Fuel-saving ignition breakthrough

Understanding capacitors
MPEG quality issues
New noise theory
Microstrip made easy
Design heat sinks in minutes
PC i/o for Windows
Internet

ISDN for all? See page 971
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 extendible)
- 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

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

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

CIRCLE NO. 182 ON REPLY CARD
Contents

982 BRIGHT SPARKS
Michael Ward's radically-new ignition system leads to a simpler, cleaner and more efficient petrol engine. And with the anti-pollution laws tightening up world wide, the big boys might just be forced to listen to him.

990 HANDS-ON INTERNET
Cyril presents tips for speeding up your searches plus news of circuit simulation software to be found on the net.

994 A WINDOW ON ANALOGUE I/O
Driven via the pc's printer port, Colin Attenborough's 12bit analogue i/o subsystem was designed with Windows control in mind.

998 UNDERSTANDING CAPACITORS
Most engineers know which type of capacitor to choose for a given job - but do they know why? Cyril Bateman explains.

1005 NEVER MIND THE QUALITY FEEL THE BANDWIDTH
John Watkinson explains how most movie frame sequences lend themselves to MPEG coding, but others certainly don't.

1013 SEEING THROUGH NOISE II
Breaking new ground, Patrick May shows how electrons emitted from the surface of a thin metal film equate to 1/f noise.

1017 SPEAKERS' CORNER
John Watkinson looks at the pitfalls of specifying the most difficult component in the audio chain - the loudspeaker.

1019 MICROSTRIP MADE EASY
Nick Wheeler shows how designing a microstrip line board can be very simple for most applications.

1022 RADIO REFLECTIONS FROM RUSSIA
One of the world's oldest technical museums, in St Petersburg, holds a wealth of early British wireless equipment, as Khatske! Ioffe explains.

1036 DESIGNER HEAT SINKS
In six easy steps, Ray Fautley shows you how to find the heat sink area needed to cool a transistor, diode or power resistor.

1045 A BATTERY OF CHARGERS
Philip Darrington looks at simple single-chip solutions for charging advanced batteries.

1026 CIRCUIT IDEAS
- Trickier keypad lock
- Fast pulse monitor
- Analogue frequency doubler
- 5MHz triangle generator
- Precise mains volt measurement
- Lead acid battery saver
- Simple ac/dc indicator
- 50/60Hz sine oscillator
- Day indicator for digital clocks

1039 NEW PRODUCTS
Pick of the month - classified for your convenience.

1051 LETTERS
Reed relay advice, 1.3V mystery, Amplifier stability issues, Flat-panel speakers, Beating frequencies.

REGULARS

971 COMMENT
At last - ISDN for all.

973 NEWS
Job prospects, £8 video camera, New PCI bus standard. Doubts over network computer technology, First FireWire products announced.

978 RESEARCH NOTES
Diamond coating stops disk head crashes, radar looks through closed doors, Organic computing.

JANUARY ISSUE ON SALE 4 DEC

Cover - Hashim Akih

Special offer
With three ranges, this sensitive frequency meter works to 2.5GHz yet costs under £100 - exclusively to EW readers. See page 1010.

This is the secret to coating disks and heads with diamond to stop hard disk crashes - see page 978.

There are complex procedures for designing high performance microstrip line circuits, but a few shortcuts result in a technique that is quick and easy to implement yet more than adequate for most applications, see page 1019.

£100 - exclusively to EW readers. See page 1010.

969
For all your Power Distribution
Olson offer a varied choice

OLSON
DISTRIBUTION UNITS

OLSON
DISTRIBUTION PANELS
FUSED WITH M.FILTER
AND R.C.O. PROTECTION

OLSON
The Rack Range
distribution panels for 19" rack mounting

OLSON
Office Furniture
Cable Management
Manufactured to BS 5296

OLSON
Mains Distribution
Panels with
From Standard Sockets

OLSON
Earth Leakage
Distribution Units

OLSON
EARTH SUCCESSFUL UNIT

OLSON
INDUSTRIAL RANGE
16 AMP 110V AND 240V
TO BS 4343 SEC 309

OLSON
19" FAN TRAYS

OLSON
The Rack Range
19" D.C. UNITS

OLSON
Service Pillars for
The Open-Plan Office

OLSON
Distribution Units

OLSON
DISTRIBUTION PANELS
INTERNATIONAL RANGE

OLSON
FLUOROS SUPER 28 AND 16-WAY UNIT

OLSON
Data Protection

OLSON
Mains Distribution
Panels

OLSON
19" Distribution
Units

OLSON
Industrial Range
16 AMP 110V AND 240V

OLSON
Electronics Limited

FOUNTAYNE HOUSE, FOUNTAYNE RD., LONDON N15 4QL
TEL: 0181-885 2884
FAX: 0181-885 2496

CIRCLE NO. 106 ON REPLY CARD
At last - ISDN for all

A mass-market for ISDN was never in doubt; the only thing that blurred the vision was the cost of providing it. While large organisations found it easy to cost-justify the start-up charges, the cost of entry barred very effectively the wider army of hobbyists, home-based workers and small businesses from exploiting the undoubted benefits of ISDN.

Workarounds were proposed to provide alternative routes onto the information superhighway 56kbit/s modems, XDSL techniques and cable modems but none of these have offered the total flexibility of real ISDN and users still waited for the cost of ISDN to fall.

And at last this fall is imminent, now that the key to providing affordable ISDN digital telephone service has been offered to UK network operators. British telecoms manufacturer GPT, which supplies the System X exchanges used by BT and many other providers, has come up with an easy-to-install package to enhance these switches. For the first time it offers a means of providing low-cost ISDN service for the mass market of small business and residential customers.

What is particularly elegant is that it achieves not only one breakthroughs. First, the cost barrier which held back smaller users from exploiting the acknowledged benefits of digital data communication has been eliminated. In particular, home-based workers now have a cost-effective means of exchanging documents and sharing data with office-based colleagues, as well as gaining faster access to the Internet and a host of interactive information and entertainment services to come.

Small businesses requiring high-speed data transfer no longer need to install special private wires for the purpose.

The second advantage is the fact users can enjoy the benefits of ISDN without forfeiting their existing networks and numbers. Unlike previous implementations of ISDN, customes do not forfeit useful services such as call waiting, three-way calling, ring back when free, 141 call return, Contrex and so on. Analogue caller display devices, which cannot operate on normal digital ISDN lines, still work under this new implementation.

It adds up to a double bonus. For network operators it is a cost-effective delivery mechanism for providing twin-channel Basic Rate ISDN (ISDN2) service without the need for a second pair of wires. The customer benefits are equally significant; users gain the enhanced capability and 128kbit/s bandwidth of ISDN while retaining the convenience and established popular features of their existing analogue connection. Because the system can provide two simultaneous connections, users are spared the cost of having a second line installed.

The technical implications are relatively modest, involving an upgrade to System X exchanges and the provision of a compact plug-in unit at the customers end for connecting a customers existing telephone equipment with direct Plug-and-Play hook-up of a PC compatible. Installing this network terminator, which replaces the existing master phone socket, does not take long and setting takes only a minute or two; the switchover from old-style analogue to ISDN service is effectively instantaneous and requires no access to customer premises.

The all-British technology is now being proposed to the European Telecommunications Standards Institute as a pan-European standard for narrowband multi-service delivery.

For network operators the new technique provides the opportunity to offer an extremely attractive ISDN package based on the current growth and marketing. In the same way as high-speed modems soon became affordable and commonplace, it is reasonable to expect ISDN will make digital data communication the norm for small users as well as large.

For people working from home (the so-called teleworkers), low-cost ISDN will provide a cost-effective means for exchanging documents and sharing data with office-based colleagues, as well as offering faster access to the Internet and a host of interactive information and entertainment services.

The entry cost of ISDN has barred very effectively the wider army of hobbyists, home-based workers and small businesses from exploiting its undoubted benefits. Small businesses will be able to link up with one another electronically to create virtual enterprises, working together to provide a single concerted service to their clients. Faster connection and data transfer will give surfing the Internet a major new impetus, opening up new prospects for online shopping and multimedia information delivery from low-cost terminals alongside the domestic television set.

Supporting this, the market for low-cost user products and solutions for ISDN is maturing rapidly, with a broad range of mini-PBXs, line cards and multi-function devices selling at truly affordable prices. One vendor offers a PC card combining ISDN file transfer at up to an effective 412kbit/s, V.34 modem emulation, Group 3 fax operation and a digital voice answering machine. It comes bundled with video conferencing software and an electronic secretary capable of storing and forwarding voice data, and fax messages. This sells for an extremely affordable 99 and with this kind of functionality on offer, users cannot fail to reconsider their attitudes to ISDN.
PROTEUS

Schematic Capture

NEW Version IV

- Produces attractive schematics like you see in the magazines.
- Netlist, Parts List & ERC reports.
- Hierarchical Design.
- Full support for buses including bus pins.
- Extensive component/model libraries.
- Advanced Property Management.
- Seamless integration with simulation and PCB design.

Simulation

- Non-Linear & Linear Analogue Simulation.
- Event driven Digital Simulation with modelling language.
- Partitioned simulation of large designs with multiple analogue & digital sections.
- Graphs displayed directly on the schematic.

PCB Design

NEW Version IV

- Automatic Component Placement.
- Rip-Up & Retry Autorouter with tidy pass.
- Pinswap/Gateswap Optimizer & Backannotation.
- 32 bit high resolution database.
- Full DRC and Connectivity Checking.
- Shape based gridless power planes.
- Gerber and DXF Import capability.

The IVth Generation

New Features

- Component Auto-Placer
- Pinswap/Gateswap Optimizer
- Background Regeneration of Power Planes
- Enhanced Autorouting 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.

"PROTEUS is particularly good
with its rip-up-and-retry
autorouter"

EWW January 1997

Write, phone or fax for your free demo disk, or ask about our full evaluation kit.
Tel: 01756 753440, Fax: 01756 752857. EMAIL: info@labcenter.co.uk
3-55 Main St, Grassington, BD23 5AA. WWW: http://www.labcenter.co.uk

Fully interactive demo versions available for download from our WWW site.
Call for educational, multi-user and dealer pricing - new dealers always wanted.
Prices exclude VAT and delivery. All manufacturer's trademarks acknowledged.
Bright prospects for UK employment

Employers are forecasting more jobs within the UK’s electronics industry, according to a recent survey conducted by Manpower. Meanwhile, the September pay bulletin from the engineering employers’ federation (EEF) has found that pay settlements within UK industry as a whole remain subdued and below the headline rate of inflation.

The average pay settlement for the quarter up to August was 3.17 per cent compared to 3.5 for inflation. Manpower’s latest Survey of Employment Prospects, conducted amongst 2,339 employers around the country, found 33 per cent of electronics employers expect to recruit during the fourth quarter of 1997, against seven per cent who expect to lay off staff, registering a balance of 26 per cent. This quarter balance exceeds the national average of 23 per cent and the manufacturing sector average of 22 per cent.

Digital tv to miss World Cup

Digital Terrestrial Television (DTT) in the UK is set to be delayed by at least three months, following the deferment in the ITC’s awarding of licences. Originally DTT was to be launched in July 1998, in time for the World Cup. Now October 1998 is the expected launch date.

"There has been a gentle slippage, but as is already known, the permission from ITC came out a bit later," said Jim Slater, project coordinator for DTT at the Digital TV Group.

Currently, the set-top box makers are waiting for the reference design from British Digital Broadcasting (BDB) for the manufacture of the first DTT receivers.

"We are currently drawing up the specification for manufacturers to build the boxes to," said a BDB spokesman.

Fairchild to decide on Temic by Christmas

Fairchild Semiconductor will make its decision whether or not to buy Temic by December. The company is also considering buying GEC-Plessey Semiconductors (GPS).

"We’re still at the discovery stage – asking: ‘Does Temic make sense?’” said Joe Martin, chief financial officer at Fairchild. “We’ll make the decision on Temic in four to eight weeks.”

“We’ve looked at 50 companies around the world since we spun-off from National on March 11th,” added Martin. Citicorp Venture Capital, part of Citibank, financed the $550m Fairchild management buy out and gave it a brief to look for acquisitions.

“A lot of companies have a semiconductor subsidiary for strategic products. Some want to divest themselves of these companies and Fairchild provides them with an opportunity as a credible vehicle for consolidating these sort of operations. We are actively soliciting these companies as part of our acquisition strategy,” said Kirk Pond, president and CEO of Fairchild.

Asked if Fairchild was interested in buying GPS. Martin replied: “We could be. It’s only recently become available. We haven’t had time to look at it yet, but it could be a possibility.”

Fairchild is interested in the semiconductor side of Temic, not the automotive components side. The main attraction of the semiconductor side for Fairchild is the former Siliconix product line of power semiconductors, including small signal transistors and its PowerMOS line, explained Martin.

New video camera has $8 price tag

Edinburgh-based e-mos camera specialist Vision has added a low cost sensor to its range. The 160 by 120 pixel digital cameras are aimed at the security, videophone, toys and games markets. Eight-bit resolution monochrome and colour cameras are available. The monochrome VV5100 is priced below $8 in volume quantities. Vision also offers a $450 development system which includes PC software, capture card and lens.

Flat and wide... NEC has put into production a 50-inch plasma display intended for the high definition television market. The Hi-Vision PlasmaX panel is capable of displaying one million pixels and will go on sale in Japan next February, in time says the company, to be used in high definition TV systems to be used during the Nagano Winter Olympic Games. But UK skiing enthusiasts – an exclusive bunch at the best of times – should be warned the selling price of the 50in flat format plasma televisions will be around £2.7m (£13000).
**PCI bus is to get a refit**

Power management and hot-plug capabilities are to be added to the PCI bus, it was announced recently. Version 2.2 of the PCI specification is to be released early next year, said Donald Coffin of the PCI special interest group.

"Power management is the hardware side of Microsoft's ACPI or advanced configuration and power interface," explained Coffin. ACPI allows parts of a PC to be powered down when not in use. Notebook PCs are already early adopters of the technology. By adding ACPI to the computer's local bus, peripherals will be more energy efficient.

Hot plug is aimed for use in servers, so that disk and Ethernet cards can be swapped without shutting down the system. The last major update to the PCI specification, version 2.1, was released two years ago. This extended the bus from 32-bit at 33MHz to 64-bit at 66MHz. Bandwidth quadrupled to 528 Mbyte/s.

"We are now seeing 64-bit, 66MHz systems, especially in servers," said Coffin.

The move to the higher rate will continue in servers and workstations over the next year to 18 months, claims Coffin.

Desktop PCs are likely to continue with the 32-bit, 33MHz version. This is because Intel's accelerated graphics port (AGP), which links the graphics system directly to the microprocessor, has greatly reduced the burden on the PCI bus.

**Awareness funding for year 2000 bug redirected**

The Government is to stop funding Taskforce 2000, the body assigned to raise awareness about the Millennium bug. Instead, £1m will be given to Action 2000, a new organisation tasked with taking a more active approach to the problem. Robin Guenier, head of Taskforce 2000, criticised the decision, saying it would waste valuable time. "We're going to lose weeks while people are appointed to [Action 2000]," he said.

"Wouldn't it have been more sensible to continue with Taskforce 2000?"

A DTI spokesman countered: 'Taskforce 2000's aim was to raise awareness and it did it very well. However, companies are not doing enough and a new impetus is required to turn awareness into action. We are showing our commitment, now it's up to industry to make its contribution.'

Guenier insisted there is still a need to continue with the awareness programme, especially with regard to how Year 2000 affects embedded systems, to get the whole of industry and commerce tackling the problem rather than just helping the estimated 15 per cent that have already begun. However, the DTI spokesman stressed the awareness campaign would continue as part of Action 2000's ambit.

**UK electronics industry warned**

The UK electronics industry faces a great threat from Eastern European-based manufacturing, according to a paper from Loughborough University.

Professor David Williams, presenting the paper to the Cambridge Centre for International Manufacturing, warned that Eastern Europe threatens "unrooted" inward investments in the UK, and that even embedded foreign investment in Scotland is vulnerable.

"Screwdriver inward investments will probably go to places like Poland and the Czech Republic," he said, pointing out that IBM had already transferred disk drive manufacturing capacity from Havant to the Republic.

Williams believes UK electronics companies need a greater awareness of their global role if they are to survive well into the next century. Success will mainly come for firms that couple investment in high value-added activities with sales into mature economies like the US. "Should we sell expensive products to rich Americans or cheap products to the Chinese?" he said.

But the UK must not pass up opportunities in the Far East for long term investment in areas of industrial growth. "We can't afford to miss another trick like we did with Singapore, where a low value region becomes a high value one," said Williams.

**NEC details handheld Risc chip**

NEC has released details of its latest microprocessor for the handheld computer (HPC) market. The VR4111 is a 64-bit Risc microprocessor based on the R4000 core from MIPS Technologies. It is an updated version of the VR4101 and 4102. The new devices are pin-compatible with the previous processors to allow easier design upgrades.

Performance reaches a claimed 130Mips at 100MHz by moving the device to a 0.25m manufacturing process. Power consumption has been reduced from 250mW to 180mW by running the device at 2.5V.

To reduce memory requirements, the devices can execute a 16-bit instruction set, similar to the ARM Thumb.

NEC has integrated HPC-specific peripherals for LCDs, keyboards, infra-red and serial I/O, audio and touch screen interface.
The new Quickroute 4.0 is here and with it a revolution in our price/performance structure. We've kept the features the same at all levels of Quickroute and just varied the number of pins you can use in a design. So now you can get started FAST with Quickroute 4.0 for just £79 (300 pins), £149 (800 pins) or £249 (full access). Prices exclude P+P and VAT.

Send me a FREE DEMO. My name, address & phone number are:

Send To: Quickroute Systems Ltd, FREEPOST 13136, Stockport, SK4 1BS
Outside the U.K please fax this coupon. (c) 1997. All rights reserved. Ref 401.

CIRCLE NO. 108 ON REPLY CARD

Circuit simulation can be seriously good fun

When you have the engineering edge, enjoy your work and catch subtle circuit behaviour before it's too late, you can afford to be light hearted. Add to this technical support from practising engineers who take a genuine interest in your work and you are really laughing.

With a free evaluation kit, you can test SpiceAge on your own circuits. The kit comes with an introductory booklet to show you how.

To hear more about this and other nice touches in SpiceAge, please contact the friendly people at Those Engineers Ltd, 31 Birkbeck Road, LONDON NW7 4BP.
Tel 0181 906 0155
Fax 0181 906 0969
Email those_engineers@compuserve.com
Web http://www.spiceage.com

CIRCLE NO. 109 ON REPLY CARD
Future bleak for NCs

Network computers (NCs) could be dead in the water as network managers decide to stick with existing network equipment.

This message emerged from a Fodor Wyllie survey commissioned from Pin Point Software, the network management tools supplier. According to the survey, 56 per cent of companies questioned did not believe the NC would make a significant impact on their organisations even though network management would be made easier.

"The momentum for network computers has been lost. We were amazed at the ambivalence towards the network computer. Clearly there is a belief that the NC can help but there’s a lot of pessimism about its implementation," said Iain Franklin from Pin Point Software. "Although the NC saves a lot of time managing the network, companies prefer to stick to what they have rather than switch their whole networks to NCs."

According to Pin Point Software, this is a surprising revelation as the market for network management devices is growing at a rate of 30 per cent per year and it has already reached the $1bn mark.

Another analyst, Bloor Research, disagrees. "I don’t believe the momentum for NCs is lost," said Rob Hallstone, chief analyst at Bloor Research. "I suspect until we see the first successful implementation of NCs people will think it’s not going to happen."

Guidelines aimed at cutting keyfob interference

The chance of getting locked out of your car by EMC problems should be reduced if guidelines by RAKE, the Radio Activated Key Committee, are adopted.

Problems arise because EU legislation added automotive keyfobs to the list of legitimate users of 433.92MHz in the UK. This already included the MoD and radio amateurs. "We are in no position to ask the other user to get off the frequency—the radio amateurs have been using it for over 40 years," said Peter Brill, RAKE spokesman at the RAC.

This said, the guidelines contain the paragraph: ‘As a first step, in the UK, the next two years will see the removal of some users of the 433MHz band to other parts of the spectrum’.

The guidelines are split into two parts: a guide to motorists and a guide to manufacturers for future products.

“One of the simple things we are encouraging manufacturers to do is ensure there is an alternative method of entry,” said Brill.

Other guidelines suggest marking ‘hot spots’ on and in the vehicle where it is most sensitive to the keyfob being held, visible instructions to remind drivers what to do if the fob fails to operate the car and a reduction in receiver bandwidth.

Motorist Web update: http://www.rac.co.uk/html/fut/pr97/008.htm

Initial products for FireWire announced

The first FireWire products are to start appearing on the market in the next six months, two years after the IEEE1394-1995 standard was agreed.

“We had the standard two years ago. It’s time to start generating products this and next year,” said Hiro Tsutsui, marketing manager at Sony Image Sensing Products in Japan.

Intel will deliver a prototype motherboard with the FireWire-1995 digital interface early next year. The software by Microsoft will also cater for this type of linking then and Apple will introduce Power Macs with this interface.

Last week, Sony announced its DFW-V300 digital colour camera, one of the first FireWire peripherals, with this high-speed serial bus standard on board. In 1998, Sony hopes to launch another six products from its image sensing portfolio.

“The real benefit is that IEEE-1394 standard allows digital data to be imported directly into a PC or device, meaning the DFW-V300 camera provides a very quick and very scalable solution for transferring video data for processing by computer," said Steve Hearn, business manager at Sony Image Sensing Products.

The next FireWire specification, IEEE1394-1998 or IEEE1394-2000, is being discussed between the industry players and the standardisation bodies including the 1394b Working Group that is working towards the 3.2Gbit/s specification.

In brief

New specs for DVD

The latest specification for the write-once DVD-Recordable (DVD-R) format has been published by the DVD Forum. The version 1.0 specification offers a 3.95Gbyte single-sided or 7.9Gbyte double-sided storage capacity that will be compatible with other DVD formats such as DVD-ROM and DVD-Video.

The next generation 4.7Gbyte DVD-R is currently under discussion by the DVD-R Working Group. Meanwhile, Matsushita Electric Industrial expects first-year total worldwide sales of DVD players to be half of that first envisaged. Initial forecasts were for sales of up to two million units, however, the forecasts have been downgraded to below one million units.

Risc processor for hand-holds

NEC has released details of its latest microprocessor for the handheld computer (HPC) market. The VR4111 is a 64-bit Risc microprocessor based on the R4000 core from MIPS Technologies. It is an updated version of the VR4101 and 4102. The new devices are pin-compatible with the previous processors to allow easier design upgrades.

Performance reaches a claimed 130Mips at 100MHz by moving the device to a 0.25um manufacturing process. Power consumption has been reduced from 250mW to 180mW by running the device at 2.5V.

To reduce memory requirements, the devices can execute a 16-bit instruction set, similar to the ARM Thumb.

NEC has integrated HPC-specific peripherals for LCDs, keyboards, infra-red and serial I/O, audio and touch screen interface.

CO2 will affect chip production

Global warming will affect the semiconductor industry, says a report from the Economic Strategy Institute of Washington DC.

The Institute warns that if proposals to cut CO2 emissions proposed by the Kyoto global warming summit are adopted, then the global economy will slow down leading to an eight per cent reduction in the demand for semiconductors.
WE PUT EVERYTHING INTO OUR NEW 48-PIN UNIVERSAL PROGRAMMER

1.8V
2.7V
3.3V
5V

FEATURES
- Supports EPROMs, EEPROMs, Flash, Serial PROMs, BPROMs, PALs, GALs, PEELs, MACH, MAX, EPLDs, and nearly 200 Microcontrollers including 87C48/SA, 89C51/52, PIC, MC705/711, St6, 286, COP etc.
- Correct programming and verification at 1.8, 2.7, 3.3 and 5V
- No adapters required for DIL parts up to 48-pins. Universal adapters for 44-pin PLCC, 44-pin PSOP and 48-pin TSOP parts
- High speed: programmes and verifies National 27CS12 in under 11 seconds
- Connects directly to standard parallel port - no PC cards needed
- Built in chiptester for 7400, 4000, DRAM, SRAM
- Lightweight and mains or battery operation
- Complete with parallel port cable, software, re-charger and documentation

Only £695

For a copy of our catalogue giving full details of programmers, emulators, testers, adapters and logic analysers, call, fax or e-mail us.
You can also access our BBS or Homepage. All our products are in stock now for next day delivery - call our credit card hotline now.

ICE Technology Ltd. Penistone Court, Sheffield Road, Penistone, Sheffield, UK S36 6GP
Tel: +44 (0)1226 767404 Fax: +44 (0)1226 370434 BBS: +44 (01)226 761181 (14400, 8NI)
Web: www.icetech.com Email: sales@icetech.com

CIRCLE NO. 110 ON REPLY CARD
Diamond coating adds twinkle to disk storage

One of the major stumbling blocks in the design of ultra-high storage disk drives is that the read/write heads must be located ever nearer to the disc surface to be able to resolve the data. At these tiny distances, impacts are inevitable so the heads must be coated. But any protective coating must be super thin too, so as not to disturb magnetic performance.

Now, a way has been found to shield disks and sliders – reader heads – with ultra-thin 'overcoats' of diamond-like carbon that can survive repeated crash landings at 3600rev/min. Success is being welcomed as a breakthrough in progress to high density storage devices.

The work has been carried out by Simone Anders of the Accelerator and Fusion Research Division at the Ernest Orlando Lawrence Berkeley National Laboratory and her colleagues from IBM and University of California, Berkeley.

IBM has already brought to market disks that store 4Mbytes/mm² of data, while densities almost twice that have been demonstrated, and researchers are aiming for 16Mbytes/mm² and more. To read a disk where magnetic domains are packed only 25nm apart, disk surface and slider will have to move so close to each other that it's almost a matter of semantics whether they will actually be touching.

Typical high-quality commercial overcoats now in use are made of sputtered-on, hydrogenated carbon 12 to 15nm thick. But higher data densities require reduced magnetic spacing between heads and disks – so disk coatings must be thinner and made of even harder material. Sputtering can't do the job, but a technique called cathodic arc deposition can.

Unlike sputtering, cathodic arcs produce a fully ionised plasma of whatever material, including carbon, is used for the cathode.

A fully ionised carbon plasma allows electrons and carbon nuclei to reassemble themselves as diamond, in a three-dimensional lattice in which each atom is bound to four others by electron pairs – a tetrahedral bond. In contrast, atoms in graphite are bound to only three other atoms, forming a much less stable configuration. By tuning the energy of the incoming carbon ions, the tetrahedral-bond content of the deposited film can be optimised, so films have been made that, while technically amorphous, are 85% diamond.

"Still, this method hasn't been practical for coating disks," says Anders, "because micron-sized chunks of the cathode boil off and contaminate the films."

For cathodic arc deposition to be useful in coating disks and sliders, a way must be found to completely filter out the macroparticles. What Anders and her team has achieved is devise a filter so good that all the goals of thin, flat, hard, macroparticle-free carbon are fulfilled.

The secret is a magnetic coil that looks much like a Slinky toy, placed between the plasma source and the substrate to be coated. The fully ionised plasma is easily bent through this S-shaped magnetic field – effectively two fields at right angles – but the massive macroparticles of carbon can't turn easily; they fly right through the sides of the coil or pile up on its walls. A coil that has been used for some time is thickly coated with a dust of macroparticles near the plasma source, yet dust-free at the substrate end.

Tests show that disks coated with cathodic arc carbon have a coefficient of friction half that of those coated with hydrogenated carbon and cause 20 times less wear on the slider. In additional studies, when a silicon wafer coated with cathodic arc carbon has been examined at nanometre scale after repeated loading, it shows virtually no scratches.

Contact, Simone Anders, Accelerator and Fusion Research Division, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, California, USA
Radar finds people behind locked doors

Lives could be saved by a prototype radar system, developed at Georgia Tech Research Institute, that can sense someone moving or breathing up to 3m behind a locked door. For police and hostage negotiators, the device, little bigger than a torch could provide vital information about where people are located inside a room. The sensor could also be used to find survivors in the rubble of accidents or earthquakes.

A narrow radar beam of about 15 to 20° and a specialised signal processor is used to detect the body movement generated by breathing.

Research that evolved into the radar torch began in the mid-1980s, with the patenting of a frequency modulated radar for remotely checking vital signs of battlefield wounded before sending in medical teams. This early technology was also tested for its ability to monitor vital signs of soldiers clothed in chemical or biological warfare suits, without requiring them to risk contamination by removing the protective gear. Now the technology has been refined for more general use.

Radar has some advantages over other technologies. The signal from the radar will penetrate clothes and detect respiration through a heavy jacket, and requires a body movement of only a few millimetres to detect human presence.

"Based on respiration signature alone, the radar flashlight allows us to detect a stationary individual behind a solid wooden door, or standing 1.2m behind a 200mm block wall," explains Gene Greneker, a principal research scientist at the GTRI.

Even so, the amount of electromagnetic radiation exposure from the device is still small – said to ten times less than the voluntary exposure leakage level for microwave ovens in the United States. Exposure is estimated to be about the same as a person receives when walking under an automatic door opener triggered by a microwave sensor.

For now, the signal processor is external to the radar sensor, and the respiration signature is displayed on a monitor driven by a computer-based radar signal processor. But Greneker plans to make everything small enough to fit inside the torch body by incorporating high-speed signal processing technology.

Contact: Gene Greneker, Georgia Institute of Technology, 223 Centennial Research Building, Atlanta, Georgia 30332-0828. Tel: 001 770-528-7744 email: gene.greneker@gtri.gatech.edu

Chill settles on car electronics

Electronics are now almost as an important component of cars as the engines and bodies themselves. Over at the Daimler-Benz Research Centre in Ulm, scientists are putting the next generation of microwave circuitry through its paces, using a specially-constructed low-temperature measuring station allows researchers to investigate the characteristics of new microwave circuits at temperatures far below freezing point. In this way, any adverse effects on the performance of superconductor elements can be predicted.

At the measuring station, tests can be carried out at temperatures as low...
as ~250°C, allowing the scientists to examine new components for high-power radar sensor units or for compact narrow-band receivers in communications technology, while detailing their behaviour at extreme sub-zero temperatures. On the basis of these results, the characteristics and capabilities of superconductor elements can be precisely predicted.

The use of superconductor materials in place of metals and the resulting new approaches to modelling in hybrid combination are seen as milestones along the road to new, highly sensitive receiver systems for the microwave band. The objective is to benefit from the advantages of various available components and unite them in a single overall system.

Automotive researchers currently regard this as the most cost-effective solution for the production of such components in small and medium volumes.

Organic computer comes closer...

Researchers at Yale University in the US have succeeded for the first time in measuring an electric current flowing through a single organic molecule sandwiched between metal electrodes. The feat could pave the way for a new generation of transistors so small that a beaker full would contain more transistors than exist in the world today, according to Yale electrical engineer Mark Reed, team leader.

The accomplishment is a fundamental step toward creating computers and sensors that are smaller, faster and cheaper than today's silicon-based computers. The next step is to design computer chips whose wires are made of self-assembling strings of organic molecules that grow in a beaker, since the wires would be far too small to produce any other way. The organic wires would adhere to metal electrodes, a revolutionary strategy for fabricating electronic devices for which Professor Reed and Yale hold a joint patent.

But Reed warns that it could take a decade to learn how to make useful devices out of quantum components made from organic compounds.

To capture the historic measurement of current across a single organic molecule, the researchers made a mechanically controllable break junction by gluing a notched gold wire to a flexible substrate, then fracturing the wire to make an adjustable gap. Next, they sandwiched a single molecule of benzene (a hexagonal ring made up of six carbon and six hydrogen atoms) flanked by two sticky sulphur atoms between the two gold electrodes. The process required self-assembly of benzene molecules onto the electrodes.

For the future, perhaps the greatest obstacle to be overcome in fabricating useful quantum devices is to find better, faster ways to make large quantities. Electron beam lithography is used at the moment and this is just not practical for volume production.

The answer could be to find materials that will assemble themselves into quantum components.

Reed says his goal is to find organic chemicals that will combine to form a substrate of conducting molecules.

Contact: Professor Mark Reed, Yale University, New Haven, Connecticut, USA, Tel: 00 1 203 432 4306 email: reed@yale.edu

...But can silicon wait?

Progress to ever smaller, faster and cheaper computers may soon come to a grinding halt because microscopic silicon chips are getting so small that eventually they will contain too few atoms to work, warn two University of Florida researchers.

By the year 2010 the limit will be reached, and microprocessors will be as small and as fast as they can get, says Kevin Jones, professor of materials science and engineering and co-director of UF's SoftWare and Analysis of Advanced Material Processing (the Swamp Center).

Jones and Swamp co-director Mark Law are concerned that the heart of the Pentium processor transistor, a layer that once was thousands of atoms thick, is getting so small that it soon will be only 50 atoms thick. They say the Pentium processor may eventually shrink itself out of function when it gets to be fewer than 10 atoms thick, in just over a decade. That means unless there is a revolutionary change in computer technology, the trend toward smaller, faster computers will have reached its limit.

Effectiveness of shrinking processors is also threatened by the impurities in microscopic silicon chips. Law and Jones are currently using 3D computer simulation to investigate the nature of the impurities in silicon which can cause current to flow where it is not supposed to. Impurities can cause catastrophic failure when the impurities run into the crystal and cause electronic switches to short circuit.

The researchers are currently making predictive models for the industry, primarily using computer simulation because testing with real materials is so expensive.

"We need to know how impurities diffuse, at what rate and at what temperature," says Law.

"We can then code that data and build predictive models that allow the industry to build better chips."

Contact: Kevin Jones, University of Florida, Gainesville, USA. Tel: 00 1 352 392 8872.
The Balance Box
Microphone or line level amplifier for balanced or unbalanced signal lines
Professional portable units operating from an internal PP3 battery or external mains adaptor

★ Precision true floating transformerless balanced input and output at microphone or line level ★ Simple interfacing and conversion between balanced and unbalanced signal lines ★ Low noise and distortion ★ High common mode rejection ★ Switchable gain selection ★ Extensive RFI protection

The Phantom Power Box – The Headphone Amplifier Box - The OneStop DIN rail mounting radio frequency interference filter and voltage transient protector for voltage and current loop process signal lines

Conford Electronics Conford Lipbrook Hants GU50 7QW
Information line: 01428 751469 Fax: 751223
E-mail contact@confordelec.co.uk
Web http://www.confordelec.co.uk/catalogue/

CIRCLE NO. 111 ON REPLY CARD

MARCONI 2370 Spectrum Analyser
(as new)

30Hz – 110MHz Frequency range
1Hz Resolution/phase lock tuning
Digital storage with dual display
Built-in tracking generator
9 digit frequency counter
£750 + carriage/vat
Includes 30 day unconditional warranty
M&B Radio, 86 Bishopsgate Street, Leeds LS1 4BB
Tel: (+44) 0113 2435649
Fax: (+44) 0113 2426881

CIRCLE NO. 112 ON REPLY CARD

Radio Technology Direct
Top quality, top technology, top service. That's our commitment to you. We build both standard and custom modules and ship direct. We've been doing so for 20 years. No-one is better. Every product is made in England, with pride.
Here are some of our products. To order, just ring us direct (credit cards accepted).
If you want something you don't see here, ring us. We can almost certainly help.

