllers**

C-programmable controller. The M168X series of C-programmable controllers is available from Microchip Technology. The device is available in a 32-pin DIP package and has a maximum operating frequency of 10MHz. The device is available in a 32-pin DIP package and has a maximum operating frequency of 10MHz.

**Passive components**

Capacitors. A new range of tantalum electrolytic capacitors from Elna. The devices are available in a range of values from 1µF to 100 µF and have a maximum operating voltage of 63V. The devices are available in a range of values from 1µF to 100 µF and have a maximum operating voltage of 63V.

**Motors and drivers**

Microstepper drive. Digikey's CD65-500 has a 7.7A output, yet is contained in a 127 by 91 by 4mm module. Outputs are optimised for 5V and 12V. These drives are being used for economic and effective motor operation. Operations may be selected for a specific voltage: 24V or 12V. The device is available in a 32-pin quad flat pack and has a maximum operating frequency of 200MHz. The device is available in a 32-pin quad flat pack and has a maximum operating frequency of 200MHz.

**Programmable logic arrays**

2000-series gate arrays. Altera's new range of 2000-series gate arrays is available in a variety of packages, including the 2000-series QFP and TQFP packages.

**Power semiconductors**

Power modules. Power modules from Fairchild are available in a range of packages, including the 32-pin QFP and TQFP packages.

**Cameras**

Miniature camera module. Computar's 405FU is a color camera measuring 35 by 43 by 20mm and intended for use in security or multimedia work. It generates a composite video output and has a range of applications, including security and multimedia. The camera measures 35 by 43 by 20mm and has a range of applications, including security and multimedia.

**New Products Classified**

Please quote "Electronics World" when seeking further information.

---

**NEW PRODUCTS CLASSIFIED**

**ACTIVE**

Discrete active devices

Power transistors, shown in curves at least 13dB at up to 30W and is line driven at up to 1GHz. It is designed for a 28V supply and has a maximum dissipation of 1300W. The device has an advantage over bipolar types in that it can be directly driven from a logic gate output. It is suitable for use in all frequencies above 1GHz. The device is available in the TO-99 package.

**Memory chips**

BiMOS and BiMOS-370: Two new memory chips from Micron Technology. Micron's M77524K12A7V.G7 device has a new, fast 3.3V CMOS input/output interface that allows it to be driven by 5V CMOS logic. The device is available in a 32-pin quad flat pack and has a maximum operating frequency of 200MHz. The device is available in a 32-pin quad flat pack and has a maximum operating frequency of 200MHz.

**Linear integrated circuits**

Power op-amps. The M8500-series of monolithic power op-amps is available in a wide range of packages, including the M8501, M8502, M8503, and M8504.

**Microprocessors and controllers**

C-programmable controller. The M168X series of C-programmable controllers is available from Microchip Technology. The device is available in a 32-pin DIP package and has a maximum operating frequency of 10MHz. The device is available in a 32-pin DIP package and has a maximum operating frequency of 10MHz.

**Passive components**

Capacitors. A new range of tantalum electrolytic capacitors from Elna. The devices are available in a range of values from 1µF to 100 µF and have a maximum operating voltage of 63V. The devices are available in a range of values from 1µF to 100 µF and have a maximum operating voltage of 63V.

**Motors and drivers**

Microstepper drive. Digikey's CD65-500 has a 7.7A output, yet is contained in a 127 by 91 by 4mm module. Outputs are optimised for 5V and 12V. These drives are being used for economic and effective motor operation. Operations may be selected for a specific voltage: 24V or 12V. The device is available in a 32-pin quad flat pack and has a maximum operating frequency of 200MHz. The device is available in a 32-pin quad flat pack and has a maximum operating frequency of 200MHz.

**Programmable logic arrays**

2000-series gate arrays. Altera's new range of 2000-series gate arrays is available in a variety of packages, including the 2000-series QFP and TQFP packages.

**Power semiconductors**

Power modules. Power modules from Fairchild are available in a range of packages, including the 32-pin QFP and TQFP packages.

