

ELECTRONICS

and Beyond

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News Report

Active colour display
from a printer



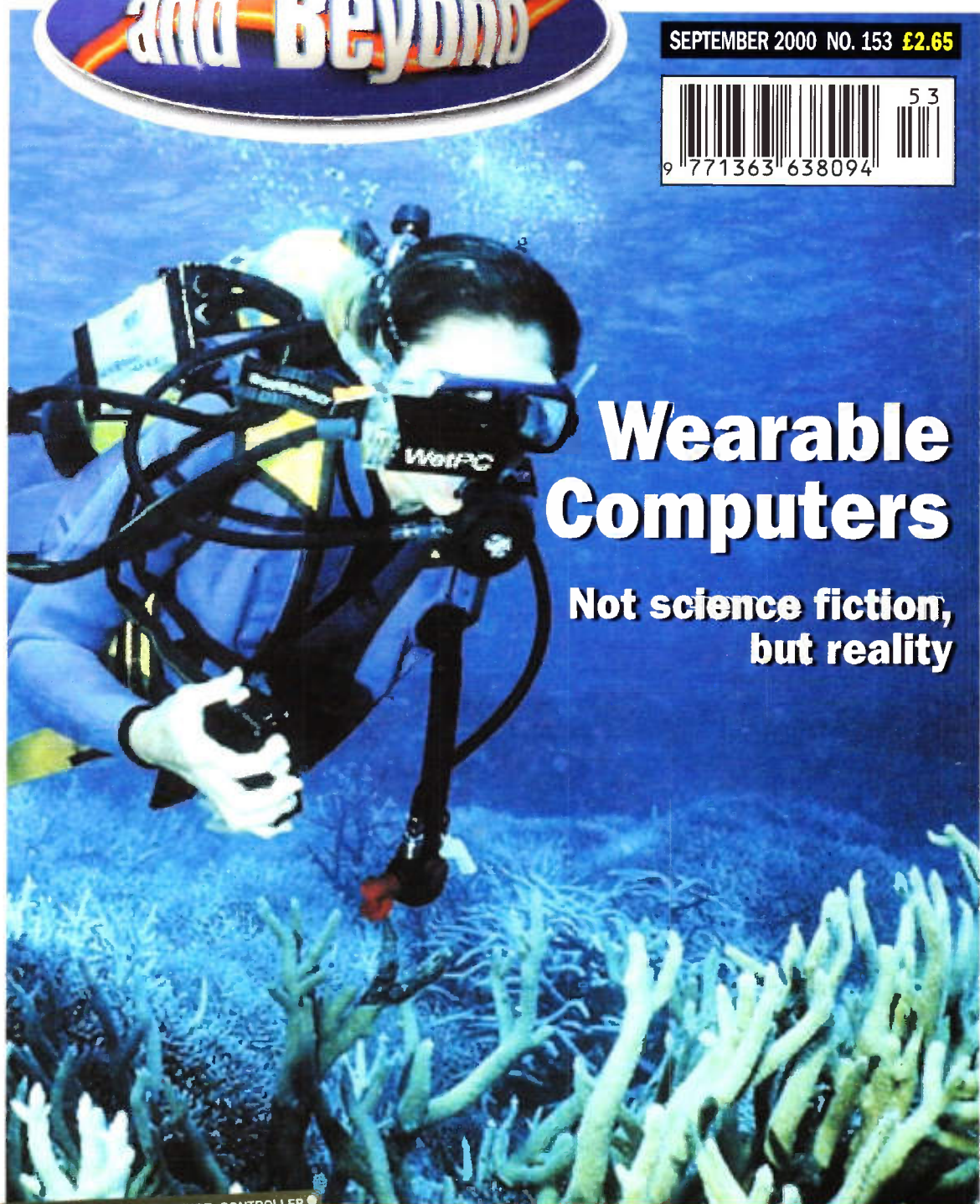
Laser Battlefield of the future

Will our eyes be protected?



Fuel Cell Developments

The desire for zero and
ultra low emission
vehicles



Wearable Computers

Not science fiction,
but reality

PROJECTS

Temperature Controller
Telephone Alert

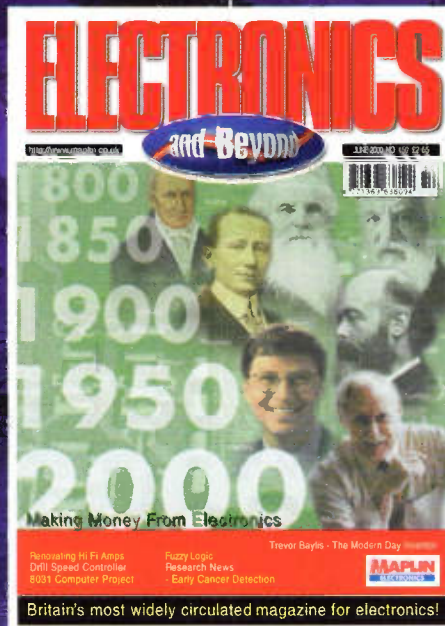


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FEATURES DVD The Next Generation ★ FET Principles & Circuits ★ Valves in the 21st Century	FEATURES Creating Artificial Retinas ★ Miniature Microsystems ★ Valves in the 21st Century Part 3	FEATURES Fuzzy Logic ★ Very Low Frequency Waves Part 2 ★ Trevor Baylis - The Modern Day Inventor	FEATURES ★ Liquid Crystal Displays ★ Speech Processing ★ Rammed Earth Building Technology	FEATURES ★ The Artificial Brain ★ Beyond the Silicon Microprocessor

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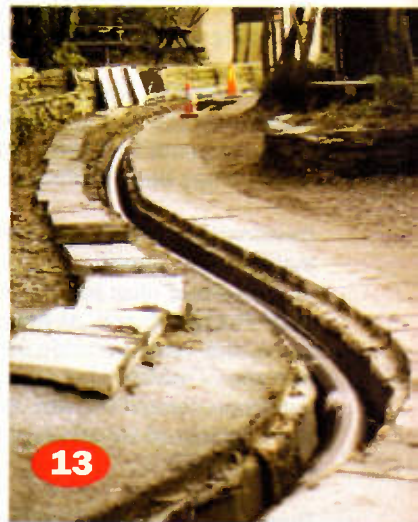
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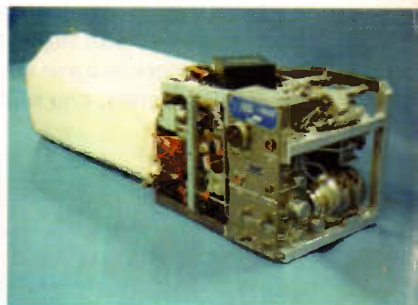
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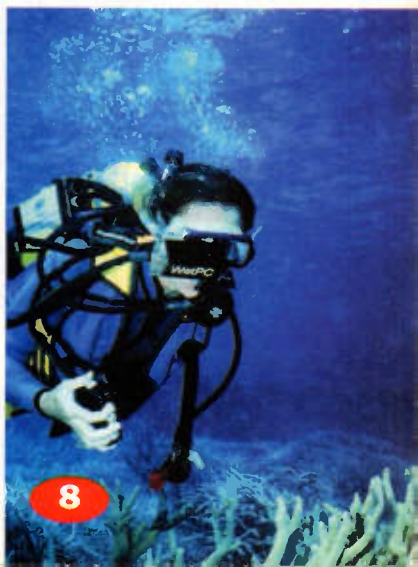
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ELECTRONICS

and Beyond

Wearable computers exist both in reality and in science fiction. Many science fiction films have tantalisingly implied the possibility of wearable computers, but now the development of such 'apparel' is now at the point where profit, actual or potential, is becoming the driving force. Increasingly, roles are being found for such equipment and the consumer market beckons enticingly in the distance. You can read more about this intriguing subject in Reg Miles's article.

It was over 160 years ago that William Grove discovered the fuel cell principle, but it is only in recent years that the concept of such energy sources has been exploited.

Development is now accelerating rapidly, due mainly to the impetus in the USA for zero emission and ultra low emission vehicles (ZEV and ULEV) and, at the other end of the scale, the many portable products using small batteries - mobile phones, camcorders, PDAs notebook computers, etc. Reg Miles describes the principle of various fuel cells in the second of his articles.

These are just two of the fascinating articles we have put together for you this month, so read on and, hopefully, enjoy.

New Uxbridge Store

Maplin has opened a new catalogue store in Uxbridge at 148-154 High Street (off Belmont Road). The store is open seven days a week (except Christmas), and offers some special bargains.



Britain's Best Magazine for the Electronics Enthusiast

NEWS

REPORT

CSR Announces Bluetooth Partnership

Cambridge Silicon Radio (CSR) has won a major order from ALPS Electric, a high-volume manufacturer of a wide range of electronic parts, for its BlueCore single-chip Bluetooth solution, which the Japanese manufacturer has chosen as the basis for its Bluetooth module.

CSR and ALPS are also collaborating on producing reference software stacks and software applications for Bluetooth.