SX450 The Wood & Douglas Flagship
• 500mW output
• UHF operation
• Fully synthesised
• Fully ETSI approved

£250 Volume Orders

RSX450 Intelligent Radio Modem
• 500mW output
• 9600 baud on air data rate
• Fully synthesised
• Fully ETSI approved

£450 Volume Orders

ST/SR450 The Discerning Discretes
• 500mW output
• Separate TX and RX units
• UHF operation
• Fully synthesised
• Fully ETSI approved
• VHF options available
• Rich in features

TX £120 RX £140 Volume Orders

TT/TR Low Cost Modules
• 100mW output
• Separate TX and RX modules
• UHF operation
• Crystal controlled
• Fully ETSI approved

TT £50 TR £80 Volume Orders

Wood & Douglas Limited
Lattice House, Bagnhurst, Titsey, RG26 0UP United Kingdom
Tel: +44 (0)118 981 1444 Fax: +44 (0)118 981 1567
E-mail: info@woodanddouglas.co.uk
http://www.woodanddouglas.co.uk

CALL NOW +44 (0)118 981 1444

CIRCLE NO. 113 ON REPLY CARD
AUTOMOTIVE ELECTRONICS

In petrol-engine efficiency terms, an increase of 5 to 10% is exceptional. Automotive engineer Michael Ward says that his ignition system can achieve this — and it can do so with the side benefits of cheaper emission-control systems together with simpler engine mechanics.

Bright sparks

The conventional inductive ignition system, based on the flyback circuit, has survived without significant challenge for almost a century. Invented and developed by Charles Kettering, circa 1910, it powers essentially all passenger cars and trucks today. It features simplicity, low cost, and reliability.

However, it masks several shortcomings — including low spark energy relative to what is required for best engine efficiency. These shortcomings are taking on a particular importance with the industry’s call for one-coil-per-plug ignition and with the international call for improved fuel efficiency to counter ever growing carbon emissions worldwide — which equates to global warming.

Related concerns of high fuel costs in Europe and Japan, and failing Corporate Average Fuel Efficiency standards, CAFE, in the US further increase the concerns. The increased popularity of minivans, sport-utility vehicles, and light trucks in the US is leading to a reduction in vehicle gas mileage — the lowest since 1985 — and to growth in US oil imports to over 50%.

In the latter seventies, Robert Bosch and General Motors showed that for best engine efficiency, an ignition system needed to deliver 150 to 250 millijoules of spark energy. Yet today’s inductive ignition systems deliver only a small fraction of that — typically 30 to 50mJ as measured by an 800V zener load, which is the industry standard.

Without a substantial increase in coil weight, from the state-of-the-art 200g to an unacceptable 500g, the required minimum spark energy of 150mJ cannot be achieved. Moreover, today’s inductive ignition systems deliver a spark with a current of 50 milliamps. This equates to a spark power of just 20 watts. But to achieve the optimum combustion power in the initial propagating flame demands a spark of around a 100W. More importantly, such spark discharges are susceptible to break-up by the high mixture flows found in engine cylinders of modern engines.

Why a bigger spark?

From the 20 years of research conducted at CEI on ignition and early flame propagation, we have found that spark power more closely equal to that produced by the initial flame is better suited for ignition of dilute mixtures. This equates to lean or high exhaust-gas recirculation, or EGR, mixtures which increase engine efficiency and lower emissions.

Such higher-power spark discharges require spark currents above 200mA, which is the demarcation...
between a low current 'glow discharge' with its high electrode drop and low efficiency, and the 'arc discharge' with its low electrode drop and higher efficiency. The arc discharge has a much greater resistance to flow segmentation, allowing the spark to be located in a more central portion of the combustion chamber where it can interact with the flow to provide the greatest lean burn capability – as we have demonstrated to the Japanese and General Motors.

Existing ignition shortfalls
Meeting the combined goals of high energy, light coil weight, high spark current, and high spark flow resistance needs a different approach to inductive ignition. To this end, we have developed a new type of hybrid inductive ignition, which we call HBI. It is based on improvements in insulated-gate bipolar transistor, or IGBT, technology and innovations in circuit and component design.

The basic inductive ignition system is made up of the car battery of voltage $V_b$, the ignition coil $T$, the power switch $S$, the clamp $D$, and the load which is a spark gap $G$ on the coil secondary winding, Fig. 1.

In operation, the system is fired to sequentially store magnetic energy in the core of the coil through current flow in the primary winding of inductance $L_p$ to a maximum peak 'break' current $I_p$. This current produces a positive sense voltage in the sense resistor $r$ which is measured by a sense and control circuit.

When switch $S$ opens, the voltages on the primary and secondary windings rise. Initially, the primary voltage rises due to the coil leakage inductance $L_{pe}$ energy charging the primary circuit capacitance and getting clipped and dissipated by a clamp $D$. Primary voltage then rises in phase with the secondary voltage $V_S$ to charge the secondary capacitance $C_S$. It continues up to the spark gap breakdown voltage $V_{sw}$, to deliver the remaining energy stored in the core to the spark gap.

Breakdown voltage $V_{sw}$ depends mainly on spark-gap size and engine load – as measured by the cylinder volumetric efficiency. It is typically 5 to 30 kilovolts.

Peak output voltage, $V_{pk}$, is controlled by the clamp $D$, which for a coil turns ratio $N$ of 90, and assumed clamp voltage $V'_C$ of 380V, limits the peak voltage to approximately 36kV as a result of transformer action. This value is greater than $N\times V_C$ due to imperfect winding coupling.

The energy that can be stored in the core, $E_p$, must satisfy limitations on the peak core magnetic flux density $B_p$ given below, where $N_p$ is the primary winding turns and $A_p$ is the core area.

**Advances in spark plug design**

Significant work has been taking place recently in improving the design of spark plug tips to minimise their quenching effects on the ignition spark and on the early flame propagation, as well as to increase spark plug life.

Such plug designs are of particular interest in this application since the HBI system produces a spark with a higher spark current which is much less susceptible to being quenched or segmented, i.e. broken up by high cylinder flow velocities.

HBI would preferably use such spark plugs with a larger spark gap enabled by the higher output voltage of the ignition. The plug tip would be placed well within the combustion chamber within the flow stream to provide even greater capability for dilute combustion, i.e. lean or high EGR. This would further improve engine efficiency.

CEI has developed its own patented version of a spark plug, called halodisc, which was successfully tested at one of the Big Three and gave an actual fuel economy improvement in and of itself. The spark plug features a thin, suspended, ground ring electrode to minimise electrode obstruction and quenching. The electrode is best made of erosion resistant material such as tungsten-nickel-iron, and has a recessed insulator to minimise fouling of the insulator end.

Being deeper in the cylinder and three times more powerful, the spark on the right acts with fuel/air turbulence to become a far more effective igniter than the traditional spark on the left.
Having a large spark well down in the cylinder allows a leaner burn. When a car slows down with its clutch engaged, fuel is sucked into the engine and wasted. Driving around town, this fuel waste is significant. With existing ignition systems, shutting off the fuel during deceleration is problematical because of lean surges during the deceleration-acceleration transition. But the leaner burn of the new system should allow a more complete fuel shut off during deceleration as one of its several benefits.

Tests carried out using the new ignition system on a traditional twin-valve push-rod engine show clear benefits. Could this route to a cleaner, more efficient engine be better than increasing the number of valves and injecting fuel? Note that 1lb/hp-h is the equivalent of 608g/kW-h.

Might we be better off without 16 valves and fuel injection?

The most effective application of the HBI system is with engines that possess some degree of controlled in-cylinder air flow, such as swirl, tumble-flow, or squish flow. Squish flow is the most desirable as it provides high flows at low engine speeds, when combustion is normally poorest.

Unlike the four-valve-per-cylinder alternative, the twin-valve push-rod engine has natural squish flow, making it an ideal candidate. It has powered more cars and trucks than any other engine in the world. And as has been pointed out in the Wall Street Journal, the twin-valve push-rod engine has a third the parts of the four-valve overhead cam engine and it does not suffer the same friction losses in the valve train.

Traditionally, the spark gap has been located in a recessed, quiescent part of the cylinder far from the burning, or broken-up. With HBI, the ignition spark is positioned in a more central part of the combustion chamber. Here, it is in the squish zone and can be directly coupled to the flow fields to spread combustion efficiently, without the fear of break-up.

In turn, the higher spark voltage associated with the flow coupling will maximise the ignition circuit efficiency. In this way, the maximum of the available, much higher, stored energy is delivered to the flow-coupled spark discharge, as in the drawing.

In tests using an early version of high energy flow resistant ignition on a Ford-Europe engine sponsored by Dr. Tony Jarrett - Group Director of Product Technology for Lucas Industries, Birmingham, England - the air-fuel ratio of the twin-valve push-rod engine tested was improved by three to four air-fuel ratios at low speeds of 1500rev/min and low flows. Gains in fuel economy were substantial, as the graphs illustrate.

At higher speeds, around 3000rev/min, and loads where the flows where much higher, but not sufficient to break up the higher flow-resistant spark, the air-fuel ratio was improved by a remarkable eight air-fuel ratios to provide the lowest possible NOx emissions with significant gains in fuel economy.

The new HBI system, and its equivalent capacitive discharge version which has comparably high spark energy and even greater resistance to flow-segmentation, can substantially improve the conventional twin-valve push-rod engine. Only a slight modification is needed to place the spark plug at the inside edge of the squish zone.

Such an approach would revitalise the twin-valve push-rod engine and make it competitive with the most advanced high-efficiency engine technologies - including the diesel engine and the recently developed gasoline direct injection (GDI) stratified charge engine. Added bonuses would be a much simpler design and lower cost than either alternative.

This would also be the case for two-stroke engines, which suffer from poor combustion at low speeds.
area. In addition, the coil windings must be designed to have acceptably low primary and secondary resistances $R_p, R_s$ to limit the resistive heat dissipation during coil operation. This prevents the coil from overheating at high engine speeds.

For the same stored energy, current, and winding length, the winding resistances $R_p$ and $R_s$ increase inversely with the fourth power of the coil diameter, increasing by a factor of 16 times when the coil diameter is halved.

More revealing, the primary circuit dissipation during coil energising, $E_{dp}$ for fixed coil size and peak flux density $B_p$ is proportional to the cube of the stored energy $E_p$ and inversely proportional to the power delivered to the primary winding. This means that it is inversely proportional to the product of the primary-winding voltage $V_p$ and the current $I_p$ through the winding. Coil energising time, or ‘dwell’ time, $T_p$, is also given below assuming $T_p$ is less than the primary circuit time constant $L_p/R_p$. Recognising that the voltage $V_p$ across the primary winding is less than the supply voltage by the switch voltage drop $V_{ce}$.

$$E_p = \frac{1}{2} L_p I_p^2$$
$$B_p = \frac{L_p I_p}{N_p}$$
$$E_{dp} = \frac{C \times E_p^3}{V_p^2}$$
$$T_p = \frac{L_p I_p}{V_p}$$

Higher output – more dissipation

Doubling the stored energy $E_p$ increases the dissipation $E_{dp}$ by a factor of eight. This makes it impracticable to maintain the higher spark energy for the same size coil, supply voltage and peak current, i.e. by increasing the inductance $L_p$, as is preferred with conventional ignition systems.

Only by increasing the primary power in proportion can the same dissipation be maintained. This is a criterion we choose to use for a properly designed ignition coil – assuming the base coil has been properly designed for heat dissipation.

For the case of a state-of-the-art inductive ignition system of Fig. 1 and ideal coil of weight 200g, the theoretical stored energy $E_p$ is 60mJ, as given below. Assuming a high coil charging efficiency of 60% and spark energy transfer efficiency of 75%, overall efficiency is high, at 45%. Resulting spark energy $E_s$ is 45mJ.

Typical parameters for such an inductive ignition system are given below, where a peak magnetic flux density $B_p$ of 1.4 tesla is assumed as the practical maximum value for standard ignition. This assumes a magnetic core material of silicon iron.

The charge or dwell time $T_p$ is calculated at full battery voltage of 13.7V, or $V_p$ of 12.4V assuming a switch drop $V_{ce}$ of 1.3V.

$$L_p = 2.4 \text{mH}$$
$$I_p = 7 \text{A}$$
$$A_p = 1.2 \text{cm}^2$$
$$N_p = 100$$
$$N = 90$$
$$B_p = 1.4 \text{T}$$
$$E_p = 60 \text{mJ}$$
$$E_s = 45 \text{mJ}$$
$$T_p = 1.4 \text{ms}$$

Doubling the stored energy $E_p$ to 120mJ and maintaining the same dissipation $E_{dp}$ requires that the break current $I_p$ be raised from 7A to 56A for the standard inductive ignition powered by the car battery. Even assuming state-of-the-art logic-level switching 400V ights with low saturation voltages, this remains impracticable in view of the high switching losses.

Switching losses are proportional to the peak current $I_p$ and increase further with temperature. The higher switching losses would be a source of further internal heating of the ight which would not be tolerable in the high temperature environment of the engine compartment.

Loses due to switching can reach 60mJ – or half the stored energy – offering no improvement in energy delivery. Moreover, even if you could attain the spark energy of 90mJ, you still have a 60mJ energy shortfall relative to the minimum 150mJ requirement.

Peak spark current $I_p$ of 620mA, would also be higher than desired. Without some significant change in strategy for inductive ignition, it is not possible to meet the competing goals of one-coil-per-plug ignition with very small coils, and the need for high spark energy for improved fuel economy, within the additional constraints of acceptable costs and other preferred features.

A new approach to ignition

The equation for dissipation $E_{dp}$ suggests the direction needed to be taken. It is necessary to make the system independent of the battery voltage – assumed to vary between 6 and 14V.

It is also necessary to raise the voltage $V_p$, or generalised supply voltage $V_c$ to a higher value of approximately three times maximum battery voltage. A value of 42V is represents a good compromise between an even higher voltage $V_c$ and a value required to limit the output voltage upon switch closure to prevent false firing of the spark plug.

By using the moderately high operating voltage of 42V, then a higher primary current $I_p$ of approximately 30A can be used. A proviso is that a snubber circuit needs to be included to reduce the otherwise high switching losses at the higher current $I_p$.

Proper design of the snubber allows for a best trade-off between conduction losses and switching losses, to the point where conduction losses dominate to allow for the use of the lowest cost, standard speed ight, versus more expensive fast or ultra-fast devices.

Table 1 shows measured values of switching and conduction losses of 600V standard speed and fast ights under operating conditions, i.e. with a peak current $I_p$ of 30A, a stored energy $E_p$ of 200mJ, and a peak snubber capacitor voltage of 440V.

As is clear from the table, conduction losses dominate, suggesting use of the standard speed ight. Among such devices, there are two choices. One is the present logic level, 400V, 15 or 20A voltage-clamped, n-channel ignition ight. The second is the 600V, 20A, unclamped n-channel general purpose ight.

In the case of the 400V ignition ight, the coil turns ratio $N$ and snubber capacitor would be adjusted to accommodate the peak voltage of 400V.

The 400V alternative has three main advantages. Firstly it has a low drive requirement of only 5V for a peak current $I_p$ of 30A. At this level, collector-to-emitter voltage drop $V_{ce}$ is only 2.5V. Secondly, the 400V ight has a low $V_{ce}$ of only 2.0V at 30A at the battery rated drive of 12V. And finally, its internal 400V clamp allows greater flexibility in use of the device including placing it at remote locations such as on the ignition coil.

The 600V general-purpose ight also has several advantages. Its collector-to-emitter voltage $V_{ce}$ is high, at 600V, and it has a low $V_{ce}$ of 2.5V at 30A at the battery rated drive of 12V for

<table>
<thead>
<tr>
<th>Device</th>
<th>Conduction loss</th>
<th>Switching loss</th>
<th>Total losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast ight</td>
<td>26.9mJ</td>
<td>18.2mJ</td>
<td>45.1mJ</td>
</tr>
<tr>
<td>Standard ight</td>
<td>22.4mJ</td>
<td>12.4mJ</td>
<td>34.8mJ</td>
</tr>
</tbody>
</table>
fourth-generation devices. This IGBT also exhibits fast switching, of 1 to 2 μs, at high junction temperatures of 150°C. It has the lowest number of masks and few critical alignments in the manufacturing process, resulting in high yields and low cost.

No clamping necessary

For the application involved here, the internal clamp of the ignition IGBT is not necessary. A snubber circuit is used with a single external clamp. Neither is the low switch drive required, as a result of the higher available voltage \( V_c \) under all conditions—including 6 V engine cranking.

On the other hand, the 600 V rating of the general purpose IGBT allows for the use of lower coil turns ratio \( N \) of 75 instead of 90 and provides higher output voltage of 42 \textit{versus} 36 kV. Also, its switching time is acceptably fast as seen above.

The lower turns ratio reduces the peak output voltage upon switch closure and reduces the number of coil secondary winding turns. This allows a heavier, lower cost wire and an easier task of wind secondary to be used. In addition, the cost of the general purpose 600 V, 20 A, standard switching speed IGBT, quoted at under $1 per unit, is lower than that of the 400 V IGBT.

As a result, the general purpose IGBT is the preferred candidate for this particular application. But note that in other ignition applications, the low drive and internal clamping of the 400 V ignition IGBT may make it the device of choice despite its higher cost. Such applications are the coil with integral switch, and a new ignition application developed by us that is yet to be announced.

With the general purpose 600 V IGBT, a saturating inductor and a low-loss active snubber, it is possible to achieve an energy storage two and a half times times the value of 60 mJ. A further effective increase of 20% to three times the energy, or 180 mJ, is possible as a result of certain parallel improvements in coil design arising from a new approach, discussed later.

Ignition circuit details

Analysis of the HBI system features, shown in Fig. 2, begins with the supply capacitor \( C_p \). It is charged to voltage \( V_p \) by the power converter, and is typically made up of two or more high-efficiency, high-temperature electrolytic capacitors which store many times the coil energy.

Included in the capacitor is a current sensor advantageously located at its low end, with a simple form of current sensing system. This sensor is based on a resistor and p-n-transistor Q, whose base-emitter junction is across the sense resistor with grounded base. The base-emitter junction voltage \( V_{se} \) decreases with temperature to provide a preferred lower current and voltage with temperature to conform to typical engine ignition requirements.

The next relevant component is the low-cost saturating inductor \( L_{sat} \). In combination with the low turns ratio \( N \) and preferred large spark gap made possible by the higher output voltage, this inductor eliminates the problem of false firing of the spark plug upon switch closure. False firing is aggravated by the higher voltage \( V_c \).

The inductor is designed to have an initial inductance approximately equal to the coil primary inductance \( L_p \), and then made to drop rapidly with current to an inductance of one order of magnitude smaller. Its function is to reduce the high-frequency peak voltage \( V_{sep} \) upon switch closure, equal to \( 2 N \times V_{p} \) to one half its value, Fig. 3.

This high-frequency, voltage doubling effect was discovered and mathematically analysed by us in 1989 (see references).

Assuming a lower turns \( N \) of 75 through use of the 600 V IGBT, the output voltage reaches a peak value of only 3000 V on switch closure. This is less than the minimum spark gap breakdown voltage.

Our HBI coil has a short energising or charge time \( T_p \) of...
approximately 400μs versus 1.5 to 5ms for standard ignition. Because of this, the time of switch closure will occur later in the engine compression stroke at a higher cylinder pressure to further reduce the possibility of false firing.

The preferred larger spark gap of 0.060in made possible by the higher output voltage of the HBI system also helps reduce false firing — i.e. sparking upon switch closure. Moreover, energy associated with the saturating inductor at the end of the charge time is not wasted, but returned in large part to the power supply by the low loss active snubber discussed next.

Low-loss active snubber

The third key circuit feature is the low-loss active snubber already mentioned. It reduces switch-opening losses and provides other benefits.

The snubber is made up of isolating diode D₁, snubber capacitor Cₛₑₕ, a p-type fet switch, snubber inductor Lₛₑₕ, and return diode D₂. It serves two main functions. First, it smooths and lowers the high-voltage transient that occurs when the switch opens. This transient is associated with the energy remaining in the saturating inductor and in the coil leakage inductance. It delivers the energy onto the snubber capacitor, minimising switching losses and electromagnetic emissions.

Secondly, the active snubber delivers most of the energy stored on the capacitor back to the power supply. This minimises clamp, switch, and resistive losses, as well as raising the ignition system efficiency, in turn reducing demands on the power converter to maximise system efficiency.

The snubber capacitor is selected to reach a peak voltage Vₛₑₕ less than the clamp voltage Vₛₑₕ from transfer of the circuit leakage energy to the capacitor. Typical ignition parameters for the HBI system operating at the preferred 42V (Vₑₕ) are,

- \( Lₛₑₕ = 0.4\text{mH} \)
- \( Iₛₑₕ = 32\text{A} \)
- \( Aₛₑₕ = 1.35\text{cm}^2 \)
- \( Nₛₑₕ = 60 \)
- \( Nₛₑₕ = 75 \)
- \( Bₛₑₕ = 1.55\text{T} \)
- \( Eₛₑₕ = 200\text{mJ} \)
- \( Eₛₑₕ = 150\text{mJ} \)
- \( rₛₑₕ = 0.35\text{ms} \)

A higher core area is assigned to the HBI system to compensate for its smaller coil size, Fig. 4. In addition, a higher flux density is assigned due to a better lamination design and the larger effective air-gap which allows for greater stressing of the core. Peak current drawn from the battery is comparable to that of today’s inductive ignitions, ranging typically between 5 and 10A. It has a very low ripple resulting from using a fast-switching power converter design.

Controlling the switch

To complete the HBI system, a particular simple and low cost form of switch controller and driver has been developed, Fig. 2.

Assuming multiple switches for one-coil-per-plug ignition, the controller holds the gates of ignition coil power switches low. It does this by means of an n-type fet switch \( Sₙ \), whose drain interconnects the igbt gates through isolation diodes.

On ignition firing, i.e. the controller receiving a conditioned trigger signal at the inverting input of a control comparator, control switch \( Sₙ \) is turned off. This enables the gates of the igbts and sequences an octal counter.

The counter provides a turn-on signal through a resistor to one of the igbts to begin energising its associated coil. This continues until the set peak current \( Iₛₑₕ \) is reached. At this point, sense transistor \( Q₃ \) is turned on, pulling the comparator inverting-input low and turning on control switch \( Sₙ \).

Control device \( Sₙ \) disables the switches by rapidly discharging the igbt input capacitances \( Cᵢₑₙ \) for rapid turn-off of the energised switch. It also disables the remainder of the igbt switches.

Supply voltage for the octal counter is derived from the output voltage \( Vₑₕ \). This is because there would not be enough voltage to drive the gate of the igbt at the lower battery voltages encountered in automotive systems during cranking.

Fig. 3. Unless counter measures are taken, in an ignition system, false firing can occur when the switch closes. This problem would be aggravated in the new system due to the significantly higher supply voltage, were it not for \( Lₛₑₕ \) and other features, which completely eliminate the problem.

Fig. 4. State-of-the-art coil on the left has a two-piece welded core, 10000 turns of 42AWG secondary and a difficult-to-implement HT terminal. The new coil on the right has a one-piece E core, 5000 turns of thicker, easier to wind wire on its secondary and provides easier access to the HT end of the secondary. Benefits are,

- One piece lamination requiring no welding and easy packaging.
- 20% lighter weight coil due to the open E design.
- 40% lower primary wire turns, i.e. 60 versus 100 turns, ideally suited for a two layer winding.
- 50% lower secondary wire turns and use of 36 versus 42AWG wire which is much cheaper and easier to handle on a winding machine (less breakage) and takes half the time to wind.
- 20% lower cost due to the above listed advantages despite the three times higher energy.
Performance with low-volatility fuels

Once this new strategy for inductive ignition is realised, numerous advantages follow. A particularly interesting one is the ability to fire the ignition with closely spaced high-energy spark pulses under engine cranking conditions.

Long-duration spark firing during cold start is possible due to the rapid charge time \( t_p \), which is an order of magnitude shorter than that of conventional inductive ignition. A much higher spark energy and longer spark duration are provided. This allows the ignition of lower volatility fuels, such as further reformulated gasolines, neat alcohol, JP5 fuel - used because of its reduced fire hazard - water-gasoline mixtures, and others.

Low volatility fuels can have a major impact on volatile organic compound, or VOC, emissions. As cars become progressively cleaner and tail-pipe emissions are reduced, evaporative VOCs become the principal hydrocarbon emission.

Evaporation of fuel upstream of the engine is projected to account for approximately 80% of the total VOCs from new cars sold in California in the year 2003. The remaining 20% will come from the tail-pipe. Ignition of low volatility fuel can be accomplished even at low battery voltages of 5 to 6V. Such voltages occur in extremely cold climates during engine cranking.

In addition, 4kV diodes may be used at the coil secondaries, allowing for even closer spaced spark firing pulses, further improving cold-start capability. Such diodes are cheaper to implement than the 8kV types.

To take full advantage of the low-cost, high voltage diodes, high inductance magnetic core spark plug wire is preferred to limit peak spark breakdown currents to under 10A. Use of such wire also reduces electromagnetic interference.

Other advantages of the new system

A particularly important advantage of the HBI system is the development of a simpler and lower cost coil resulting from the low coil primary inductance dictated by the new approach. The low inductance permits use of simple open E-core coils versus the two piece welded design shown in Fig. 4.

When considering the benefits mentioned in Fig. 4, keep in mind that new coil delivers around 150mJ of spark energy versus approximately 50mJ for the current inductive ignition.

Table 2 compares ignition characteristics of the HBI system against various standard and state-of-the-art ignition systems.

These were measured, in part, by a reputable car manufacturer conducting the testing of the various ignition systems.

Where biasing magnets in the magnetic cores are needed to reduce size, this can be done more easily with the HBI coil because of its larger inherent air gap, retaining its three times higher energy density over the standard inductive ignition.

Unexpected benefits

There are other significant advantages than that of the ignition coil which follow from implementation of the HBI system. Most of these were not anticipated at the outset of the work to develop the HBI system and therefore only add to the motivation for use of this new system.

- Higher peak voltage to allow use of larger spark gap to further improve ignitability.
- Greater resistance to spark plug fouling due to the much lower inductance, faster rise times, and higher energy.
- Elimination of the need for computerised dwell - making the ignition universally retrofittable.
- Elimination of power switch (igbt) operation in the linear mode with its high dissipation and possibility for destructive oscillations due to unstable feedback loop in linear mode.
- Lower overall switch dissipation despite the much higher energy and peak currents as a result of the rapid charging of the coil and use of the low-loss snubber.
- Higher spark current characterised by higher spark power and greater resistance to spark segmentation by the high engine flows in modern high-output engines.

Three important questions remain regarding the new HBI system - what is the system cost, can it easily be implemented on a typical four-cylinder engine and what fuel efficiency gains can be expected?

Cost comparison

System cost can be analysed in a preliminary, general way by comparing 'costs of the three new critical systems of HBI against cost savings associated with the power switches and ignition coils. This assumes that biasing magnets are used in the coils of the conventional inductive ignition to bring its spark energy to 100mJ - a value which is still short of the 150mJ offered by the new system.

From data on switch costs, savings of $1 to $3 are achieved based on the prices quoted for the 400V, 20A ignition igbt which would be required for the improved standard ignition, versus that quoted for the 600V general purpose igbt. For the new ignition coils, 20% reduction results from the use of one piece lamination, half the number of secondary turns, 36AWG wire versus 42AWG, and removing the cost of biasing magnets.

The estimated overall cost savings are equal approximately to the cost of the additional components making up the HBI system. That includes the power converter with its input filtering capacitors, output capacitors, the transformer, the fet switch, and output diode. It also includes the saturating inductor, the active snubber and various other low-cost components.

Elements of the HBI system, i.e. power converter, saturating inductor, and the low-loss snubber, and the associated igbt switches can be mounted in the controller box. Preferably though, they would be mounted in a separate box located near the ignition coils, but sufficiently remote to avoid overheating.

On the other hand, predictions have been made by Kassakian (MIT), Wolf (Mercedes-Benz), Miller (Ford), and Hurton (G.M.) as reported in IEEE Spectrum, August 1996, that 42V will be made available in the passenger car engine compartment for operating motors and actuators. If this is the case, the HBI system can be fully integrated with an equal cost or cost savings despite its numerous advantages and benefits.

Fuel economy

On the issue of improved fuel economy, with high-energy igni-
tion, extensive experience over a 20 year period - which has included testing at GM, Mazda Motors, Lucas Industries, and Chrysler Corporation - has shown fuel economy to be improved by up to 20%. This is based on dilute combustion, principally lean burn.

Typically, the fuel economy gains would be largest under light load where air-throttling losses are high, and minimal at high loads. A conservative estimate over the typical driving cycle is 6% assuming air dilution is used at the light loads where NOx is low, and EGR is used at the higher loads where NOx is high.

| Table 2. Comparison between standard, state-of-the-art and HBI ignition systems reveals high energy output and efficiency of the new system. |
|---|---|---|---|---|---|---|
| Ignition | Inductance | Resistance | Spark energy | Coil weight | Efficiency | |
| HEI | 6.6mH | 0.4/950ΩΩΩ | 40mJ | 750g | <20% | |
| Waste Spark | 3.5mH | 0.4/6000ΩΩΩ | 35mJ | 260g | 25% | |
| Make 1 | 3.0mH | — | 50mJ | 255g | — | |
| Make 2 | 2.5mH | 0.6/— | 50mJ | 190g | 35% | |
| Make 3 | 2.8mH | 0.7/780ΩΩΩ | 50mJ | 210g | 35% | |
| HBI | 0.4mH | 0.15/500ΩΩΩΩΩ | 150mJ | 200g | 50% | |
These figures assume a full implementation of the HBI system which includes, in addition the electronics described, a larger spark gap and better penetration of the spark plug tip in the combustion chamber. Placing the plug deeper in the cylinder allows the spark to interact more fully with the high in-cylinder air flows, resulting in higher output at cold start, etc.

A 6% improvement in fuel economy on an average of 25 miles per gallon would bring the mileage closer to the current CAFE standard of 27.5 miles per gallon – a target which car companies are currently missing. It translates to 1.5 miles per gallon improvement, or a saving in CAFE penalties of $75 per vehicle – a far greater cost than any additional cost associated with the HBI system.

In terms of gasoline savings over the life of a car, assumed at 125,000 miles, this comes to a savings of 300 gallons of gasoline, which in the US would amount to $400 based on a fuel price of $1.33 per gallon and in Europe and Japan to $1000 based on a price of $3.33 per gallon. Even the smaller cost savings in the US would be well over ten times the projected additional small cost increase of the HBI system.

In summary

A new form of inductive ignition system has been developed which provides the required three times higher energy density of state-of-the-art inductive ignition systems and numerous other benefits not initially anticipated when this development program was begun some two years ago.

This new inductive ignition uses a higher, independently generated, constant voltage source of 42V – the value projected as best suited for other vehicle systems. It incorporates a standard speed, low-cost, 600V general purpose unclamped IGT as the switching element. It also uses a low cost saturating inductor to handle the switch closure false-firing problem and an active low loss snubber to minimise switching losses, rf and system heating, as well as maximising system efficiency.

Complementing the system is a unique, low cost, 85% to 90% efficiency high-output power converter based on the use of state-of-the-art low cost 60V fets, a ferrite core transformer, a 150V ultra-fast output diode, and a simple form of controller made up of a dual comparator.

Applied to current engines, HBI provides the small, high-energy coils of the one-coil-per-plug ignition the industry seeks, and a range of other benefits. These include short dwell time, fast rise-time, resistance to plug fouling and high efficiency.

More importantly, given the current growing concerns over fuel efficiency and emissions, HBI has the potential for up to 10% improvement in fuel economy and large savings in capital investment to car manufacturers willing to revitalise their current power plants – such as their twin-valve pushrod engines – to make them cleaner and more efficient.

My thanks to Dr Tony Jarret of Lucas Industries and Joe Franklin, both of London, England, for their unwavering support of this work.

Reference

Ward, M., 'A new spark ignition system for lean mixtures based on a new approach to spark ignition,' Society of Automotive Engineers' Technical Paper Series, No 890475, Warrendal, PA.

---

**A Powerful 12Bit Virtual Measuring Instrument For The PC**

Four integrated instruments are giving you all the possibilities for different kind of measurements and good documentation features.

**NEW**

- **OSCILLOSCOPE**
  Special developed controls make controlling the oscilloscope very easy and intuitive.

- **FFT ANALYZER**
  Spectra with records of 8K long and 6 window types. Simultaneous display of the signal in the oscilloscope and spectrum analyzer.

- **VOLTMETER**
  The voltmeter has up to six fully configurable displays. A car graph is added to each display for a quick signal size overview.

- **RECORDER**
  With the transient recorder slowly changing events, like temperature, can be measured.

- **CURSOR READOUT**
  For each channel there are two cursors. With the cursors several quantities of the signal can be measured.

- **DOCUMENTATION**
  To document the measured signals an option to place text balloons is available. In each text balloon specific text can be placed.

Handscope 2 specifications: 32KWord memory, 100% pre-post triggering, 12 bit resolution, 200 kHz sampling on each channel. 0.1 to 80V full scale, no external power supply, connected to printer port. Prices are excluding VAT.

TiePie engineering (UK): 28 Stephenson Road, Industrial Estate, St. Ives, Cambs, PE17 4WJ, UK Tel: +44 1480 460028, Fax: +44 1480 460340

TiePie engineering (NL): P.O. Box 290, 8600 AG NIJMEGEN, The Netherlands, Tel: +31 513 418 819, Fax: +31 513 418 819.

Call for a free demo disk or see our website: http://www.tiepie.nl    Email: info@tiepie.nl
Hands-on Internet

The Internet provides designers with the ability to locate and download sources of needed information into a personal computer. Tracing through random links can sometimes be surprisingly successful, but methodical use of a search engine is more reliable. Benefits of the net are maximised by quick search responses and fast download times for Web pages or files.

Internet access can be extremely slow during peak times, and of late, this slowness is extending well outside the peak periods for many popular sites. Traditionally, one sent a 'Ping' to check that an address was 'on-line'. I now find sending regular 'Pings', say one a second, can help in maintaining my route. A utility called 'Ponger', which runs on Win95, can be obtained from Tucows\(^1\), the specialist Winsock archive, to automate this task, Fig. 1.

Two years ago relatively few Web pages existed, so today's popular search engines had not been devised. Archie, Gopher, Veronica and Wais\(^2\) were the methods then used to locate sources. FTP was the only practical method available to download files from Internet.

One year ago, Java applets and the Netscape2 browser were introduced. Direct software downloads using a browser became commonplace, effectively supplanting use of FTP. As the numbers of Web pages increased, the AltaVista, Excite and Infoseek keyword search engines were developed to supplement the older directory searching methods.

There has since been an explosion of Web pages, to the extent that some companies now host 1000 Web pages on their site. This rapid expansion has resulted in major changes to all search engines - the largest now maintaining indexes covering more than 50 million Web pages and more than two-million URL site addresses.