**Cameras**

Miniature camera module. Computar's 405FU is a color camera measuring 35 by 43 by 20mm and intended for use in security or multimedia work. It generates a composite video output and has a range of applications, including security and multimedia. The camera measures 35 by 43 by 20mm and has a range of applications, including security and multimedia.
NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information.
Please quote "Electronics World" when seeking further information.
Modern crystal in Spice

At higher pressure levels, for example, 90 to 100dB, very little or no bass lift is needed, confirming the normal frequency characteristic of the built-in equalizer. In other words, our hearing becomes flatter at higher sound levels.

Amplifier designers of the late fifties and sixties almost always included a bass boost control for the ear’s non-linearity. Why is it no longer considered a useful addition? A loudness-overdrive switch would keep those with ‘flat ear’ happy.

Confused? Read this...

In the letters section of Electronics World, February 1998, Malcolm Brown stresses the need to faithfully check code, which he totally agrees with. However, he also suggests that assembler kits can kill: this is worrying since the following are equivalent and would work just as well.

The comparison instruction for the AX register will always take the form ‘0x3D,0xNN,0xMM’. Here, NN and MM are the two closely spaced modes is particularly valuable for SC cut resistance models to establish the activity of quartz crystal maintaining circuits, as described by Tele Quarz.

Amplifier designs of the late fifties and sixties were responsible for the ear’s non-linearity. Why is it no longer considered a useful addition? A loudness-overdrive switch would keep those with ‘flat ear’ happy.

Confused? Read this...

In the letters section of Electronics World, February 1998, Malcolm Brown stresses the need to faithfully check code, which he totally agrees with. However, he also suggests that assembler kits can kill: this is worrying since the following are equivalent and would work just as well.

The comparison instruction for the AX register will always take the form ‘0x3D,0xNN,0xMM’. Here, NN and MM are the two closely spaced modes is particularly valuable for SC cut resistance models to establish the activity of quartz crystal maintaining circuits, as described by Tele Quarz.
In today's crowded radio spectrum, it is all too common for radio users to experience interference, the causes of which can be complex. Alan Wood details potential sources of interference in telemetry applications, and suggests possible solutions.

Interference on radio links falls into three categories. There is interference internal to the radio and associated electronics, interference classed as 'in-band' and interference that is described as being 'out of band'. Reference timing clocks in associated equipment are a source of internal interference. Modern electronic equipment invariably contains a clock for timing purposes. Quite often such clocks are derived from a high-frequency crystal that is divided down to match the lower frequency of the circuitry in use.

It is possible for higher multiples or harmonics of the clock source crystal to fall on the exact frequency that a radio link is attempting to operate on.

Modern high-quality radio uses a heterodyne or mixing technique to convert the high-frequency rf or vhf signals to a lower frequency that can be filtered and processed more readily. Typically this will be a conversion to 45MHz, 21MHz or 10.7MHz, followed by a second conversion to 25kHz and this were to pass through into the receiver local-oscillator signal would create a problem if this is the frequency being used.

At my company, we use test procedures to bring such problems to light and cure them before any product is issued.

Power-supply ripple

Modern equipment often has a switch-mode power supply to ensure maximum power efficiency. Switch-mode power supplies are electronic-chopper circuits that create an ac waveform from a dc input to allow it to be transformed to a new potential where it can be rectified and smoothed back to dc.

This process causes switching noise at the chopper frequency. A great deal of care is needed to ensure that this noise is fully filtered and suppressed from the power supply lines to the radio module. Also, careful choice of switching frequency is needed.

If, for instance, the switching frequency was 25kHz and this were to pass through into the transmitter, it could cause spurious sideband signals at 25kHz intervals around the main carrier output. Any receiver listening to adjacent channels would hear these as interference signals. Likewise, a 25kHz ripple on the receiver local-oscillator signal could create a whole array of mist local-oscillators on the adjacent channel frequencies, causing overlying of many channels onto the wanted one.