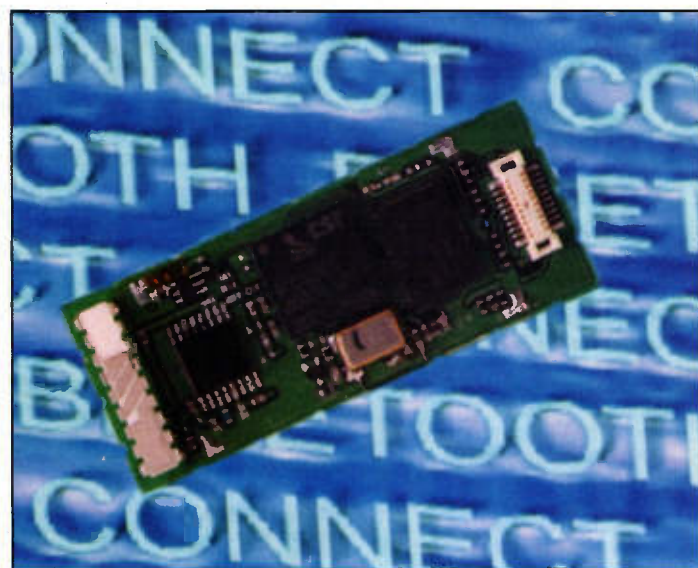
The new Class 1 module from ALPS is smaller than comparable products on the market at the moment. It includes an integral antenna, and therefore can be fully pre-certified to the Bluetooth standard, significantly decreasing the time to market.

CSR was the first company to offer a fully integrated 2.4GHz radio, baseband and microcontroller Bluetooth solution on one CMOS chip, with its BlueCore01.

CSR's BlueCore01 is the world's first true single chip Bluetooth system. Together with the Flash ROM containing the CSR Bluetooth software stack, it provides a fully compliant Bluetooth system for data and voice communications.

Bluetooth is a worldwide technology standard that uses short-range, low-cost radio links to connect multiple devices. For further details, check: www.cambridgesiliconradio.com.

Contact: Cambridge Silicon Radio, Tel: (01223) 424167.



Fujifilm Camera has Definition for Large Prints



The FinePix 1400 from Fujifilm has a Fujinon aspherical 3x optical zoom lens - the first of its kind for less than £300 - for razor sharp images. In addition, the camera has a conventional 1.3 million-sensor CCD that delivers a

1280 x 960 resolution file that is large enough for colourful, picture-perfect 4 x 6 inch prints.

For further details, check: <www.fujifilm.com>.

Contact: Fujifilm, Tel: (020) 7586 5900.

Logica Shows Japanese Alternative to WAP

Logica has announced the global launch of m-WorldGate, the world's first commercially available cHTML gateway, based on a cut down version of HTML.

m-WorldGate will allow operators outside of Japan to either complement their existing WAP strategies or to build new mobile Internet services based on cHTML.

m-WorldGate takes advantage of Logica's experience of the Japanese market to allow content to be presented on mobile phones supporting cHTML browsers regardless of the underlying network technology.

Logica believes that the Japanese approach to the mobile Internet is a proven business and technology model and that handsets capable of supporting an industry variant of cHTML on CDMA and GSM/GPRS networks are expected to be commercially available at the end of this year.

Compact HTML is a defined sub-set of HTML, the mark-up language of the Internet, and means that content providers can develop applications quickly and easily without having to learn new methods of programming or relying on WML-based WAP converters. For further details, check: <www.logica.com>.

Contact: Logica, Tel: (020) 7637 9111.

Micromuse Acquires NetOps



Micromuse is to acquire NetOps. NetOps produces a network problem diagnosis application called Visionary, which is compatible out of the box with Micromuse's Netcool family of realtime fault monitoring and service assurance applications.

By analysing management information from industry-standard Internet devices and applications, Visionary provides realtime, device-centric diagnoses that explain why a problem occurred in the network infrastructure, at the device level.

The Visionary technology also has the ability to predict - and therefore prevent - problems from occurring in the future, while providing significant savings on operational support.

For further details, check: <www.micromuse.com>.

Contact: Micromuse, Tel: (020) 8875 9500.

Mobile Phone Perils

If they're not dropped down toilets, munched by animals or had drinks spilt over them in pubs - one is stolen every three minutes. So with nearly half the UK's population owning one, it's no surprise that insurance claims relating to them are increasing all the time.

A survey by Mobile Phone Centre, operated by Vodafone, the 100-strong nationwide retailer, has found that accidents involving loos, beer and our four-legged friends are amongst the most common - jointly accounting for 21% of mobile phone insurance claims.

Although such incidents, which have included a phone being munched by a pig, another being buried in the back garden by a pet dog and even one falling from a bar into the slop tray, are amusing at first sight, people are left with the inconvenience of managing without a phone and the cost of its replacement, which can be 10 times the original price.

But it's not just the accidents that leave mobile phone users wishing they had insurance or thankful that they have. With mobile phones being stolen regularly, Mobile Phone Centre had 485 theft claims on its scheme in 1999 alone, which cost almost £70,000 and accounted for 51% of claims. In fact, around 15,000 mobile phones are stolen every month in Britain.

For further details, check:

<www.vodafone.co.uk>.

Contact: Mobile Phone Centre, Tel: (020) 7709 9000.

NEWS BYTES

Intel and Mitsubishi to Develop 3rd Generation Chipset

Intel and Mitsubishi are jointly developing a chipset for third-generation cellular phones. Mitsubishi hopes to increase its annual worldwide sales of cell phones from 25 million this year to 60 million in 2003.

For further details, check:

<www.intel.com>.

Contact: Intel,

Tel: (01793) 403000.

Intel Publishes Chip Details

Intel has released technical details of its new Itanium microprocessor over the Internet, in a bid to boost the use of the Linux operating system with its chips.

Linux, an open-source operating system whose technical details are made freely available to software developers and engineers, is increasingly found on the servers that Intel hopes will soon be using its chips.

For further details, check:

<www.intel.com>.

Contact: Intel,

Tel: (01793) 403000.

Cyber Security - Locking out the Hackers

iKey 1000 is an electronic key to protect computers from unauthorised access - has been developed by encryption specialists Rainbow Technologies.

iKey costs £29 and fits on a key-ring and slots into a desktop or laptop PC's universal serial bus (USB) port allowing authorised users easy access, but keeping others out.

The iKey is smartcard compatible, but since it uses USB technology is considerably cheaper to implement than the use of smartcard readers.

For further details, check:

<europe.rainbow.com>.

Contact: Rainbow Technologies,

Tel: (01932) 579 200

IBM Teraflop Supercomputer Chosen as Platform for Earth Simulator

The Potsdam Institute for Climate Impact Research (PIK), has selected a 200 Processor IBM RS/6000 SP system as its next generation supercomputer. This supercomputer will significantly enhance the capabilities of PIKs' researchers to assess mankind's impact on climate and other major components of the ecosphere.

The new system will be fifteen times more powerful than the preceding IBM machine operating at PIK since 1994 and it will rank among the 100 most powerful supercomputers in the world. Moreover, the system will be upgraded to teraflop performance in 2002 utilising IBM's ultra-fast Power4 multichip modules.

The SP system is based on the 64-bit, 375MHz POWER3-II microprocessor, a powerful copper chip developed for IBM's RS/6000 servers and workstations. The remarkable power of the POWER3-II microprocessor is derived from IBM pioneered copper wiring.

Copper increases microprocessor performance substantially compared with chips that use traditional aluminium.

The RS/6000 SP is a highly scaleable system made up of building blocks called nodes. An SP system can consist of just one or two nodes all the way up to hundreds of nodes. The system's performance scales almost linearly with its size. Each node contains one to sixteen microprocessors and its own random access memory (RAM) and disk storage.

For further details, check: <www.rs6000.ibm.com>

Contact: IBM, Tel: (0990) 426426.

Iomega Demos Klik!-Enabled MP3 Player

Iomega has demonstrated the first Klik! portable digital media player. The RaveMP 2300 digital media player with a built-in Klik! drive gives music enthusiasts virtually unlimited, affordable access to their music libraries.

In addition to playing back digitally recorded music, the RaveMP 2300 records voice messages and allows users to download Microsoft Outlook names, phone numbers and e-mail addresses directly to Klik! disks.

The RaveMP 2300 features nearly 10 hours of continuous play with a single charge of the rechargeable lithium ion battery and incorporates skip-free sound with a built-in memory buffer, which is superior to current CD or Mini-Disc players.

For further details, check: <www.iomega.com>

Contact: Iomega, Tel: (01628) 828444.

Dell Shows Digital Audio Receiver

Dell this month showed its Digital Audio Receiver for the first time. The new appliance will enable listeners to enjoy CD-quality music stored on a PC in any room of the home by distributing audio to remote receivers or home stereo systems.

Powered by S3 Rio Audio technology, the Dell Digital Audio Receiver offers customers the ability to search, sort and play their entire PC music collection by artist, title, album, play list or genre. For further details, check: <www.dell.com>. Contact: Dell, Tel: (0870) 907 9078.



IBM Triples Capacity of World's Smallest Hard Drive



IBM has tripled the capacity - but not the size - of the world's smallest hard disk drive, paving the way for a new generation of 'go-anywhere' pervasive- computing devices and applications.

Packing a gigabyte (GB) of data storage capacity on to a disk the size of a penny, IBM's newest Microdrive can hold up to 1,000 high-resolution photographs, a thousand 200-page novels or nearly 18 hours of high-quality digital audio music.