This enormous increase in activity is linked to the trend towards larger and more glossy corporate Web pages,

Where to surf

2. Surfing with intent. C. Bateman. EW\&WW June 1995
9. LookSmart Search Engine http://www.looksmart.com
large graphical images and extensive use of Java applets. My present Internet access speed is frequently no faster using a V34 modem than it was two years ago with slow hardware. A recent and growing tendency for links to work initially quite quickly then slow considerably - or worse, simply drop out - has become apparent when downloading Web pages or transferring files.

In the November issue, I reported on the new Micro-Cap V software. I abandoned several attempts to download the 1.7 Mbytes evaluation version because my Netscape browser closed down the transfer before completion of the file. On one occasion this happened when the transfer was more than 90% complete.

One obvious solution is to use a traditional FTP client, but FTP from a Web page is only possible if that page provides an FTP address. Having only an http link, my FTP client could not be used to download the Micro-Cap V software file.

When a browser downloads slow or stalls, requesting a second download which you immediately cancel, often seems to 'wake-up' the route. Sending regular 'Pings', even continuously moving your mouse, sometimes helps maintain the route. Combining these techniques, I completed the download.

The Software Explorer page recently reviewed a potentially better transfer method for browsers. The 'GetRight' utility is a mini FTP client add-on which can even permit resumption of a broken transfer. Windows 3.1 users should first read the special instructions on the Headlight Software page.

**Routeing**

Internet's growth has resulted in two aspects contributing to these problems. You may have noticed that the time taken by your browser to look up Internet addresses has increased. These addresses are stored in increasingly large subnet tables on dedicated servers, used to determine the routings used.

Transfer from the Web server to your computer does not happen in a direct fashion, but as a number of 'hops'. Each hop determines the next hop location. Of course Internet uses many supplementary routes, rather like having a number of bucket chains, with each handler passing its bucket to whichever chain is next ready to accept.

A secondary problem results from data packets queuing at these routers. When their buffer memory overflows, routers lose data packets. Packet loss is an increasing problem, thought to result in e-mails going missing and to contribute to file transfer problems. While not generally relevant, any data packet which requires 255 or more hops to reach its destination, is automatically killed.

'Ponger' and 'GetRight' are palliatives. A diagnostic approach is needed to identify whether problems are caused by Internet, your provider or your phone line or hardware. Most modern operating systems provide usable utilities. 'Ping' has already been mentioned; Traceroute, IPtrace and TCPdump, or variations on these names, can help.

Traceroute can identify your outgoing Internet routing, but the return route might be quite different. 'Traceback' is a more difficult problem when running from your own computer, but it can be run using software at the NCDC site. My recent test indicated 18 hops were needed from Spectrum-Soft, several packets were lost and seven routings delayed, Fig. 2.

'NetMedic' is an excellent diagnostic utility and Internet tuning aid for Win95/NT. Its 'hop' monitor can be installed onto Netscape's toolbar, for continuous use, Fig. 3.

**Search engines**

Launched in May 1996, HotBot is Wired's entry into the search engine market. It uses Inktomi technology and has more than 50 million Web pages indexed. It provides an easy menu selection for your desired search parameters, Fig. 4.

LookSmart, launched by Reader's Digest in October 1996 using AltaVista technology, was redesigned in June this year and provides two search modes. Clicking on one of the border categories reveals more menu selections, thus combining the AltaVista keyword virtues with a simplified directory search.

**More bugs**

Following on from last months WinNuke problem, two bugs, affecting Microsoft or Netscape's browsers have been reported. News.COM reports of 5 and 11 September detail the bug discovered by the Massachusetts Institute of Technology. This problem affects Microsoft's Explorer 3, and its beta 4 version, software. It results from the Java
methods used within the browser, not a function of Java itself, Fig. 5.

A PC Week article dated 12 September details that Microsoft is actively removing all Java applets from its Web sites. This is apparently part of a campaign to speed up the downloading rate for its pages. Where needed, Java applets will be replaced by HTML code or Javascript.

The second bug, discovered by Ben Mesander and reported by News Com B and 12 August, affects both Microsoft and Netscape browsers. It can be demonstrated using Ben’s test page which houses two demons, demonstrating the two variations.

Ben first uses a harmless applet to redirect and download an image from Microsoft’s pages. For security, Java applets are only permitted to communicate with their host page, so should not transfer this image. I tried my machine, which passed this test.

Ben’s second test demonstrates the ‘Class Loader Bug’. In this test, the applet tries to download a harmless text ‘ticker’ again by redirection, from http://www.hq.af.mil. I also tried this out on my system, running Netscape 2.02 under OS/2 Warp4, and failed this test. The running ticker can be clearly seen.

While Ben’s tests were deliberately designed to be harmless, others could as easily use these techniques, to cause harm, Fig. 6.

Simulation and design software

Not all circuit simulation software is based on Spice. Many vendors specialise in providing frequency-domain-only simulation to extremely good effect.

One such system originates from Number One Systems – a long established UK developer. My very first commercial simulator was their original Analyser of 1983, running on the BBC model B microcomputer.

Since then I have regularly relied on the company’s Windows suite of integrated packages, for quick look-see simulation and final pcb design. Number One’s Layout simulator is able to extract printed circuit layout traces as circuit elements. These combine with conventional elements for Analyser simulation. If desired the results can be exported seamlessly to their Smith-chart program.

If you are looking for a low-cost, easy-to-use integrated suite of Spice based simulator, schematic editor and pcb layout tool, which you can download and evaluate before purchase, SuperCAD from Mental Automation is worth a look. The company’s SuperSpice simulator displays results using a virtual oscilloscope like display, having volts/division adjustment for each of four traces. Mental claims its SuperCAD schematic editor is fast becoming an industry standard.

Circuit applications

The Mc Graw-Hill Encyclopedia of Electronic Circuits is a cd rom containing 1000 circuit designs taken from industry leaders.

Also developed by Mental Automation this rom is based on the popular six-volume book series from Mc Graw-Hill and the circuits used were selected by the original author of the series, Rudolf Graf. Each circuit can be viewed or printed out using the supplied schematic viewer or can be edited with the Super/CAD schematic editor.
Electronics World incorporating Wireless World is applied electronic design. We'll show you how to use the latest silicon technology plus...

- CAE software
- New product reviews
- Technology reports
- Detailed circuit diagrams
- Innovations
- Explanations of complex technology
- Comment and much more in your issue.

So whether you are designing your own system or you're curious about your competitors, Electronics World will help you keep the leading edge.

Money back Guarantee.
Receive a full refund on your subscription within the first 90 days if you are not completely satisfied. Thereafter, we'll refund the unused portion of your subscription should you wish to cancel.

SAVE UP TO 10%
Yes, I would like to subscribe to Electronics World incorporating Wireless World.

1 Year  □ UK £32          □ Europe £46          □ Rest of world £56
2 Years  □ UK £58 SAVE 10% □ Europe £83 SAVE 10% □ Rest of world £101 SAVE 10%

Name
Job Title
Company
Address

Post Code  Country
Telephone  Fax  Internet Address

THREE WAYS TO PAY

1 □ I enclose a cheque made payable to Electronics World incorporating Wireless World for £

2 □ Please charge my Mastercard/Access/Visa/Diners Club/American Express (please delete appropriate card) with the sum of £

Card number  Expiry Date

Signed  Date

3 □ Please invoice me/my company. Purchase order number

Company VAT registration number

Please allow 28 days for delivery of your first issue. □ Please tick here if you do not wish to receive direct marketing promotions from other companies.

Post In the UK to Electronics World Subscriptions, FREEPOST ECC 2419, PO Box 302, Haywards Heath, RH16 3BR. Telephone 01444 445566

Post from elsewhere to Electronics World Subscriptions, PHQ-D/I700/RH, PO Box 302, Haywards Heath, RH16 3BR, UK. Telephone +44 1444 445566
TRANSFORMERS FOR BALANCED LINES IN HIGH PERFORMANCE AUDIO SYSTEMS

SOWTER TRANSFORMERS

E A SOWTER LTD
PO Box 36 IPSWICH IP1 2EL ENGLAND
Tel: +44(0)1473 252794
Fax: +44(0)1473 236188
E.Mail: sales@sowter.co.uk
Web: http://www.sowter.co.uk

Design and Manufacture of all types of Audio Transformer using Nickel and Grain Oriented cores

Free catalogue
Free technical support service
Popular types from stock

CIRCLE NO. 114 ON REPLY CARD

RF Power Modules from TDC & Mitsubishi

Standard parts stocked, replacement parts for many Yaesu/ Icom transceivers, ideal for linear PA designs.

<table>
<thead>
<tr>
<th>Part</th>
<th>Frequency</th>
<th>Part/Mode</th>
<th>Price (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M57726</td>
<td>144-148MHz</td>
<td>43W/FM</td>
<td>£43.71</td>
</tr>
<tr>
<td>M57729</td>
<td>430-450MHz</td>
<td>30W/FM</td>
<td>£42.00</td>
</tr>
<tr>
<td>M57737</td>
<td>144-148MHz</td>
<td>30W/FM</td>
<td>£27.23</td>
</tr>
<tr>
<td>M57762</td>
<td>1.24-1.3GHz</td>
<td>18W/SSB</td>
<td>£67.53</td>
</tr>
<tr>
<td>M57788M</td>
<td>430-450MHz</td>
<td>40W/FM</td>
<td>£66.99</td>
</tr>
<tr>
<td>M67715</td>
<td>144-148MHz</td>
<td>13W/FM</td>
<td>£36.48</td>
</tr>
<tr>
<td>M67727</td>
<td>144-148MHz</td>
<td>37W/SSB</td>
<td>£124.59</td>
</tr>
<tr>
<td>M67728</td>
<td>430-450MHz</td>
<td>60W/SSB</td>
<td>£99.04</td>
</tr>
<tr>
<td>Mi407-01 Pin diode up to 800MHz/25W</td>
<td>£1.21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Many other frequencies/ power combinations available, please call with your requirements.

Data sheets available for specific items on request.

Call for Amateur/ Education discounts or volume pricing

COMING SOON - Linear power amplifier 'Starter Packs' for 2M & 70cm.

MITUBISHI ELECTRIC

TDC also stock Modern, Networking and GPS receiver and antenna products, visit our web site at http://www.tdc.co.uk for more information.

CIRCLE NO. 115 ON REPLY CARD

REMOTE DESIGN COMMUNICATIONS LTD

Stroudley Road
Basingstoke
Hampshire
RG24 8FN

Telephone: 01256 332800  Fax: 01256 332810
e-mail: sales@tdc.co.uk

Access/Visa accepted, prices include VAT @ 17.5%, Postage & Packing £5

CIRCLE NO. 116 ON REPLY CARD

December 1997 ELECTRONICS WORLD
A window on analogue i/o

Colin Attenborough outlines a 12-bit analogue input and output subsystem that runs via the pc's printer port. Colin is also making available his Visual Basic software for controlling the port via Windows.

Subroutines and functions available to Visual Basic

These subroutines and functions are included in my software, which is available on 3.5in disk for £12.50 fully inclusive by writing to Department VB2, Electronics World Editorial, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. You need Visual Basic only to run this software.

With the two combined, you can control the analogue i/o port hardware shown via the graphical user interface shown in the screen shot here.

The address of the printer port is represented by _port. This is usually 37816, but watch the screen as the computer wakes up to check. Function are as follows.

initialise(int _port)
Sets the d-to-a converter chip enable, and clears all other lines on the printer port.

shutdown(int _port)
Clears all lines on the printer port.

AdcOn(int _port, int _d)
Sets the a-to-d converter power line to turn on the a-to-d converter, and takes some dummy readings to allow the supply voltage to settle. Variable _d is the delay parameter already mentioned.

AdcOff(int _port)
Clears the a-to-d converter power line to turn off the a-to-d converter.

in_A(int _port, int _d)
Returns an integer representing the a-to-d converter output. Variable _d is the delay parameter.

out_A(int _port, int _data)
Gives an output of _data millivolts from the d-to-a converter.

out_D(int _port, long _data)
Sets the digital outputs to _data.

The circuit of the analogue input/output hardware shown here can be built on its own or added to the digital i/o subsystem previously described. Both clock and data lines use the same pins on the printer port in both cases. Analogue and digital functions available in Visual Basic when the analogue and digital circuitry of the present and previous article are combined are listed in the appendix.

Levels between 0 and 2.5V are accepted by the analogue input; the d-to-a converter output generates between 0V and 4.095V.

Analogue input
The analogue section of the LTC1286 a-to-d
B²Spice & B²Logic

£199

Not Just a Pretty Interface
Software for the professional design engineer

Just some of the features

Fully Integrated and Interactive
Build the circuit on the screen and set up the simulations by choosing options from menus and dialogues. Run the simulation and view your results.

Flexible Visualisation of Results
In B²Spice results can be displayed in graphs, tables or directly in voltmeters and ammeters. Change from typical to worst case analysis and include the effects of temperature, components. You can customise everything, right down to the colour of an individual trace.

Versatility
A plethora of components includes resistors, capacitors, inductors, mutual inductors, transformers, controlled sources, bipolar junction transistors, zener diodes, power MESFETs, JFETs, MOSFETs, voltage regulators, operational amplifiers, optocouplers, voltage comparators, quartz crystals, IRIS VO buffers and switching matrix connectors and much more. All devices and model parameters can be edited to suit your needs. Implement hierarchical circuits in your designs quickly and easily.

No Limits
With B²Spice and B²Logic there is no limit on the number of components in the circuit.

Models
There are thousands of models included. The complete Berkeley SPICE model library as well as commercial libraries from manufacturers such as Motorola, Texas Instruments, Burr-Brown, Maxim, National Semi, APEX Comlinear, AMP, Elantec, Linear Tech, and many more. Included with B²Spice is a full model and symbol editing package so you can create, import and edit custom models.

Cross Probing
Cross probing allows you to display waveform results simply by marking pins, wires and devices on the circuit drawing. Monitor results while the simulation is in progress then plot analogue results on linear or log scales.

Waveform Analysis
Display and compare multiple response curves in a single graph at the same time. B²Spice simulation results can be selectively displayed and analysed graphically and in numerical format as well as exported to other applications. All of B²Space and B²Logic's display capabilities are completely flexible.

Devices & Stimulus for Simulation
In B²Spice sinusoidal, constant, periodic, exponential, single frequency FM, AM, DC voltage, AC voltage, VCO, Vcc, piecewise linear, exponential, polynomial / arbitrary source, voltage-controlled voltage, voltage-controlled current, current-controlled voltage, current-controlled current, lossy and ideal transmission line, MESFET uniform RC, current and voltage switches are all available.

Graphs
In B²Space analogue traces may be displayed as raw voltages and current values or further processed using arithmetic expressions, functions and Fast Fourier Transforms. You plot values corresponding to the cursor position on the graph and get data from multiple simulations in one graph. Multiple graphs to be aligned and compared.

Data Analysis
Plots, detection with mouse for data points, import and export data to and from other industry standard SPICE programs.

Digital Options.
B²Logic is completely flexible. Set up ROM, RAM and PLA to your own requirements. Shrink a whole circuit to a block and use it as a component in a new design. Run the simulations in real time or step by step. Customise rise and fall time of all components. Results displayed in a logic analyser or table. Select parts from all major logic families. Create your own custom libraries. Create and run pre-programmed simulations.

Professional engineers need software that produces results they can rely on. Anything less is a liability. B²Spice & B²Logic will give you the accurate results you need fast.

The best way to find out if a package is really what you need is to try it, which is what we're giving you the chance to do... risk free for 30 days.

We guarantee you will be 100% satisfied with the results or your money back.

For more information and to order call:
01603 872311

http://www.paston.co.uk/spice
email: rd.research@paston.co.uk

RD Research
Research House, Norwich Road, Eastgate, Norwich. NR10 4HA
Postage & packing £4.50. Prices quoted are ex VAT. All trademarks are acknowledged.
This 12-bit accuracy analogue-to-digital and digital-to-analogue I/O subsystem is controlled via the PC's printer port. Optoisolators not only provide protection, but also allows floating measurements and removes ground-loop problems.

Fig. 1. Designed for battery-powered operation, this 12-bit accuracy analogue-to-digital and digital-to-analogue I/O subsystem is controlled via the PC's printer port. Optoisolators not only provide protection, but also allows floating measurements and removes ground-loop problems.

By default, chip enable is at logic 1 to power down the a-to-d converter. To make a conversion, clear chip enable to logic 0 and apply fifteen clock pulses; read data at the rising edge of each clock pulse, most significant bit first, and then set chip enable to logic 1.

Optoisolators convey the chip select, clock and data signals; a fourth opto isolator switches power to the whole analogue input system. Since the system is powered by a battery – of typically four AA cells – power conservation is important.

I've chosen to isolate the analogue input section from the computer via opto isolators; this allows floating voltage measurements to be taken, and avoids earth loops with their attendant errors.

The a-to-d converter is most accurate when fed from a low source resistance, so a TLC271 op-amp is inserted as an input buffer. This op-amp also has the virtue of buffering the voltage being measured from the capacitive switching input current spikes which occur during conversion.

To allow the op-amp some headroom (shouldn't that be footroom?) I have exploited the differential input of the a-to-d converter, putting the negative input a diode drop above the system 0V line. This means that the op-amp output is always comfortably above its negative supply.

The system needs a supply voltage of between 4.5 and 6V. While the optoisolators specified have a breakdown voltage of 2.5kV,
other factors may limit the voltage that can safely be applied. Layout of whatever pcb or other form of construction is used in the area of the optoisolators is an example. In any case, consider your own safety when there are large voltages across the optoisolators.

Converter setup and accuracy issues
I have deliberately run the optoisolators at low currents to extend battery life. The penalty is that the comparatively high load resistors mean that the rise times at the phototransistor outputs are quite long.

To guarantee correct clocking, I have included a delay parameter in the function which reads the a-to-d converter. This is just a counter for a delay loop; a large value gives a large delay. Start with a large value, of say 2000, read the a-to-d converter with a known input voltage, and reduce the delay as far as possible while reliably getting the same output reading.

The delay does not affect accuracy. With a 100MHz 486 machine, a delay parameter of 250 gave stable results; the conversion time was about 1.5ms. Faster machines will need a larger value for the same a-to-d converter clock pulse width.

The offset adjustment potentiometer should be adjusted so that with no input voltage the output code flickers between 0 and 1.

Input voltage is defined by,

\[ V_{in} = \frac{\text{code} \times V_{\text{ref}}}{4095} \]

If you want to obtain best accuracy from the system, take into account that the reference generated by the REF25Z can be between 2.475 and 2.525V. If you have a sufficiently accurate voltmeter you can measure it and take into account its real value when you use the converter. Alternatively, you can calibrate it against a known voltage with a voltage source more accurate than the REF25Z.

Analogue output
I've used an LTC1451 serial d-to-a converter. Rather like the a-to-d converter, chip enable, referred to as CS* in circuit diagram, is at logic 1 by default.

To convert a digital data stream – most significant bit first – to an analogue output voltage, clear chip enable to logic 0 and apply twelve clock pulses, with the bits of the data stream valid at the rising edge of the clock pulses, and then set chip enable to logic 1.

The d-to-a converter gives an output of,

\[ V_{out} = \frac{2V_{\text{ref}} \times \text{code}}{4096} \]

For the nominal reference voltage of 2.048, this simplifies to,

\[ V_{out} = \text{code} \times 1 \text{mV}. \]

There is a maximum offset error of ±12mV at room temperature; the nominally 2.048V reference has a maximum error of ±40mV.

I would like to thank Cambridge Consultants Ltd for permission to publish this article.
You may know which capacitor technology to choose for a given task, but do you know why it's the best choice? Having spent thirty years designing, specifying and troubleshooting capacitors, Cyril Bateman shares his expertise.

Understanding capacitors

To my surprise, recent review of my publications library revealed a scarcity of capacitor articles. Perhaps I should have anticipated this since on reflection, many textbooks and circuit simulators all consider capacitors as ideal, so why delve further. On the other hand, capacitors have also been called 'strange devices', i.e. unfamiliar, which this article seeks to remedy.

Thirty years of experience as a capacitor design and applications engineer has convinced me that over-stressed or mis-applied capacitors are involved either directly or indirectly in most circuit failures. All components wear out in time, but mis-applied capacitors can fail extremely quickly. Worse still, before the capacitor ultimately fails, it can directly contribute to failure of semiconductors, masking the prime failure mechanism.

The best way to understand unfamiliar components is to perform measurements on representative samples, then dismantle them to understand their differing constructions. But with capacitors, not all the significant details are immediately apparent.

Capacitor overview

The fundamental definition of capacitance relates to charge and voltage, measured statically. Descended from the Leyden jar, a capacitor is essentially an energy storage device. Since its stored energy can be charged or discharged extremely quickly, alternative common usage ac definitions have been derived, as discussed in the panel entitled 'Defining capacitors'.

Of these definitions, the most important relates a capacitor's impedance to frequency,

\[ |Z| = \sqrt{R^2 + (X_C - X_I)^2} \]  

(1)

Where,

\[ X_I = 2\pi f L \]  

(2)

and

\[ X_C = \frac{1}{2\pi f C} \]  

(3)

Throughout this article, the series equivalent expressions are used, denoted as \( X_C \), \( R \), etc., unless otherwise stated.

At any frequency, the term \( X_C - X_I \) can be simplified to \( jX_C \), giving the fundamental vector equation for impedance, \( Z = R + jX_C \).

This vector equation leads to the common usage expressions for impedance magnitude \( |Z| \), and phase angle,

\[ \theta = \tan^{-1} \frac{X_C}{R} \]

This phase angle definition results in the second most important quantity for capacitors – loss factor,

\[ \tan \delta = \frac{R}{X_C} \]

An ideal capacitor would have a phase angle, hence \( \tan \delta \), that remained constant regardless of frequency. Since by definition, eqn 3, a capacitor's reactance, \( X_C \), is totally dependent on frequency, so also must be the capacitor's series resistance, \( R \), known as esr. This is clearly demonstrated by the results measured for a very high quality polystyrene capacitor, Table 1.

What is a capacitor?

Any two conducting surfaces, separated by an insulator, exhibit capacitance. The value of this capacitance increases with surface area and reduces with separation.

The fundamental definition of capacitance assumes this insulator is a vacuum, thus directly relating to the permittivity of free space.

**Capacitance**

Free space permittivity × \( \frac{\text{Area}}{\text{Separation}} \)

But area and separation alone are insignificant compared to the contribution provided by a change of insulation material. Each insulation material used is rated for dielectric constant, or

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Capacitance (nF)</th>
<th>Tanδ</th>
<th>'Q'</th>
<th>ESR (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100kHz</td>
<td>9.9982</td>
<td>0.00010</td>
<td>9000</td>
<td>17.0</td>
</tr>
<tr>
<td>1kHz</td>
<td>9.9988</td>
<td>0.00005</td>
<td>20000</td>
<td>0.8</td>
</tr>
<tr>
<td>10kHz</td>
<td>9.9996</td>
<td>0.00015</td>
<td>6000</td>
<td>0.26</td>
</tr>
<tr>
<td>100kHz</td>
<td>10.0000</td>
<td>0.00005</td>
<td>3000</td>
<td>0.05</td>
</tr>
</tbody>
</table>
'K' value. This represents its permittivity relative to free space.

In practical materials used to make commercial capacitors, this 'K' ranges from 1.00059 for air, 2.0 to 4.0 for plastic films, 8 for aluminium, 28 for tantalum electrolytics, and from 6 up to 12000 for differing ceramic formulations.

Given this wide range of dielectric constants, it is natural to loosely categorise all capacitors by the dielectric material used. While in general this is valid, the final capacitor's size and electrical properties also vary according to the construction methods used.

For a given dielectric, thickness - or rather thickness - is all important in determining the capacitance achieved in a given physical size. Usable dielectric thickness is limited by its ability to sustain the required voltage as well as surviving manufacturing methods. Common plastics which can be manufactured in micrometre thicknesses, withstand around 500V dc per micrometre, at room temperature, short term.

Since the dielectric for electrolytic capacitors is 'formed' in situ on the base foil, it doesn't need a minimum thickness to provide handling strength, as do plastic films. Together with certain multilayer and disc ceramic construction techniques, electrolytic dielectric thickness is limited only by the voltage that needs to be sustained.

To minimise the final size, the dielectric together with its conducting surfaces - the electrodes - may be compacted using winding, stacking, folding or layering techniques. These processes lead to supplementary descriptions including wound, stacked and multilayer.

Electrodes formations

The conducting surface for paper or plastic dielectric materials is produced by one of two common techniques. In one of them, an extremely thin, visually transparent coating of metal, generally aluminium, is vapour deposited on to the insulator in a vacuum chamber, resulting naturally in the description metallised capacitor. This method however cannot be used with polystyrene.

When the dielectric itself is not metallised, the alternative and electrically superior method uses thin flexible soft metal foils or discrete metallised plastic foils, as electrodes. These foils are interlaid with the dielectric during assembly.

The surface of ceramic dielectrics is generally made conductive by coating with suitable metal inks. After air drying, these are 'fired' at high temperature.

With aluminium electrolytics, the aluminium base anode foil has the dielectric oxide, i.e. Al₂O₃, pre-formed electrolytically on its surface prior to assembly. The anode foil acts as one conducting electrode.

This electrolytically formed dielectric's thickness is self regulating, attaining some 14Å for each volt applied in manufacture. At 10V working for example, this represents only 0.02µm dielectric thickness (1µm, or micron, is 0.000001m). The second electrode is the electrolyte material with which the separating tissue paper is impregnated.

Assuming a polarised capacitor, connection to the electrolyte is made using a second, usually thinner, aluminium foil or cathode. While this cathode is not deliberately formed, it inevitably possesses a much thinner naturally occurring aluminium oxide, electrically equivalent to a few volts. In this way, a pair of back to back capacitors is created. One has the desired capacitance and voltage capability while the other has a much greater capacitance but only a few volts capability, applied in reverse.

With a non-polarised, or bi-polar capacitor, this uniformed cathode is replaced by a second deliberately formed anode foil. This results in two capacitors back to back, usually having the same capacitance and voltage capability.

Depending on the desired life-length characteristics, the pre-forming voltage used can range from 1.2 times to more than double the working voltage, trading size and cost against leakage current, and hence endurance.

Properties of capacitors

Every capacitor needs conducting surfaces, or electrodes, which inevitably have some intrinsic resistance. Having a physical cross section and length equates automatically to inductance, called self-inductance. As a result, a capacitor must be represented as a series CLR combination circuit.

This CLR network results in a circuit whose resonant frequency depends on the capacitor's value and construction. At the resonant frequency, the capacitor represents a dc blocking low value resistance, and a dc-blocking but inductive reactance at frequencies above this resonance.

At any frequency, a perfect capacitor, having neither resistance nor inductance, would sustain a voltage in quadrature with the applied current. Analysed on a polar display, voltage would be -90° and current 0°, so the complementary angle delta would be zero. Having no resistive element, this perfect capacitor cannot lose or dissipate energy.

The self-inductance results in a voltage at +90°. This subtracts magnitude from the capacitive voltage, increasing the apparent capacitance value which would be measured.

With a near perfect capacitor, the above resistance, appearing in series with the capacitive reactance, degrades this -90° angle, resulting in the complementary angle delta increasing. This change in phase angle represents the resistive element which dissipates energy as heat in the capacitor, Fig. 1.

With capacitors, it is usual to refer only to this delta loss angle, which is generally described as tanδ.

Dielectrics

Unfortunately, all dielectrics other than vacuum contribute their own particular degrada-

Fig. 1. This simple vector diagram shows the relationship between tanδ and cosφ. Both are essentially equal only with small loss angles. The interaction between the capacitance χc and inductance χl vectors is also visible.

nations from this near ideal capacitor. In general the more highly stressed the dielectric, in volts per micron, the greater the degradation.

Since the characteristics of both vacuum and air capacitors depend principally on the particular insulators used to support their assembly, they are excluded from these discussions.

Depending on the symmetry of its molecular structure, each plastic dielectric can be described as having either polar or non-polar characteristics. A symmetrical-molecule plastic, or other non-polar dielectric, has electrical characteristics effectively constant with changing frequency, and exhibits minimal dielectric absorption effects.

If this polymer molecule is not symmetrical, it has a dipole moment resulting in increased dielectric constant. Similarly, ferroelectric ceramic crystal poles and domains can produce extremely high dielectric constants. Such types are known as high-K dielectrics.

Both result in polar characteristics, i.e. a capacitance that reduces and a tanδ that increases with frequency. These are functions of the basic materials used - not to be confused with the constructional terms polarised and non-polarised or bi-polar, as applied to electrolytic capacitors.

While manufacturing techniques cannot change a polar dielectric into a non-polar, they can enhance the polar effect. Stressed with dc voltages, polar materials exhibit a reluctance to accept or release their full charge instantaneously - a behaviour called dielectric absorption.

What is dielectric absorption?

If a capacitor is fully charged, to say 10V, for a considerable time, briefly discharged using a short circuit, then left to recover, a voltage is found which develops with time. The ratio of this resultant voltage compared to the initial charge voltage, is described as dielectric absorption.

In past years dielectric absorption was only
Some degree of piezoelectric effect, which can result in a voltage when they are mechanically constrained, whether physically or from temperature changes while rigidly or surface mounted. Some care is needed to differentiate this effect from that of dielectric absorption.

Both effects are small and are irrelevant for most applications. However when working with sample/hold circuits, charge amplifiers, etc., capacitor choice should account for these effects.

According to manufacturing techniques used, every practical capacitor exhibits some dielectric absorption effect. However polystyrene or polypropylene film/foil and COG NPO dielectric ceramic capacitors, show minimal effects.

With the inclusion of this dielectric absorption mechanism, it is now possible to deduce the equivalent circuit for a practical capacitor, Fig. 2.

**How temperature affects capacitors**
Ceramic COG NPO type capacitors are restricted to ±30ppm/°C change of capacitance with temperature and are the most stable available. With the exception of these, all dielectrics show easily measured larger capacitance changes over their temperature range. General-purpose ceramic capacitor dielectrics are categorised under the EIA classification scheme. The popular X7R material is thus restricted to a box envelope allowing ±15% change in capacitance over its working temperatures. However the exact profile within this envelope differs with manufacturer.

Change in temperature also results in a change of measured tanδ for most common dielectric materials. Non-polar dielectrics show very small changes, but with a polar dielectric, the maker’s data should be consulted.

**Voltage effects**
Many polar dielectrics have a capacitance which changes with applied ac or dc voltage. With voltage, capacitance tends to increase above that measured at 1V then declines. Since this behaviour depends on the precise dielectric chosen and manufacturing technique, makers data should be consulted.

**Frequency effects**
As shown in published data, almost all capacitors exhibit a frequency-dependent capacitance change. Less well known, the dielectric strength or voltage withstand of film dielectrics, can reduce with increasing frequency. For many applications this is not important since the power or current rating constraints which should be applied, dominate.

With pulse waveforms having large peak-to-mean ratios, power constraints no longer dominate, so it is essential to consult makers’ data when choosing a capacitor for pulse duty.

More significant for general applications, every capacitor regardless of dielectric has frequency dependent tanδ losses, which increase with frequency.

**Power limitations**
Having mentioned power ratings, surely since current and voltage are in quadrature, no power is dissipated in a capacitor?

I mentioned that a near ideal capacitor has
conducting surfaces with a finite resistance. These electrodes must connect to the outside world using one of a variety of means, inevitably adding resistance. The sum of these metallic resistances, true series resistance, or rts, is a very low value fixed resistance. For convenience, since it cannot be otherwise separately measured, it is sometimes viewed as being the minimum impedance, seen at resonance, on a conventional impedance and frequency plot, Fig. 3.

However other, usually much larger, loss resistances are found in practical capacitors. Every capacitor exhibits a leakage current, which is voltage and temperature dependent. A rule of thumb based on the Arrhenius law, is to assume this current doubles for each 10°C increase in temperature. Obviously this current can be represented by a high value insulation resistance in parallel with the dielectric. More conveniently, following the parallel-to-series conversion rules, it equates to a very small fixed value series loss resistance. With most capacitors, the dielectric’s tanδ, frequency, voltage and temperature related losses dominate. These are also expressed as series resistance.

The sum of all these resistances, at any one frequency, is called the equivalent series resistance or esr. As can readily be seen, esr is frequency, voltage and temperature dependent, so when quoted in makers’ data, it only applies to the particular conditions quoted.

To aid understanding, it is perhaps easier to consider esr as a combination of the above leakage resistance and rts, together with a polar plot, or on a Smith chart, this X term has a negative value for capacitors, Fig. 1.

The commonly used expressions,

\[
\tan \delta = \text{abs} \frac{jX}{V} \quad \text{and} \quad C = \frac{-1}{2\pi f X}
\]

also apply.

**Series or parallel?**

The impedance vector of a practical capacitor at any one given frequency can be represented using an equivalent circuit of the device with a resistor. The resistor, used to degrade the phase angle to that measured, can be either a high value in parallel with the device, or a low value in series with the device, leading to the term ‘equivalent series resistance’ or esr.

While the parallel equivalent values have use for certain calculations, the series equivalent values are more commonly used. Throughout this article, the series equivalents are used unless otherwise stated.

Take this practical example. An impedance vector, magnitude 100Ω and phase angle -84.3° at 1kHz, represents a capacitor having a tanδ of 0.1 and a Q of 10. This vector would result from a series combination of 9.95Ω resistive and -99.52Ω reactive, i.e. a 1.6µF capacitor or a parallel combination of 100Ω and 1.584µF. A difference in equivalent capacitance value of 10%. The equivalent series resistance would be 9.95Ω.

**Parallel impedances**

Certain measuring instruments or mathematical calculations are more suited to the equivalent parallel expression, which can easily be converted to or from the series values.

\[
R_p = \frac{R^2 + X^2}{R} \quad \text{and} \quad X_p = \frac{R^2 + X^2}{X}
\]

Sometimes the measured results are needed as admittance rather than impedance; conversion from the parallel impedance expression is simple,

\[
Y = \frac{1}{R_p \pm jX_p} = G_p \pm jB_p
\]

\[
G_p = \frac{R}{R^2 + X^2} \quad \text{and} \quad B_p = \frac{X}{R^2 + X^2}
\]

The conversion from parallel impedance back to series impedance format, following,

\[
R = \frac{R_p \times X_p}{R_p^2 + X_p^2} \quad \text{and} \quad X = \frac{R^2 \times X_p}{R_p^2 + X_p^2}
\]

is equally simple.
number of variable contributions dependent on frequency, voltage or temperature. This esr, together with the alternating current passing through the capacitor, can be used to calculate the power dissipated in the capacitor.

When the capacitor is subjected to a sinewave, simple calculations suffice. Given a complex waveform, the only method that ensures accurate results is to use Fourier transforms to characterise the waveform into its discrete frequency components.

Only when a capacitor is measured at its final working frequency, temperature and voltage can its esr be derived directly from bridge measurements of tanδ and capacitance. But in most applications it is not practicable to make bridge measurement under such conditions. Consequently esr must be estimated taking account of each variable in turn.