Careful filtering of the supply to the module is therefore essential. Al Wood & Douglas modules accept an unstabilized supply since they incorporate stabilisation and filtering. However, it is difficult to ensure total immunity to all possible frequencies that could be carried on the power supply wiring.

In-band interference

In-band interference can be defined as problems due to signals within the radio pass-band of the module in question.

On-channel interference is the worst and most obvious form of interference. It occurs when one user has chosen exactly the same frequency as another user. It can be most frustrating to verify this type of interference if the other signal is intermittent, or if it has a duty cycle and leads to data loss on the required link for no apparent reason.

A site radio survey is needed to identify the existence of this type of interference, to locate its source and, if necessary, its legality. Data corruption can then be logged and plotted to determine when and how often the problems occur. Is it only during working hours? Is it at the same time each day or hour, etc?

Having traced the source and its legality, there may be potential to negotiate with the other user to modify their power output levels or the antenna configuration to reduce the impact on your service. It may also be possible to improve your receiving site's immunity to the interference by use of directional antennas, or by changing from vertically polarised antennas to horizontal or vice versa.

Remember, though, that this type of signal is always going to be there and is not a characteristic of the equipment being used. Of course, the technical specification of the radio may be too good and cause it to be too sensitive. Attenuation in the antenna lead, which would reduce sensitivity and transmitted power, might help.

Radio telemetry modules that we make are capable of letting you hear what is on the chosen frequency by simply connecting to the recovered audio output with a high impedance ear piece or small speaker driven amplifier. This is a simple method of monitoring the frequency but very effective.

Adjacent-channel interference

The vhf and uhf radio spectrum is divided up into channels spaced either 12.5kHz or 25kHz apart. The channel either side of the one you have chosen is the adjacent channel.

The ability of your receiver to only listen to the signal on the required frequency, while ignoring any signals on the adjacent channels and beyond, is called the selectivity of the receiver, or adjacent channel rejection.

The ability of the receiver to discern only the channel you wish is a reflection of the filtering of the first and second intermediate conversion frequencies. More filtering will ensure better rejection of signals on adjacent channels and typically, figures of 60dB should be sought to ensure relatively trouble-free operation.

What does this mean in practice? It simply means that a signal on the adjacent channel has to be one million times bigger than the wanted one.

Solving this type of problem requires the implementation of some form of in-band or out-of-band filtering. The higher the order of the filter, the lower the gain of the unwanted signal at the desired frequency. Typical filter gain values are 20 and 30dB and such filters would be placed in the radio module.

In addition, the adjacent channel rejection of the radio module could be improved by positioning the antenna to improve the signal to noise ratio to the degree that the wanted channel becomes the dominant signal.

Careful design of the radio module is therefore essential to ensure that it can operate in a hostile environment.
RF DESIGN

Third-order intermodulation-free amplitude of wanted to unwanted local-oscillator to intermediate-frequency conversion, no amount of receiver due to its mathematical relationship will allow lots of signals, including the signal you want, through to the first rf amplifier stage. To avoid the array of inputs causing the receiver to go into overload, the front end device, and subsequent stages, will generally need a significant amount of supply current passed through it.

Therefore, a radio designer designed for low current operation won't be as effective on this basis as a manner with a higher intermodulation performance. This is important to note if you're considering radio spectrum. Typically 5-10mA will be needed in each stage to ensure relatively trouble free operation.

Check the manufacturer's total current consumption or a specific intermodulation specification: some receivers offered on the market consume only 5mA in total. A figure of 50mW minimum is ideal for a really good product, a figure of 65dB is typical.

Desensitisation. Desensitisation is a dynamic effect caused by strong signals in band, rather than on the operating frequency. These signals totally overpower the front end of the receiver causing it to partially or fully shut down. This leads to a loss in sensitivity and a reduction in the strengths of the signals that the receiver is trying to hear. It can be heard as sudden 'silence' on the receiver audio.