The 1GB Microdrive brings affordable high-capacity, high-performance data storage to a wide variety of handheld electronic products - including digital cameras, handheld PCs, personal digital assistants (PDAs), portable Internet music players and video cameras. It can also serve as a data-exchange accessory to notebook computers, desktop

computers and printers. For further details, check: <www.ibm.com>. Contact: IBM, Tel: (0990) 426426.

AMD Duron Processor Targets Consumer PCs

AMD has introduced the AMD Duron processor, delivering industry-class performance for businesses and consumers in the value PC space, that typically sell for less than £600. The AMD Duron processor is available at speed grades of 700 MHz, 650 MHz, and 600 MHz.

The AMD Duron processor provides up to 25% more performance on many industry leading benchmarks than an Intel Celeron processor at the same clock speed.

Leading computer manufacturers worldwide have announced plans to offer AMD Duron processor-based systems, including Compaq, Fujitsu-Siemens, Hewlett-Packard Company, IBM and NEC.



The AMD Duron processor is a derivative of the award-winning AMD Athlon processor and is designed to provide an optimised solution for value conscious business and home users.

Employing an innovative design, the AMD Duron processor features a sophisticated cache architecture with 192kB of total on-chip cache; a high-speed 200MHz front-side bus, and a superscalar floating point unit with enhanced 3DNow! technology.

For further details, check: <www.amd.com>. Contact: AMD, Tel: +1 800 222 9323.



World's First Ink-Jet Printed Full Colour Plastic Display Developed



Seiko-Epson and Cambridge Display Technology (CDT) have developed a 2.5-square-inch full colour display using CDT's light emitting polymer (LEP) technology, an innovative display science that paves the way for the creation of ultra-small, paper-thin consumer electronic displays.

The prototype colour display has been made using CDT's red, green and blue polymer materials and an industry-first ink-jet printing process developed for the project. The colour display achieves colour

quality equal to current liquid crystal display (LCD) technology and is comparable to displays found in many portable computer products.

This latest development follows an initial announcement in 1998 when CDT and Seiko-Epson demonstrated a monochrome plastic television display based on LEP technology and announced their intention to develop a colour LEP display.

The prototype colour display measures 2.5 square inches, has a resolution of 200 by 150

pixels, with 16 grey scaling at system level, and will be targeted at initial market entry points for LEP displays products such as mobile phones and personal digital assistants (PDAs). Beyond this, CDT and Seiko-Epson expect this technology eventually to penetrate all other display markets.

Based on an innovative manufacturing technique which uses ink-jet printing to deposit individual pixels made up of the red, green and blue LEP materials directly onto the substrate, potential display size is limited only by the size of the available wafer with no impact on the overall throughput when deployed in existing manufacturing lines.

The ink-jet technique allows the LEP material to be printed from a liquid solution and brings advantages when compared to existing and emerging display manufacturing processes by eliminating the need for backlights, colour filters and polarisers used in LCD displays and complex multi-shadowing techniques for depositing small molecules.

For further details, check: www.cdtltd.co.uk.
Contact: CDT, Tel: (01223) 723555.

Faster Lifecycles Create Headaches

The trend toward 'lifestyle' and designer products, the growing need to differentiate products and the acceleration of time-to-market competition is creating a new set of problems for computer vendors according to leading provider of inventory management services, PST.

PST believes that manufacturers are finding it harder to judge which products to manufacture and in what quantities and the result is that vendors are compelled to make compromises in production output.

Intense competition in the PC market - which is mirrored in all related component and peripheral markets - and the influence of on-line selling has forced vendors to reduce their time to market as much as possible.

In response, manufacturers are being forced either to produce very large quantities of very basic products that can be sold very cheaply, or use the most advanced technology and design to make the product more desirable. Typically, these products are produced in smaller numbers and sell at higher prices, but are still not guaranteed success.

For further details, check: www.pst.co.uk.

Contact: PST, Tel: (01628) 782233.

ARM Receives Deloitte & Touche Hot 100 Award

ARM has received a Hot 100 Award from Deloitte & Touche. The Hot 100 awards are presented annually by the professional services firm, to recognise and champion fast growing businesses in London and the UK.

The Hot 100 Awards focused on companies with turnovers of up to £100 million in their latest year that had achieved a significant year-on-year growth in their turnovers.

Companies were then ranked according to their average compound turnover growth rate over four financial years. ARM was ranked 11th, based on the company's results from 1994 to 1998.

Hot 100 companies achieved average compound growth rates ranging from between 18% and 95% over this four-year period and companies included in the ranking came from traditional as well as new economy sectors.

For further details, check: www.arm.com.

Contact: ARM, Tel: (01223) 400400.

Ericsson is Absolutely Wireless



Three elements of the Ericsson Bluetooth portfolio had their world premieres at CommunicAsia in Singapore this month: the first GPRS phone with Bluetooth - the triple band R520, the Bluetooth PC Card and the first Bluetooth mobile phone - the triple-band, WAP-enabled T36.

The R520 is the first step toward more advanced mobile Internet applications, featuring GPRS, High Speed Data (HSCSD), Bluetooth wireless technology and WAP. Besides maximum speed levels the R520 also offers complete wireless

connectivity with a built-in Bluetooth chip, removing requirements for cables between the phone and other mobile devices, such as PCs and handsfree devices.

The Bluetooth PC Card proves Ericsson's leading position in Bluetooth wireless technology. Ericsson also unveiled the T36 and the R520 mobile phones, which are the first phones to feature built-in Bluetooth communication. This means Ericsson is the first company to have a complete portfolio of voice and data products that use Bluetooth wireless technology.

The Ericsson T36 is the first mobile phone to have built-in Bluetooth wireless technology. Bluetooth makes it possible to connect the phone to other devices without using cables. It features WAP offering access to the Mobile Internet, and supports High Speed Data (HSCSD), making it capable of sending and receiving large amounts of data over the Internet at high speed. It is also the first triple band (GSM 900/1800/1900) phone from Ericsson, which means it can be used in Europe, Asia Pacific and America - in fact everywhere in the world where GSM frequency is prevalent.

For further details, check: www.ericsson.com.
Contact: Ericsson, Tel: (01628) 415500.

MIT And Bell Labs Researchers Create Electronic Brain

Researchers at the Massachusetts Institute of Technology and Lucent Technologies' Bell Labs have created an electronic circuit that mimics the biological circuitry of the cerebral cortex, the brain's centre of intelligence.

The circuit is composed of artificial neurons that communicate with each other via artificial synapses. All of these elements are made from transistors fabricated on a silicon integrated circuit.

Like neurons in the cortex, nearby artificial neurons affect each other. There also is an inhibitory neuron that receives input from the 16 excitatory neurons and returns inhibition to them. This inhibitory feedback keeps in check excitatory feedback that can lead to explosive instability.

In the brain, synaptic feedback connections are thought to mediate neurons' cooperative and competitive interactions. Such interactions are expressed most strongly in the circuit when multiple stimuli are presented at the same time.

When simultaneous electrical currents are applied to two artificial neurons, the circuit responds to only one stimulus and suppresses its response to the other, much like a frog choosing which of two flies to strike at. Like the brain, there is no single element in the circuit that decides which stimulus to suppress. The decision is the outcome of an emergent, collective property of all the neurons.

A typical neuron in the brain might be connected to 10,000 other neurons. Because there are billions of neurons, this makes the brain a vast and intricate network.

For further details, check:
<www.mit.edu>.

Contact: Massachusetts Institute of Technology, Tel: +1 617 253 1000.

Queen Opens Cadence Design Centre

Her Majesty The Queen officially opened Cadence Design Systems' Livingston Design Centre in Scotland in June.

The £20 million Livingston Design Centre (LDC) is the world's largest independent electronics design centre.

The LDC's focus is digital and analogue integrated-circuit and electronic systems design for wireless and datacom/telecom applications.

The LDC is located in The Alba Centre, the hub of a major Scottish initiative that is driving the future of electronics design. After deciding to build the centre in 1997, Cadence opened a temporary facility at Livingston.

The primary focus of Cadence and other organisations located at the Alba site is system-on-a-chip (SOC) design, which incorporates all of the components of an electronic system onto a single microchip.

For further details, check: <www.cadence.com>.
Contact: Cadence, Tel: (01344) 360333.



NASA Goes From Plants to Planets



NASA scientists have gone back to the garden, planting wireless webs of small sensors in gardens here on Earth in preparation for missions to help monitor biological activity on planets.

Sensor webs like those being tested will help make possible a key NASA goal to establish a virtual presence for exploration throughout the solar system. Like satellites and telescopes remotely measuring planets across the vast reaches of space, the webs allow large areas to be monitored.

Unlike remote operations, sensor webs are placed inside the environment - thus making them capable of on-site detection not possible from afar. For example, satellite measurements cannot penetrate deep below the ocean surface or detect extremely small quantities of gases coming off a planetary surface.

The sensor webs could combine the spatial coverage of a satellite with the precision of an on-site instrument. Tests are now underway at Huntington Botanical Gardens, California. For further details, check:

<www.nasa.gov>.
Contact: NASA, Tel: +1 202 358 0000.

Intel Dot.Station Web Appliance Targeted at Service Providers

Intel has announced the Intel Dot.Station Web appliance, a communication product for the family that integrates access to the Internet, e-mail, a built-in telephone and home organisation applications.