I have stressed that esr is frequency dependent, but does it really change by a significant amount, or am I simply being pedantic?

Consider the esr of a high-quality 10nF polystyrene foil/film capacitor. I selected such a device as one of the standard capacitors when building my capacitance bridge. All measurements were taken using a four terminal Wayne Kerr 6423 precision component analyser, with a test voltage set to 1V, Table 1.

These results show clearly how esr values do change significantly with frequency, for this high quality capacitor. Many writers on this topic have confused these esr and tsr terms. Obviously they differ substantially, except at that frequency when the capacitor is self resonant.

Since correct understanding of esr is essential to avoid over-stressing capacitors, I make no apology for labouring the point.

Implications of voltage ratings

Many years ago, when impregnated metallised paper capacitors were the standard workhorse, it was considered that a capacitor rated for 400V dc or above could be used on 250V ac mains. Since these capacitors were impregnated, this was just about feasible. Unfortunately this premise tends to continue even today.

When the then new unimpregnated metalised PET capacitors became commonly available thirty years ago, 400V dc parts were used for many of these 250V ac mains requirements. Result - misery. If you were lucky, the end terminations eroded, disconnecting the capacitor. If you were unlucky, the capacitor caught fire.

Even today, I have vivid recollections of this unhappy time, when my task was to withdraw from all 250V ac applications and re-rate the capacitors to 160V ac, on behalf of my employer, for this particular construction.

Why should this problem arise?

Given an impregnated or otherwise solid, void free, capacitor construction, 250V ac and above causes no insuperable problems. However with non-impregnated non-solid constructions, air voids occur within the capacitor.

According to Paschens curve of ionisation, an air-filled void having optimum size and air pressure can exhibit ionisation inception at voltages as low as 185V ac. This is why 160V ac was adopted in the previously-mentioned application to provide a safety margin.

Once triggered, the ionisation current is self sustaining at lower voltages - in fact almost to zero volts. Thus once triggered, the resulting discharge continues for at least 50% of the periodic waveform.

This ionisation discharge is damaging to almost all dielectric materials, resulting ultimately in a short circuited capacitor.

From these experiences, international and national safety rules for class X capacitors, used across the 250V ac domestic mains, were developed. Two main capacitor styles emerged. These were a much updated resin impregnated metallised paper capacitor and the two-in-series metalised polypropylene style, which worked since its two series capacitor elements shared the applied voltage.

Manufacturing measurements

National and international capacitor approvals require manufacturers' measurements to be 'true' values, i.e. traceable to nationally held standards. In general, this means that measurement equipment must have an inherent accuracy ten times better than any claimed component parameters. Measured values must be 'inset' sufficient to eliminate all known measuring equipment errors.

With low-loss or close-tolerance capacitors, these requirements are not easily attained. A test frequency of 1kHz is standard for capacitors of value greater than 1nF except for electrolytic types, which are generally tested at 100Hz. Resulting from their high impedance at 1kHz, capacitors equal to or less than 1nF are tested at 1kHz. In general, test voltages of 1V ac or lower are used.

Experimenter's measurements

Commercially available capacitance test equipment can supply a DC polarising voltage to the component, but is generally restricted to a maximum of 20V dc.

However an adapter permitting much higher voltages can be simply made. Hewlett Packard application note 346 - A Guide line for Designing External DC Bias Circuits - provides details of adapters for their ranges of precision meters. However these principles can easily be extended to any equipment...
Power stress circuit

When designing switching supplies, much benefit derives from measuring a capacitor at its final working voltage and frequency. While low power measurements using a bridge are possible, other techniques are essential for higher powers or voltages.

These power or voltage limitations result because taking current in quadrature with voltage stresses any power amplifier. The amplifier's power dissipation increases rapidly when driving a capacitive load, leading to instability or failure.

If this capacitive load is resonated using a suitable inductor, the power amplifier is presented with a zero phase load. The inductor provides either the voltage needed to the capacitor, or the current. Since it also needs to supply only voltage or current and not both, amplifier power dissipation can be low, Fig. 5.

Using a series-resonant circuit, the amplifier supplies the required through current but at a much reduced voltage. With a parallel resonant circuit, the amplifier supplies the required voltage at a much reduced current. The inductor's stored energy supplies the missing voltage or current drive required by the capacitor. The amplifier only supplies the power needed to replace that lost due to capacitor dissipation, inductor resistive losses and the protection resistor.

Using a stable air cored inductor with a Q of ten or better, and a 100W moslet audio power amplifier, capacitor voltages of 250V can be easily attained using the series circuit. An air cored inductance provides the stability needed for meaningful calculations.

Conversely the parallel configuration easily provides 5A. The schematic circuit suggests using a series resistor to protect the amplifier in the event of capacitor failure. Much higher levels are possible if this resistor value is reduced.

Capacitance change with frequency, voltage or current can be calculated from the circuit's change in resonant frequency, the voltage drop and through current measurements of the test capacitor.

which might need to be used, Fig. 4.

Commercially available capacitance testers can often measure using more than 1V ac test voltage, but they rarely extend above 20V ac. Higher test voltages are possible using Wheatstone bridge methods but care is needed not to overload either the test source or the bridge measurement arms — especially with increasing frequency.

A low accuracy alternative method which can measure to very high voltages and frequencies requires use of a power amplifier together with suitable high 'Q' inductors. Depending on whether higher voltage or greater current than can be sourced by the amplifier is needed, these inductors are used to either series or parallel resonate with the capacitor. Using these techniques, satisfactory measurements to 500V ac and several amps at frequencies to 1MHz have been performed, Fig. 5.

Capacitor life

Qualification testing requires capacitors to survive continuous operation at maximum ratings and maximum temperature for typically 1000 hours. In some instances the capacitors are required to be stressed in excess of claimed levels, or for much longer times. To understand the implied life-test claims, you need to read the specification.

Compared to actual end use 1000 and even 10,000 — hours endurance is extremely short. But components in end use are not generally continuously stressed, certainly not to their maximum capability and temperature. Arrhenius law suggests that insulation resistances halve, alternately leakage currents double, for each 10°C increase in temperature. Consequently 1000 hours at 125°C can represent a useful life under normal end use conditions, of 10 to 20 years — even assuming maximum applied voltage.

A secondary benefit results from reduced voltage. All capacitors, including electrolytics, exhibit prolonged life with reduction in operating voltage, even to zero dc, provided any applied ac does not otherwise contravene the capacitor specifications.

One common mis-statement that electrolytics exhibit no capacitance with zero or reverse bias — is completely unfounded. The dielectric film is chemically robust and cannot in the short term be changed. Long term, assuming reverse voltage is within the permitted levels, leakage current increase can result in parametric failure.4 However if an electrolytic which has been operated for some time at reduced voltage, is then subjected to increased voltage, a temporary increase in leakage current results. The capacitor may then fail to meet its specification. Since the converse also applies, any capacitor subject to excess temperature, voltage or current or mechanical stress, will fail quite quickly.

One special aspect which certainly causes electrolytic failure, is unwitting excessive repetitive reverse bias. This can arise when a polarised capacitor is used to couple the drive waveform into a switching transistor base and at the same time block dc. This mis-use is especially common. I have personally experienced this failure mechanism many times, in both television and satellite receivers.

With switching power supplies, an early indication of an electrolytic being reverse biased is increased transformer noise and notable temperature increases. However with television line and frame timebase generators being less audible, the first indication can be either reduced drive amplitude or semiconductor failure.

Such abused capacitors usually show visible signs of overheating or electrolyte leakage, measurable loss of capacitance and increased esr and reverse voltage withstand. I hope to delve further into this topic in a subsequent article which explores and measures various capacitor constructions.

References
1. Reference Data for Radio Engineers, pub Newnes.
5. Safety requirements for EMI suppression capacitors, http://www.rifa.se
6. A guideline for designing external dc bias circuits, Hewlett Packard Application Note No 346.
IF HELICAL BPF FILTERS (7H series) for Set-top Box/Video Sender/WLAN/WLL/CMDA/REPEATER/MA... YOU MAY SPECIFY ANY OF TF-FREQUENCY & BANDWIDTH (3X-35MHz).

<table>
<thead>
<tr>
<th>PARTS NO. (Refer to Table 2A)</th>
<th>Fo (MHz)</th>
<th>Fo ± 2dB</th>
<th>Fo ± 10%</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>707145-35000/7H-1000</td>
<td>70/54</td>
<td>67/54</td>
<td>70±10</td>
<td>50</td>
</tr>
<tr>
<td>707146-35000/7H-1500</td>
<td>70/54</td>
<td>67/54</td>
<td>70±10</td>
<td>50</td>
</tr>
<tr>
<td>707147-35000/7H-2000</td>
<td>70/54</td>
<td>67/54</td>
<td>70±10</td>
<td>50</td>
</tr>
<tr>
<td>707148-35000/7H-2500</td>
<td>70/54</td>
<td>67/54</td>
<td>70±10</td>
<td>50</td>
</tr>
</tbody>
</table>

COLOMOR ( ELECTRONICS LTD) 170 Goldhawk Road, London W12 8HJ Tel: 0181 743 0899 Fax: 0181 749 3934 Email: giacomelli@colomor.demon.co.uk

CIRCLE NO. 120 ON REPLY CARD

HALCYON EAI220 DUAL regulator 8-15V, 2A 9.5-14V, 1A

CIRCLE NO. 119 ON REPLY CARD

---

**VALVES WANTED - NEW AND BULK**

| KTB6 - GEC | £80.00 each |
|KTB6 - GEC | £80.00 each |
|EL84 - Mullard | £12.00 each |
|EL84 - Mullard | £12.00 each |
|DA20 - GEC | £10.00 each |
|FT51 | £20.00 each |
|DA20 - GEC | £10.00 each |
|P22 - StC | £10.00 each |
|P22 - StC | £10.00 each |
|UM84 | £10.00 each |
|UM84 | £10.00 each |

---

**PRECISION FREQUENCY SOURCES**

1kHz to 16MHz, Sinewave output, 0.001% resolution, Easily settable via decade switches, VCO backup as standard.

**OFF-AIR FREQUENCY STANDARD**

1MHz, 5MHz and 10MHz outputs, Options include Sinewave, Signal inhibit and Audio Warning

CIRCLE NO. 112 ON REPLY CARD

---

**HALCYON ELECTRONICS Off-Air Frequency Products**

We manufacture a range of Off-Air Frequency products including frequency standards, sources and disciplined standards including GPS, Customised units also available.

CIRCLE NO. 121 ON REPLY CARD

---

**HALCYON ELECTRONICS 243 Kingston Road, Wimbledon Chase, London SW20 8JR**

Phone: 0181 542 6383 Fax: 0181 542 0340

CIRCLE NO. 122 ON REPLY CARD
Never mind the quality — feel the bandwidth

As MPEG video and audio compression becomes increasingly popular, there are signs that the quality is suffering. Here John Watkinson explains why compression artifacts occur and — more importantly — what can be done to reduce them.

In audio/visual program material, the advantages of compression are many — hence its popularity. Compressed material requires less bandwidth which is ideal for broadcasting, where the radio spectrum is under increasing pressure from other mobile services.

Compression also allows the cost of storage or recording to be reduced, although as recording economics improve year on year this may be a transient advantage.

Compression principles
Figure 1a) shows that in all real digital program material the bit rate is the product of the sampling rate and the word length. In practice the overall bit rate is made up of a varying mixture of unpredictable or novel material, known as entropy, and the remainder which could be deduced from first principles, known as redundancy.

An ideal compressor would separate the two perfectly so that only the entropy need be sent. An intelligent decoder would work out the redundancy for itself and reproduce the source signal without loss.

Entropy is a characteristic of the signal and varies. Figure 1b) shows that if all of the entropy is not sent there is quality loss. The ideal is a variable rate channel which allows constant quality. If a fixed rate channel has to be used, the quality will vary.

In an MPEG-2 transport stream, several compressed signals can be statistically multiplexed together. It is unlikely that all will reach an entropy peak together, consequently a transport stream can be divided into a number of varying bit rate channels.

Provided that the overall bit rate remains constant, individual channels can demand more bandwidth when difficult material is encountered on the assumption that other channels are probably handling easier material at that time.

In the DVD — digital video disk, also known as digital versatile disk — a variable bit rate is supported in a single program stream simply by changing the rate of disk accesses.

Unfortunately the ideal coder of Fig. 1 is infinitely complex and has an infinite processing delay. Practical coders have to constrain both. When either of these constraints are applied, the bit rate has to go up to maintain quality, as Fig. 1c) shows. Figure 2 shows that for constant quality the bit rate will reduce as the latency increases.

Video compression
In MPEG-2, the temporal compression is obtained by sending motion compensated difference pictures, and further spatial compression is obtained by transform coding the differences.

Differential coding simply subtracts the previous picture from the current picture and sends the difference. When there is motion differences increase. This is handled by measuring the motion between pictures on a 16-by-16 pixel block, or macroblock, basis.

John Watkinson, F.A.E., B.Sc., M.Sc.

Fig. 1. Entropy is always less than bit rate, a). To avoid quality loss, all entropy must be sent, b). The simpler or faster the coder, the more data that must be sent, c).
and transmitting a vector for each block. The decoder and the encoder both shift the previous picture using the vectors and only the difference between the shifted previous picture and the current picture need be sent.

Pure differential coding fails if there is a transmission error because that error propagates indefinitely. It also makes it hard for the viewer to change channels. In practice periodic whole picture have to be sent to prevent error propagation and to create decoder entry points. These are known as intra-coded, or I, pictures because they make no reference to any other picture and are only spatially compressed. In between these I pictures differential coding is used.

Moving objects cause problems in differential coding because they reveal background at their trailing edge which is previously unknown.

This is overcome by using information from future pictures. Figure 3 shows that in bidirectional coding a picture can be decoded using information from pictures before or after. The decoder does not need a crystal ball to obtain the future pictures; instead, pictures are sent out of sequence.

Figure 4 shows that after an I picture, a future picture is differentially coded in the forward direction only. This future P (predicted) picture is sent immediately and stored in the decoder.

Pictures between the I picture and the P picture can now be sent these B (bidirectional) pictures can be created by forward or backward motion compensated differences on an individual macroblock basis.

The pictures and difference pictures are spatially compressed. The process begins by performing a dct, or discrete cosine transform, which expresses an 8-by-8 pixel block as a set of 64 coefficients. In typical video material, many of the coefficients will have zero or negligible values so that only the significant ones need to be transmitted.

Compression artifacts

Compressors are generally iterative and are driven by a bit-budget measurement. If the output bit rate is too high for the channel the dct coefficients will have to be expressed in fewer bits. In the case of large value coefficients, when low order bits are lost they become less accurate. In the case of small value coefficients, they may be truncated to zero.

This has a number of side effects. Coarse quantising of large value coefficients means that after the inverse dct at the decoder the eight-by-eight pixel block may have considerable errors in the sample values.

While these are not necessarily visible in themselves, the errors in adjacent blocks will mean that there is a discontinuity in the block boundaries so that the blocks become visible as shown in Fig. 5a). If high frequency coefficients have been truncated to zero the block will lack detail and resemble a tile as in 5b).

This effect occurs in both the luminance and colour difference paths. In luminance the effect is called contouring whereas in colour the effect is called posterising, where gradual colour changes have been replaced by a limited colour set, as might be available in a box of poster paints. In MPEG the colour posterising can be quite obvious because the chroma blocks are the size of a macroblock and have four times the screen area.

Effects of truncating hf coefficients

Where high-frequency coefficients have been truncated to zero, the effect is to introduce ringing on edges. This is because an edge contains high frequencies and removing them is the equivalent of a sub-optimal low pass filter, hence the ringing. This is particularly noticeable on graphics and captions, less so on natural subjects.

When the prediction of the temporal coding fails, the data in the difference pictures will necessarily increase and this will force the compressor to quantise more heavily, raising the artifact level. This is particularly noticeable on B pictures since they are generally allocated only 10% of the data rate.

Fig. 3. Bidirectional coding uses information from both past and future picture frames.

Fig. 4. Bidirectional coding requires pictures to be transmitted out of sequence.

Fig. 5. Discrete cosine transfer blocks may not blend together if excessive truncation is used, a). Where high-frequency coefficients are also discarded, dct blocks become tiles, b).
Temporally difficult material, such as when frequent cuts are made, may overload an encoder. Cuts remove temporal redundancy and defeat bidirectional coding. Following a cut, several pictures may contain serious blocking artifacts.

The real MPEG killer material is video from a press conference where flashguns are firing. Each flash drives up every single pixel value for one picture, and then in the next picture the values come back to normal. This causes temporal chaos and most MPEG coders substitute a picture of the designer’s bathroom wall under these conditions.

Pre-processing controls artifacts
The level of artifacts can be controlled by pre-processing. There are three levels at which a pre-processor can operate,

- By removing noise from the source material.
- By removing entropy from the source material.
- By aligning the 1 pictures in the coder output with the temporal entropy of the source.

Noise in a source pixel block creates more coefficients than a noise free source would. Thus all coefficients have to be truncated more aggressively to carry them, raising artifact level. Noise also increases data in difference pictures. Hence noise reduction will lower artifact levels by reducing spurious coefficients and reducing picture difference data.

If, after other steps, the artifact level is still too high, then the only approach is to restrict the entropy entering the coder. This is done by down-sampling the source images either spatially, so they contain less pixels, or temporally, so there are fewer pictures per unit time, or both.

In source material from telelence, the use of 2:2 and 3:2 pull-down creates what could be called false entropy, because in 2:2 frames are interlaced to make fields, giving a false doubling of picture rate.

The ratio 3:2 gets its name because 24Hz film frames are alternately converted to two and three fields to give a 60Hz output. One in five fields is redundant. Prior to MPEG coding telelence material has to have redundant fields discarded and remaining field pairs are de-interlaced to obtain the original frames.

The largest usage of data in MPEG is the 1 picture. This is because it does not use any previous information from the source. Consequently it makes no difference if the source I picture is radically different from the ones which went before. In contrast both P and B pictures will require significantly more difference data if there is a cut.

It follows that a significant reduction in artifacts can be obtained if I pictures are temporally aligned with source cuts. The only drawback of this approach is that to do it in real time a great deal of memory is needed to pipeline a stack of frames so that picture type decisions can be taken.

The alternative is to use a time coded source recording and use a two-pass encoding process. On the first pass the cuts are detected and used to design a picture type structure which is stored, and on the second pass the structure is implemented.

John is an independent consultant in digital audio, video and data technology and is the author of fifteen books on the subject, including Compression in Video and Audio. He is a Chartered Information Systems Practitioner, a Fellow of the Audio Engineering Society.

The Low Cost Controller
That’s Easy to Use

**Features**

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

**Analogue**
- 4 Channels in 1 Channel out
- 36 Digital in or out & Timers
- RS-232 or RS-485 plus 12C
- LCD both text and graphics
- Upto 8 x 8 matrix keyboard
- >2Mbytes available on board
- Many modes to choose from

**Development**

- The PC Starter Pack provides the quickest method to get your application up & running

**Operating System**
- Real Time Multi Tasking
- ’C’, Modula-2 and Assembler

**Languages**
- Easy to expand to a wide range of peripheral cards

**Expansion**

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

**Other Features**

- Cambridge Microprocessor Systems Limited

Unis 17 - 18 Zone ‘D’
Chelmsford Road Ind Est
Great Dunmow Essex CM6 1XG
E-mail cms@dial.pipex.com

Phone 01 371 875 644

SEE OUR WEBSITE

http://www.cms.uk.com
Without an engineering degree, a pile of money, or an infinite amount of time, the revised 289-page Interfacing With C is worth serious consideration by anyone interested in controlling equipment via the PC. Featuring extra chapters on Z transforms, audio processing and standard programming structures, the new Interfacing with C will be especially useful to students and engineers interested in ports, transducer interfacing, analogue-to-digital conversion, convolution, digital filters, Fourier transforms and Kalman filtering. Full of tried and tested interfacing routines.


Listings on disk – over 50k of C source code dedicated to interfacing. This 3.5in PC format disk includes all the listings mentioned in the book Interfacing with C. Note that this is an upgraded disk containing the original Interfacing With C routines rewritten for Turbo C++ Ver. 3.

Price £15, or £7.50 when purchased with the above book.

Especially useful for students, the original Interfacing with C, written for Microsoft C Version 5.1, is still available at the special price of £7.50. Phone 0181 652 3614 for bulk purchase price.

<table>
<thead>
<tr>
<th>Use this coupon to order</th>
<th>Price</th>
<th>Qty</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enh. Interfacing with C book + disk</td>
<td>£22.49</td>
<td></td>
<td>£22.49</td>
</tr>
<tr>
<td>Interfacing with C disk</td>
<td>£15</td>
<td></td>
<td>£15</td>
</tr>
<tr>
<td>Original Interfacing with C book</td>
<td>£7.50</td>
<td></td>
<td>£7.50</td>
</tr>
<tr>
<td>Postage + packing per order UK</td>
<td>£3.50</td>
<td></td>
<td>£3.50</td>
</tr>
<tr>
<td>Postage + packing per order Eur</td>
<td>£7</td>
<td></td>
<td>£7</td>
</tr>
<tr>
<td>Postage + packing per order ROW</td>
<td>£12</td>
<td></td>
<td>£12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>£37.44</strong></td>
</tr>
</tbody>
</table>

**Please send me:**

**Title** | **Price** | **Qty** | **Total**
--- | --- | --- | ---
Enhanced Interfacing with C book @ | £14.99 |     | £14.99 |
Enh. Interfacing with C book + disk @ | £22.49 |     | £22.49 |
Interfacing with C disk @ | £15 |     | £15 |
Original Interfacing with C book @ | £7.50 |     | £7.50 |
Postage + packing per order UK | £3.50 |     | £3.50 |
Postage + packing per order Eur | £7 |     | £7 |
Postage + packing per order ROW | £12 |     | £12 |

**Name**

**Address**

**Phone number/fax**

Make cheques payable to Reed Business Publishing Group Ltd
Or, please debit my Master, Visa or Access card.

**Card type (Access/Visa)**

**Card No**

**Expiry date**

Mail this coupon to Electronics World Editorial, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS, together with payment. Alternatively fax full credit card details with order on 0181 652 8956 or e-mail them to jackie.lowe@rbp.co.uk. Orders will be dispatched as quickly as possible, but please allow 28 days for delivery.
December 1997  ELECTRONICS WORLD  1009

Control Essentials from Milford Instruments

BASIC Stamps - low cost alternative to PLCs
BASIC Stamps are small, low cost reprogrammable controllers running easy-to-program BASC languages. Features: built-in source, bus to 20mA and support buttons/keyboard/LEDs/EDS/Comms/Serial Driver Chips etc. Once programmed from the PC, Stamps are fully autonomous and will find many uses in test equipment, one-offs and as an alternative to expensive PLCs.

| Part No.  | Description | Quantity
|----------|-------------|---------
| B51 IC  | -25 | £25
| B52 IC  | -39 | £39

Data Logging
B52 IC based Data collection board with real-time clock/calendar, up to 32kbytes EEPROM, dual 12 bit ADC and user development area. Kit complete with extensive manual and ready-to-go software routines which may be user tailored.

| Part No.  | Description | Quantity
|----------|-------------|---------
| B51 IC  | -25 | £25
| B52 IC  | -39 | £39

Serial LCD Modules - banish lcd hassle
Three quality, backlit LCD modules each fitted with an easy-to-use serial driver board. Simple 3 pins to interface to PC, micro or Stamps (+5vdc, Gnd and signal). Enhanced driver board supports full screen height numbers, standard characters and software switchable backlight RS232 interface at 2400 or 9600 baud.

| Part No.  | Description | Quantity
|----------|-------------|---------
| B51 IC  | -25 | £25
| B52 IC  | -39 | £39

DC Servo Control
DC Motor control chipset for use with incremental encoders.

| Part No.  | Description | Quantity
|----------|-------------|---------
| B51 IC  | -25 | £25
| B52 IC  | -39 | £39

Other items available for sale include:

- Easy to use LCD display units
- LCD controllers
- LCD digitizers
- LCD modules
- LCD drivers

To order or request further information, please call Milford Instruments at 01977 683665, fax 681465.
2.5GHz frequency meter for under £100?

Hand-held and battery-powered, the FC2500 costs just £99 exclusively to Electronics World readers.

Normally, the FC2500 2.5GHz frequency meter retails at £116.33 including VAT. But for a limited period, Electronics World in conjunction with Vann Draper Electronics is making this instrument available exclusively to Electronics World readers at the special price of £99 - including VAT and postage, representing a discount of £17 on an already low price. Simply fill in the coupon and post it to Vann Draper at Unit 5, Premier Works, Canal Street, South Wigston, Leicester LE18 2PL. Tel. 0116 2771400, fax 0116 2773945.

### Specifications

<table>
<thead>
<tr>
<th>Range</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.5GHz</td>
</tr>
<tr>
<td>Span</td>
<td>50MHz-2.5GHz</td>
</tr>
</tbody>
</table>
| Sensitivity | ≤100mV, 50-75MHz,
|           | ≤50mV, 76MHz-2.5GHz |
| Gating | 2.75s sample, 100Hz resolution
|        | 1.5s sample, 200Hz resolution
|        | 0.75s sample, 500Hz resolution
|        | 0.5s sample, 1000Hz resolution |

<table>
<thead>
<tr>
<th>Range</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>500MHz</td>
</tr>
<tr>
<td>Span</td>
<td>10MHz-50MHz</td>
</tr>
</tbody>
</table>
| Sensitivity | ≤120mV, 10-35MHz,
|           | ≤50mV, 35-350MHz,
|           | ≤120mV, 351-450MHz |
| Gating | 0.75s sample, 100Hz resolution
|        | 1.5s sample, 50Hz resolution
|        | 5s sample, 20Hz resolution
|        | 6s sample, 10Hz resolution |

<table>
<thead>
<tr>
<th>Range</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10MHz</td>
</tr>
<tr>
<td>Span</td>
<td>10Hz-10MHz</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>≤50mV</td>
</tr>
</tbody>
</table>
| Gating | 0.5s sample, 10Hz resolution
|        | 1.25s sample, 1Hz resolution
|        | 6s sample, 0.2Hz resolution
|        | 11s sample, 0.1Hz resolution |

<table>
<thead>
<tr>
<th>Range</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Period</td>
</tr>
<tr>
<td>Span</td>
<td>10Hz-10MHz</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>≤50mV</td>
</tr>
</tbody>
</table>

### Features of the FC2500

- High sensitivity at VHF and UHF
- Battery operated
- Hand-held and fits in the pocket
- 0.1Hz resolution on 10MHz range
- Measures frequency and period
- Data hold
- Relative measurement feature
- Records min., max. and average readings
- Auto power down
- High-contrast 13mm, 8-digit LCD
- Precision time-base
- Optional antenna for checking tx output

### Use this coupon to order your FC2500

Please send me .... FC2500 2.5GHz frequency meter at the fully inclusive special offer price of £99 each – fully inclusive, plus .... AT20 Tx measurement antenna at £6.95 inclusive.

Name

Company (if any)

Address

Phone number/fax

Total amount £...........

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

Card type (Access/Visa)

Card No

Expiry date

Please mail this coupon to Vann Draper Electronics, together with payment. Alternatively fax credit card details with order on 0116 2770345 or telephone on 0116 2771400. Address orders and all correspondence relating to this order to Vann Draper Electronics at Unit 5, Premier Works, Canal Street, South Wigston, Leicester LE18 2PL.

*Overseas readers can also obtain this discount but details vary according to country. Please ring, write or fax to Vann Draper Electronics.
ANCHOR SUPPLIES Ltd
The Cattle Market Depot
Nottingham NG2 3GY, UK
Telephone: +44 (0115) 986 4902/
+44 (0115) 986 4041 24hr answerphone
Fax: +44 (0115) 986 4667

ONCE IN A LIFETIME OFFER
MANUFACTURERS SURPLUS OSCILLOSCOPES
Every one is NEW and BOXED and comes complete with Probes, leads and Manuals
Note: We can’t advertise the makers/distributors name but be assured it is one of the
UK’s Leading Electronics Companies

DSM 3850A Hand held Digital storage Oscilloscope
50MS/sec, 8 bit resolution. 2 channels
5" LCD display Built-in RS232 port
Horizontal and Vertical Cursors
Built-in 4 digit Digital Multimeter featuring
Frequency. Data Logger
Internal battery/exter DC operation (7.5-9V DC @ 300mA)
Size only: 50mm x 235mm x 153mm Weight only 11.1kg
Complete with Soft Carry Case
VERY LIMITED QUANTITY.
ONLY £399+£9.95 UK del+vat

DTV 100 3 channel 8 trace 100MHz Oscilloscope
DC-100MHz (-3db) bandwidth
Twin timebases with Delay
Size: 146mm x 360mm x 384mm Weight 10kg
Including Probes, Leads, Manual
VERY LIMITED QUANTITY.
ONLY £399+£9.95 UK del+vat

DTS 40 40MHz Dual channel
Digital storage Oscilloscope
On Screen Readout with Cursors. DC-40MHz (-3db) Bandwidth
20MS/sec max Digital sample rate giving an effective 4MHz B/W
Size: 145mm x 357mm x 445mm Weight 10.5kg
Including Probes, Leads and Manual
VERY LIMITED QUANTITY.
ONLY £399+£9.95 UK del+vat

DTA 20/DTA 40...20/40 MHz
Twin channel 4 trace Oscilloscope
Size: 140mm x 335mm x 375mm Weight 7.3kg
Including Probes, Leads and Manual
VERY LIMITED QUANTITY.
DTA 20 ONLY £225+£9.95 UK del+vat
DTA 40 ONLY £299+£9.95 UK del+vat

NOTE: All Surplus Equipment is Unconditionally Guaranteed for 30 Days
OPEN 6 DAYS A WEEK
Mon-Fri 9am-6pm Sat 8am-4pm
NO APPOINTMENTS NEEDED. CALLERS ALWAYS WELCOME
NATIONAL AND INTERNATIONAL MAIL ORDER A SPECIALITY
VISIT OUR NEW WEB SITE
http://www.anchor-supplies.ltd.uk
e-mail sales@anchor-supplies.ltd.uk

Please note: Requests for catalogues MUST be accompanied by a first class SAE

December 1997 ELECTRONICS WORLD
SMART CARD READER/PROGRAMMER

Extremely versatile unit to enable the user to Read and Write to all types of Smart Card. A must for the serious development engineer.

Requires an IBM PC and a power supply between 12-18 volts

Supplied with all operating software and "useful" data on various subjects relating to Smart Cards.

£89.95

UNIVERSAL PIC PROGRAMMER

Runs on IBM PC, plugs into centronics printer port and requires 12-18 volt power supply.

Powerful menu-driven software to Read, Write, Copy and Edit PIC 16C54, 55, 56, 57, 58A 61, 64, 65, 71, 74, 84, 620, 621, 622 & Memory Chip 24C01 thru to 24C65.

Supplied with operating software and 12 months parts and labour guarantee.

£69.95

GAL/PAL PROGRAMMER

• Programs 16V8, 16V8A, 20V8, 20V8A, 20V8Z.
• Works on IBM PC compatible, laptops, Notebooks etc.
• Plug into Centronics port.
• Easy to use software.
• Supplied with PLAN Logic compiler software.
• Complete with examples, connection lead, PSU and user manual.

£89.95

MEGAPROM II

• Programs from 2k to 8 Meg
• Programming voltage from 12-25 volt covering all types of Eprom, EEprom and Flash memory.
• Supplied with operating software and 12 month guarantee.

£89.95

CROWNHILL ASSOCIATES LIMITED
THE OLD BAKERY
54 NEW BARNLS ROAD
ELY
CAMBS CB7 4PW

Tel: 01353 666709
Fax: 01353 666710

PICICE II

OSC2 output, RTCC Input

On board 4 channel A/D for PIC16C71 with A3 ref or VCC ref

Analogue to Digital conversion 17us.

Top quality components used throughout.

Complete package consists of:-
PIC software for 16C54-55-56-57-84, PIC ICE hardware, leads and headers to connect to target board, ASM examples and Circuit Schematics for hardware projects.

£99.95

CIRCLE NO. 127 ON REPLY CARD

Radio Receiver Trainer

An Invaluable Learning and Design Tool for all Experimenters

The Radio Receiver Trainer contains nine receiver building blocks and a comprehensive training manual.

Simply connect the building blocks to build AM, SW, Superhet and Direct Conversion receivers. Decode SSB, CW & FM! Use proven building blocks to develop and test your own designs.

Full technical support and advice given.

Pricing:

Complete £129.00

Kit £89.00

(Pkt excludes case & headphones)

P&P is £5 (UK), £8 (EC), £12 (World)

Add 17.5% VAT to Total Price

Building Blocks:

RF Input Tuner
RF Oscillator
Mixer
IF Filter
IF Amplifier
AM Detector
Beat Frequency Oscillator
Audio Filter
Audio Amplifier

The manual contains complete schematics and theory of operation of all the building blocks. Use this trainer to receive frequencies from 500KHz to 110MHz!

A set of proven alternate building block designs are included in the manual for you to get started with your own designs. There is no need to get your complete receiver design working all at once. Build and test each block one at a time.

Mail Order To: Pyramid Electronics Ltd.
204 Ferndale Road, Brixton, London SW9 8AG
Phone (0171) 738-4044 Fax (0171) 274-7997 Out of office ordering by answering machine.

CIRCLE NO. 128 ON REPLY CARD
Seeing through noise II

Patrick May extends his new noise theory to deal with surface diffusion as a 1/f noise source in thin metal films and explains how this work leads to a better understanding of low-frequency noise in thin-film resistors and semiconductors.

I show here that the impulses due to the emission of electrons from the surface of a continuous thin film of metal into the electron cloud at the surface produce a diffusion current in the metal. For the first time, I show that this effect in thin films equates to 1/f noise.

My mathematical analysis reveals that this gives rise to a time varying component of electron carrier density in a layer near the surface; the square of the Fourier transform of this time function has a 1/f characteristic which manifests itself as 1/f noise.

Calculations of this noise are made using a modified form of the Richardson-Dushman equation to estimate the rate of electron emission from the surface. These show that the estimated noise in copper thin films is equal to that measured and reported by others in the field. Also, there is good agreement with the strong temperature dependence, observed during experiments.

Current thinking on 1/f noise

In semiconductor devices, holes and electrons recombine in the surface under the auspices of the 'fast surface' states. It has been shown that the impulses produced by the ejecting carriers give rise to a diffusion current which produces a time varying component in carrier density in a layer near the surface.

It is assumed that a similar phenomenon occurs in metals. But in the case of metals it is the thermionic emission of electrons from the bulk to the 'electron cloud' at the surface which provides the impulses. The analysis for a semiconductor strip has already been presented\(^1,2\). A similar analysis for a thin metal film is presented here. Next, I present a study of the thermal emission of electrons from the surface of a metal into the 'electron cloud' surrounding the surface.

Electron emission

Figure 1 shows a thin film resistor on a substrate. The rate of electron emission per unit area from the bulk into the 'electron cloud' covering the surface of the metal is derived from the Richardson-Dushman\(^3\) equation,

\[
J = AT^2e^{\frac{-q}{kT}} \text{ Am}^{-2}
\]

where \(J\) is the current density, \(A\) a constant for metals, \(T\) the absolute temperature, \(k\) Boltzman's constant and \(\phi\) the work function of the metal.