An example of this is when MPT1329 telemetry products operating at 45MHz, or does 356MHz mixed with 410MHz. This second frequency, which is acceptable to the IF, is called the image frequency. If the receiver front end filter does not reject any signals on this image frequency, they will pass through and be just as acceptable to the IF processing electronics as the required signals, causing a problem in the phase-shifted mixing components in the receiver.

In summary

If you want a robust, reliable device to withstand today's demanding telemetry bands, then you may pay attention to and ask questions about those confusing spec sheet parameters such as intermodulation, blocking, desensitisation, image rejection and adjacent channel rejection. The success and reliability of your radio link may depend on it. But so will the price.
Lateral Connections

At the forefront...

We are one of the market leaders for recruitment in the RF, mobile radio and telecommunications fields. We currently have a wide range of opportunities with a high level of client requirement, to enhance all disciplines and at all levels and in this advertisement is all we can do to give you a flavour of what is available.

If you interested on one of our opportunities and would like to give your career a kick-start, send us your CV, either by post, fax or e-mail and one of our consultants will contact you to discuss the situation. If you cannot see what you are looking for check out our web site which currently details more than 200 opportunities.

RF DESIGN ENGINEERS to £50,000 + South

This client is an internationally renowned consultancy, specialising in communications, especially mobile co...
GSM NETWORKS
Systems Specialists

Technical expertise in cellular switching, signalling or radio systems and excellent communication skills will enable you to specify the future architecture and technical strategy of the most dynamic European mobile networks.
One of the top 5 infrastructure companies heavily investing in people & technology to work directly alongside operators key specialists.

Ref: AW/10

RFIC DESIGN TELECOM APPPS
UK/Europe/USA
Excellent Package

A background in digital design will enable you to join the dynamic organisation working on leading edge electronics hardware and software technology for embedded processor design.

Ref: ML/10

MICROCONTROLLER DESIGN
Europe/USA
Excellent Package

As a result of significant investment in Europe, a broad new design centre dedicated to microcontrollers has been opened by one of the world leaders in electronics. They now seek experienced design engineers to work on next generation microcontrollers.

Ref: ML/11

SOFTWARE TEAM LEADER
GSM RADIO PLANNING TOOL

South West
Excellent Package

International, growing rapidly expanding telecoms company now seeking experienced software developers to lead a team of software engineers to design network planning tool software. Opportunities to work with market leaders across the world.

UNIX/C, X-Windows, Embedded SQL, central, GSM and team management experience preferred.

Ref: AR/11

ELECTRONICSAPPOINTMENTS

Tel: 0181 652 3620

To find out more about these opportunities, please telephone quoting reference number on 01273 820911 until 7.00pm this week or next. Alternatively, post / fax / email your CV to:
Quest Recruitment Solutions Ltd
24-26 Meeting House Lane
The Lanes
Brighton
East Sussex
BN1 1HB
Tel: 01273 820911
Fax: 01273 820922.
E-mail: quest@pavilion.co.uk
Web: www.questsolutions.co.uk

ELECTRONICS APPOINTMENTS

Tel: 0181 652 3620

£45K

Superb opportunities for ENGINEERS

* RF
* MICROWAVE
* ANTENNA
* RADIO SYSTEMS

Our clients are world leaders in the design, manufacture and support of mobile communication systems and they are all expanding rapidly. Consequently they can offer a broad range of career opportunities both Permanent and Contract.

Call the STS Recruitment team now to see what is available and what it could mean to you, there’s never a better time than the present.
### ADVERTISERS' INDEX

| ADEPT SCIENTIFIC                  | 473 |
| ANCHOR                            | 494 |
| AIRLINK                           | 518 |
| BOLTON INSTITUTE                  | 457 |
| CMS                               | 504 |
| COLOMORE                          | 477 |
| CONFOR                            | 463 |
| CROWNHILL                         | 477 |
| DATAMAN                           | 461 |
| DISPLAY ELECTRONICS               | 523 |
| EQUINOX TECHNOLOGY                | 463 |
| HART ELECTRONICS                  | 525 |
| JOHNS RADIO                       | 493 |
| JGP ELECTRONICS                   | 518 |
| LABCENTER ELECTRONICS             | 452 |
| LANGREX                           | 479 |
| M & B RADIO                       | 504 |
| MILFORD INSTRUMENTS               | 457 |