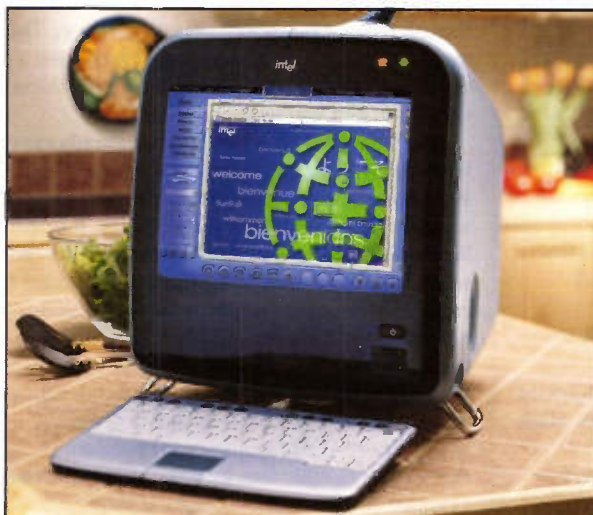
Intel is in discussions with service providers worldwide to deliver the final product to consumers packaged with their services.

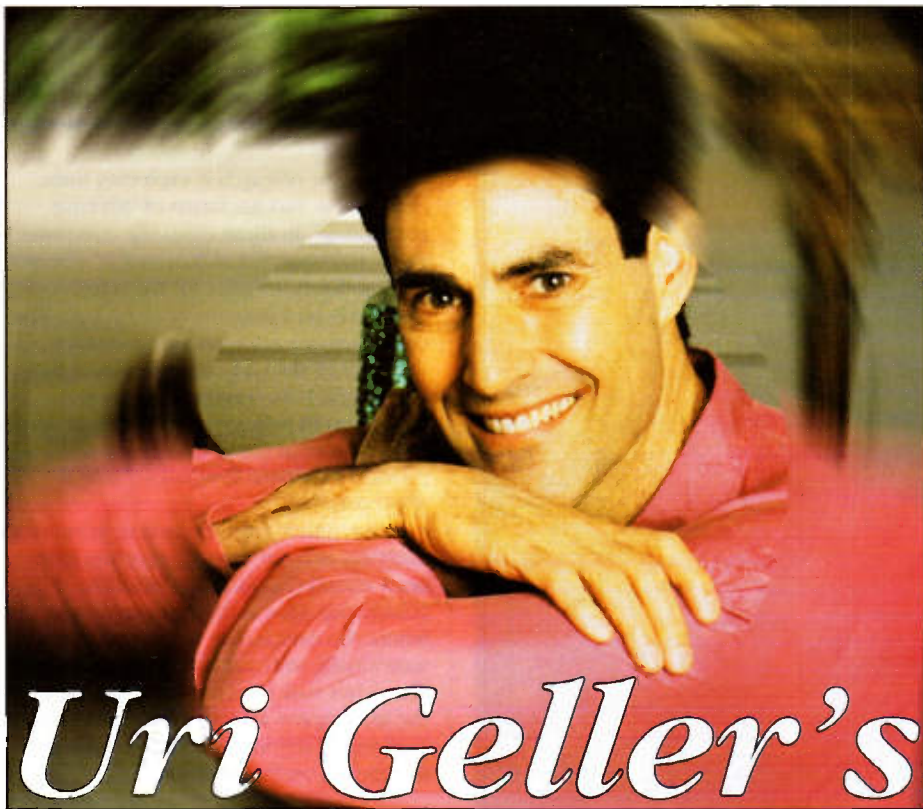
The Intel Dot.Station Web appliance also comes with the Intel System Management Suite, a unique capability that allows service providers to remotely manage and upgrade the new appliances as the

Internet evolves. The Intel Dot.Station and the Intel System Management Suite form the foundation for Intel's complete Web appliance solution for service providers.

For consumers, the Intel Dot.Station Web appliance is an easy-to-use communication product that offers Web browsing, e-mail, a built-in telephone, and convenient home organisation features for the entire family.

For further details, check:
<www.intel.com>.
Contact: Intel, Tel: (01793) 403000.





Uri Geller's EXTENDED REALITY

Telepathy and Twins

As I mentioned in my July column, the first scientist to take a serious interest in twins was Sir Francis Galton. In an article first published in 1875, he noted that he had found "a similarity in the association of their ideas" in eleven out of the thirty-five twins he studied. He did not use the word telepathy, of course, because it hadn't been invented then (it was coined by Frederic Myers in 1882).

It was a very long time before anybody looked more thoroughly into the twin connection. Not until 1961, in fact, when a team of psychologists from Toronto published their report on it. They never actually got around to doing any experiments, but they did question a total of 35 twins, the same number as Galton studied, and came up with almost exactly the same percentage of those who had felt they had experienced some kind of telepathy with their brothers or sisters.

This is the kind of thing they reported: "Yes, I frequently know when there's something wrong." "Once when my sister cut her hand, I could feel the pain in my hand." "I can imagine what he's doing and see the place ... even if I've never been there."

The Toronto team took a closer look at the twins who had experienced this kind of thing, and found they had three things in common. Firstly, they were absolutely identical and had been brought up together, going to the same schools. Secondly, they were extraverts rather than

introverts by nature, and finally they had no problem admitting the possibility of telepathy.

Again, it was to be a long time before anybody followed up their recommendations. In fact, as far as I have been able to discover, the first really large-scale survey of twin telepathy was not published until 1987, when a private researcher and mother of twins named Mary Rosambeau received six hundred replies after making an appeal in the national press.

Her questionnaire included all aspects of twinhood, and two of the questions she asked were if they had thought they had ever read their twin's mind, and if they had ever had the same pain or illness at the same time? A total of 187 said yes, they had almost exactly the same percentage as Galton and the Toronto team had reported.

Mary Rosambeau made an important discovery. Telepathy between identical twins, she found, always involved bad news: an accident, illness or death. Or it could just be one twin "just knowing" that the other was in some kind of distress. She did not come across a single case of a twin picking up good news.

This probably explains why the few laboratory experiments that have been done have produced pretty unexciting results. The ideal experiment from the researcher's point of view (but not the subject's) would be to give one twin a whack on the head and see if the other reacted at a distance!

Actually, two experiments along these lines have been carried out, one of them in public, though without causing any harm to anybody. In 1975, a team of Spanish doctors and psychologists set up an experiment in the home of two four-year-old girls, which was disguised as a routine medical checkup. The father took one little girl to an upstairs room, where there was a camera running as there was in the downstairs room where the other twin, with her mother, was given a number of tests by the doctor in charge.

First, he tapped her on the knee to get a knee-jerk reflex. He got it, and so did the upstairs twin, who began to kick so wildly that her father had to hold her leg down! Then the downstairs one had a bright light shone into her eye. The upstairs one began to blink rapidly. Then she shook her head and held her nose her sister was being given a noseful of a strong scent.

As it happened, on the day of the researchers' visit, one of the girls had banged her head on a door, whereupon the other one burst into tears, which her sister did not. Their parents reported numerous similar incidents once, one of them was ten miles away with her grandparents when she burned her hand on a clothes iron, causing a large blister to appear. At exactly the same time a red spot of the same size appeared on her twin's hand in exactly the same place.

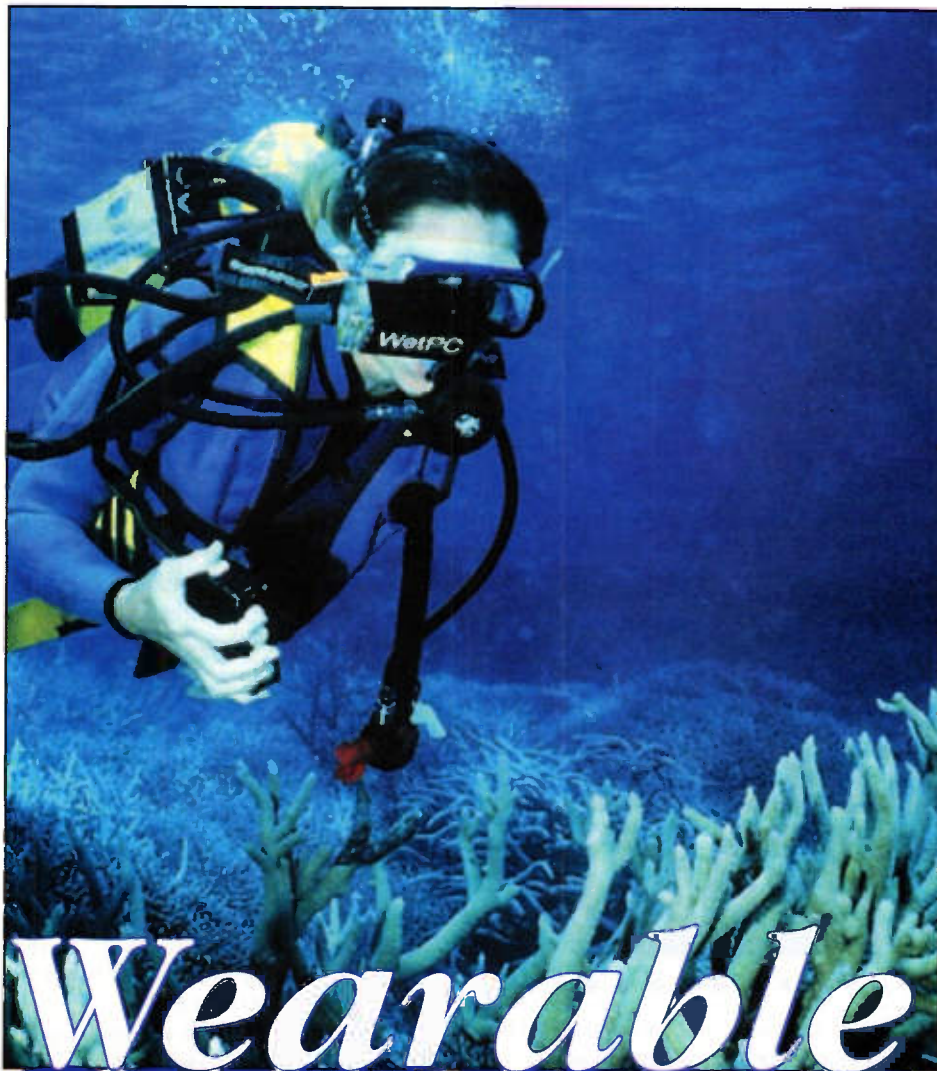
The second experiment was included in Paul McKenna's 1997 series of TV programmes on the paranormal. One twin sat in the studio in front of a large audience (and several million viewers) and was just told to relax and look at the large pyramid a few feet in front of her. As she did so, her sister was in another part of the building wired up to a polygraph and watched by a leading expert.