The current is due to electrons having an energy greater than the work function. The energy of electrons emitted from the surface into the 'electron cloud' is much lower. According to the image theory, there is no potential barrier at the surface, but the image theory does not hold for short, atomic, distances from the surface. If there is a small barrier potential \(\psi\) at the surface of the metal, equation 1 must be modified\(^4\) as,

\[
J = AT^2e^{\frac{-q}{kT}} \left[ e^{\frac{-\psi}{kT}} + \frac{1}{4} e^{\frac{-2\psi}{kT}} + \frac{1}{9} e^{\frac{-3\psi}{kT}} \right] \text{ Am}^{-2}
\]

Electron emission per unit area, \(v\), is given by \(J/e\) where \(e\) is the electron charge.

Metal thin-film 1/f noise – a thermal problem

One of the earliest manifestations of 1/f noise was in directly-heated thermionic valves, these had tungsten filaments which also formed the cathode. In the model I propose here, I show that 1/f noise in thin metal films is due to thermionic emission from the surface of the metal.

Aspects of the analysis are based on thermionic valve technology dating back to the early part of this century.

A practical application of this work is in precision thin metal film resistor design. The 1/f noise in the film can be estimated over a wide range of temperatures using constants that are readily available in physics text books.

The ideas presented here reinforce the surface-diffusion theory of 1/f noise in semiconductors.\(^1,2,4\) They can be used to study 'fast surface states' in semiconductor devices, enabling optimisation of low-frequency noise performance.

The constants involved in the calculations are readily available in physics textbooks. There is no credible alternative model that predicts 1/f noise in thin metal films and no attempt has been made to explain its strong temperature dependence.\(^9\)
Diffusion current

The emission of electrons from the bulk gives rise to a diffusion current in the metal. The analysis appertaining to the diffusion process is based on the continuity equation,

$$\nabla \cdot J = - \frac{dP}{dt}$$  \hspace{1cm} (3)

where $J$ is the current density and $P$ is the charge density.

The metal film can be visualised as a strip of metal on a substrate having a thickness less than 1μm, Fig. 1. Thermal emission of electrons from the main face produces a diffusion current in one dimension perpendicular to the surface. You can assume that the emission is evenly distributed but uncorrelated.

If current density, $J$, is assumed to be a diffusion type current, equation 3 for currents in the x-direction perpendicular to the main faces becomes,

$$\frac{dn}{dt} = D_s \frac{d^2n}{dx^2}$$  \hspace{1cm} (4)

where $n=n(t,x)$ is electron density and $D_s$, the diffusion constant.

The solution to equation 4 for an impulse of unit strength is,

$$n = \frac{1}{(\pi D_s)^{1/2}} \exp \left[ - \frac{x^2}{4D_s t} \right]$$  \hspace{1cm} (5)

This equation expresses the probability of the absence of an electron at any point in the bulk after the ejection of an electron from the surface. For $t > 0$ the boundary condition below must prevail,

$$\int_0^\infty dx = 1$$

The square of the modulus of the Fourier transform of $n$ is,

$$|N(\omega, x)|^2 = \frac{1}{D_s \omega} \exp \left[ - \frac{2}{\sqrt{D_s} \omega} \right]$$  \hspace{1cm} (6)

Note that expression 6 gives the amplitude of the square of the fluctuating component of $n^2$ – the carrier density squared – in the frequency range $\omega$ to $\omega+\delta\omega$. The amplitude of these fluctuations are only significant for the condition,

$$x > \frac{2\omega}{D_s}$$  \hspace{1cm} (7)

when the expression 6 becomes,

$$|N(\omega, x)|^2 \cong \frac{1}{D_s \omega}$$  \hspace{1cm} (8)

It is evident from equation 7 that there is a cut off frequency for a given thickness of film. The time varying component of $n^2$ is many orders of magnitude lower than $n^2$ in the sample. It depends on the spectral expression given in equation 8, the rate of emission of electrons per unit area expressed in 2 and the thickness of the sample, $L$. It is given by,

$$S_1(\omega) = \frac{J}{eLD_s}$$  \hspace{1cm} (9)

This can be expressed in hertz as,

$$S_1(\omega) = \frac{J}{eLD_s} \frac{1}{\Omega}$$

Estimating noise

The expression for 1/f noise in equation 11 shows a strong temperature dependence. The quotient $J/D_s$ gives its temperature dependence. By making $V$ in the expression for $J$, in equation 2, equal to 0.01eV, the temperature dependence of,

$$\frac{S_1(\omega)}{\Omega}$$

expressed in equation 11 follows that obtained experimentally for copper thin films. The experimental value of,

$$\frac{S_1(\omega)}{\Omega}$$

has been measured for a sample of thickness $L=10^{-7}m$ at 303K as $6.4x10^{-16}Hz^{-1}$. This was repeated independently and confirmed. The evaluation of,

$$\frac{S_1(\omega)}{\Omega}$$

from equation 11 for copper is obtained from the following physical constants: $n$ is the effective number of free electrons, $m^*/m=2.5x10^{-4}m$ (from reference 9), $e=1.6x10^{-19}C$, $J=0.65x10^{3}T^4 \left[ \frac{9}{4} \frac{1}{e^2 \Omega} + \frac{1}{4} \frac{1}{e^2 \Omega} + \frac{1}{9} \frac{1}{e^2 \Omega} \right] A/m^2$

and $D_s=0.8x10^{-4}m^2$s. For $T=303K$, $\omega=0.01eV$ and $L=10^{-7}m$, the calculated value is $7.2x10^{-16}Hz^{-1}$ at 10Hz. The result is very close to the value obtained experimentally by Voss. This can also be shown to be true for silver films.

In summary

The basis of the diffusion current analysis lies in the equation for an impulse of unit strength, equation 5. This equation only applies in practice when a very large number of electrons is ejected – or injected – evenly from a plane surface. This ensures a one-dimensional diffusion current in the bulk of the thin film perpendicular to the surface.

The absence of an electron per unit area in the bulk as a result of the ejection, or injection, of an electron from the surface is described by a density probability function. This function applies to every single ejected or injected electron. This means that in the transient case, when all the $N$ electrons per unit area are ejected, the solution is given by the product of $N$ and the expression in equation 5.

The result agrees with that of the Haynes-Shockley experiment. Note that equation 5 holds when the electrons are ejected or injected evenly from a plane surface irrespective of whether they are ejected simultaneously as a transient or whether they are ejected continuously and randomly in time as a steady state process. This is the case in the diffusion-current analysis, and leads to the application of Carson's theorem.

The expression in equation 5 fulfils the necessary condition of absolute integrability. This results in equation 6 leading to the conclusion in equation 11.

From the proposed model it is clear that the origin of 1/f noise – like Johnson noise – is the kinetic energy of the electron carriers. Their kinetic energy is responsible for both the thermal emission at the surface and the consequent diffusion current in the bulk which is accompanied by a fluctuation in
electron concentration.

Under equilibrium conditions, the diffusion current is opposed by an equal drift current from the 'electron cloud' resulting in a zero average current. The average carrier concentration is that normally quoted for the metal but it fluctuates about this value.

The fluctuations are not affected by the bias drift current because it makes a negligible contribution to the electron thermal velocities responsible for the diffusion process. The fluctuations involve the whole of the carrier population under equilibrium conditions. Hence the argument by Weissman, that the 'tied individual electrons must remain in the sample' for periods well in excess of the actual time they spend in transit does not apply to my model.

On the other hand, Weissman's argument does invalidate some theories on 1/f noise; it shows that the N term -- total carrier population -- in the empirical Hooge formula is unacceptable. Accordingly, equation 1 does not contain N. But it shows that 1/f noise is inversely proportional to the thickness of the film as has been demonstrated experimentally.8,10

Hooge's formula does not predict temperature dependence. Nor does it allow for the wide scatter in experimental results.11-13 My model predicts the noise level and is the only proposed model to predict temperature dependence.

The wide scatter in experimental results is also accounted for; thermionic emission is very sensitive to surface treatment. There is, however, a component of 1/f noise in continuous thin films which is not temperature dependent13 and may be associated with the substrate.

My thanks to University of Exeter's School of Engineering for providing library facilities and to Drs MR Belmont, J Baker and MK Horwood for their encouragement and advice.

References
John Watkinson looks at the problems involved in specifying a loudspeaker.

T

here is no point in designing a loudspeaker without a clear idea of the technical specification it should meet. Without a technical specification, objective testing is impossible and development proceeds in the dark.

As the loudspeaker is only for human indulgence, the technical specification must be derived from psychoacoustic considerations. A good general specification for a loudspeaker is that over the audible frequency range it should reproduce the original electrical waveform as an acoustic waveform. It should do this both on-axis and within reasonable angle off axis at a realistic sound pressure level.

Microphones, recorders and amplifiers have to do this and so it seems a reasonable goal for a loudspeaker. This goal implies a flat frequency response which is phase linear and a transfer function which is also linear. True phase linearity is virtually impossible to achieve in a transducer.

Fortunately this also includes the human ear. Consequently an acceptable goal is a minimum phase characteristic. Rapid phase changes, particularly within a critical band, should be avoided which requires a greater degree of discipline in crossover design.

The audible frequency range requires some defining. At the top end, we usually pay lip service to a 20kHz bandwidth in recorders and circuitry even though many of us cannot hear such a frequency. It does no harm to specify such a bandwidth in the hope that a good transient response will result, but I am not convinced that a rule-flat response to that frequency is necessary. A mild but monotonic roll-off is quite acceptable provided it is truly monotonic.

Interestingly enough the same argument applies at low frequencies. The lowest frequency to be reproduced is debatable and depends upon the material to be reproduced. If we want to be able to reproduce all musical instruments, response has to be maintained to around 20Hz. Low frequency roll-off is unavoidable but it must be monotonic and preferably have a slope of no more than 12 dB/octave.

Toned speakers having ports or auxiliary bass radiators use resonance to extend the low-frequency response, but the result is that the ultimate roll-off is much steeper, leading to a now-you-hear-it, now-you-don't effect. In any case such tuning techniques are undesirable because they introduce linear distortion, audible as hangover.

While porting allows more sound-pressure level, or lower cost, accurate low-frequency requires phase linearity and only an unported unit can achieve that.

The ported speaker is so common that many people think of it as the norm. The trouble is that it doesn't bear comparison with the original. A clear example is the offset - i.e. the opposite of onset - transient which occurs when the air supply to an organ pipe is cut off. On a linear-phase woofer this is audible whereas on a tuned woofer it is masked by hangover.

Music editors prefer phase linear woofers because if the low and high-frequency components of a transient do not arrive time aligned there is some ambiguity over where the edit point should be.

An unported woofer still has a fundamental resonance due to the moving mass and the compliance it sees, but in a correctly designed unit this resonance is damped by the negligible output impedance of the amplifier. The result is that the damped speaker acts as a high-pass filter, rolling off monotonically at 12dB/octave.

When considering the power of a speaker, quoting the input power is a waste of time. What matters is what comes out. If realism is the goal, the sound-pressure level must be the same as the original.

Musical instruments - especially the piano - and the human voice change timbre as they get louder. With a good recording there is only one level at which it sounds right.

The threshold of hearing is irregular and rises at low frequencies. While active techniques can extend low frequency response almost arbitrarily, there is no point in doing this if sufficient sound-pressure level is not available as it simply won't be heard.

Non-linear distortion is the generation of harmonics due to the transfer function not being straight. This is critical in stereo because the creation of multiple images assumes linear superposition of the pairs of signals belonging to each image. Non-linearity causes intermodulation which results in phantom sound objects in the stereo image.

At high frequencies cabinet diffraction must be carefully controlled otherwise it causes multiple re-radiation which puts ripples in the on-axis response and makes the polar diagram extremely uneven. This causes colouration in the reverberant field which contributes to listening fatigue.

While these are strict requirements, they should not discourage the market for mediocre loudspeakers is well supplied by traditional products. The only hope for a newcomer is to create a new market by attempting the impossible. Sometimes, however, the barriers are self-imposed rather than technological and the impossible becomes a product.

Speaker criteria

- Frequency response accurate enough to avoid timbral change.
- Linear distortion or phase linearity accurate enough to reproduce transients.
- Non-linear distortion low enough to eliminate false sound objects in stereo.
- No resonant or tuned behaviour to prevent hangover.
- Realistic sound-pressure level over whole frequency range.
- Enclosure diffraction controlled to give clean polar diagram.
- Wide dispersion so that reverb has same frequency response as direct sound.
- Fatigue free to allow extended listening.
Books to buy –
domestic security systems

Build or improve your own intruder alarm system

House break-ins have increased threefold in the UK over the last 20 years. Few have not been touched by the affects, even if only through the experience of family and friends who have suffered a burglary. There is a way to reduce significantly the chances of being targeted by thieves: fit an alarm. But isn’t that expensive and complicated? Not if you build your own system. This book shows you how, with common sense and basic DIY skills, you can protect your home.

Every circuit is clearly described and illustrated, and contains components that are easy to source. Advice and guidance are based on the real experience of the author who is an alarm installer, and the designs themselves have been rigorously put to use on some of the most crime-ridden streets in the world.

To illustrate the principles, Tony Brown uses two examples of houses, one a typical semi-detached home and one an average three-bedroomed detached bungalow (for which designs would also suit an apartment). Working systems are shown in operation. Designs include all elements, including sensors, detectors, alarms, controls, lights, video and door entry systems.

* build your own security system
* practical guide to domestic security, including basic systems
* includes all elements including sensors, alarms and lights

CONTENTS: Input sensors; System control architecture; Output signalling devices; Installation; Testing and maintenance; Existing systems; Security lighting; Video camera and door entry systems; Suggested tooling; Index

ISBN 0 7506 3235 6 : 192pp : 216 x 138 mm :
70 line illustrations : Paperback :
UK £15.00 Europe £17.00 ROW £19.00

Intruder Alarms
Specification, installation and maintenance. Gerard Honey

This book covers Intruder Alarm Systems (C+G 1851 syllabus) as well as providing the underlying knowledge required to achieve a level 2 NVQ (National Vocational Qualification) in Understanding, Specifying, Installing and Maintaining Intruder Alarms (C+G 1863, 1864 and 1865). Familiarity with the contents of this book are required before an award will be made.

Gerard Honey is an experienced installer and writer and has used that experience to produce a book that not only provides essential information in a way that is easy to follow and learn, but also makes the book a fine practical source of advice. Each chapter contains summaries, self-tests and other features designed to help the student to understand and gain knowledge easily. Intruder Alarms has been published with the help of SITO, the Security Industry Training Organisation, who design courses and organise training for security installers and professionals.

* Only course book written for syllabus for Security NVQ
* Comprehensive study of intruder alarms
* Author is a practising international security systems expert

CONTENTS: Intruder alarm systems; Circuitry; Detection devices; Power supplies; Control equipment; Signalling systems; Wiring systems; Inspection of the mains supply; Commissioning, maintenance and fault finding; Index

ISBN 0 7506 3238 0 : 192pp : 234 x 156 mm :
50 line illustrations : Paperback :
UK £27.50 Europe £29.50 ROW £37.50

Return to Jackie Lowe, Room L333, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Please supply the following titles:

<table>
<thead>
<tr>
<th>Qty</th>
<th>Title or ISBN</th>
<th>Price</th>
</tr>
</thead>
</table>

** All prices on these pages include delivery and package **

Total

Name

Address

Postcode

Telephone

Method of payment (please circle)

Access/Mastercard/Visa/Cheque/PO

Cheques should be made payable to Reed Business Information

Credit card no

Card expiry date

Signed

Please allow up to 28 days for delivery
Microstrip made easy

Nick Wheeler explains that although there are complex procedures for designing high performance microstripline circuits, a few shortcuts result in a technique that is quick and easy to implement yet more than adequate for most applications.

Microstrip principles

Most microstrip calculations refer to traces of width W on an infinite layer of dielectric whose dielectric constant is \( \varepsilon_r \) and of thickness \( h \) backed by an infinite ground plane, Fig. 1.

In practice — and more so with increasing frequency — the electric field is concentrated in the volume of dielectric lying directly under the trace. However, some of the field is in air, leading to the concept of \( \varepsilon_{\text{eff}} \), the effective dielectric constant, which is lower than that of the dielectric.

The greater the width of the trace the more \( \varepsilon_{\text{eff}} \) tends towards \( \varepsilon_r \). If the ground plane and dielectric are truncated, as in Fig. 2, there is little effect upon \( Z_0 \) if \( T > 2W \). If only the dielectric is truncated\(^2\), as in Fig. 3, \( Z_0 \) is raised by less than 0.5\% when \( T/W \) is greater than 0.5.

Because \( W/h \) is dimensionless, if the dielectric thickness is halved, the same \( Z_0 \) is achieved with half the trace width. There are many published formulae for accurately calculating \( Z_0 \). These take into account the thickness \( t \) of the trace and even whether the etching process has resulted in a trace of...
RF DESIGN

trapezoidal rather than rectangular cross-section.

For traces produced by etching ordinary 1oz circuit board material, with a thickness t of 0.0014in, and for typically useful values of $Z_0$, these considerations are very much second-order effects. The effect of varying t from 0.0014in to 0.0056in on ordinary G-10 board of 0.0625in thickness is to reduce the trace width for $Z_0=50\Omega$ from 0.11984in to 0.11691in. Incidentally, the trace width for 50$\Omega$ on this board is commonly specified as 0.1in or 0.12in clearly a better approximation. This can be achieved by carrying out the following.

Evaluating complex formulae is tedious and there are many published tables relating W/h, $\varepsilon_r$ and $Z_0$. The graph of Fig. 4, derived from several sources, gives trace widths for a useful range of $Z_0$ using commonly available double-sided glass-epoxy PCB material it should be accurate enough for most purposes. This is particularly so since G-10 and FR-4 are supplied by various manufacturers with $\varepsilon_r$ varying over a range from 4.22 to 4.9. The most commonly quoted range though is 4.3-4.5.

Applying microstrip

There are in print several well-documented project descriptions. These give a good implementation of what can be done using this technique. Quarter wavelength, or $\lambda/4$, transformers for frequencies around 1GHz are particularly easily implemented, but bear in mind that the electrical length of microstrip is the reciprocal of $\varepsilon_{eq}$ multiplied by the physical length. The term $\lambda_e$ is commonly used to describe the on-board wavelength.

Perhaps one of the most useful applications is in conjunction with monolithic microwave ICs, or mmics, as these are 50$\Omega$ devices in most cases. On the other hand, many other devices can be matched.

It is important to bear in mind that the cross-section of the trace of a typical microstrip is very small. If it is operated at significant power levels in a mismatched condition, destructive current antinodes may lead to failure.

Some general-purpose microstrip applications are dealt with below.

Applying microstrip

As reference I suggest, microstrip can be implemented by attaching, with superglue, 0.1in strips, or other widths, of thin copper foil to the plain side of single-sided PCB material. This works quite well, but I will now describe a reproducible photo-etch approach.

I use Windows 95 with one of the many available graphic design programs, in my case Serif Draw Plus, an HP Deskjet 693C, and the appropriate Premium Transparency Film. This combination I can vouch for, but there are doubtless other suitable films and many other software packages and printers that will work too. Do not attempt to use films designed to take spirit-based felt pens or films made for overhead projector transparency work.

The transparencies produced are fine as masks for conventional photo-etching. It is important to remember that printer ink takes a long time to dry on transparency film. I recommend leaving for at least half an hour. I will not describe this well-known technique, except to point out that the transparency should be flipped so that the pattern ends up in face down, in direct contact with the PCB material before exposure.

Serif Draw Plus V2.0 has the option of selecting a grid based on 0.1in, with a spatial increment of 0.01in. You will suffer serious problems if you try to create circuit boards on a metric grid of any coarser resolution than this. I've tried it.

Graphic programs define line widths in 'points.' As far as Serif Draw is concerned, 7 points closely approximate to 0.1in*. This makes 8 points a good line width for 50$\Omega$ on 0.0625 G-10 board.

Most transmission-line configurations can readily be implemented in microstrip. References 1-3 give many examples. The attraction here is that any $Z_0$ within a range generally quoted as being from 162 to 1250$\Omega$ can be achieved without resorting to tedious methods such as replacing the inner conductor of coaxial cable with wire of a different diameter.

A few practical points. Parallel traces, separated by a distance of W or less couple and can be used to effect directional couplers. Undesired coupling can be virtually eliminated by making the spacing >2W. The design parameters for couplers are highly interactive, and the empirical approach — i.e. suck it and see — may be the least difficult.

Bends can be radiused or mitred. Bends through any angle with a radius, to the centre line of the trace, >4W do not have a significant effect on standing-wave ratio. Mitred bends, which occupy less board space, are theoretically complicated. However, using the approach of Fig. 5 seems to yield generally satisfactory results.

The advantage of using the computer-graphi-

---

*Fig. 4. Derived from several sources, this graph gives trace widths for a useful range of $Z_0$, assuming common glass-epoxy PCB.

*Fig. 5. Not an ideal microstrip bend shape, but it does the job for most applications.

*Fig. 6. 800MHz setup for testing microstrip for standing waves and losses. Although 50$\Omega$ is the norm for $Z_0$, other impedances can be matched — at a loss — via a pad at point A.

*A point is 1/72 of an inch — Ed.
ic approach is that your artwork is stored and can easily be altered before committing to transparency. Good results — within the limitations of the transfer sheets available — can be obtained much more directly by the use of etch-resistant PCB transfers. Note that not all transfers are etch-resistant, though they can save a lot of time in producing artwork for photo-etching.

Making measurements

In many cases, the success of a microstrip line circuit design can be estimated by driving it from a source of the right impedance, terminating it correctly and looking for standing waves or excessive losses.

I made a line 210mm long on G-10 board. One source quotes $\varepsilon_{eff}$ for a 50Ω line as about 3.4, when $\varepsilon_r$ is 4.4. Using a test frequency of 800MHz, this accommodates just over a wavelength. An $\varepsilon_r$ of 4.5 is favoured in references 1.

Figure 6 shows a test setup. The signal source is a UK431LO television tuner, which has a local-oscillator output ranging from 431 to 900MHz. Many other tuners have local-oscillator outputs. This signal is buffered by a suitable microm. Almost any of those currently available will suffice.

Frequency is measured using the gigahertz prescaler of reference 4. The detector probe is connected to the 75Ω input of the low-cost spectrum analyser described in reference 5. A 25Ω series resistor at the probe tip ensures negligible loading effects when applied to the line under test. Measurements are made by the null method of varying the attenuator to produce the same outputs at the points being tested.

As the spectrum analyser uses a television tuner there is obviously plenty of scope for the use of other tuners. Although I have not tried it, the raw intermediate frequency from any tuner could be amplified and inspected on a modest oscilloscope.

In the case of my test line, probing it when properly terminated with 50Ω disclosed no perceptible standing wave pattern. Operating with no termination produced deep voltage nodes separated by 100mm — almost exactly — on the board. These are, of course, $\lambda_0/2$ apart.

Working backwards through the relationships outlined above, you can deduce that in this case the apparent $\varepsilon_{eff}$ is 3.5. This degree of agreement lies well within the limits which might be expected.

An error of 1% in the measurement of the distance between the nodes could account for more than half the difference. Because of the element of empiricism inherent in all microstrip line calculations this seems to be a very good first attempt, and easily good enough for almost all applications.

In summary

I have shown that microstrip line is a versatile technique, easily implemented to useful accuracy for many uhf applications. I recommend a computer-graphic approach for the generation of the artwork, since this gives quite precise control over trace widths.

The rigorous treatments of references 2 and 3 are available to those of you wanting to use more precise techniques. This will not normally be necessary unless high power levels are to be involved.

References

1. ARRL Handbook.
Radio reflections from Russia

St Petersburg’s Alexander Popov Museum of Communications – one of the world’s oldest technical museums – houses a wealth of early British wireless apparatus – as Khatskel Ioffe reveals.

Founded in 1872 as a telegraph museum, the Alexander S. Popov Central Museum of Communications in St. Petersburg has a collection of British equipment dating from the earliest stage of the development of wireless. Building on last month’s article, which described artefacts ranging from Fleming’s diode to a Marconi direction finder, this article covers our Marconi 250-1300m receiver, 500W transmitter and a wavemeter – Fleming’s cymometer.

A standard for 250 to 1300m
A receiver for 250 to 1300m from our collection is shown in Photo 1. An identical receiver is depicted in a magazine printed in 1915, where it makes part of a field wireless outfit. At around the same time, a receiver for this range also made part of the Marconi Company’s 0.5, 1.5 and 5kW ship and coastal wireless stations.

We consider this receiver to be Marconi’s standard apparatus for 250 to 1300m during WWI. The receiver is complete with two carborundum contact detectors, one of which was a spare.

The receiver also has terminals for connecting a magnetic or another external detector. This allowed reception of strongly damped oscillations in addition to the undamped or feebly damped oscillations then coming into use.

The receiver has two subranges, 250–800m, and 500–1300m, selected by placing an aerial tuning capacitor in parallel or in series with an aerial tuning inductance coil, respectively. Placed into the aerial circuit, in addition to the variable inductance coil, is a moving detector-coupling coil.

Along with the Billi condenser, the detector and the telephone, this coil makes up the detector circuit. Connected to the receiver is an external storage battery which secures a required mode of operation of the receiver using a potentialmeter. Provided along the periphery of the top panel are holes for screws fastening the receiver at its location on the frame of the transmitter-receiver station.

Our museum has two such receivers.

500W field transmitter
A wireless transmitter with a rotary spark discharger for a 0.5kW field wireless station mounted on a cart is shown in Photo 2. In the late 1900s and early 1910s wireless telegraph with a shock-excited transmitter generating a musical spark were becoming popular.

The Marconi Company obtained this effect by means of a rotary, toothed, spark discharger wherein a spark arose as each tooth passed under fixed high-voltage electrodes. The use of shock excitation meant a transition to feebly damped oscillations, which increased the energy sent by the station and enhanced its efficiency.

Installed on a two-wheel cart, the Marconi Company’s 0.5kW wireless station was used in the Russian Army during WWI. In our set, a 7hp air-cooled two-cylinder Douglas petrol motor and an electrical generator are installed on a cast-iron base. The shafts of the motor and generator are connected by a bilateral coupling. A toothed spark discharger is
fixed on the shaft of the electrical generator.

The spark discharger is separated from the electrical generator by a chamber made of an aluminium alloy. The spark discharger has a copper disc, 7mm thick, fixed on a hard-rubber hub, through which a shaft supported in ball bearings passes.

Mounted in the chamber case are two fixed electrodes constituted by two copper rods, 4mm in diameter, placed inside hard-rubber insulators, the disc tooth-to-electrode spacing being set at 0.15-0.2mm.

The electrical generator has a stator with 12 poles arranged as 6 pairs. In the magnetic field formed by these poles, an anchor rotated with dc and ac windings. The current of the dc winding was fed into the collector and used in the excitation circuit while the current of the ac winding was fed into the rings. The ac voltage, transformed via an external high-voltage transformer, was fed to the electrodes of the spark discharger.

The spark discharger is of the synchronous type. It has the same rotational speed as the electrical generator and discharges at each peak of the ac voltage, i.e. at each alternation. Running at 1900rev/min, the electrical generator produced a 190Hz alternating current and the spark discharger produced 380 discharges per second. This corresponds to a relatively good tone — the musical spark effect.

On air in the air
The transmitter of an aeroplane wireless is shown in Photo 3. This is one of the first transmitters designed for the purpose.

It dates back to the times of WWI. It is a low-power spark transmitter consisting of an induction coil with a mechanical interrupter, an adjustable spark discharger in the form of two cylindrical aluminium electrodes, and an oscillatory circuit. The latter is comprised of a fixed capacitor and a variometer whose fixed coil is placed in the aerial circuit.

Using the variometer, the 230–430m wavelength range is covered. The induction coil was operated from an external dc power supply. A telegraph key was hooked into the power supply circuit. At the front of the transmitter case, access is provided to the spark discharger. Also provided is an inspection window to inspect the spark discharger.

Fleming's cymometer
The earliest type of the Marconi Company's wavemeter was Fleming's cymometer. I believe that the instrument that we have dates from 1906–1907.

This cymometer opened up the use of scientific methods for tuning transmitters and receivers. Earlier methods involved trial and error. It comprises a variable inductor and a variable capacitor. In the inductor, a coil of bare copper wire is wound around an ebonite tube. The self-inductance is variable by means of a slide contact.

The variable capacitor - a Billi condenser - consists of two thin-wall brass tubes separated by a hard-rubber bushing. The capacitance is varied by moving the outside tube using a handle.

As the tube moves, the slide contact of the coil also moves so that the values of both elements of the measurement circuit are varied at the same time and in the same direction.

In order to find the instant that the measurement circuit is at resonance with the transmitter frequency, a neon tube was connected in parallel to the capacitor.

The scales of the instrument are calibrated in the values of an 'oscillation constant' – the term used by Fleming to denote the expression \( \frac{\nu}{L} \). There are also scales for wavelength in metres, wavelength in feet, and the numbers of oscillations per \( 1/1,000,000 \)th of a second.

It is known that the Marconi Company produced four types of cymometers to cover the ranges 33–700m, up to 2000m and up to 3000m.

Our cymometer is for 33–700m. To determine the wavelength of a transmitter, the cymometer was installed parallel to an antenna section. The operator moved the handle of the instrument in either direction so as to attain the brightest glow of the neon tube. The scale indicator, rigidly bound with the handle lever, ensured direct readings of the wavelength and frequency from scales.

To measure capacitance and inductance, the operator connected these components to a standard self-inductance or standard capacitance, respectively. The components excited oscillation via an ancillary inductor with a spark gap. The cymometer was used to determine \( \frac{\nu}{L} \), whereafter the unknown value of \( C \) or \( L \) could be calculated.

Rounding up
All of the above-described apparatus were received by our museum in the 1920s from Russia's various communications establishments and educational institutions.

The British equipment presented in this article along with the apparatus of the Popov-Ducetet, Slaby-Arico and Telefunken systems of the early 20th century, also in the keeping of our museum, preserves the memory of the first steps in the development of wireless worldwide.

I cannot guarantee the accuracy of the dating and operating descriptions of the instruments described since my collection of literature is limited. Any corrections will be gratefully received.

Translated from the Russian by L.N. Kryzhanovsky. Khatshelkov is with the A.S. Popov Central Museum of Communications, St. Petersburg.

Reference
Back issues of Electronics World are available, priced at £2.50 in the UK and £3.00 elsewhere, including postage. Please complete the coupon and send with correct payment to:
Electronics World, Quadrant House, The Quadrant, Sutton Surrey, SM2 5AS.
Note that not all issues are available and please allow 21 days for delivery.

<table>
<thead>
<tr>
<th>Issue (Month/Year)</th>
<th>Quantity</th>
<th>Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Name
Address

Post code
Method of payment (please circle): Access/Mastercard Visa Cheque PO
Cheques payable to Reed Business Publishing

Credit Card Number
Signed
Expiry Date
For more information about any of the products or services in this issue of ELECTRONICS WORLD, simply ring the relevant enquiry number. Enquiry numbers may be found at the bottom of each individual advertisement.

101 102 103 104 105 106 107 108 109
110 111 112 113 114 115 116 117 118
119 120 121 122 123 124 125 126 127
128 129 130 131 132 133 134 135 136
137 138 139 140 141 142 143 144 145
146 147 148 149 150 151 152 153 154
155 156 157 158 159 160 161 162 163
164 165 166 167 168 169 170 171 172
173 174 175 176 177 178 179 180 181

Name
Job title
Company
Address
Telephone
DECEMBER 1997

Only tick here if you do not wish to receive direct marketing promotions from other companies.

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

Newsagent order form

Pass this order form to your newsagent to ensure you don't miss the next issue of EW.

To ..................................................
(name of Newsagent)

Please reserve me the January issue of Electronics World - on sale 4th December - and continue to order every month's issue until further notice.

Name ..............................................
Address ...........................................
.......................................................

Thank you
<table>
<thead>
<tr>
<th>SUBSCRIPTION RATES</th>
<th>Airmail</th>
<th>Student (Air/proof required)</th>
<th>UK 1 year</th>
<th>UK 2 years</th>
<th>Europe 1 year</th>
<th>Europe 2 years</th>
<th>Rest of the world 1 year</th>
<th>Rest of the world 2 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>£32</td>
<td>£38</td>
<td>£86</td>
<td>£98</td>
<td>£88</td>
<td>£98</td>
<td>£101</td>
<td>£101</td>
</tr>
<tr>
<td>Europe</td>
<td>£46</td>
<td>£53</td>
<td>£120</td>
<td>£131</td>
<td>£120</td>
<td>£131</td>
<td>£134</td>
<td>£134</td>
</tr>
<tr>
<td>Student</td>
<td>£28</td>
<td>£31</td>
<td>£72</td>
<td>£78</td>
<td>£72</td>
<td>£78</td>
<td>£80</td>
<td>£80</td>
</tr>
<tr>
<td>Student</td>
<td>£26</td>
<td>£29</td>
<td>£66</td>
<td>£71</td>
<td>£66</td>
<td>£71</td>
<td>£75</td>
<td>£75</td>
</tr>
<tr>
<td>Surface mail</td>
<td>£37</td>
<td>£42</td>
<td>£91</td>
<td>£100</td>
<td>£81</td>
<td>£91</td>
<td>£97</td>
<td>£97</td>
</tr>
<tr>
<td>Surface mail</td>
<td>£37</td>
<td>£42</td>
<td>£91</td>
<td>£100</td>
<td>£81</td>
<td>£91</td>
<td>£97</td>
<td>£97</td>
</tr>
</tbody>
</table>

CREDIT CARD HOTLINE
Tel: +44 01444 445447
Fax: +44 01444 445656

Please enter my subscription to ELECTRONICS WORLD. I enclose £

Please charge my Mastercard/Visa account with £

Name
Job Title
Address
Postcode
Tel:
Country
Expiry Date
Signature

Please tick here if you do not wish to receive direct marketing/promotion from other companies.

License No. CYZ11

Business Reply Service

P.O. Box 302
Haywards Heath
West Sussex RH16 3DH UK.

CREDIT CARD HOTLINE
Tel: +44 01444 445447
Fax: +44 01444 445656

Please enter my subscription to ELECTRONICS WORLD. I enclose £

Please charge my Mastercard/Visa account with £
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-draw 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 file and hard-copy 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 20ksample/s. This single-channel converter benefits from all the instrumentation features of the ADC200-50.
Trickier keypad lock

While small keypad locks are simple and quick to make, their four-digit code offers limited security; it would be possible, if tedious, to plod through them all. This circuit puts a further barrier in the way in that two buttons must be pressed at the same time, and the hopeful thief does not even know to do that, let alone which two. In the circuit shown, the entry code is 4, 1, 7, 92; the pair of buttons are best well separated to avoid accidental operation.

Keys on the pad I used had one side common. Cutting one track and wiring the switch in series gave the circuit shown. An LS7220 does the job, but others would perform in the same way.