**NUMBER ONE SYSTEMS**

| NUMBER ONE SYSTEMS                | 472 |

**OLSON ELECTRONICS**

| OLSON ELECTRONICS                 | 450 |

**PICO**

| PICO                              | 479 |

**PS CONSULTANTS**

| PS CONSULTANTS                    | 08C |

**QUICKROUTE**

| QUICKROUTE                        | 455 |

**SEETRAX**

| SEETRAX                           | 455 |

**SOWER TRANSFORMERS**

| SOWER TRANSFORMERS                | 477 |

**SPEAKE & CO LTD**

| SPEAKE & CO LTD                   | 479 |

**STEWARD OF READING**

| STEWARD OF READING                | 477 |

**SURREY ELECTRONICS**

| SURREY ELECTRONICS                | 463 |

**TANDEM TECHNOLOGY**

| TANDEM TECHNOLOGY                 | 457 |

**TECHNOLOGY SOURCES**

| TECHNOLOGY SOURCES                | 457 |

**TELFON ELECTRONICS**

| TELFON ELECTRONICS                | 491 |

**TELNET**

| TELNET                            | 505 |

**THOSE ENGINEERS**

| THOSE ENGINEERS                   | 515 |

**TIE PIE**

| TIE PIE                            | 484 |

**WARTH**

| WARTH                             | 463 |

---

**SUPPLIER OF QUALITY USED TEST INSTRUMENTS**

<table>
<thead>
<tr>
<th>SUPPLIER OF QUALITY USED TEST INSTRUMENTS</th>
<th>SUPPLIER OF QUALITY USED TEST INSTRUMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPPLIER OF QUALITY USED TEST INSTRUMENTS</td>
<td>SUPPLIER OF QUALITY USED TEST INSTRUMENTS</td>
</tr>
</tbody>
</table>

**CONTACT**

<table>
<thead>
<tr>
<th>Unit Four, Fordingbridge Site, Barnham, Bognor Regis, West Sussex, PO22 0HD, U.K.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tel: (+44)01243 545111/2 Fax: (+44)01243 542457</td>
</tr>
<tr>
<td>Web: <a href="http://www.cooke-int.com">http://www.cooke-int.com</a></td>
</tr>
</tbody>
</table>

E-mail: info@cooke-int.com

CIRCLE NO. 137 ON ADVERTISERS' INDEX
New for '98
FREE Data Acquisition Software Tool
DAQ Designer '98 from National Instruments, is a free system configuration tool that reduces the complexity and time it takes to configure a PC-based data acquisition system and assures that system developers have the right plug-in boards, signal conditioning products, cable accessories, and software packages for their application.
Call National Instruments now for your FREE copy on 01905 522345

CABLING SOLUTIONS FROM THE LCD EXPERTS
Trident Microsystems' new LVDS system provides the cabiling solution to overcome all the problems associated with driving Digital TFT over long distances.
Trident's new LVDS system now allows for digital drive of up to 80 metres in length.
For further details call Trident today
Tel: 01737 790790
Fax: 01737 771908

NEW JENSEN TOOLS CATALOGUE
Colourful new catalogue, hot off the press from Jensen Tools, presents unique new tool kits for service/support of communications equipment. Also latest test equipment from many major manufacturers. Includes hard-to-find tools: PCL/LAN diagnostics, bench accessories, static control, technical manuals and more. Ring 0800 833246 or Fax 01737 771908 for a free copy.
Jenner Tools, 10-12 Reavens Way, Northampton NN3 6UZ