The chart showed a sudden peak at the very moment that the pyramid exploded in a cloud of coloured smoke. "Looks like a surprise," the expert commented.

I hope more experiments of this kind will be done to make clear what perhaps one third of identical twins already know: telepathy does happen, but only under certain conditions. I hope we don't have to wait another hundred years before everybody realises this.

Uri Geller's novels *Dead Cold* and *Ella* are published by Headline at £5.99.

Mindmedicine is published by Element at £20. Visit him at www.uri-geller.com and e-mail him at urigeller@compuserve.com



Wearable COMPUTERS

Not science fiction but reality, Reg Miles describes developments in this fascinating field.

Wearable computers exist both in reality and in science fiction. The reality is that small bits of hardware are distributed about the person; the science fiction is everything integrated into clothing - initially the wiring, peripherals and connectors, eventually the computers themselves. Originally driven by geekish dreams, the development of wearable computers is now at the point where profit, actual or potential, is becoming the driving force as roles are being found for the equipment and the consumer market beckons enticingly in the distance.

The Need for Wearable Computers

Who needs to wear a computer? One answer is anyone who needs to operate one while doing other things. An engineer, for example, can be building or repairing something and have continuous access to

relevant information - hands-free if a speech interface is used. Another answer is anyone who needs to constantly use a computer. A notebook computer has limitations in those circumstances. It cannot be used while walking, it can only be used inconveniently in a restaurant, and when you want to use it on the move you must set it down (probably get it out of a bag), open it up and switch it on. Notebooks were used as the basis for some of the earliest wearable computer designs. They still feature in many of the DIY efforts by those who do not possess the skills or have the inclination to build, test and modify their own computer (and when they are not on the move it can revert back to being a notebook). But they are basically two different concepts. The notebook is really no more than a conveniently small and portable version of a desktop computer that can be used in different locations, on any convenient surface including the lap. A wearable does

not require a surface, nor is it restricted to usable locations; it is not just a tool but something of a state of mind - free and personal (no matter that such things are purely illusory), and an apparent extension of the body.

Academic research is exploring these concepts as various forms of 'affective computing'. In these cases the computer is worn and operational for most of a person's waking hours in order for them to effectively be a communications hub. The computer can act as an aide memoire throughout the day, recognise faces that they might have forgotten, provide navigation in unknown areas, and generally recognise what the user is doing and provide assistance in whatever way is appropriate.

In the rather more mundane world of the everyday present, two approaches have been adopted to facilitate wearable computing. One is the genuine article, where the user is able to operate individually with self-contained equipment. The other is an intermediate stage in which the user carries a basic 'client' that is linked to a central server - wirelessly or wired depending on the situation.

Network-Dependent Approach

This network-dependent approach is really only practical within a limited radius, as would be the case within the confines of a company. The application resources are only required by the server, rather than being distributed over all the clients; while any changes that are necessary to update, upgrade or reconfigure the system need only be implemented on the server. Which is ideal if all the clients are going to be used for the same purposes all the time and thus require only limited application resources.

An example of this approach is one provided by SyVox, with their SpeechNet system. This enables mobile workers in factories and warehouses to communicate with computers while keeping their hands and eyes free for their work (Figure 1a). Workers wear a small, wireless Speech Data Terminal (Figure 1b) which acts as a speech input/output device. In operation the worker communicates information and instructions to the SpeechNet Control Unit, this then exchanges information with an enterprise network - such as a warehouse management system - and transmits instructions back to the worker. Apparently, the system can be used in noisy environments (80-95dB) without errors; and is speaker independent so that it does not have to be trained to recognise any particular speaking voice. The system can also incorporate complementary data capture devices such as scanners, pens and keyboards to introduce greater flexibility.

Various experimental studies have been and are being done on the uses of audio in the workplace. The use of auditory cues to indicate the state of machinery within a factory, is a typical example. Distinctive sounds played simultaneously merge to allow workers to hear the factory both as a whole and as individual aspects such as the



Figure 1a. SyVox SpeechNet System.

rate and functioning of machinery. Any problems in the running of machines could be indicated by changes in the sounds and by specific signals to indicate the type of problem.

Similar techniques are being explored for managing messages with the minimum of personal disruption. Thus a person receiving a wirelessly communicated e-mail or voice mail will be notified by a discreet audio cue, including an indication of its priority, rather than have it suddenly displayed or played. This could be either a client in a local area network or a full wearable computer.

The point about a wearable is that it has to be worthwhile to actually wear it. If it was just a computer then its uses would be very limited as most people have no requirement for computing on the move (most people have no requirement for computing at all, but that is another matter). Computing has to be just one of a number of facilities that have different priorities at different times, but that are thoroughly integrated, or there never will be a market beyond the industrial and military.

Wearable Computers

That IBM has produced prototype wearables probably indicates that the situation is about



Figure 2. IBM prototype wearable computer.

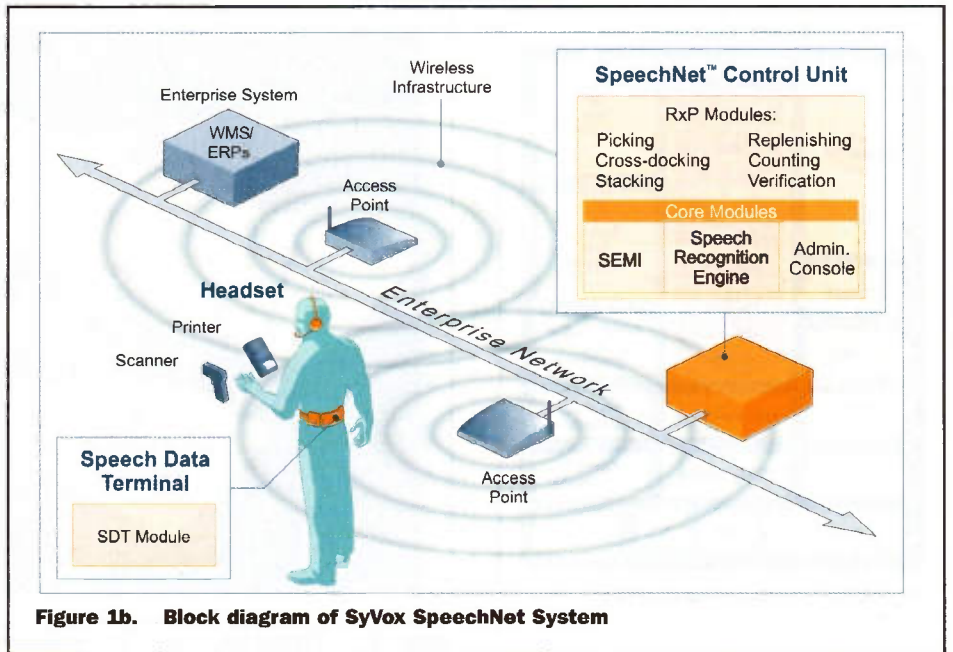


Figure 1b. Block diagram of SyVox SpeechNet System

to change and move to a more mainstream market. The latest is a 299g unit the size of a personal stereo, incorporating a 233MHz processor and an IBM microdrive, connected to a micro-display headset and a one-handed controller with microphone, tracker and click button - see Figure 2.

As yet there are not that many wearable computers actually being manufactured; and specialist companies such as ViA and Xybernaut are doing all the running. This limited production has inevitably meant that the prices are comparatively high, which has in consequence limited the demand and made any increase in production impractical. Just as a notebook is more expensive than a desktop for the same specifications, so a wearable is more expensive than a notebook. Prices begin at \$2000+ for a basic system without accessories and go up to over three times that amount (the market is largely confined to the USA at present).

The wearable concept began with people

making their own, and a lot of people are still doing so because of the high prices. One company, Circus Systems, is planning to launch a series of low cost kits to enable people to build their own wearable computer and accessories, in addition to launching ready-built products.