Neville Frewin
Fontainebleau
South Africa (A31)

5MHz triangle generator

Generating linear, high-frequency triangular waves has its problems. Although there are dedicated ICs, some are fairly expensive and others put out a linear waveform, but at the expense of bandwidth. This circuit avoids these problems.

Instead of the usual op-amp RC integrator, the constant charging current is provided by a pair of current mirrors contained in a TPQ6502 array to give a good match. In response to the output waveform, an LM311 comparator switches the current mirrors on and off via $\text{Tr}_{13}$, slopes being independently determined by the values of $R_{4,4}$, which may be replaced by variable resistors. Frequency is set by $R_{7}$, which may also be made variable, and $R_{9}$ adjusts the dc level of the output.

Board layout demands care: supply lines to $\text{Tr}_{12}$ and those to the comparator must all be kept separate from the supply to the mirrors. A single ground and good decoupling are essential for a good performance at high frequencies.

Higher frequencies than 5MHz are possible, while retaining good linearity, if the LM311 is replaced by a faster type.

K P Cummings
University of Nottingham
(A30)

Constant capacitor charging current in this triangular-wave generator comes from current mirrors, which produce good linearity at higher frequencies than op-amp integrators.
Ac/dc indicator for 7-segment display

This is possibly the simplest idea yet seen in this column and is ingenious. It indicates whether the input is ac or dc by virtue of the fact that, if it is dc, the “a” element does not light and the display reads lower-case “dc”. If ac, the element lights and the display shows “ac”. Resistor R should be Vcc-1.7/0.01Ω.

Raj K Gorkhali
Kathmandu
Nepal
(A38a)

Small motor drive

This drive for small dc motors is a variation on those described by Peter Hale in his article ‘Driving and controlling small motors’ in EW, May 1997, p.397. It uses a single supply rail and consists of two drive transistors, the two upper devices acting as voltage-dependent resistors. At low voltage, resistance is low, the reverse applying, so that the bridge halves behave as switches.

Ray Stead
Hampton,
Middlesex
(A35)

Digital clock day indicator

For those who, on waking, are often unsure not only of where and possibly who they are, but also what day it is, this little addition to a digital clock will reassure them. If the clock has an am/pm signal, applying it to the counter steps it on once per day, the relevant led being illuminated.

Raj K Gorkhali
Kathmandu
Nepal
(A38b)

Amplitude-stable phase-shift oscillator

This low-frequency oscillator runs from an unregulated supply and is meant for use where precise frequency setting is not a requirement.

It is based on the classic design of RC sinewave oscillator, each RC contributing 60° towards the necessary 180° phase shift from collector to base. Unlike the standard design, amplitude stability comes from the p-n-p current source instead of a thermistor or an agc circuit.

Capacitors are grounded to allow the use of electrolytics. Components are not critical, except that the n-p-n transistor should have an hfe of at least 180. Amplitude and frequency remain within about 10% with double the supply voltage.

L S Whitlock
Taunton
Somerset
(A32)

Vcc (5 to 25V)

1N4148

1k

22k

22k

22k

4k7

C = 100n f = approx 250Hz

C = 220µ f = approx 0.07Hz

approx 1V peak-to-peak

Variation on the classic phase-shift oscillator, having a constant-current collector load to avoid the use of thermistors or an agc circuit.
HIGH QUALITY - All steel RackCap

Made by Eurocraft Enclosures Ltd to the highest possible spec. Cabinet is built at a price earned with top side, front and back doors. Front and back doors are mounted in stainless steel and offer five secure 6 lever barrel locks. The front door is locked with a key and the "designer" style smoked acrylic front panel to add a touch of class to your equipment. The rear panel, yet remain unobtrusive. Internally the rack features fully adjustable shelved and software enabled clips to take the heaviest of Rack equipment. The menü is designed to be used with as many different systems as possible and to fit on the shelf plate etc. Other features include: full motion and floor level adjustment, hi spec cable / connector access etc. Supplied in excellent, slightly used condition or new. A major advantage of RackCap is that all materials are handmade - from the top to the bottom. With the exception of integration to a plastic used in the manufacture of the panel, the rack is 100% made of steel. Call for full details.

The Ultimate in "Touch Screen Technology" made by the experts -

Call for full details on the amazing RackCap!!

LOW COST RAM & CPUS

INTEL 'ABOVE' Memory Expansion Board. Full length PC/XT and PC/AT compatible 2 Mb of memory on board. Only £95.00 (plus £5.50 for despatch by m/)

Half length 8 bit memory upgrade cards for PC/XT expands to either PC/XT or PC/AT. Only £22.95. Each card £99.50 (A1)

FULL RANGE OF COMPO-PROCESSORS EX-STOCK. CALL FOR DETAILS

BLOCCOBINS

EPSON D0142 40x40x20 mm 12V DC £7.95 + £5.50

PAPIST Type 812 80x40x20 mm 12V DC £5.50

MITSUBISHI MMF-58CD2M 80x20x20 mm 12V DC £4.90 + £4.90

PANAKE 12-32x5-50x20 mm 12V DC £8.95

PANAKE 12-60x5-50x20 mm 12V DC £14.50

PANAKE 12-60x5-50x20 mm 12V DC £19.95

Shipping on all fans (A) Blowers (B) 50,000 Fans Exc STK CALL

FANS & BLOWERS

CALL 08181 679 4414

FAX 0181 679 1927

FOR ALL PRICES & QUOTATIONS, PLEASE CALL 08181 679 4414

All prices for UK mainland & customers in the U.S. 17.5% VAT. UK order rate. Minimum order unit. Minimum order unit. (If domain name over 1000 £10, other items over £200 £10, other items over £400 £20). Approximate prices are subject to the correct time of year, exchange rate and delivery address. All prices subject to change, no order acceptance without our written approval. Dispute cancelling initial internal fixing studs, rush punch after receipt of order. Orders for non standard items are subject to these restrictions. Orders now subject to stock. Discounts for volume. All CASH prices for surplus goods. All trademarks etc acknowledged. © Display Electronics 1986. E & O E.
**Analogue frequency doubler**

Two comparators may be connected to either a difference amplifier or to a summer to produce a frequency doubler or a variable-width output pulse.

Basic comparator operation in Fig. 1 shows the effect of reversing inputs, the arrangement in Fig. 2 producing, in response to a sawtooth input waveform, positive pulses at pins 1 and 7, the width of which depend on the rectangular $V_{\text{ref}}$, $V_{\text{in}}$ waveforms and $V_{\text{out}}$. Subtracting one from the other in the LM301 difference amplifier gives the output shown in Fig. 3.

Alternatively, connecting the comparator outputs to a summer combines the comparator outputs to give a pulse proportional to the input and reference voltages, variable from zero to 100%. Output spectrum is variable in this way, so that given harmonics may be eliminated or created by varying the reference voltages.

Kamil Kraus
Rokycany
Czech Republic
(A40a)

**Fig. 1. Comparator output with rectangular wave applied to either of the inputs.**

**Fast pulse capture/analysis**

Needed to detect the presence of a single 1µs pulse, which was too fast for a logic analyser to see. I made the circuit shown here, which will show the presence of a pulse down to 10ns in width and also indicates the activity on a signal line.

Indication is by a series of leds. Logic high at the input causes the red led to illuminate, a low lighting the green one. Inverted and non-inverted versions of the input form clock signals for the two edge-triggered flip-flops; a low-to-high transition triggers the Q output at pin 5 to light the orange led, a high-to-low triggering the pin 9 Q output to illuminate the yellow led; a single pulse turns on both orange and yellow leds, the red and green indicating whether it is negative or positive going, as shown by the table.

Switch $S_1$ resets both flip-flops. Continuous activity on the line causes the red and green leds to flash.

Ken Yang
La Jolla
California
USA
A43

Using only two ic's, this logic-level indicator will capture a single pulse of around 10ns in width and analyses the state of a signal line.
Micro Video Cameras
Direct from the sole authorised importer

• Wire up in minutes. Only three connections - ground, +12V and composite video output for feeding straight to your Scart connector or monitor input.

• Tiny and lightweight. Ideal for surveillance and security, the A-721 Micro-video camera pcb measures just 32 by 32mm. The complete camera weighs only 30g.

• Integral lens. 3.6mm 5-element lens, interchangeable with our wide range of replacement lenses.

• Low cost. The A-721 Micro-video camera costs just £65 - including VAT.

• Incredible low light performance. The A-721 has a light sensitivity of < 0.1 lux (normal light).

• Reliable. The A-721 is manufactured using state-of-the-art equipment and under strict quality control.

• Fast delivery mail order. We endeavour to dispatch all orders same day.

• 12 months guarantee.

And more ... This is just a small sample of the huge range of Camera and Video Surveillance equipment we stock.

Ring 0115 986 4902 now, or fax us on 0115 986 4667

* Prices include VAT but exclude carriage at £5.00 UK mainland

CIRCLE NO. 134 ON REPLY CARD

TOROIDAL TRANSFORMERS
High Quality Low Prices

In addition to our standard range we will be pleased to quote for your special requirements.

PRICE LIST

<table>
<thead>
<tr>
<th>VA</th>
<th>2+</th>
<th>10+</th>
<th>25+</th>
<th>50+</th>
<th>100+</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>14.59</td>
<td>15.21</td>
<td>16.79</td>
<td>18.69</td>
<td>20.52</td>
</tr>
<tr>
<td>30</td>
<td>16.04</td>
<td>16.92</td>
<td>18.45</td>
<td>20.35</td>
<td>22.25</td>
</tr>
<tr>
<td>50</td>
<td>17.83</td>
<td>18.48</td>
<td>20.49</td>
<td>22.49</td>
<td>24.49</td>
</tr>
<tr>
<td>60</td>
<td>18.02</td>
<td>18.71</td>
<td>20.99</td>
<td>22.99</td>
<td>24.99</td>
</tr>
<tr>
<td>80</td>
<td>18.78</td>
<td>19.68</td>
<td>21.98</td>
<td>23.98</td>
<td>25.98</td>
</tr>
<tr>
<td>100</td>
<td>21.07</td>
<td>21.84</td>
<td>24.01</td>
<td>26.01</td>
<td>28.01</td>
</tr>
<tr>
<td>120</td>
<td>21.54</td>
<td>22.31</td>
<td>24.58</td>
<td>26.58</td>
<td>28.58</td>
</tr>
<tr>
<td>150</td>
<td>25.98</td>
<td>26.75</td>
<td>29.02</td>
<td>31.02</td>
<td>33.02</td>
</tr>
<tr>
<td>180</td>
<td>23.83</td>
<td>24.60</td>
<td>26.76</td>
<td>28.76</td>
<td>30.76</td>
</tr>
<tr>
<td>220</td>
<td>30.10</td>
<td>30.87</td>
<td>33.14</td>
<td>35.14</td>
<td>37.14</td>
</tr>
<tr>
<td>250</td>
<td>34.32</td>
<td>35.09</td>
<td>37.36</td>
<td>39.36</td>
<td>41.36</td>
</tr>
<tr>
<td>300</td>
<td>46.19</td>
<td>47.32</td>
<td>49.35</td>
<td>51.35</td>
<td>53.35</td>
</tr>
<tr>
<td>400</td>
<td>50.48</td>
<td>51.61</td>
<td>53.64</td>
<td>55.64</td>
<td>57.64</td>
</tr>
<tr>
<td>625</td>
<td>53.09</td>
<td>54.32</td>
<td>55.64</td>
<td>56.97</td>
<td>58.29</td>
</tr>
<tr>
<td>750</td>
<td>58.39</td>
<td>60.62</td>
<td>62.85</td>
<td>65.08</td>
<td>67.31</td>
</tr>
<tr>
<td>1000</td>
<td>78.80</td>
<td>81.13</td>
<td>83.46</td>
<td>85.79</td>
<td>88.12</td>
</tr>
<tr>
<td>1250</td>
<td>82.45</td>
<td>84.78</td>
<td>87.11</td>
<td>89.44</td>
<td>91.77</td>
</tr>
<tr>
<td>1500</td>
<td>105.10</td>
<td>108.43</td>
<td>111.76</td>
<td>115.09</td>
<td>118.42</td>
</tr>
<tr>
<td>2000</td>
<td>114.45</td>
<td>118.18</td>
<td>121.91</td>
<td>125.64</td>
<td>129.37</td>
</tr>
<tr>
<td>2500</td>
<td>163.04</td>
<td>167.67</td>
<td>172.30</td>
<td>176.93</td>
<td>181.56</td>
</tr>
</tbody>
</table>

These prices are for 240volt primary and two equal secondaries with 8" colour coded fly leads. Each transformer is supplied with a mounting kit (steel dish washer pads, nut and bolt).

Mail order prices include vat and postage. Please do not hesitate to telephone or write with your particular requirements.

Airlink Sales Co
16 Knight Street, Sawbridgeworth, Herts CM21 1AT
Tel: 01279 600139 Fax: 01279 726379

CIRCLE NO. 135 ON REPLY CARD

ADVANCED ACTIVE AERIAL

The aerial consists of an outdoor head unit with a control and power unit and offers exceptional intermodulation performance: SOIP +50dBm, TOIP +55dBm. For the first time this permits full use of an active system around the II and mF broadcast bands where products found are only those radiated from transmitter sites.

• General purpose professional reception 4kHz-30MHz.
• –10dB gain, field strength in volts/metre to 50 Ohms.
• Preselector and attenuators allow full dynamic range to be realised on practical receivers and spectrum analysers.
• Noise – 150dBm in 1Hz. Clipping 16 volts/metre. Also 50 volts/metre version.

• Broadcast Monitor Receiver 150kHz-30MHz.
• Stereoliser and Frequency Shifters for Howl Reduction
• Stereo Variable Emphasis Limiter 3
• 10-Outlet Distribution Amplifier 4
• PPM10 In-vision PPM and chart recorder
• Twin Twin PPM Rack and Box Units
• PPM91 hybrid, PPM99 microprocessor and PPM98 IEC/DIN – 50/6dB drives and meter movements

SURREY ELECTRONICS LTD
The Forge, Lucks Green, Cranleigh GU6 7BG
Telephone: 01483 275997 Fax: 01483 276477
s.e@ndirect.co.uk www.ndirect.co.uk/-se/se.html

December 1997 ELECTRONICS WORLD
Precise mains voltage measurement

Having a need to display high-resolution mains voltage readings in the 190-250V ac range at the input of an uninterruptible power supply which has an 8-bit a-to-d converter, I had to convert the range into a 0.5-4.5V dc swing, that being the input range of the converter. In addition, I needed overvoltage and undervoltage warnings on a seven-segment display.

Ups output is transformed, full-wave rectified (the 6-0-6V transformer was handy) and passed through two second-order 15Hz filters. Output is adjusted to give 7V dc for a 190V ac input, the swing being 7-9.22V dc for the full 190-250V ac mains excursion.

This goes to a difference amplifier, of which the other input is 6.8V, so that the 0.2-2.4V swing, having been amplified by a factor of two, is within the limits of the a-to-d converter at B.

An out-of-range signal results from the action of the window comparator, which takes its input from B and has comparison levels of 4.9V and 0.4V, producing a logic 1 at the output when the input is within range.

Jayant Kathe
India

(A33)

Software depends on the configuration, but this flow should give you some ideas. Assuming a 1s display update, an a-to-d converter can be taken every 64ms (64msx16=1.024s).

1 If port pin is high then goto 6
2 Get stored ADC count
3 If I/P ADC count <80₁₆ Display
4 If I/P ADC count >80₁₆ Display
5 goto 1
6 Get ADC count
7 Right shift one bit and ADD to MAINS-VOLT location
8 If 16 samples are not over than wait for 64ms goto 1
9 Add the MAINS-VOLT location 16 value to the DIS-
PLAY-DATA-TABLE start address.
10 Update the display
11 Reset the sample counter to 0 goto 1
PIC listing on disk

Because the assembly language routine for the PIC would have taken up around four magazine pages we were unable to publish it. If you want a copy of this fully-annotated listing and the Excel spreadsheet, on 3.5in disk, send £10 to cover administration and copying to Electronics World's editorial offices, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS, with a clear note of what you are requesting and your address.

---

50/60Hz sine oscillator

A Wien-bridge oscillator is the obvious type of circuit to use for a VLF oscillator, providing a low-power, stable output while using low-voltage, low-current supplies—particularly if op-amps providing rail-to-rail output are used. However, the circuit shown offers good initial accuracy and low-frequency drift by virtue of the crystal clock oscillator, and amplitude stability. No adjustments or high-value precision capacitors are needed.

The R2R ladder is driven by the logic-level i/o lines from a PIC microcontroller, data coming from a software look-up table. Resolution is to seven bits and amplitude 0.02V-2.61V. A 3-bit counter output is also available. High ladder resistance provides a light load for the logic outputs, although they are capable of much more current. The circuit takes 52µA as shown, and may be reduced by scaling up resistor values at the risk of increased emi.

At a standard clock frequency of 32.768kHz, output frequencies are 49.951Hz and 60.235Hz; to make these exact, the clock should be 32kHz. You can do this, at the expense of a higher quiescent current and a greater number of components, by using a 4.096MHz crystal and dividing it in, say, a 74HC4060 binary counter/divider to give exactly 32kHz.

MAX951 contains an op-amp, a comparator and band-gap reference, the op-amp and reference providing a 2.63V supply for the microcontroller and the comparator converting the microcontroller’s msb to a ‘phase’ signal that goes high during positive half-cycles of the output.

As well as the look-up table for both frequencies, the

---

Begin and end of the Excel file, below, used to determine values in the PIC program illustrates how a spreadsheet can break the back of a digital design.
Microcontroller drives resistive ladder from a look-up table to produce an accurate sine output at selectable 50Hz or 60Hz frequencies, with a 3-bit period timer output and a sync signal.

Tim Herklots
Maxim Integrated Products
Reading
Berkshire
(A42)

Lead-acid battery saver

When a lead-acid battery is flattened completely, it is little further use. This circuit, which is small enough to use in a battery pack, prevents such abuse, automatically disconnecting the battery if its voltage drops below 10V. It allows the occasional voltage drop caused by equipment drawing a high inrush current and also automatically connects the battery to a correctly applied charging voltage.

Starting from the condition when the relay is on, the battery voltage appears at the output terminals and the potential divider applies 0.81V to the transistor base, assuming battery voltage is more than 10V, the resulting base current turning it on and maintaining the relay.
Falling battery voltage reduces base current and eventually, at about 9.5V, the transistor turns off and the relay drops out, disconnecting the battery; the same result is brought about by the off button.
Starting from the odd condition, pressing the on button momentarily injects current into the transistor base and turns it on.

Daniel Greenspan
Jerusalem
(A44)
Designer heat sinks

Using two worked examples, Ray Fautley shows how quick and easy it is to determine heat sink size for any transistor or diode using a design table.

Semiconductor devices need to be mounted on metal panels of sufficient size and thermal conductivity to be able to conduct excessive heat away from the junction of the transistor or diode. This is necessary to prevent the temperature of the device's junction from exceeding its maximum rating.

The total thermal path between the device junction and the ambient temperature existing inside the case of the equipment is measured as a thermal resistance. It is referred to as $R_{th(j-amb)}$, or as $\theta_{j-a}$. This term that is easy to assess. You only need to know three things. One is the maximum allowable junction temperature - which for most discrete silicon devices may be assumed to be about 200°C. Secondly you need to know the ambient temperature, which, inside electronic equipment is usually about 50°C, and finally you need to know the power dissipated in the semiconductor.

This total thermal path $R_{th(j-amb)}$ comprises three parts,

1. The thermal path from device function to its case, $R_{th(j-c)}$, also called $\theta_{j-c}$ or $R_{th(j-mb)}$.
2. The thermal path between the case of the device and the heat-sink to which it is fitted, $R_{th(c-hs)}$, also called $\theta_{hdc-hs}$.
3. The thermal path between the heat-sink and the ambient temperature inside the equipment, $R_{th(hs-amb)}$ or $\theta_{h-amb}$.

All of these three paths - and of course, the total path $R_{th(j-amb)}$ are measured in °C/W. This makes the total thermal path $R_{th(j-amb)}=R_{th(j-c)}+R_{th(c-hs)}+R_{th(hs-amb)}$.

The first of the three terms, $R_{th(j-c)}$, can be found in the data sheets provided by the manufacturer of the semiconductor device.

Path $R_{th(c-hs)}$ depends on the method used to mount the transistor or diode to the heat-sink. In some cases the device may be mounted directly on to the heat-sink, but in others it may be necessary to provide some form of electrical insulation between the device and the heat-sink.

Unfortunately, electrical insulation also means some degree of heat insulation so a compromise is necessary. A thin mica washer can provide the electrical insulation. As the semiconductor’s working voltage does not exceed a few tens of volts, a thick insulator is unnecessary.

Heat conduction is assisted by the use of silicon grease between the surfaces. Path $R_{th(c-hs)}$ can be considered to be between 0.1 and 0.7°C/W. In practice, a value of 0.4°C/W is usually acceptable for this term. This leaves the third term, $R_{th(hs-amb)}$, which needs to be evaluated.

Heat sink design steps

1. From the semiconductor data sheet, find $R_{th(j-c)}$ in °C/W.
2. Determine $R_{th(c-hs)}$ in °C/W. This value depends on the effectiveness of the thermal contact between the case of the semiconductor and the surface of the heat-sink. A value of 0.4°C/W will be a good enough approximation if the actual value is unknown.
3. Determine the power dissipated in the device,

   a) For power-amplifier transistors the power dissipated is,
   $$P_D = P_h-P_{out} = V_{DC}I_{DC}-P_{AC}$$

   b) For rectifier diodes,
   $$P_D = V_{DC}I_{ave}$$

4. Find,

   $$R_{th(j-amb)} = \frac{T_j - T_{amb}}{P_D}$$

   For silicon devices, maximum junction temperature $T_j$ is usually 200°C, but to be safe it is better to design around 150°C. In some cases $T_j$ may be specified lower than 200°C, so always check with the manufacturer’s data before proceeding with the heat-sink design. Inside the equipment, the ambient temperature $T_{amb}$ can be assumed to be 50°C.

Ray Fautley, C Eng, MIEEE
5. Determine,

\[ R_{th(hs-amb)} = R_{th(j-amb)} - R_{th(j-c)} - R_{th(c-hs)} \]

6. The surface area of the heat-sink required to provide the necessary \( R_{th(hs-amb)} \) can be found from Table 1.

A variation of the thickness of the heat-sink between 1mm and 5mm does not have very much effect. It is surface area that counts. These figures should provide adequate design margins.

Note that the surface areas in the table are for one side of the heat-sink only, the total surface area is thus twice the table figure – plus twice the thickness of the metal.

All heat-sink surfaces are assumed to be painted matt-black and mounted horizontally. Vertical mounting increases the cooling effect and adds a further margin of safety. But bright metal surfaces will need the figures of Table 1 to be increased by some 33%.

Note that the figures were arrived by experimentation. After comparing various results using different methods for arriving at the necessary surface area for the same value of \( R_{th(hs-amb)} \) agreement was not 100%.

**Design examples**

These two worked examples should help clarify the design procedure for you.

**Example 1.** A rectifier diode, for which the manufacturer’s data gives \( R_{th(j-c)} = 5°C/W \), has a forward voltage drop 1.0V when the average current through it – or dc load – is 5A. The maximum junction temperature \( T_j \) of the diode is given at 100°C. Inside the equipment that the rectifier is to be used in, the ambient temperature will be assumed to be 50°C.

**Design procedure**

1. \( R_{th(j-c)} \) is known to be 5°C/W.
2. Assume that \( R_{th(c-hs)} \) will be 0.4°C/W.
3. Power dissipated in the diode is,

\[ P_d = V_d \times I_{ave} = 1.0 \times 5 = 5W \text{ for a } T_j \text{ of } 100°C \]

4. \( R_{th(j-amb)} = \frac{T_j - T_{amb}}{P_d} = \frac{100 - 50}{5} = 10°C/W \)

5. \( R_{th(hs-amb)} = R_{th(j-amb)} - R_{th(j-c)} - R_{th(c-hs)} = 10 - 5 - 0.4 = 4.6°C/W \)

6. Referring to Table 1 gives the following dimensions for a suitable heat-sink.

For copper, 84cm² or 9.2cmx9.2cm
For aluminium, 105cm² or 10cmx10cm
For brass, 113cm² or 10.6cmx10.6cm
For steel, 128cm² or 11.3cmx11.3cm

**Example 2.**

A BLW81 transistor is to be used as a vhf power amplifier to provide a cw output of 10W.

**Design procedure**

1. The thermal resistance from junction to case \( R_{th(j-c)} \) is given by its manufacturer as 4.3°C/W.

2. Say \( R_t \) is 0.4°C/W.

3. Efficiency of the BLW81 is given as about 60% as a cw amplifier, so the input power for 10W output will be,

\[ P_e = \frac{P_{out}}{0.6} = \frac{10}{0.6} = 16.7W \]

So,

\[ P_d = P_{in} - P_{out} = 16.7 - 10 = 6.7W \]

4. \( R_{th(j-amb)} = \frac{T_j - T_{amb}}{P_d} = \frac{150 - 50}{6.7} = 14.9°C/W \)

5. \( R_{th(hs-amb)} = R_{th(j-amb)} - R_{th(j-c)} - R_{th(c-hs)} = 14.9 - 4.3 - 0.4 = 10.2°C/W \)

6. From Table 1, suitable heat-sinks are,

For copper, 29cm² or 5.4cmx5.4cm
For aluminium, 35cm² or 5.9cmx5.9cm
For brass, 37cm² or 6.4cmx6.4cm
For steel, 130cm² or 11.4cmx11.4cm

My thanks to Anglia Microwaves of Billericay, Essex for their help in providing semiconductor data.
ACTIVE

Discrete active devices
15W rf power. Ericsson's surface-mounted, PBT20220 rf power transmitter, provides 15W output power in the 915-960MHz cellular radio band. It is a Class AB n-p-n, common-emitter device for pep and cw use, efficiency being 54% and power gain a typical 10dB at 15W. Ericsson Components AB, Tel., 01793 488300; fax, 01793 488301.

Efficient small-signal mosfets.
Using the company's high-cell-density mosfet, Mobility has added a new range of SOT 23-packaged, low-<em>/ds</em>(on) mosfets show a 50% power-loss reduction over Powerex. On resistances vary from 5kΩ at 10V in the 60V MMBF107LT1 down to 0.085kΩ at 10V in the 20V MSF102LT1. Four of the six new devices are n-channel types; two 20V p-channel devices give 0.12 and 3.5kΩ at 10V. Motorola, 01 602 244 6108; fax, 01 602 244 4597.

Linear integrated circuits
High-power op-amp, OA547 by Burr-Brown is designed to drive a variety of heavy loads, such as motors and actuators, for use in power supplies or audio amplifiers. It will take a single 8-60V supply or dual 24V to 330V lines and produces a continuous current output of 500mA. It is protected against excess temperature and current overload and there is provision for an accurate, user-set current limit of up to 750mA, not using a power resistor but by means of an indirectly sensed current, a limit pin accepting input from a potentiometer or d-a converter. Thermal shutdown is indicated by a status pin. Burr-Brown International, Tel., 01923 233897; fax, 01923 233979.

Hybrid 4kW pwn amplifiers. Apex Microtechnology SA03/04 pwm amplifiers are for use in applications from motor control to low-frequency sonar, providing continuous current output up to 30A and handling an input voltage range of 16-200V; all circuits are microprocessor controlled and are completely sealed MO-127 power packages rated at temperatures in the −55°C to 125°C range. These devices accept analogue or digital input and switching frequency is 22.5kHz or, for lower frequencies, external oscillator input is provided. Ashwell Electronics Ltd. Tel., 01438 364194; fax, 01438 313461.

Memory chips
4Kb SPI eeprom, 25C040 from Microchip is the newest member of the 5V, 10 and 32kBit Serial Peripheral Interface eeprom family, designed to interface directly with the SPI port of many microcontrollers, including PIC16CXX and PIC17CXX types. This 3MHz device has several security features, including user-selected write protection and up to 10 million erase/write cycles are guaranteed. A serial eeprom designers' kit is available. Atmel Microchip Technology Ltd. Tel., 01628 851077; fax, 01628 850259.

Non-volatile sram. In a single ic, the STK 14C88 from Simtek, there is a fast 32K by 8-bit static ram with an access time of 25ns in the fastest version, backed up by an eeprom. By means of a function called Autostore, the device monitors the 5V supply and starts a backup cycle if power is switched off or low. If one cannot be sure that the supply will stay above 3.6V during the 10ms backup time, a 100µF capacitor can be used to hold it up. On reappearence of the power supply, the data is automatically backed back to the sram, this being possible at any time under the user's control. Pronto Electronics Control Ltd., Tel., 0181-554-5700; fax, 0181-554-6222.

Motors and drivers
Ac motor power conversion. International Rectifier's series of PowerRtrain power conversion systems for ac motors is increased to handle 1.1kW (IRPT2095) and 5.6kW (IRPT4065) motors, each device containing all necessary circuitry to make motor drives and controls, with or without building in packages 75% smaller than competing types. Both types take 460V ac inputs, the former being in a chip-and-wire module and the latter a surface-mounted assembly on a metal substrate. Both include a board containing a driver with fault protection and shutdown facilities. A new brochure on PowerRtrain devices is available. International Rectifier, Tel., 01883 732020; fax, 01883 733410.

Optical devices
Dual-wavelength wdm transceiver. Using the company's active silicon integrated optical circuits technique (ASOC), Bookham Technology's BKMi2400 dual-wavelength transceiver, provides full duplex, single-mode, single-fibre, dual-wavelength operation on 1310nm and 1550nm at data rates of 155Mb/s or faster. It is meant for use in bidirectional networks such as point-to-point and passive optical networks for fibre-to-the-kerb, fibre-to-the-building and fibre-to-the-home. Transmission is on 1310nm and reception on 1550nm, a wavelength-dependent waveguide structure routing the signals to the appropriate circuits. Bookham Technology, Tel., 01235 827200; fax, 01235 827201.

PASSIVE

Cameras
Camera chipset. Sony's SS-1 three-chip set, together with a single colour ccd, forms a low-cost, light weight PALNTSC camera meant for use in security and multimedia. It carries out all cod driving and signal processing functions, working with Sony ccds from 0.2in, 180k-pixel types to 0.5in, 380k-pixel versions. A CXD2165 signal processor has an 8-bit to 8-b, or 1-bit to 0-bit converter, or a 9-bit or 10-bit converter may be used externally for better resolution, generates sync, and luminance/chrominance processing for both standards. Both analogue and CIIR601-4 compatible digital output is available. Silicon Concepts Ltd. Tel., 01428 751617; fax, 01428 751603.

Passive components
Low-esr electrolytics. Sanyo POSCAP surface-mounted electrolytics are for use in high-frequency power supplies, offering low equivalent series resistance and impedance; they use a conductive organic polymer for electrolyte. There are two versions: examples, the AP (aluminium) 16V, 2.2µF capacitor has an esr of 120µm2 and 80mA RMS ripple, while the tantalum TP-220µF handles ripple current of 1.2A and has an esr of 80mΩ. Semicon UK Ltd. Tel., 01279 422224; fax, 01279 433339.

Membrane pots. MP27 890 is part of a range of membrane potentiometers developed by CTS Corp., in which the resistive layer is formed by a carbon deposit on a substrate providing a resistive

Linear document reader. A colour cod linear sensor for A4 image scanners is announced by Sony, LSX24A, a raster-reduction type sensor having a shutter for each colour and, with 6µ by 6µ pixel size, has 35000 effective pixels to read an A4 document at 1200 dots/in, anti-reflection coating on the lower glass reducing unwanted signals. The sensor is contained in a 24-pin dip, requires 12V and a 5V clock pulse. Sony Semiconductor Europe, Tel., 01256 478771; fax, 01256 818194.

Audio products
MPEG2 decoders. Philips has announced a family of multi-channel audio decoders to the MPEG2 standard for use with DVD-Video players, set-top boxes, multimedia pcs and the rest. The first to emerge is the SAA 2502 decoder, which provides a down-mix of the soundtrack and so enables 5+1 (5 main speakers and an 8 set or 7+1 (7 and the 8) to be preserved when heard as a stereo output; this would not be the case without this chip, as the additional audio information in MPEG2 would be lost and the MPEG1 data only heard. For this reason, MPEG standards are reverse

December 1997 ELECTRONICS WORLD
NEW PRODUCTS CLASSIFIED

Please quote "Electronics World" when seeking further information

and forward compatible. Further chips in the family, to the AC-3 standard for NTSC, will appear later, as will dual-standard devices. Philips Semiconductors (Eindhoven), Tel., 00 31 40 2722091; fax, 00 31 40 2724285.

Connectors and cabling

Thin s-m connectors. Up to 30 contacts are possible within a mounted height of only 2mm in the JAE LZ Series of wire/braid connectors. Pitch is 1.25mm and there is a polarising key to prevent misalignment. Current rating is 1A and dielectric strength 500V ac. Flint Distribution. Tel., 01530 510333; fax, 01530 510275.

Surface-mounted coaxial connectors. Transradio’s MMT series of s-m coaxial connectors provide very low vear, low insertion loss and good shielding. There are models for use at frequencies from zero to 6GHz and a designers’ kit and an extraction tool are available. MMT connectors consist of a s-m receptacle, mating with a right-angled plug, the receptacle having a male centre contact. The plug is nickel-plated, die-cast, and has a cramped ferrule, being suitable for cable types including RD316 double-screened 2.5mm diameter cable, RG174 and RG178 types. Receptacles are stamped and formed and has a gold-plated body and centre contact, standing 6.5mm off the board. Transradio Ltd. Tel., 0181-997-8880; fax, 0181-997-0116.

Displays

RGB dot-matrix led module. The American company Lumex announces a 5-by-7 dot-matrix RGB array of leds, 2.03in high. There are three leds per dot, giving a minimum of 300/10 at 10mA in blue and a viewing angle of 100°. Each colour of every dot may be addressed either individually or collectively and response time is short enough for fast animation. Dots are 0.3mm diametre on 0.3mm centres, two rows of 11 pins on the back, in 0.1pin pitch being suitable for pcb mounting. Non-standard sizes or patterns may be made to order. Lumex Opto/Components Inc. Tel., 001 847 359-2970; fax, 001 847 359-8904.

Access to bgas. Difficulties in attaching probes to bal-grid arrays for test purposes are eliminated by the adapter produced by Winslow International. They consist of a solder-down module to suit any device with a square matrix down to 1mm pitch (interstitial), using a hard-ball post with pins coming from the top, for which any interface arrangement can be supplied. Winslow International Ltd. Tel., 01874 625555; fax, 01874 625500.

Filters

Drive-bay signal conditioners. Kemo has a range of active filters and signal conditioners that fit into the 5.25in floppy drive bay, which is now usually little used. Benefits of this type of mount are that screening is much better than when mounted in a card slot, and that the larger space allows better layout; filtering, too, is independent of the computer type and operating system. The Model 100 range has front-panel BNC connectors for inputs and cabling at the rear to connect the relevant data acquisition card. Signal conditioning may be computer-controlled or manual, the latter having two-panel switches to set functions. Kemo Ltd. Tel., 0181-658-3838; fax, 0181-658-4084.