Professional Test & Measurement Equipment
Rafe Electronics are suppliers of high end professional T&M equipment on a second-hand basis.
We specialise in stock and sourcing, HP, Tektronix, Marconi etc.
012029029 quality assured.
Call or fax us for our stock inventory or download it from: www.rafe-electronics.co.uk
Tel: +44 1382 423 593 Fax: +44 1382 800 800

EQUINOX TECHNOLOGIES
Educational Computing - AVR Basic
• Target speeds comparable to small single chip microprocessors
• Compiles BASIC on-line to AVR machine code
• 8051 Previewed

Over 170,000 buyers are using the UK Kompass Register every day to find companies like yours.
Is it you they're finding or your competitors?
To advertise in the next edition, simply fill in the coupon and post it back today to:
Real Business Information, Windsor Court, East Grinstead House, East Grinstead, West Sussex RH19 1XD
or Fax it on 01342 333747

Available to book and CTR-Prompt versions and also on the internet.
www.kompass.com

Contact Joneh Cox on 0181 622 3620

A regular advertising feature enabling readers to obtain more information on companies' products or services.
Is this the end of wireless as we know it?

Couple all the power of the latest Windows PCs (not just the fraction that you can squeeze down an RS232 connection) to the latest synthesised receiver design techniques, and you'll get the ultimate in wide range, all mode programmable radio reception.

The WR3000iDSP include AD hardware signal processing for total signal processing.

WinRADiO™ provides a complete communications system on a full-length ISA PC Card, with software for Windows 3, NT or 95.

New optional Digital Suite software includes facilities for recording, audio spectrum, packet radio, oscilloscope display, HF fax, Squelch-controlled Audio Recorder and Playback, Signal Classifier, DTMF, ACARS, CTSS - use with SoundBlaster™ compatible audio cards.

Use WinRADiO™ scanning PC communications receiver systems for...

Broadcast • Media monitoring • Professional and amateur radio communications • Scanning
Spot frequency and whole spectrum monitoring • Surveillance (and recording) • Instrumentation

Model No

<table>
<thead>
<tr>
<th>Construction</th>
<th>Frequency range</th>
<th>Modes</th>
<th>Tuning step size</th>
<th>IF bandwidths</th>
</tr>
</thead>
<tbody>
<tr>
<td>WR-1000i</td>
<td>Full length ISA card</td>
<td>0.5-1300 MHz AM,SSB,CW,FM-N,FM-W</td>
<td>10 kHz (5 Hz BFO)</td>
<td>6 kHz (AM/SSB), 17 kHz (FM-N), 270 kHz (FM-W)</td>
</tr>
<tr>
<td>WR-3000i-DSP</td>
<td>Full length ISA card</td>
<td>0.15-1500 MHz AM,LSB,USB,CW,FM-N,FM-W</td>
<td>100 Hz (10 Hz for SSB and CW)</td>
<td>2.5 kHz(SSB/CW), 9 kHz (AM), 17 kHz (FM-N), 270 kHz (FM-W)</td>
</tr>
</tbody>
</table>

Receiver type
PLL-based triple-conv superhet

Scanning speed
10 ch/sec (AM), 50 ch/sec (FM)
200mW
8 cards
65 dB
no
yes
yes
yes

Audio output on card
Max on one motherboard
Dynamic range
IF shift (passband tuning)
DSP in hardware
IRQ required
Spectrum Scope
Visitune
Published software API
Task Manager/scheduler
Audio Recording/Playback
Signal Strength Recorder
Logger

Price (ex VAT)
£275
£995

Digital Suite Software £69
£69

New! Digital Suite Software option- only £69+vat (requires a SoundBlaster 16 compatible sound card), and currently features facilities for:

- WEFAX / HF Fax
- Packet Radio for HF and VHFs
- Aircraft Addressing and Reporting System (ACARS)
- Audio Oscilloscope, real time Spectrum Analyzer with calibration cursors
- Squelch-controlled AF Recorder and Playback
- DTMF, CTSS decode and analyse

WINRADiO and Visitune are trademarks of WinRADiO Communications pty.