The processor speeds of commercial wearables varies between 133-266MHz. This will probably be one of the types intended for embedded applications, such as a PC/104 CPU module, the Cyrix MediaGX, Motorola's ColdFire or one of the Intel range such as the Pentium MMX or StrongARM. There are four reasons for such a choice: the first is that the processor and peripherals form a small, lightweight device with low power consumption. Figure 3a shows an arrangement of PC/104 modules - which can also be stacked, while Figure 3b shows the integrated ColdFire microprocessor. The second is that product development time is significantly reduced with these standardised products; the third is that they

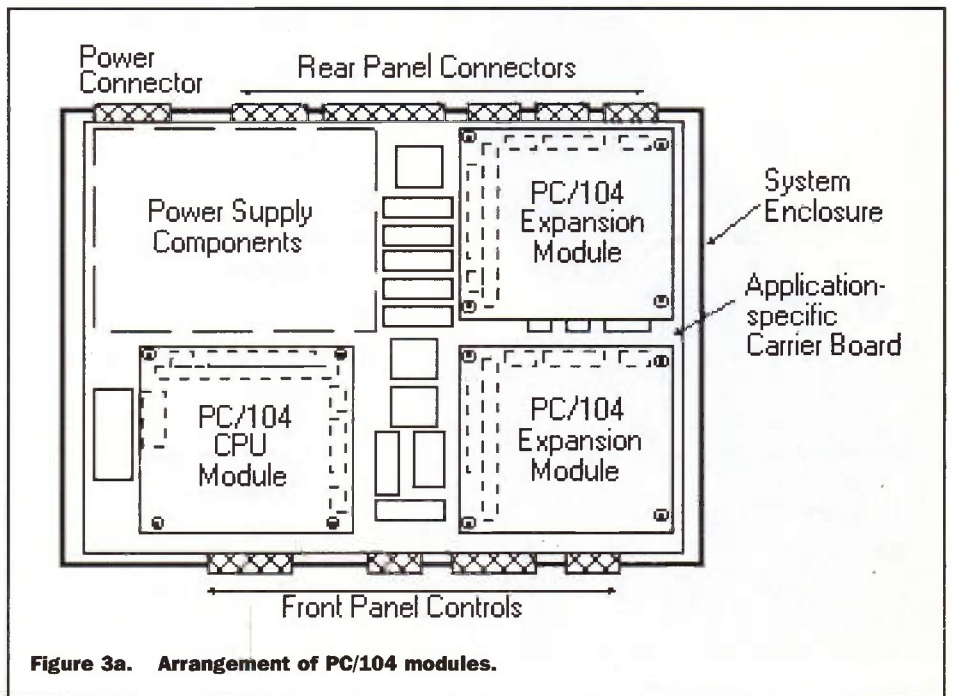


Figure 3a. Arrangement of PC/104 modules.

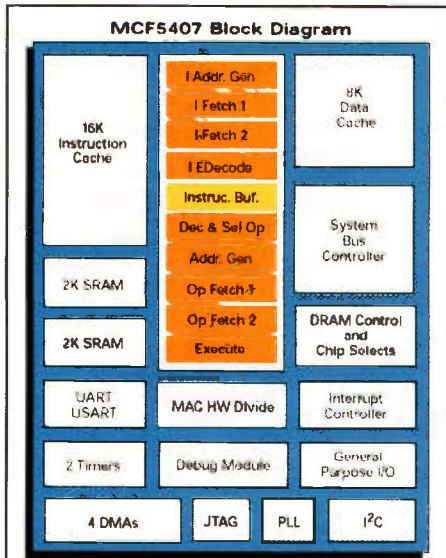


Figure 3b. Integrated ColdFire microprocessor.

are more robust than a conventional computer design; and the fourth is that they are cheaper. Which is why they are also favoured by people making their own wearables.

In commercial wearables RAM generally begins at 32MB, with options up to 128MB. Obviously if speech recognition and synthesis are going to be used the more memory there is the better. Also, the greater the capacity of the hard disk the better. The range goes from over 1GB to over 4GB, so there should be no shortage of storage space. There will also be an optional external floppy disk drive. A range of ports and PCMCIA slots are provided, either directly or via adapters, for further storage. Any device that would be suitable for use with a notebook will be equally suitable for a wearable. Figure 4 shows the connectors

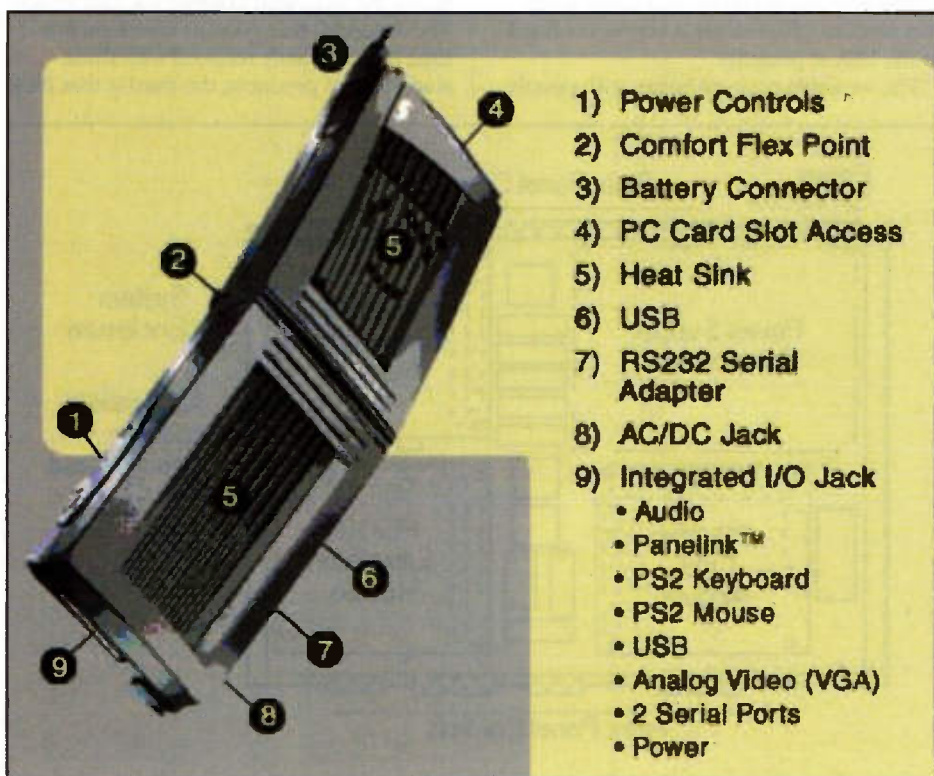


Figure 4. VIA II connectors

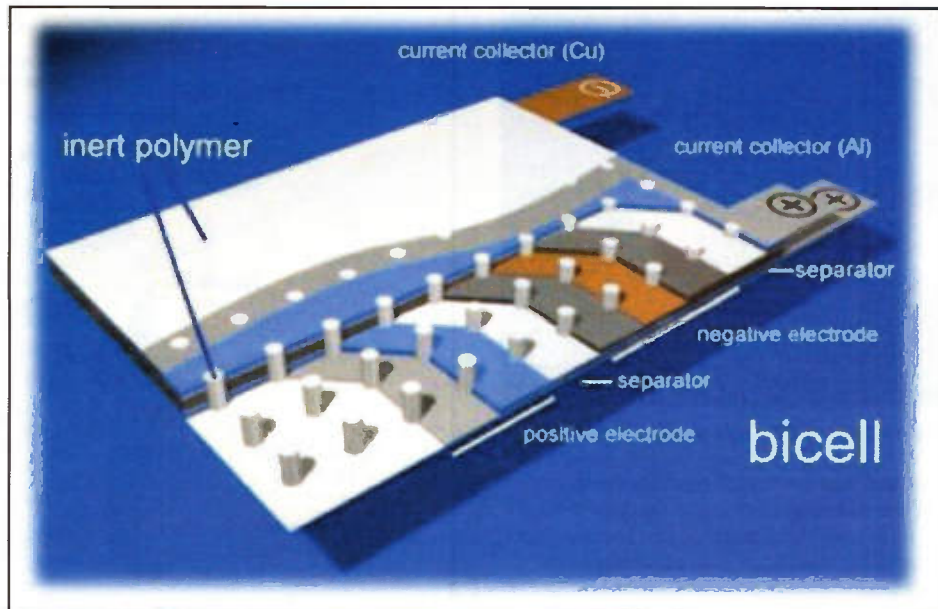


Figure 5. Phillips Lithylene 'rivet technology' battery.

on the VIA II model - it also shows the centrally hinged design that makes it possible to wear it lengthways on a belt instead of having it hanging down. Thus the user will have access to CD-ROM, CD-R and CD-RW; magneto optical, including MiniDisc; the high capacity floppy disk drives; Zip drive; small external hard drives; and various types of flash memory devices.

Other devices provide for wired or wireless LAN, modem, cellular phone, GPS, etc. - a wearable user need feel no sense of inferiority! The only considerations are the size, weight and power consumption.

Lithium-Ion Battery Supply

Everyone seems to favour the lithium-ion battery to provide the power. Which is not

surprising, given that its price-performance ratio is better than that of the alternative technologies - nickel metal hydride, nickel cadmium and lead acid; and that it is ideally suited to intensive use with a long runtime between charges (it is also maintenance-free). Because a wearable draws less power than a notebook a fully charged battery will last from two to three times as long. And the commercial models at least allow hot swapping. Alternative means of powering them are an AC adapter and a car adapter.