Hardware

Desicators. Brownell has a range of desicators designed to eliminate humidity and condensation inside equipment housings. They are small polycarbonate mouldings in two types: one uses silica gel for general use, the other having molecular sieves for use with optical and laser equipment. Both types protect enclosures with volumes up to 1000, the type selected depending on volume and IP rating or equivalent. Each unit has a saturation indicator to show the need for reactivation or replacement. Brownell Ltd. Tel., 0181-965-9281; fax, 0181-965-3229.

No-tracking enclosures. K Box, a new division of Boss, has a new method of making low-cost plastic enclosures that need no tooling and are designed to order. They are made entirely of flat sheet material, so that moulding or forming is needed and prototypes are available in a few days, modifications being easily accommodated. The cases can be produced in several materials in 2-10mm thickness, may be internally coated for shielding and designed to take tough handling. Boss Industrial Moldings Ltd. Tel., 01638 718101; fax, 01638 716554.

Test and measurement

Analogue oscilloscope. Hitachi’s V-252 20MHz, dual-channel oscilloscope is claimed to be the best value for money and, since the information supplied says it costs £0.000, there is no arguing with that. Unfortunately, further enquiry reveals a price of £435, which is still pretty good. It’s warranty lasts three years, Y sensitivity is 1mV/div using x5 magnification and timebase speed a maximum of 0.1us/div with a 10x magnifier. All the usual X and Y facilities are provided, as are accessories including a viewing hood, although an electrostatic charge repellent blue screen filter helps with high ambient light levels. Hitachi Denshi (UK) Ltd. Tel., 0181-202-4311; fax, 0181-202-2451.

Accessible oscilloscopes. While sacrificing nothing in the way of performance, Hewlett-Packard has reduced the resemblance of digital storage oscilloscopes to 747 flight decks, so that the new Infinium family of instruments looks rather more like a ‘real’ oscilloscope, with controls like the older, purely analogue types. Even so, with bandwidths to 1.5GHz, sampling rates to 8Gsamples/second and memory depths up to 64K/channels, these are top-end instruments. A Windows ‘95-based graphical user interface eases access to advanced features via dialogue boxes and icons and an information system gives a guide to measurements of noise and jitter, to settling up advanced facilities such as FFTs and other, even basic procedures. Hewlett-Packard Ltd. Tel., 01344 366666; fax, 01344 362269.

Emissions testing. Laplace has added two new facilities to its 1.1GHz EMC-emission test S41000 hardware and software, addressing problems of test site anomalies and widespread unfamiliarity with the subject. Ideally, test sites should be open, free of reflections and using a 4m mast, a set of conditions that is rarely met. The new software automatically corrects for test site errors. To take account of unfamiliarity with the process, the software now includes the...
TestDirector mode, essentially an expert system that guides the user in the procedure. Laplace Instruments Ltd., Tel., 01692 500777; fax, 01692 406177.

Oscilloscope/recorder. Yokogawa’s DL708 is the first in a series of instruments that combine the capabilities of oscilloscopes and recorders, costing less than either of similar performance. Display is on a 10.4in colour fitt screen and there is a built-in thermal printer for hard copy. Data can be saved on the 1.2GByte hard disk or on a 3.5in floppy, the drive also being built in. There is a number of signal-conditioning modules, with bandwidth to 2MHz and 16-bit resolution, and up to eight channels may be plugged into the mainframe for simultaneous capture or recording. Analysis comprises voltage measurement, timing and FFT and waveforms can be analysed in terms of overshoot, period, standard deviation and rise time. Marton Instruments Ltd., Tel., 01494 459202; fax, 01494 535002.

Recorder with memory. The Hoki Model 8806 400sample/s memory recorder is a battery-powered, two-channel recorder that uses pc

ram cards to extend its capacity and to allow data to be analysed on the pc, operating in both recorder and memory modes. It will handle two analogue inputs and two logic signals, which are displayed on a 5in screen and printed immediately or saved for later printing. Telonic Instruments Ltd., Tel., 01734 786911; fax, 01734 792338.

Surface resistance tester. SRM100-3/8 from Practical Power checks surface resistivity in the 10-100V range and displays the result on an analogue panel meter. It uses a single 2.5kg weight with a square probe and conforms to BS EN100015, has CE marking and EMC approval. Practical Power Ltd., Tel., 0118 9699170; fax, 0118 9699171.

Three data recorders. Gould has introduced three new recorders. DL350 performs the functions of data logging, multipoint recording, alarm annunciation and digital indication and is available in 16-64 input form, any combination of thermocouples, rtds, current and voltage and being simultaneously monitored. RS232 or RS485 communication is provided. With up to 15 channels, the DL100 is a 100mm type having four inputs for mV, V and mA input and a variety of thermocouples and rtds, inputs being selectable for linear, square root and/or log characteristics. Finally, the Digigraph is a paperless recorder for six channels, a 16-bit a-to-d converter giving good resolution; data points are stored in a buffer for display, alarm, calculation or archiving. Many maths functions are available and results are displayed on a 5in colour_lcd with touchscreen menu. Gould Instrument Systems Ltd., Tel., 0181-500-1000; fax, 0181-501-0116.

Curve tracer. Hamreng’s HM6042 semiconductor curve tracer is simple to use, is suitable for the testing of two and three terminal devices and gives an on-screen display of five curves, with additional information on an lcd. The five displayed curves indicate base voltage, base current, collector current, collector voltage and beta, characteristics of the device under test being entered by means of a front-panel keypad. A power limiter prevents damage to the device. Sets of curves may be stored in memory to ease comparison with other devices. Feedback Test and Measurement, Tel., 01892 653322; fax, 01892 653717.

Interfaces

Eight-channel driver ic. Allegro offers the LD2987FLW, designed as an interface between standard low-level logic and higher-power devices such as relays, motors and lamps. It is in a 20-pin, wide-body soc and has thermal shutdown and output transient protection with clamp diodes for use with sustaining voltages up to 35V. Each channel has a latch to turn the channel off in the presence of excessive current, all channels being turned off in thermal shutdown, either condition being indicated by a common fault output. All outputs produce over 100mA continuously and inputs handle 5V and 12V logic, including ttl, schottky ttl, di, pmos and cmos. Allegro MicroSystems Inc. Tel., 01932 253355; fax, 01932 246622.

Literature

Burr-Brown CD-rom catalogue. On one CD-rom, Burr-Brown has collected the data from two 1300-page data books of analogue and mixed-signal devices and an applications handbook, together with search facilities. It is free and can be obtained by e-mail on cd-rom@burr-brown.com, from the website http://www.burr-brown.com/ or from Burr-Brown International, Tel., 01923 239837; fax, 01923 233979.

Rf transistors. Two catalogues from Ericsson on rf power transistors describe around 100 devices, ranging from 0.25W to 175W at frequencies from 300MHz to 2.2GHz, in both ldmos and bipolar types and contained in flange and surface-mounting packages. One of the publications is a short listing with a selection guide, while the other is a 350-page data book. Ericsson Components AB, Tel., 01793 488300; fax, 01793 488301.

DC-to-dc converters. Power Convertibles offers a six-page selector, giving details of the company’s models in the 0.75W to 100W range, including the new, low-cost 2W and 3W types. Those models in the 0.75-5W area are isolated-output types in s and sip/dip packages, providing 5V, 9V, 12V and 15V, while the WFC02R and WFC03R 2W and 3W models are lower in cost and are 81% efficient, in 32mm by 20mm by 10mm packages and 24-pin dils. There are also 8000V isolation types with output hole down to 1mV pk-pk. Power Convertibles Ireland Ltd. Tel., 00353 61 474133; fax, 00353 61 474141.

Power supplies

100W power supply. Weir Lamba’s new Excel 100i is a 100W, four-output, convection-cooled supply for general-purpose use. It meets the EN61000-3-2 but is available without power-factor correction for those applications in which it is not needed, in which case it costs less. It stands 42mm high without its cover (43mm with) and fits a 1U rack. As standard, outputs are three positive and a common zero, in a variety of arrangements. Input is 85-127V and 170-254V. Weir Electronics Ltd. Tel., 01243 865991; fax, 01243 868613.

60W dc-to-dc converters. The PKG 2000 f /current of 11mm high converters by Ericsson have a power density of 20W/cm³, working at an efficiency of more than 84%. The units are intended for use in decentralised 24V dc systems and accept inputs of 18-36V, turning off at 16V. PKG 2611 provides one output of 5V at 12A, the
Please quote "Electronics World" when seeking further information

PKG 2623 giving two of 12V at 4A, and all can be connected in parallel or series. If forced convection cooling is applied, the units need no heat sink up to 60°C. Acal Electronics Ltd, Tel., 01344 727272; fax, 01344 424262.

Radio communications products

Full duplex wi-fi chipset. Harris's Prism 8-chip set forms a full duplex, heterodyne radio transceiver with agc and carrying voice and data for use in wireless fms, point-to-point microwave, hand-held data transceivers and personal communications. It operates in the 1.7-2.7GHz band and carries out all necessary functions of amplification, up/down conversion and modulation/demodulation. Receiver sensitivity is -11dBm and agc range 90dB. Harris Semiconductor UK Tel., 01276 888886; fax, 01276 682323.

Pll synthesisers. Var-L PLL300/400 series of phase-locked loop synthesisers for mobile communications, industrial use and wireless modems use a patented single-ended voltage-controlled oscillator for very low phase noise, low harmonic content and stability. The devices contain all necessary circuitry, including programmable dividers, phase detectors and loop filter to make a complete circuit. There are frequency- agile devices, requiring serial programming and fixed-frequency units, with or without programming. In 13 variants, centre-frequency coverage is 755-992MHz, swinging ±15MHz, and two units of 2150MHz and 2450MHz centre-frequency swinging ±50MHz. Acal Electronics Ltd, Tel., 01344 727272; fax, 01344 424262.

Protection devices

600W transient suppressors. Surface-mounted components from Semitron, using the glass passivated TVS diode technique as the axial-lead types, are now available. SMB Series transient suppressors have large contacts to handle fast rising pulses caused by lightning, inductive switching and static, and are rated at 600W during a 10x100μs double exponential waveform. Fast turn on, a low clamping factor and low on impedance make them suitable for the protection of cmos ic's, the surface-mounted form with its lower lead inductance leading to an application on high-speed, low-voltage data lines. Voltage stand-off range is 5-170V, clamping to 9V taking place in under 1μs. The devices are unidirectional or bidirectional; in the forward direction the SMB series sustains 100A for 8.3ms. Surtech Distribution Ltd, Tel., 01256 840055; fax, 01256 479785.

Fused resistor networks. Ericsson offers the PBR53001/7 and PBR530001/1, which protect telecommunications line cards against induced voltages or direct shorts from underground power lines; they have integral thermal fuses and open safely when temperature in the device is greater than 240°C for 20s, protecting the pcb from melting or charing, and reducing the risk of fire. Sustained overvoltage causes the resistive elements to crack and open, the fuses taking care of slow-burn conditions caused as above. Resistances are 50Ω and 20Ω respectively, matched to within ±0.5%. Ericsson Components AB, Tel., 01793 488300; fax, 01793 488301.

Switches and relays

Pcb switches. A new range of tactile, sealed switches for pcb mounting are 12.5mm square and allow keyboard layouts to be designed on a 12.7mm grid. All models in the Seome Cosmos range are proof against dust, splashing, wave soldering and cleaning solvent and are provided with removable covers in various shapes and colours. Silver or gold-plated dome contacts are used and the switches can have a red, yellow or white led. Ratings are 24V, 125mA, the gold ones switching down to 50μA. Insulation at 100V is over 1GΩ. Hawlit Electronics Ltd, Tel., 0121-784-3355; fax, 0121-783-1657.

Transducers and sensors

Digital thermometer. DS1624 from Dallas is a direct-to-digital temperature sensor having 256byte of eeprom on-chip to store temperature-related compensation information, eliminating the need for an external eeprom or the use of a microcontroller's memory; no external components at all are needed. It is chiefly intended for use in crystal compensation, in which the eeprom contains data on the frequency/temperature curve of the crystal. Temperature information is in the form of a 13-bit, two-complement word, equivalent temperature measurement being in the -55°C to 125°C in 0.03125° steps, which Dallas says is the smallest available. Supply is 2.7-5.5V and the device uses the two-wire bus with three-bit addressing for up to eight chips on the bus. Sensors come already calibrated. Dallas Semiconductor, Tel., 0121-7822959; fax, 0121-7822156.

Data acquisition

Data acquisition pod for pcs from Thurby-Thandar, the VIPS 10 is a software/hardware package consisting of an 8-channel anaologue/digital converter pod that fits a pc's parallel port to form a multi-channel system for applications from low-speed data logging to fast, 12 bit data acquisition, up to four such pods working from one printer port, from which the pods take power. VIPS Windows software (95 or 3.1) gives display and control for up to four pods and supports direct data exchange between VIPS and other Windows applications. There are five types of pod for input/output in analogue/digital form, operating in any combination. And there are more to come. Thurby Thander Instruments Ltd, Tel., 01480 412451; fax, 01480 450469.

Vision systems

Video conference kit. Premier's H.324-compliant kit consists of a PCI card, a colour camera and cable, the software providing facilities for video conferences, moving picture storage and frame grabbing, with set-up assistance for user details, e-mail address, resolution and picture quality, PAL, SECAM and NTSC formats are available and the system copies with communication between computers or connection to the Internet over standard lines, ISDN or lan. The software allows storage of motion video direct to disk in an AVI file. Requirements are a 33MHz 486, 16Mbytes, 5Mbyte hard disk space and Windows 95. Premier Electronics Ltd, Tel., 01922 634652; fax, 01922 634616.

Switched relays

Pcb switches. A new range of tactile, sealed switches for pcb mounting are 12.5mm square and allow keyboard layouts to be designed on a 12.7mm grid. All models in the Seome Cosmos range are proof against dust, splashing, wave soldering and cleaning solvent and are provided with removable covers in various shapes and colours. Silver or gold-plated dome contacts are used and the switches can have a red, yellow or white led. Ratings are 24V, 125mA, the gold ones switching down to 50μA. Insulation at 100V is over 1GΩ. Hawlit Electronics Ltd, Tel., 0121-784-3355; fax, 0121-783-1657.

Computers

Hardy paintop. Fully proofed against most of the hazards of this world, Ultimap paintop computers are 386SX-based (Ultimap 2000) and 486DX2 66MHz-based (Ultimap 4000) and operate for long periods on four AA batteries; they are made by ST Research Corp. Both models are provided with two PCMCIA slots, memory upgrade from 4Mbyte to 16Mbyte in the 2000 and from 8Mbyte to 32Mbyte in the 4000, a backlit display and keyboard, which is a sealed membrane, tactile type, The 2000 is dos-based and has a CGA lct, while the 4000 runs Windows or dos software, has two serial ports, one external configurable connector,
Development and evaluation

78K/IV development. New from NEC, a software system simulator for the 16-bit, 32MHz 78K/IV microcontroller family. The simulator is Windows-compatible and simulates all peripheral functions of family devices, including timers, interrupt controller and I/O ports, allowing the simulation of waveform output, pull-up/down resistors, LEDs, keyboards and external interrupt sources. In program development, there is a single-step operation with a trace and access to source-level debugging. Cost of the simulator is $85. Sunrise Electronics Ltd, Tel., 01908 263999; fax, 01908 263003.

PIC emulator. RF Solutions’ new single-board, in-circuit emulator for PIC microcontrollers provides real-time, non-intrusive development to 20MHz and costs less than $300. ICEPIC Junior 5X rapidly identifies system bugs in all members of the Microchip PIC 12C5XX and 16C5X families. Source-level debugging is in either assembler or C, running in Windows; the system can therefore set an unlimited number of hardware breakpoints and arrange real-time emulation or single, multiple and procedure step execution. The emulator contains a Microchip emulation IC, 8K of emulation memory and an RS232 interface for data transfer at 115Kbps. RF Solutions Ltd, Tel., 01273 488880; fax, 01273 480861.

Mass storage systems

Rewritable disk/CD-rom drive. Panasonic’s LF-1196 is a removable, rewritable optical disk drive, combining an IDE ATAPI interface and Seagate software to provide 650Mbyte of storage on optical disk or to allow reading of 80-120mm CD-roms at up to 8x. There is no need to install an additional SCSI board, and Windows 3.1 and ‘96 versions of Seagate Backup Exec simplify backup and restore facilities by means of its easy Wizard interface for simplified backup and restore and an advanced interface for customised work. The drive is a half-height device, mounted vertically or horizontally, with seek times of 92ms for both optical disks and CD-roms, data transfer proceeding at 1141Kbps and 1200Kbps respectively. Panasonic Industrial (Europe) Ltd, Tel., 01344 853157; fax, 01344 853081

Software

WorkBench PC v3.0 Strawberry Tree’s WorkBench PC for Windows has undergone a major upgrading to produce version 3.0 of this graphical data acquisition package, which allows the collection, analysis, display, logging of data and the control of external systems, the only programming needed being the shuffling of icons. A choice of modules provides for the representation of data inputs and outputs, controls, displays and functions for data reduction, signal analysis, maths and statistical operations, the modules being selected from a pull-down menu and “connected” on screen. The new version has a cut-and-paste facility for the selection of modules by mouse for copying to other parts of the worksheet or to a macro box. An optional tool caters for up to 20 pages to be designed either in this program or to be imported as BMP files and virtual instruments may be integrated into the design. Five new modules include a counter/timer, a formula interpreter, an RS232 output, trigger modules and a min/max module. Adept Scientific Micro Systems Ltd, Tel., 01462 480055; fax, 01462 480213.

Bar-code labels. BAR-ONE Platinum v.4.0 from Zebra Technologies is the company’s newest bar-code label design and print software, which allows users to access, process and combine variable information, including text and graphics, from many sources, this latest version having improved networking capability. It meets Microsoft’s Open DataBase Connectivity standard and runs under Windows, so that a preview feature in the print queue allows a sight of the label before it is loaded for printing. Zebra Technologies Europe Ltd, Tel., 01494 472872; fax, 01494 450103.

NEW PRODUCTS CLASSIFIED

Please quote “Electronics World” when seeking further information

ADVERTISE FREE OF CHARGE

Subscribers* to Electronics World can advertise their electronic and electrical equipment completely free of charge

Simply write your ad in the form below, using one word per box, up to a maximum of twenty words. Remember to include your telephone number as one word. You must include your latest mailing label with your form.

* This free offer applies to private subscribers only. Your ad will be placed in the first available issue.

This offer applies to private sales of electrical and electronic equipment only.

Trade advertisers – call Joannah Cox on 0181-652 3620

All adverts will be placed as soon as possible. However, we are unable to guarantee insertion dates. We regret that we are unable to enter into correspondence with readers using this service, we also reserve the right to reject adverts which do not fulfil the terms of this offer.

Please send your completed forms to:
Free Classified Offer: Electronics World, L333, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS

December 1997 ELECTRONICS WORLD 1043
The Home of Hi-Fi, mas. It's not what you do, it's HOW you do it that counts!

Hart Audio Kits and factory assembled units use the unique combination of circuit designs by the renowned John Linsley Hood, the very best audio components, and our own engineering expertise, to give you unbeatable performance and unbeatable value for money.

We have always led the field for easy home construction to professional standards, even in the stickies we were using exactly assembled printed circuits when Heathkits in America were still using teeboarders. Many years of experience and innovation, going back to the early Dickason and Bailey classics gives us incomparable design background in the new and the home construction. This simply means building a Hart kit is a real pleasure, resulting in a piece of equipment that not only saves you money but you will be proud to own.

Why not buy the reprints and construction manual for the kit you are interested in to see how easy it is to build your own equipment the Hart way. The full cost can be credited against your subsequent kit purchase.

'AUDIO DESIGN' 80 WATT POWER AMPLIFIER.

This fantastic John Linsley Hood designed amplifier is the flagship of our range, and the ideal powerhouse for your ultimate hi-fi system. This kit is your way to get BP performance at bargain basement prices. The printed circuits use both as fully set stabilised power supplies give this amplifier World Class performance with state of the art performance. As already mentioned in the new and the home construction. This simply means building a Hart kit is a real pleasure, resulting in a piece of equipment that not only saves you money but you will be proud to own.

Hart high quality, purpose designed, ‘singles ended’ class A audio amplifier for ‘stand alone’ use or to supplement those many power amplifiers that do not have a headphone facility. Easy installation with special technical notes. The unit uses our Andante Ultra Hi-Fi line stage, and Linsley Hood headphone output modules. The pre-amp is essentially an all transistors system.

K110 Complete Standard Stereo Amplifier Kit. £145.21
K110 Comp. Complete SLAVE Amplifier Kit. £38.38
K1000M Complete Mono/Bi-amp Amplifier Kit. £277.20
RH410 Kit. Amplifier Circuits. £10.80
K1000CM Construction Manual with Full parts lists £5.50

ALPS “Blue Velvet” PRECISION AUDIO CONTROLS.

Now you can throw out those noisy B&W matched carbon pots and replace with the Hart exclusive ALPS “Blue Velvet” range of controls. Breathe life into your system, or upgrade to full Hart Hi-Fi Kit class amplifiers. The improvement in trek accuracy and matching reality is incredibly good, and you'll wonder why you ever thought something so cheap could make anything. Range is also available factory assembled.

MANUAL POTENTIOMETERS
-2 Gang 10kL. £15.17
-2 Gang 10kR or 10k L. £16.40
-2 Gang 10k Special Balance, zero crook and zero centre £17.48

MOTORISED POTENTIOMETERS
-2 Gang 20k Log Volume Control £26.20
-2 Gang 100k Special Balance, zero crook and zero centre £17.48

TOROIDAL MAINS & OUTPUT TRANSFORMERS for EL34, 30W VALVE AMPLIFIERS

Special set of toroidal transformers, 2 output & 1 mains for the “Hart Blue Power” valve amplifier design described in the Oct. 1993 issue of “Wireless World”. Total Wt 6.4g. Special price for the set. £200 with RUP. Photographs of the Article by Jeff Macaulay. £2

PRECISION THREE Purpose Test TASCAS TCD1.

Are you sure your tape recorder is set up to its best? Our latest purpose test tape cassette the three most important tape playback tests: non-sweep, non-sweep, non-sweep. Ideal when tuning in new heads. A professionally quality, digitally mastered test tape at a fraction of the cost. Test Tascas TCD1. Our price only £9.99

SHUNT FEEDBACK PULLUP PREAMPLIFIER

The Andante Linear Technology AUDIOPOWER SUPPLIES are specially designed for exacting audio use requiring absolute minimum noise, low hum field and total freedom from mechanical noise. Utilising linear technology throughout for smoothness and musicality makes it the perfect partner for the above units, or any equipment requiring fully stabilised ±5V supplies.

K1200A: “Singles Audiphi Kit with selected components £115.46
K1200SA: “Singles Audiphi”, Factory Assembled £115.46
K1200C Construction Manual £25.50

HART TACTICAL BOOKSHELVE

Send for your FREE copy of our LISTS
Send for your FREE copy of our LISTS

24 Hr. ORDERLINE 01691 652284
Fax. 01691 662284

All Prices include UK/EC VAT.

CIRCLE NO. 139 ON REPLY CARD

Send for your FREE copy of our LISTS
Send for your FREE copy of our LISTS

24 Hr. ORDERLINE 01691 652284
Fax. 01691 662284

All Prices include UK/EC VAT.

Send for your FREE copy of our LISTS
Send for your FREE copy of our LISTS

24 Hr. ORDERLINE 01691 652284
Fax. 01691 662284

All Prices include UK/EC VAT.

Send for your FREE copy of our LISTS
Send for your FREE copy of our LISTS

24 Hr. ORDERLINE 01691 652284
Fax. 01691 662284

All Prices include UK/EC VAT.
A battery of chargers

Battery design being what it is, battery chargers are not the simple devices they used to be. They even talk to computers, as Philip Darrington explains.

Ever since people decided they needed to carry computers, tape players, radios, telephones and all those life-enhancing games around with them, and the parking-meter reader stopped writing the numbers in a little book, the battery makers have had an extended birthday. But the one-discharge type of battery came a bit expensive and a bit too big and heavy — for some of the current-hungry devices, so rechargeable types were needed.

Cave for new chemistry: you can now be faced with nickel-cadmium, nickel-metal hydride, rechargeable alkaline and lithium ion batteries all in the same household and all needing chargers with various protective limiting facilities. Maxim makes ICs for the purpose, described in the Maxim Engineering Journal vol.27, from which this is an extract.

NiCd versus NiMH

If you need a high current in short bursts, nickel-cadmium (NiCd) batteries are the choice; they have a lower capacity than lithium ion (Li+) or nickel-metal hydride (NiMH) types, but possess low impedance.

NiMH batteries are in some ways similar to NiCd ones, but have more capacity, although self-discharge rate is about double at 1% of capacity per day and they do not, therefore, hold a charge for long periods. Both types can be fast-charged in about an hour by a current equal to the capacity in amp-hours, although this process will not give a full charge because of losses; to get a full charge, charge for longer or with a higher current.

Charge termination is slightly different for the two types: charging a NiCd battery should stop when its terminal voltage begins to decrease, because the thing will probably explode if provoked for much longer; an NiMH charge should be stopped when the voltage peaks.

You can trickle-charge both types without worrying about stopping the charge or checking the voltage because temperature rise is not nearly enough to cause any trouble. Trickle current should be around (capacity in Ah)/15.

Lithium-ion batteries

Li+ batteries have the edge over other rechargeables as regards capacity. Compared with NiMH types, energy per unit volume is 10%-30% better, but energy per unit mass is about double, since they are lighter.

But they are not perfect; current and voltage both need watching in both charge and discharge regimes (if you keep discharging the battery to a low voltage, it loses capacity).

For these reasons, Li+ packs usually have a fuse to prevent overcurrent and a switch to disconnect the battery if it looks like venting or, to put it another way, exploding.

Li+ battery packs usually use mosfets to disconnect the battery if it is being subjected to under or overvoltage. These mosfets also make a different charging method possible, in which a constant-current charge without voltage limit is applied, the mosfets turning on and off as needed to maintain the battery voltage. Battery capacitance slows

Figure 1. Simple linear charger for one lithium ion cell. Heat generated by this type confines its use to the cradle type of separate charger.
down the voltage rise, but care is needed because the capacitance varies with frequency and with battery type.

In some kinds of equipment powered by, say, alkaline AA batteries, an intermittent load calls for more power than the battery can supply, for example during transmission in a two-way pager. In such a case, the answer is to have an extra, rechargeable type to answer the call for action and then to relapse into relative inactivity while it is recharged by the main alkaline battery ready for the next assault on its composure.

Chargers
Separate chargers, including the cradle type into which the cellphone, for example, or its battery pack fits do not have to be extravagantly efficient, since any heat generated, within reason, will not affect the equipment.

Figure 1 shows the simplest type of charger for this purpose—a linear regulator designed to charge one Li+ cell at 1A. An external power transistor drops the input voltage to 2V, the transistor dissipating most of the power in the circuit, the MAX846A charger, with its internal reference, staying relatively cool and therefore stable. Series input current-sensing resistor R1 and the ISET resistor R2 set the current regulation level and ISET the current limit, in this case 1A. Terminal VSET allows for voltage limit adjustment.

If the series-pass transistor is contained in a small volume without cooling, heat might still be a problem. For four NiCd cells charging at 1A, total power dissipation could be 8W, 4.4W of that being in the transistor.

Built-in chargers are another matter; the life of a heated battery is shorter, but not necessarily sweeter. Linear regulators have to give way to switching regulators, which dissipate little power, regardless of the input/output difference, and which are smaller than the linear type. There is the disadvantage of the necessary filter, of course, although the battery capacitance can form part of the filter, if C is suitable for the filter frequency.

Noise can be a nuisance, but some switchers can be synchronised to an external signal to move the noise away from sensitive frequency bands. Good layout and shielding will avoid most of the trouble.

A four-cell NiCd/NiMH charger of the switching type is shown in Fig. 2. This is the kind that works with a microcontroller to terminate the charge, having no provision for that in itself. If the equipment has no such controller, it only needs to be an inexpensive type with an a-to-d converter. The MAX1640 chops the input by means of the switching transistor N1A and synchronous rectifier N1B; the chopped waveform being imposed across the inductor to form a current source, the diode D2 preventing the

---

**Fig. 2. Switching charger, which can be made smaller than the linear type. This one has no method of charge termination, since it relies on a microcontroller in the host equipment.**

**Fig. 3. Charger for smart battery packs, using the SMBus interface. This one is 89% efficient. The MAX874 is a voltage reference.**
battery reversing the process and supplying current to the source. In response to controller signals on pins D0 and D1, there are three modes of working: fast charge, pulse-trickle charge, and top-off charge. Fast charging produces a current of 1.5A, in top-off the current is about a quarter of the fast-charge current, or 0.38mA, and in trickle charge it is the same but pulsed with a 12.5% duty cycle. All these current levels are produced by the voltages on SET and REF pins and the value of the current-sense resistor, in this case 0.1Ω, all selected by the microcontroller input signals.

If everything goes according to plan, the circuit stops the charge when the battery voltage rise becomes zero or negative, depending on whether the battery is an NiMH or NiCd type. If it doesn’t, the potential divider R6,7 are there to set a limit to which the battery voltage may rise, in this case 8V.

Smart-battery chargers
One has the thought that battery design might perhaps be getting a little out of hand when even battery packs have microcontrollers. Nevertheless, they do and are useful in that one type of charger is able to cope with any kind of battery that conforms to the smart-battery standard. You can also replace a battery with any other that conforms to the standard, which is concerned with the manner in which the battery pack connects to the equipment it powers and the way in which it communicates with it using the Intel SMBus, itself derived from the I²C protocol. There are many I²C-compliant ics around, Figure 3 shows a charger with an SMBus interface.

Currents under 31mA, which corresponds to the five least significant bits from the a-to-d converter in the host controller, come from an internal linear current-source, since the switching regulator and its low-value current-sense resistor cannot handle the 1mA resolution needed. Currents over 31mA are provided by a switching regulator to maintain an efficiency of 89%, but the linear source remains active so that monotonicity at the a-to-d doesn’t suffer whatever the value of the sense resistor or current-sense amplifier offset.

If the input voltage is much greater than the battery voltage, transistor Q1 helps to relieve the power dissipation in the internal linear regulator; inputs up to 28V are acceptable and outputs are selectable at 1A, 2A and 4A. Switching is at 250kHz, the size of the inductor reflecting the fact.
Spreadsheet Analysis for Engineers and Scientists
With this practical, hands-on guide, engineers and researchers learn, quickly and easily, the latest and most useful electronic spreadsheet methods. Using a variety of interactive techniques, including worksheets, self-test and practical programs on the included disk, Spreadsheet Analysis for Engineers and Scientists show you how to harness the power and versatility of spreadsheet programs, including those that contain the fast Fourier transform, complex operations and Bessel functions, and how to customise your own applications.

Includes disk
0471 126837, 330pp
UK £37.50, Europe £39.50, ROW £49.50

Electronic Component Reliability
Fundamentals, Modelling, Evaluation and Assurance
This text approaches the quality and reliability of electronic components from a unique standpoint. Traditionally the twin subjects of reliability physics and reliability statistics have been treated as separate entities. Here, the author examines both areas and reveals how components fail and how failures develop over a period of time.

0471 952966, 374pp
UK £30.50, Europe £33.50, ROW £66.50

Fuzzy Logic Implementations and Applications
Offering a new perspective on a growing field, this text explores the many hardware implications of fuzzy logic based circuits. As use of AI increases, so the VLSI area of circuits is becoming a growth subject. Opening with an overview of fuzzy sets and fuzzy logic the book moves on to cover a range of non-standard solutions for fuzzy logic VLSI circuits. Future trends, new concepts and ideas are all examined and supported with practical examples from the author’s research.

ISBN 0471 950599, approx 340pp
UK £50.50, Europe £53.50, ROW £66.50

Microelectronic Switched-Capacitor Filters
Switched-capacitor filters and associated MOS integrated circuits are now an established technology finding applications in the telecommunications and instrumentation fields. With unrivalled breadth of coverage, this book surveys the design techniques of an important class of analogue signal processing systems. An accompanying diskette containing a comprehensive computer-aided design package (ISICAP) enables readers to gain a greater depth of understanding of the described techniques. Containing both source code files and an executable version of the main design package, this alone will be an indispensable tool for many circuit designers.

Includes disk
0471 950407 384pp
UK £75.00, Europe £79.00, ROW £92.00

The I2C Bus From Theory to Practice
With a special emphasis on the I2C Bus, this guidebook through the world of micro controller-managed serial buses presents comprehensive coverage of the theory necessary to design the best possible communications bus for any particular application. The book examines typical industrial and consumer applications and enables the reader to design effectively in a real-world environment. A disk containing software for the I2C bus is also included.

Includes disk
0471 96268 6, 314pp
UK £54.50, Europe £56.50, ROW £65.00

High Frequency Analog Integrated Circuits
As one of the first textbooks to discuss integrated circuit design considerations and actual designs from the basic concepts, this title provides a solid background in designing basic circuits, advanced circuits and synthesis techniques.

0471 530433 424pp
UK £80.00, Europe £83.00, ROW £95.00

Speech Coding
A Computing Laboratory Textbook
This is one of the first lab manuals with software dedicated exclusively to speech processing and coding. It takes advantage of the development of the personal computer by making this technology accessible to a wider audience. The manual and DOS based software together create a user-friendly digital signal processing lab which allows the user to perform a wide variety of speech coding and speech processing experiments. The text presents and explains a set of basic speech coders analytically and in terms of the specific parameters controlling each coder. The manual leads the student through the experimental process of understanding how speech coders work and sound via over 70 exercises and projects. The class-tested menu-driven, DOS-based software can be operated by students with little or no training.

Includes disks
0471 516929, 194pp
UK £31.97, Europe £33.97, ROW £39.97

Solar Cells and their Applications
The past decade has witnessed numerous important breakthroughs in solar cell technology, many of which have occurred in just the past few years. Far cheaper to produce and maintain, exhibiting a longer lifetime, and considerably more efficient than ever before, solar cells are, at last, in a position to compete with traditional technologies for both small and large-scale energy conversion applications. Including contributions from some of the world’s leading experts in the field, this book reports the most important recent advances in solar cell technology. From in-depth discussions of breakthroughs in cell, module, and system technologies to a probing look at important environmental, health, and safety issues in the photovoltaic industry, it covers a broad range of topics of vital interest to solar cell researchers, power systems designers, and all those with professional interest in current and future capabilities of this important technology.

Offers a detailed look at cutting-edge solar technology from an international team
All prices are fully inclusive of packing and delivery

Return to Jackie Lowe, Room L333, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

Please supply the following titles:

<table>
<thead>
<tr>
<th>Qty</th>
<th>Title or ISBN</th>
<th>Price</th>
</tr>
</thead>
</table>

** All prices on these pages include delivery and package **

Total

Name

Address

Postcode

Telephone

Method of payment (please circle)

Access/Mastercard/Visa/Cheque/PO

Cheques should be made payable to

Reed Business Publishing

Credit card no

Card expiry date

Signed

Please allow up to 28 days for delivery
Why Wien?
I was interested to read Bryan Hart’s article on the design of Wien bridge oscillators in October issue of Electronics World. But why would anyone nowadays want to build a Wien bridge oscillator? I find a double-integrator oscillator – such as described on pages 53-57 of the ‘Analog Circuits Cookbook’ by Bill Linfoot – to be a reliable and predictable. Moreover, its effective filtering action makes it possible to use diode limiting in the feedback path for level control, and still maintain a low level of harmonics.

True, this alternative requires two more op-amps, but as you can buy four high quality op-amps in one package for about £1 result, it is a price well worth paying.

J S Linfoot
Oxford

Flat-panel speakers
The article on solid-diaphragm speakers, ‘Flat but not flat’ in the August issue, rather bypasses the matter of woofers with polystyrene diaphragms of maximum strength.

Two or three decades ago you published two remarkable articles I cannot trace, by the same author. One showed that acoustic grammophone records could give a useful audio power at reasonable fidelity, provided the grooves were cut not with a diamond profile, but shaped with a solid of revolution so as to give line contact with a suitably shaped stylus.

The other showed that a very rigid diaphragm for flat-panel speakers could be made from polystyrene foam with stretched aluminium foil glued to each side, and possibly because of this the Kefkit 3 I used to listen to so many years ago, would work. You’ll have the advantage of zerocolouration. It does not sound like a loudspeaker.

I see a 1949 book ‘The Why and How of Need Reproduction’ by G H Briggs is still on offer from one of your advertisers and wonder if the people who worry about cabinet resonances would not be happier following his suggestion for students of using a drainpipe on a cabinet with a speaker set on top of it and locked spacing it off the floor: in such configurations one can set up a device connected to the centre of the speaker to disperse the higher frequencies and of course add a tweeter, though I think he was probably using Wharfedale speakers (his own firm) intended for all frequencies. To make more of a port at the bottom a rectangular-section port could be built with blocks taking its plan view up to the size of the pipe. Alternatively, owners of rectangular speaker cabinets could glue in large numbers of light wooden spars going in all directions but favouring the centres of the panels, damping the spars with felt.

With regard to the letters on speaker design suggesting that speaker cabinets can be tuned to match the room. I very much doubt the room affects what happens at the speaker front panel, and also I’ve been told that in judging levels people use only the direct speaker sound. On the other hand Cecil Bull Watts used to say that solo instruments should be recorded without reverberation as the reverberation in the listening room did the trick. Who is right? Sometimes I wish we could stop worrying about speakers, but we don’t.

Name not available
London

The attraction of reed relays
Specifications of a reed-relay can be made to change drastically with the aid of a permanent magnet:

- increasing magnetising influence, depending on the magnet’s position relative to the axis of the relay and its ‘strength’, the permanent magnet can:
  - make the relay pull in and release at smaller currents than without the permanent magnet (normally open),
  - make the pull-in current still smaller, latching and opening only if the current is reversed (memory), and
  - make the relay normally closed, opening only with the current reversed. And closing again at further increase.

The use of the permanent magnet affects both speed and reliability and increase the pull in to release current ratio. Less than 1cm of the magnetic PVC strip that keeps the door of your old refrigerator closed will do the job. Just cut it with scissors and glue it to the top of your reed-relay.

Scott Arnesen
Oslo

Norway

Stability in audio amplifiers
Electronic stability. Audio amplifiers must remain electronically stable during normal – and sometimes abnormal – operation, if only to avoid writing off output transistors and possibly speakers.

A solution adopted by many designers including Doug Self,1 is to connect a capacitor of say 100μF across the voltage amplifying stage (VAS). Ed Cherry recommends that this capacitor be connected to include the output devices so as to gain useful level and crossover distortion. There is perhaps understandably some reluctance to try this, but I can concur with Ed that it can indeed work and result in stable amplifiers.

I discovered this after reading Ed’s comment about instability in driver stages. Firstly, I connected 39pF across the base of the BD139/BD140 drivers of my type II emitter follower output stage. A clearly discernible improvement in sound quality was noted. I do say my drivers on short leads, but clearly the pch track inductance is sufficient to cause instability in this stage when using transistors having frequency responses up to 100MHz or so. The output devices are BD971/BD972. Many thanks Ed.

The Cms capacitor of 100μF was connected between the output stage and the input base of the VAS stage. A 1kHz square wave response showed only a small amount of overshoot with a reactive load (5Ω in parallel with 2pF). Response was optimised by means of a 22pF capacitor in series with 150kΩ, connected between VAS collector and the negative feedback point on the input pair.

Final response and stability are good. Audible results are very satisfactory. Again, thanks Ed.

The amplifier circuit includes a cascade stage and three transistor current mirror on the input pair, and a cascade VAS stage. Drivers and output devices are operated on 335V rails. Input and VAS stages are fed from similar, but voltage stabilised rails. Input impedance of the amplifiers are around 35 kΩ and voltage gain is 20.

I always check and do initial setup of all amplifiers and drivers and outputs stages supplied via ±15V 1 A current limited supplies – just in case.

Thermal stability. It can be difficult to ensure that optimum quiescent current is maintained during operation of class B emitter follower driver/output stages. Common practice is to mount drivers and output devices on a common heat sink and to use a single – or perhaps double – transistor Vbe multiplier, also mounted on the heat sink – or possibly on one of the output devices. This is far from ideal as the drivers and output devices invariably operate at different temperatures.

A better solution is to use a conventional Vbe multiplier connected in series with two forward biased diodes. The Vbe multiplier transistor should be mounted as closely as possible to the drivers and output devices. An advantage of the arrangement is that driver devices can be located more conveniently, possibly away from the main cooling fins.

I claim not to be the only one for the use of diodes to control quiescent current. This was done by B J Codd2.

Ken Hough
Amersham,
South Bucks


1.3V mystery
I have been an electronics engineer for 30 years and I have just realised that I do not know how a quartz watch can work so efficiently from only one 1.3V cell. The same goes for calculators and thermometers with liquid-crystal displays.

So what is the secret and why don’t many other things use the same technology? One single cell is so convenient and contains size for size much more energy than say a PP3.

You never see a circuit diagram of one of these single cell devices. Is there a conspiracy by the battery makers? Is there a parallel universe that uses a semiconductor that only needs a bias voltage of a millivolt?

While we are on the subject of the unknown, how do hearing aid makers make all the electronics into such a small space, and without feedback? Do they use normal sm or again is there another Flint in this parallel universe that supplies 1/100 size components?

Ken Hawes
London SW17

LETTERS

Letters to "Electronics World" Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS

December 1997 ELECTRONICS WORLD 1051
On beating frequencies
In the September 1997 issue on page 786, Chris Bulman raised a question about beating frequencies. This query prompted an unusual, high response. These are the last few responses that we are able to publish on the subject, but many thanks to everyone who replied. Ed

Chris Bulman is correct in thinking that a sinewave signal very close to the Nyquist frequency will, when sampled, produce a set of data points which encode a “wuhwuhwuhwuh” (sic).

Fourier analysis of the wuh (forgive the abbreviation) would show in his example at 19.999kHz and one at 20.001kHz. There are also pairs of tones at 59.999kHz/60.001kHz and all subsequent odd multiples of the Nyquist frequency, with gradually increasing amplitude.

If you fed the data to a d-a-to-a converter and listened to the output, I’m sure those with a reliable aural response to 20kHz would hear this pulsating effect.

But this is not what happens in a proper digital audio system. A proper system uses an anti imaging filter whose primary role is to remove the higher of the wuh tones, leaving the lower one pure and constant.

This filter would indeed have a delay of many seconds if it had to resolve the 2Hz frequency difference between the wuh tones, which is why a ‘guard band’ is used between the highest encoded frequency and the Nyquist frequency. It makes the anti-imaging – as well as the anti-aliasing – filters economically realisable, whether they are ‘traditional’ analogical or computational exercises in silicon.

kendall Castor-Perry, Kerno Ltd, Kent

The “paradox” is easily resolved if one bears in mind what the spectrum – or Fourier transform – of a sampled signal looks like, and the practicalities of designing an appropriate reconstruction filter.

Shannon’s sampling theorem states that if a signal is bandlimited to WHz then it may be reconstructed from its values taken at 1/2W (s) intervals.

Consider the process of sampling and reconstruction in the time and frequency domains. In the frequency domain the act of sampling causes the spectrum to be made periodic, in a way that is best represented by the diagram, and the reconstruction process consists in filtering out the copies. If the copies overlap the resulting reconstruction is not the original signal and an aliasing error has occurred. In the time domain the reconstruction involves a convolution – an averaging process in which a ‘window’ is slid along the data and the weighted average of the samples in the window is computed.

The form of the weights determines the frequency characteristics of the filter. To pass frequency f1 Hz and reject f2 Hz requires a window of at least 1/f1−f2 seconds in duration: over a shorter period, cos(2nf1/t) and cos(2nf2/t) are not significantly different.

The Shannon reconstruction filter has a vertical cut-off at W, and therefore requires a window of infinite time extent.

Considering Mr Bulman’s example, when a 19.999kHz sinewave is sampled at 40kHz, the spectrum of the samples contains components at 19.999kHz, 20.001kHz, 59.999kHz, 60.001kHz, and so on. Exact reconstruction requires a filter that passes all frequencies up to 20kHz and rejects higher ones: in particular, it must pass 19.999kHz and reject 20.001kHz.

Can this be done in practice? In practice the window length is restricted to, perhaps, 100ms. This gives a selectivity of 0.01kHz, and so if 19.999kHz is to be passed then 20.001kHz will come through as well.

Having established that a practical reconstruction contains both the desired sinewave and its first alias, it is easy to see what happens: the two frequencies beat together in the way that Mr Bulman describes. Note that the beat frequency does not actually occur in the spectrum – though the signal were nonlinearly distorted it would. The problem will not arise if the difference between the signal and Nyquist frequency is reasonably large – perhaps 1kHz – because then the signal’s aliases can be removed very effectively.

It is therefore a good idea, once the sampling rate has been selected as 2W, to remove all frequencies above rW (for some r less than 1) before sampling. This creates a guard band between the highest frequency present, rW, and the Nyquist frequency, W, and makes accurate reconstruction a much more practical proposition. Helms and Thomas were the first to discuss this in a classic paper on rapidly-convergent sampling expansions; since the sampling expansion gives the filter weights, their work is of immediate relevance in the design of reconstruction filters.

Richard Martin
GEC Marconi Research

What happens when two sinewave signals are added together, consider an A-level maths book, where you will find the identity,

\[ \cos A + \cos B = 2 \cos \left( \frac{A+B}{2} \right) \cos \left( \frac{A-B}{2} \right) \]

which is also known as ‘two cos semi-sum cos semi-diff.’

This formula shows that sinewave waves of 19.999kHz and 20.001kHz will beat together to give a result that is a 20kHz sinewave signal (the cos(A+B) term) multiplied by a 1Hz sinewave signal (the cos(A-B) term), which is the waveform originally described by Chris.

Once you realise that C.B.’s fluctuating signal is actually a pair of frequencies, then all you have to do is put the brick-wall filter in, and, since it removes everything above 20kHz, what is left is 19.999kHz, as per Nyquist’s theory. The 20.001kHz signal that has been removed is known as an alias signal.

Incidentally, a true brick wall filter is impossible to realise. The more brick-wall like a filter is, the more delay the filter have, and an infinitely steep brick-wall response would require an infinite delay. However, replacing the brick-wall filter with a real filter, and leaving a guard band between the highest signal frequency and the Nyquist frequency, as is done in practice, does not in any way alter the paradox as described by Chris, and its explanation as given above, since the delay in the filter – ideally – affects all frequencies by the same amount.

Brian Pollard
Maidstone
Kent
ARTICLES FOR SALE

PCB CAMERA £39.00 + VAT
B/W MODULES
32mm. 3.5 lens or pinhole £39.00 + vat each
42mm • lens with audio add £10 + vat
(UK CARRIAGE/PACK/INSURANCE £4 UP TO 10 PIECES)

DISCOUNT FOR QUANTITIES
SEE OUR WEB SITE
OPEN 6 DAYS A WEEK FOR CALLERS
MAIL-ORDER OR EMAIL

HENRY'S
404 EDGWARE ROAD
LONDON W12 1ED
Tel: 0171 258 1831 Fax: 0171 724 0322
e-mail: sales@henrys.demon.co.uk internet address: http://www.henrys.co.uk

RF DESIGN SERVICES
All aspects of RF hardware
development considered from
concept to production

WATERBANE ELECTRONICS
TEL: 01223 862550
FAX: 01223 440853

CAPACITORS
Large volume availability of capacitors
direct from manufacturers in pitch sizes 5,
7.5 & 10. VDC 63, 100, 250, 400 & 630.
µF 0.001 - µF 0.68
For further details please contact:
PALA CAPACITORS
Tel: 01483 569590
Fax: 01483 566050

ADRETT 740A
Signal Generator
0.1 - 1120 MHZ
Price: £1,500

TELFORD ELECTRONICS
(0044) 01952 605451

DAT RECORDER Sony Portable TCD-EN 129
(1/4 inch pickup), boxed in perfect condition. Used
for 2 hours only. Telephone: (01904) 426696
(Evenings).

PLUXE 876B graphical multi meter, five months
old, with leads and manuals. £550 ono. Tel: 01482
815625.

JRC RADIO TEST SET NIZ 900E. £450. Tel:
01635 552285.

ARTICLES WANTED

VALVES and CRT's AVAILABLE
ONE MILLION VALVES stocked for Audio, Receiving, Transmitting
& RF Heating. Rare brands such as Mullard & GEC available.
Also MAGENTRONS, KLSTRONS, CIRTS and SOCKETS.
Large stocks of Russian and Sovekt items.
Please ask for our free catalogues of valves or CRTs.

VALVES, etc, WANTED
Most types considered but especially KT88 (£60), PX4/PX25 (£60),
KT66 (£38), KT77 (£18), EL34 (£15), EL37 (£15), ECC83 (£3).
Valves must be UK manufacture to achieve prices mentioned.
Also various valve-are equipment, e.g. Garrard 301, (up to £80).
Ask for a free copy of our wanted List.

BILLINGTON EXPORT LTD., Billington, Sussex RH14 9EZ
Tel: 01403 784961 Fax: 01403 783519
VISITORS STRICTLY BY APPOINTMENT.
MINIMUM ORDER £50 plus VAT

TOP PRICES PAID
For all your valves, tubes, semi conductors and IC's.

Langrex Supplies Limited
1 Mayo Road, Croydon
Surrey CR2 2QF

Tel: 0181-684 1166
Fax: 0181-684 3056

WANTED - Old cipher equipment and "spy
radio sets", 02880. Rag Osmund, Hostenbroek
10 DK-3460 Birkeroed, Denmark. Fax: ++45
44681514.

WANTED - WW2, German and S.O.E.
clandestine sets, receivers. Also incomplete sets, 02880
Rag Osmund, Hostenbroek, 10 DK-3460
Birkeroed, Denmark. Fax: ++45 44681514.

SALES MANAGER
We are a small company supplying transmission systems to the
telecommunications industry and are looking for a Sales
Manager to take over the running of our sales department.
You should have a technical background, ideally with some
experience of radio.
Please apply with letter and CV to:
Alan Brown, Radica Broadcast Systems Ltd.,
18 Bolney Grange Industrial Park, Hickstead,
Haywards Heath, West Sussex, RH17 5PB

RECRUITMENT

INTERESTED IN A HIGHER DEGREE?
Why not read "Gaining a Master's Degree by
Aiden Brown", available from book shops or
HowItWorks, Plymouth House, Exeter Road,
Plymouth PL2 7EQ. Tel: 01752 202301, Fax:
01752 202301, 29.99

MICRO CCD CAMERA
High definition and sensitivity
>380 lines < 0.1 Lux 92 deg. lens
1.3" b/w PCB. 12V 75mA
38*38*30mm
Standard 1 Volt 625 line video o/p.
ONLY £64.95
Inc uk. p&p, and VAT
Send cheque or PO to Retech Ltd., Unit 1,
Dorcus Business Village, Swindon, SN3 5HY.
Send s.a.e. for details and latest
list of AV and Satellite offers

WANTED — any AVO model with hopefully
undamaged movement. Tel: 01326 312901.

INTERESTED IN A HIGHER DEGREE?
Why not read "Gaining a Master's Degree by
Aiden Brown", available from book shops or
HowItWorks, Plymouth House, Exeter Road,
Plymouth PL2 7EQ. Tel: 01752 202301, Fax:
01752 202301, 29.99

SALES MANAGER
We are a small company supplying transmission systems to the
telecommunications industry and are looking for a Sales
Manager to take over the running of our sales department.
You should have a technical background, ideally with some
experience of radio.
Please apply with letter and CV to:
Alan Brown, Radica Broadcast Systems Ltd.,
18 Bolney Grange Industrial Park, Hickstead,
Haywards Heath, West Sussex, RH17 5PB

WANTED — any AVO model with hopefully
undamaged movement. Tel: 01326 312901.

INTERESTED IN A HIGHER DEGREE?
Why not read "Gaining a Master's Degree by
Aiden Brown", available from book shops or
HowItWorks, Plymouth House, Exeter Road,
Plymouth PL2 7EQ. Tel: 01752 202301, Fax:
01752 202301, 29.99

INTERESTED IN A HIGHER DEGREE?
Why not read "Gaining a Master's Degree by
Aiden Brown", available from book shops or
HowItWorks, Plymouth House, Exeter Road,
Plymouth PL2 7EQ. Tel: 01752 202301, Fax:
01752 202301, 29.99
Grad/Engineer/Leader/Manager

**Senior RF Engineer**

This leading radio design company who is focused on the automatic meter reading (AMR) market is leading the way in AMR throughout Europe and beyond. You will lead a team of strong engineers who have the desire to be part of the successful team. The job will include working closely with the RF and analogue designers to develop new designs. You will also work closely with the production team to ensure the company remains on target for its production schedule. You will also be involved in the development of new RF and analogue components for the next generation of products. The successful candidate will be expected to manage a team of junior engineers and to lead by example. A minimum of 5 years' experience in the radio frequency domain is required.

Salary: £18-28K

**Driving Technology**

**Essex**

We are looking for a number of good academic Engineers (2-3 Hours or better) to join the Audio, Power, Train, Body Electronics and in-Car Control Systems dept of a well known automotive manufacturer. You will join multi-discipline teams working on N/EU European and Worldwide commercial vehicles projects to go into production at the turn of this decade. We are keen to talk to Engineers with a good degree, at least 12 months in industry plus experience of digital/microprocessor and/or analogue electronics. Experience of automotive, electronic, control systems, powertrains, audio, instrumentation or sensors would also be useful. Please call for further details.

Andrew Langridge - Ref: AL/4200W

**Peter Gabriel Has One!...**

So does Phil Collins, Sting and the Beeb to name just a few customers - we are talking serious SOUND MIXING! To continue their success in the professional audio and broadcast arena, this company have an URGENT requirement to recruit innovative, passionate and ambitious Design Engineers who don't mind dabbling in a mixture of Hardware, FPGA's, Analogue etc, etc. We need to talk to you if you have a hobby or interest in electronics, are a hands-on Engineer, you want to engineer, and you want your electronics to work!

Andrew Langridge - Ref: AL/4200W

**Power Supply/Electronics**

See PSU Designers below. £20-25K

**RF, RF, RF**

RF Design
RF/GSM Design
RF and System
RF Test
RF Planner
RF Support/Design
RF Systems/Test Engineer
Senior RF Engineer

**N/Home Counties**

A leading systems/board level development house responsible for R&D activities into the PMS/RF field require a Test Equipment Team Leader. You will be responsible for the co-ordination of a small Test Development Team, and project managing new developments, also acting as a functional part of the team - yourself being involved in Test Development activities. You will liaise with R&D and FDI Testability issues and on determining test strategies. £20-30K.

Peter Starling - Ref: PS0300X

**Cash**

World leader in the provision of transaction products and services based in the South of England are looking for Digital and Analogue Electronic Engineers at all levels. Digital position requires electronic design experience with VHDL/Verilog and experience of communication protocols. Good candidates will be expected to work in a hands-on role, individually and as part of a team. We're keen to talk to Engineers with experience of digital and/or analogue hardware in addition instrumentation/telephonic equipment experience would be an advantage.

Roma Das Gupta - Ref: RDG29EXW

**RF/MW Eng Mgr - RF/MW Comps/Modules**

A company involved in the design/development of Microwave/RF components require a Manager. You will be responsible for determining the current and future directions of the RF Division, you will set up and co-ordinate dedicated Development Teams in the development of components/modules for markets aimed at the Satellite/Wireless Comms, Space and Automotive industries. You will liaise with Marketing on the definition of future product directions. Degree qualified, 10 years in a Senior Engineer/Product Development role, vast experience in RF/MW component development, project management.

Peter Starling - Ref: PS0320W

**Graduates of '96 & '97**

2/2/11/15/MSC/PhD

This companies are offering superb salaries, career prospects and training are now looking for bright articulate and ambitious graduates to join them. If you are experienced in:

- Power
- Comms
- Telecoms
- RF
- DSP
- Analog
- Digital
- Optoelectronics

We offer excellent opportunities.

Caroline Papp - Ref: CP01EWO

**Development Engs - Video/RF**

**N/Home Counties**

A company who design/develop and manufacture network broadcast equipment primarily for the Cable/Consumer Network industry require Design Engineers. You will be responsible for the development of Video and RF circuits for consumer based products. You will take product development from conception to manufacture and will liaise with other parties along the way to ensure DHOF criteria are met. Have Degree Electronics, component level design Video/Digital use of design tools - PSPICE etc. Knowledge of Set Top Box/Cable TV products an advantage.

Peter Starling - Ref: PS090EWO

**DSP Engineers**

Continuing European growth has led to the immediate requirement for a couple of good all round DSP Engineers to join this small interactive team. You will be responsible for Hardware and Software Design (algorithm design, coding and testing) used in the development of new GSM and PMR comms products. Experience, allied to a degree level qualification should include real-time embedded software experience in C/C++ and Assembler with solid experience in Texas DSPs.

Frazier Martin - Ref: FM9E5W070

**Software Test**

Testing times indeed! We can't find enough good experienced Software Test Engineers, therefore we have numerous vacancies from Junior to Team Leader level with clients in Telecoms, Datacomms and Consulting industries. Their requirements are similar in that they all seek quality, well trained Engineers to take responsibility for their critical production area, whether you have just one years experience or whether you develop your test strategy, enhancements, procedures and seek a move into Consultancy - we have probably got a good move for you.

Frazier Martin - Ref: FM9E5W753

**Fraud/Security Systems**

As part of this major network provider/operater you would be responsible for the design/implementation of security and fraud systems into the existing comms infrastructure. You should possess a good knowledge of systems and protocols, encryption and authentication techniques. Additional exposure to GSM or RF would be advantageous.

Frazier Martin - Ref: FM9E6W40

**Software Tools/Billing/CTI**

The UK's most popular Mobile Telecoms company require talented qualified Engineers to join them in developing software tools for their next generation GSM cellular systems, CTI, business critical software, designing subscriber administring systems software or simply planning/optimising tools for their new and current networks. You will have a good Degree plus experience of development in C++, C++, D, RDMS.

Frazier Martin - Ref: FM9E6W63

**Development Manager**

Our client is a leading blue chip company who require an experienced Development Manager. Based in Hampshire you will be developing a wide range of satellite based (GSM) positioning and using a range of communication systems including RF tagging products. You will also be involved in taking the designs through the complete product lifecycle and have some contact with customers and suppliers. You will be qualified to Degree level in Electronics and/or have a background in analogue and digital design and some knowledge of embedded microcontroller firmware design. A good allround package is offered to the ideal candidate.

David Tillyer - Ref: DT15E/W

**Midlands**

Various companies in the East and West Midlands have a number of openings for Hardware Engineers with digital and analogue skills in the following fields:

- Medical
- Automotive
- Instrumentation
- Power
- Avionics
- ASIC Design

Roma Das Gupta - Ref: RDG29EXW

**Cash**

Various companies in the East and West Midlands have a number of openings for Hardware Engineers with digital and analogue skills in the following fields:

- Medical
- Automotive
- Instrumentation
- Power
- Avionics
- ASIC Design

Roma Das Gupta - Ref: RDG29EXW

**Design Engineer**

East

A leader in the field of medical instrumentation is looking for a Hardware Design Engineer to develop new ideas. The company who are based in the East of England have just received a SMART grant to produce state-of-the-art medical equipment. The successful candidate must be prepared to work in a hands-on role, individually and as part of a team. We're keen to talk to Engineers with experience of digital and/or analogue hardware in addition instrumentation/telephonic equipment experience would be an advantage.

Roma Das Gupta - Ref: RDG23EXW

Please call quoting the appropriate Ref. No.on 01442 212555 or fax/email/apt your CV to 2nd Floor, 89 The Marlowes, Hemel Hempstead, Herts, HP1 1XY

Tel: 01442 212555
Fax: 01442 231555

email: swprecurr@dailipex.com (preferably WORD format please)
**Telecomms Systems**

**E. Midlands**

£20-35K

Fast expanding internet company but small close knit group. You shall have wide systems experience in elite switching networks or mobile radio. Some UK travel is necessary. This is a good move from a pure technical role to a more commercial and customer focused activity.

Contact: Gordon Short  
Ref: GS4900

---

**ASIC Design**

**UK Wide**

to £50K & Benefits

Exceptional opportunities with major semi-conductor companies, electronic manufacturers and design consultancies. The following skills are in high demand: VHDL, VERILOG, CADENCE, SYNOPSIS, MOS/BIPOLAR technology etc. Applications include Telecoms, Datacoms, Video/TV, Multimedia etc. Vacancies at all levels from Graduate to Project Leader some involving UK/European travel.

Contact: Brian Cornwell  
Ref: BC4903

---

**Research Assistant**

**Bucks**

to £30K

International standards and consultancy between design groups require an understanding of protocols and the ability to travel. You may be a research assistant in Telecommunications looking for your first career or you may already be established in switching, GSM or broadband systems. You will become the acknowledged company expert in your field.

Contact: Gordon Short  
Ref: GS4901

---

**Mixed Signal Designer**

**M3**

c£28K

With this company only 2 years Analogue/Mixed Signal design will give you real responsibility and career development opportunities. If you have transistor level CMOS, BICMOS or Bipolar design experience with Mentor, VHDL, PSPICE, ELDO, LEDIT or Sabre skills phone me NOW!

Contact: Brian Cornwell  
Ref: BC4904

---

**Low Noise Amplifier Hardware Design**

**Hants/Bucks**

£18-38K

Whatever your RF skills or experience, our client will train you to do better. Worldwide projects include fixed access and satellite communications. Working at circuit, systems or advanced research level you will join a young dynamic team set to produce equipment to celebrate the millennium!

Contact: Gordon Short  
Ref: GS4902

---

**Communications**

Ambassador House
575-599 Maxted Road
Hemel Hempstead
Herts HP2 7DX

Telephone (days): 01442 231691  
Eves/wkends: 01442 235300

Fax: 01442 230063  
Email: executive@dial.pipex.com  
Web: http://www.ers.co.uk/ers

A member of Executive Recruitment Services plc group of companies
**Electronic Update**

Contact Joannah Cox on 0181-652 3620

A regular advertising feature enabling readers to obtain more information on companies' products or services.

**PXI Modular Instrumentation**

PXI delivers the high-precision instrumentation, synchronisation and timing features of more expensive platforms at an affordable price. Combining mainstream PCI computing technology and Windows software with rugged industrial packaging, PXI offers high performance test, measurement, data acquisition and industrial computing solutions.

For your free brochure call National Instruments on 01635 523545

**NEW Feedback T&M Catalogue**

The latest edition of the Feedback Test & Measurement catalogue is now available. Over 60 pages packed with more than 800 products divided into over 20 sections. The catalogue is indexed for both product and manufacturer and is fully illustrated. Whether you are looking for an individual product, a complete workstation, or a solution to a particular Test & Measurement need the NEW Feedback catalogue will solve your problems, send for a copy NOW!

**NEW JENSEN TOOLS CATALOGUE**

Colourful new catalogue, hot off the press from Jensen Tools, presents unique new tool kits for various support of communications equipment. Also latest test equipment from many major manufacturers. Includes hard-to-find tools, PC/LAN diagnostics, bench accessories, static control, technical manuals and more.

Ring 0800 833246 or Fax 01604 785573 for a free copy.

Jensen Tools, 10-12 Ravens Way, Northampton NN3 9UD

CIRCLE NO. 141 ON REPLY CARD

**HEWLETT PACKARD**

1646B serial data generator £500
1151A attenuator set £350
3336A synthesizer/level generator £2000
332A switch/test unit £1000
332A synthesised function generator 91/92 £1500
332500/332520 programmable attenuators 401Hz, with driver 11513A £1000
As above but 185Hz set £750
3565A mainframe £2000
33015A banch power supply £175
3774A/40 digital hierarchy test set £950
37900C signalling test set with 2 x 3391A interface cards £550
4140B pA/meter, DC voltage source £4000
4275A multi frequency lcr meter £3000
4548A (04) in-service TIM set £250
4085B protocol tester base (PT300) £3500
54510A 1GHz digitising oscilloscope, now inc 2 x 10Hz active probes £1500
54632A logic analyzer £1500
6632A systems power supply £650
8019A serial data generator £1500
803A pulse generator 250MHz £2000
8111A pulse generator 20MHz £1250
83411C lightwave receiver 1300/1550nm £1750
83446C lightwave detector 80GHz 1200/1500 nm £3000
8356B with 8399A 10MHz-2GHz swez generator £1500
16013A/16015C 1MHz-2GHz swez generator £1750
67510A gain-phase analyser 100kHz-3GHz £8500
8990B modulation analyser £4500
J2314A/301A portable multimeter test set £1500
J2304 internet advisor with ethernet interface £2500

CIRCLE NO. 143 ON REPLY CARD

**raffe electronics**

36 Eastcote Lane • South Harrow • Middx HA2 8DB • England • TEL (+44) 0181-422 2593 • FAX (+44) 0181-423 4009

**FOR EXCLUSIVE ACCESS TO OUR COMPLETE STOCK INVENTORY AND SPECIAL BARGAIN DISPOSAL DEALS PLEASE CHECK OUR WEBSITE**

http://www.raffe-electronics.co.uk

CIRCLE NO. 139 ON REPLY CARD

**TEST EQUIPMENT**

**URGENTLY REQUIRED**

HEWLETT PACKARD 8720 series network analysers £20,000+paid for 'C'
HEWLETT PACKARD 8510 series microwave analysers, anything considered
HEWLETT PACKARD 85668 series spectrum analysers £10K-£20K paid
HP8753C + vector network analysers, we pay top prices for late models.
Guaranteed top prices paid for all current model spectrum/network analysis.

For more details call 01615 971391

CIRCLE NO. 142 ON REPLY CARD

**ISO9002 ACCREDITED STOCKIST MEASUREMENT & TEST EQUIPMENT**

New for '97 Free Data Acquisition Software Tool

DAQ Designer 97 is a free system configuration software tool for the PC that takes you through your application step-by-step, asking you questions, and recommending all the right equipment, including: PC plug-in DAQ boards, PCMCIA DAQ cards, Signal Conditioning and Sensor Interfacing, Cabling and Software.

Call National Instruments for your free copy on (01635) 523545

CIRCLE NO. 141 ON REPLY CARD
AVR™ Professional Starter System

Features:
- Supports programming of Atmel 90S(AVR) microcontroller families
- Supports both Parallel and Serial programming modes
- Comes complete with:
  - Serial programming cable: AT90S1200 microcontroller, assembler, CD-ROM Databook, Parallel cable and Power supply

£59.95 Order Code: AVR-ST

NEW

The above software is now available with all our programmers featured in this ad

89S Socket Stealer Module

Simply plug this into your existing 8051 or AVR socket for INSTANT In-System Programming. No Target system redesign required.

£49.00 Order Code: SS-89S-DIL40

The Embedded Solutions Company

PROVIDING THE SOLUTIONS TO YOUR PROBLEMS!

For product information visit our web site at:
www.equinox-tech.com
E-mail: sales@equinox-tech.com
229 Greenmount Lane Bolton BL1 5JB UK

A comprehensive range of 51 Starter & Development Systems are also available.
Surely not. Surely someone somewhere has developed a portable programmer that has even more features, even greater flexibility and is even better value for money. Actually, no. But don’t take our word for it. Use the feature summary below to see how other manufacturers’ products compare.

Dataman-48LV
- Plugs straight into parallel port of PC or laptop
- Programs and verifies at 2, 2.7, 3.3 and 5V
- True no-adaptor programming up to 48 pin DIL devices
- Free universal 44 pin PLCC adaptor
- Built-in world standard PSU - for go-anywhere programming
- Package adaptors available for TSOP, PSOP, QFP, SOIC and PLCC
- Optional EPROM emulator

$\text{NEW MODEL}$

Dltaman-481N
- Plugs straight into parallel port of PC or laptop
- Programs and verifies at 2, 2.7, 3.3 and 5V
- True no-adaptor programming up to 48 pin DIL devices
- Free universal 44 pin PLCC adaptor
- Built-in world standard PSU - for go-anywhere programming
- Package adaptors available for TSOP, PSOP, QFP, SOIC and PLCC
- Optional EPROM emulator

**Money-Back 30 day Trial**
If you do not agree that these truly are the most powerful portable programmers you can buy, simply return your Dataman product within 30 days for a full refund.

**FREE 30 DAY TRIAL**

Still powerful, portable

**free software upgrades + technical support for life**

**Support**
- 3 year parts and labour guarantee
- Windows/DOS software included
- Free technical support for life
- Next day delivery - always in stock
- Dedicated UK supplier, established 1978

**Dataman S4**
- Programs 8 and 16 bit EPROMs, EEPROMs, PEROMs, 5 and 12V FLASH, Boot-Block FLASH, PICs, 8751 microcontrollers and more
- EPROM emulation as standard
- Rechargeable battery power for total portability
- All-in-one price includes emulation leads, AC charger, PC software, spare library ROM, user-friendly manual
- Supplied fully charged and ready to use

**S4 GAL module**
- Programs wide range of 20 and 24 pin logic devices from the major GAL vendors
- Supports JEDEC files from all popular compilers

Still as unbeatable as ever!
Beware of cheap imitations. Beware of false promises. Beware of hidden extras. If you want the best, there’s still only one choice - Dataman.
Order via credit card hotline - phone today, use tomorrow.
Alternatively, request more detailed information on these and other market-leading programming solutions.

**Support**
- 3 year parts and labour guarantee
- Windows/DOS software included
- Free technical support for life
- Next day delivery - always in stock
- Dedicated UK supplier, established 1978

Dataman Programmers Ltd, Station Road, Maiden Newton, Dorchester, Dorset, DT2 0AE, UK
Telephone +440 1300 320191
Fax +440 1300 321012
BBS +440 1300 321095 (24hr)
Modem V.34/V.F.EV.32bis
Home page: http://www.dataman.com
FTP: ftp.dataman.com
Email: sales@dataman.com