The lithium ion type is not perfect however, it is subject to ageing with a life expectancy of no more than a couple of years, and so should be used intensively from the beginning. Hence companies are working on a variation of the technology, known as lithium polymer. Phillips is developing its Lithylene 'rivet technology' for licensing (see Figure 5): two single-sided positive electrodes are placed on either side of a double-sided negative electrode with a separator between; both electrodes have small (1mm) holes into which a heated polymer is forced, and once set hard this holds the active materials together and provides a stable battery structure without the need for a conventional metal can. The result is thin flat batteries with a higher energy density per volume. An American company called Electrofuel has a lithium polymer battery claimed to give up to sixteen hours of notebook use in a 1kg titanium pack measuring 223 x 300 x 9.5mm.

Looking further into the future, Xybernaut and DCH Technology have begun co-operating on a project to develop a wearable that will run on hydrogen fuel cells. DCHT specialises in hydrogen technology and is developing a proton exchange membrane, also known as polymer electrolyte membrane, (PEM) cell licensed from Los Alamos National Laboratory. Hydrogen is supplied to the anode where a platinum catalyst separates it into protons (hydrogen ions) and electrons - see Figure 6. The electrode conducts protons but not electrons, so while the protons pass through the central membrane

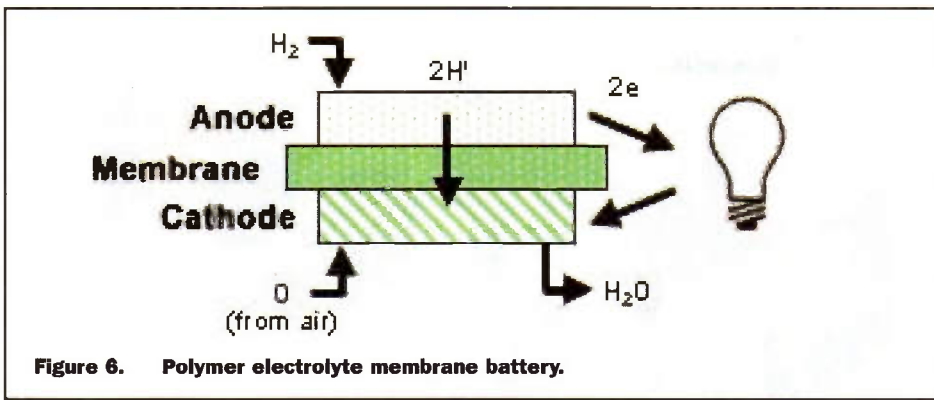


Figure 6. Polymer electrolyte membrane battery.

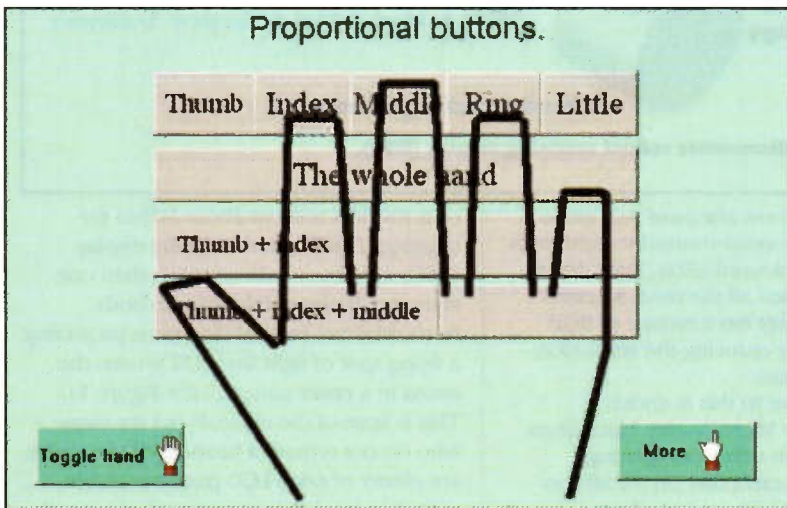


Figure 7. 5-button Kord pad.

the electrons must travel through the external circuit and thus provide electrical power. Another platinum catalyst then recombines the protons and electrons, and adds oxygen from the air to produce water for the humidification necessary for the passage of the protons. The hydrogen can be supplied from a metal hydride or from a hydrogen rich fuel such as methanol.

The alternative approach to increasing operational times is to reduce the power consumption through components that draw less power and through more intensive power management.

A related area of research is concerned with reducing the waste heat of power consumption. The large heatsinks shown in Figure 4 clearly illustrate the intrinsic problem of dissipating the heat generated by components packed closely together in a necessarily small case. The obvious way of dealing with it is to have components that require less power to operate, and that make more effective use of the power - not wasting it as it travels around the chips. But that is the province of the chip manufacturers. Part of the additional cost of wearables is spent on achieving designs that compensate for what the chip manufacturers have not yet achieved. Active cooling using a fan obviously consumes battery power, and requires a larger case. Passive cooling may not always be sufficient. One aid to passive cooling that is being tried is embedding the components in a polymer to facilitate conduction. Another is to use a phase change material within the casing that will melt at a certain temperature and also facilitate conduction (this can be combined with the former) - but cooling is not a

problem confined to wearables.

Of course, fuel cells and battery technologies are not being developed exclusively for wearable computers. In fact much of what I have described thus far could equally well apply to a small notebook - there is also the same choice of operating systems, with commercial wearables normally having one of the MS Windows systems installed while the DIY people tend to favour Linux. Where the difference does become noticeable is in the input and output devices that are required to make the concept practical.

Chordic Keyboard

One such device is the chordic keyboard. This takes its name from the fact that combinations of keys are pressed for entry just like playing musical chords. There can be as few as five keys - four fingers and

thumb - to enter letters, numbers, words, commands or other strings. The most popular chordic product is the Twiddler, made by Handkey: a one-handed device with twelve finger and six thumb keys that give over four thousand combinations, plus an integral pointing device that operates by tilting the Twiddler. A new alternative to this is the Kord pad, a five button keyboard that has been designed by the Australian Institute of Marine Science, originally for use by divers with the Institute's WetPC. It is the first chordic keyboard to have an on-screen GUI display that shows which fingers must be used to press the keys for particular tasks, obviating the need to memorise them - see Figure 7.

The WetPC, incidentally, is based on a PC/104 embedded processor. It is connected by a cable to a mask-mounted scanning display and by another cable to the chest-mounted Kord pad (Figure 8 shows the placement and the computer).

Other types of keyboard are available for wearables use - small QWERTY arm mounted ones and even smaller wrist mounted ones. There are also small pen pads. It is also possible to use the finger as a pointing device, either directly on a touch-sensitive screen, or indirectly, in combination with a head-mounted camera and tracking software. In the latter, an image is superimposed onto a head-up display (the finger's movements being recorded by the camera, tracked by the software, and displayed on the virtual screen as an active pointer).

Head-Up Displays

There are a number of head-up displays available. Most of them employ tiny active matrix LCD screens of less than 1in, with



Figure 8b. The WetPC arrangement.

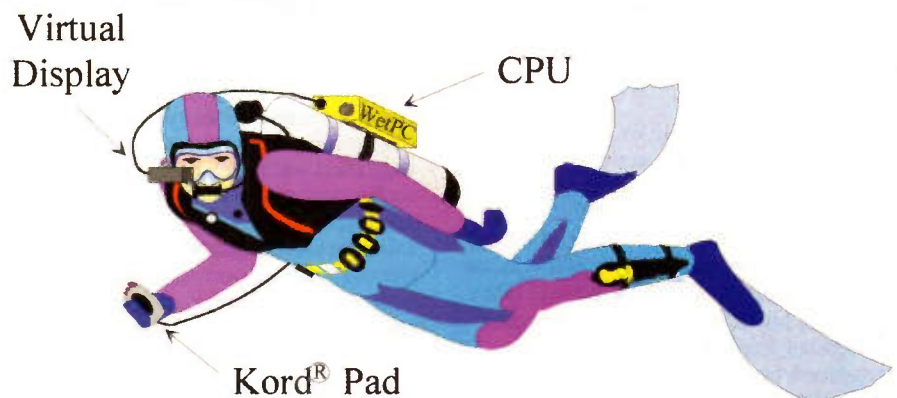


Figure 8a. The WetPC arrangement

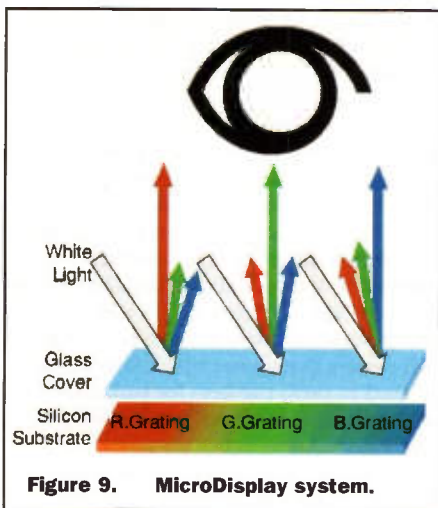


Figure 9. MicroDisplay system.

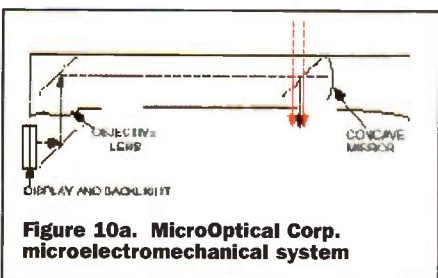


Figure 10a. MicroOptical Corp. microelectromechanical system



Figure 10b. MicroOptical Corp. glasses

magnifying optics to produce a larger virtual image. Other technologies with equally small screens are being used or tried out: variations on LCD, such as ferroelectric liquid crystal (FLC) and dynamic nematic liquid crystal on silicon (DNLCS); and

emissive technologies, such as electroluminescent (EL), active matrix electroluminescent (AMEL), field emissive display (FED), LED, organic LED (OLED) and active matrix organic LED (AMOLED).

The resolution may be 640 x 480 VGA, or 320 x 240 quarter VGA, some achieve 800 x 600 SVGA, and a few manage even higher resolutions. But being small makes the image look better than the figures suggest. The sequential displays will also look better than the filtered ones. The former run at approximately three times the normal

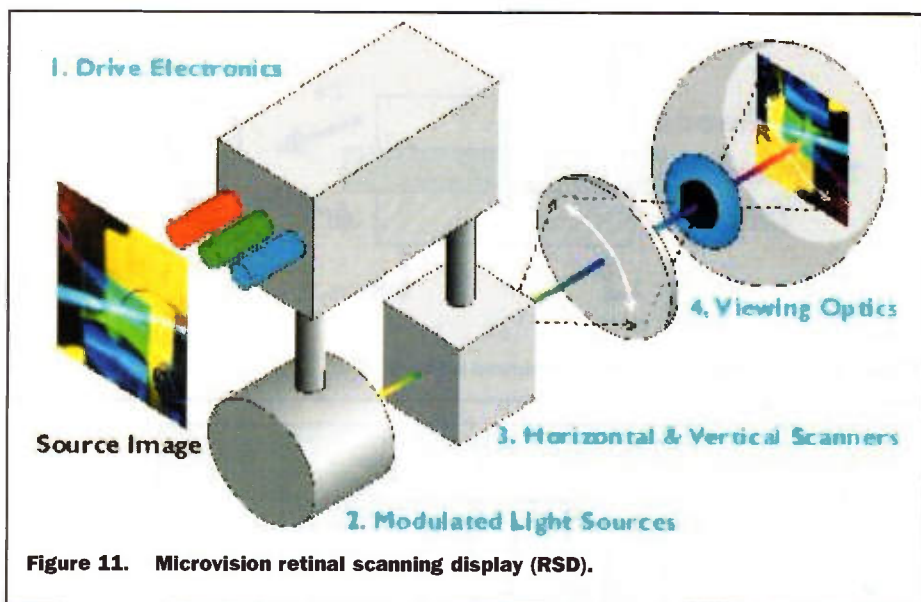


Figure 11. Microvision retinal scanning display (RSD).

refresh rate to show alternate red, green and blue images synchronised to light from appropriately coloured LEDs. Note that all the pixels are used all the time, whereas the filtered display has a mosaic of RGB filters, effectively reducing the resolution - and the brightness.

One alternative to this is under development by MicroDisplay. Here filters are replaced with diffraction gratings, produced at no extra cost on the silicon backplane during fabrication; three differently spaced gratings per pixel give red, green and blue light under white light illumination - see Figure 9.

Head-up displays also come in two types - closed and open. The former is like an electronic viewfinder, you look into it with one eye and keep the other open. The latter is transparent, so that you look through what appears to be a large display suspended in space some distance in front of your face. Generally, the displays are monocular, unlike the virtual reality displays - although these can be used as well.

There are also displays that can be attached to glasses. The AlbaTech Personal Monitor clips onto the bridge and projects a single LCD image into both retinæ via dividing mirrors. The effect is apparently one of viewing a 26in display suspended two metres away in the centre of vision, with the environment visible all around.

Monocular Displays

MicroOptical Corp. takes a slightly different approach. They have a monocular display that attaches to the side of the glasses. The company is also developing integrated displays. Here, the image is reflected and magnified within the eyeglass lens by an embedded optical relay (Figure 10a - Figure 10b shows the glasses). The advantage of this approach is that when the display is off the user can see normally because the reflector is translucent, and normal prescription lenses can be fitted.

MicroOptical is also working on microelectromechanical systems (MEMS) for scanning images, but information was not forthcoming. But another company, Microvision, seems to be further advanced,

or is just less reticent about MEMS for imaging. Their retinal scanning display (RSD) employs a mirror of less than one square millimetre, this scans in both horizontal and vertical directions projecting a flying spot of light from LEDs onto the retina in a raster pattern - see Figure 11. This is state-of-the-art stuff, but for those who do not require a head-up display there are plenty of small LCD panels available, including ones that can be wrist mounted.

Even more state of the art is computers built into clothing. Conductive fibres can be woven into materials, and conductive inks can be printed onto fabrics. People are already walking around with wearable systems integrated into their normal clothing and accessories, including microswitches as one means of keying in data, a fabric antenna, and such like. Philips in Redhill has a current project aimed at using electronics to enhance clothing; not wearable computing, but their sensor jacket gives a good indication of what can be done - see Figure 12.

If you fancy buying a wearable system, or constructing one, or are merely interested, then a good place to start looking is Wearables Central (<http://eyetap.org/wearable/>). The site has information, and links that will lead you directly or indirectly to all the other relevant sites - new ones appeared even as I was working on this article, so it is certainly taking off and we can expect to see some big changes in computing on the move in the near future.



Figure 12. Philips sensor jacket

Making good use of **WASTE HEAT**

What do you do with all the waste heat that is created from our electrical power stations? Even now the majority of that heat is sent into the atmosphere via cooling towers or discharged at sea or into our rivers. Power stations are quite frequently away from urban centres and therefore it has been argued, would be uneconomic to transport heat over long distances. There was one notable exception in the past and that was Battersea Power station in London where the waste heat was distributed around the surrounding estates.

'Greener' attitudes have brought into focus the nonsense of wasting this heat and that it could be used in a better way.

Governmental changes more recently now means that virtually anyone can generate their own electricity, be they a commercial concern or individuals and that liberalisation will bring electrical generation back into urban centres. The other added benefit to this is, with approval, surplus electricity can be exported into the national grid network. One method of generating electricity on a small to medium scale is Combined Heat and Power.

CHP

Combined heat and power systems make good use of the by-product heat that is generated as a result of generating electrical

power by conventional means ie heat energy usually in the form of a hot gas produces rotational energy. In a Combined Heat and Power unit that heat is typically used for keeping buildings warm or for example in a chemical plant, heat might be required for increasing the speed of chemical reaction. There are now a growing number of installed CHP units in the UK generating around 4GW at present and a governmental directive has said that CHP output should increase to 10GW by 2010. These small power plants might typically appear on waste reclamation sites, leisure centres and now more recently on large industrial works.

District Heat Main at CAT

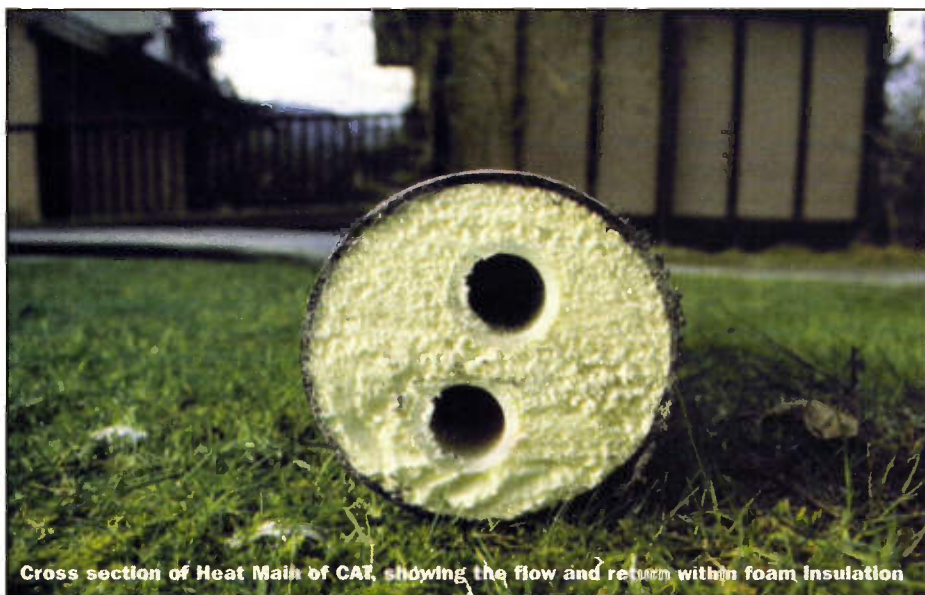
The Centre for Alternative Technology in Wales has installed a heat main. This is where heat can be 'traded' across the site from a variety of sources. The sources in this case are a resident wood chip boiler and the solar water heating system. The wood chip boiler runs from waste wood chip from local forestry plantations. The new solar water heating panels installed on the new information centre has an area of 120m² and these panels feed solar heat into the heat main. The heat main consists of two 40mm plastic flow and return pipes



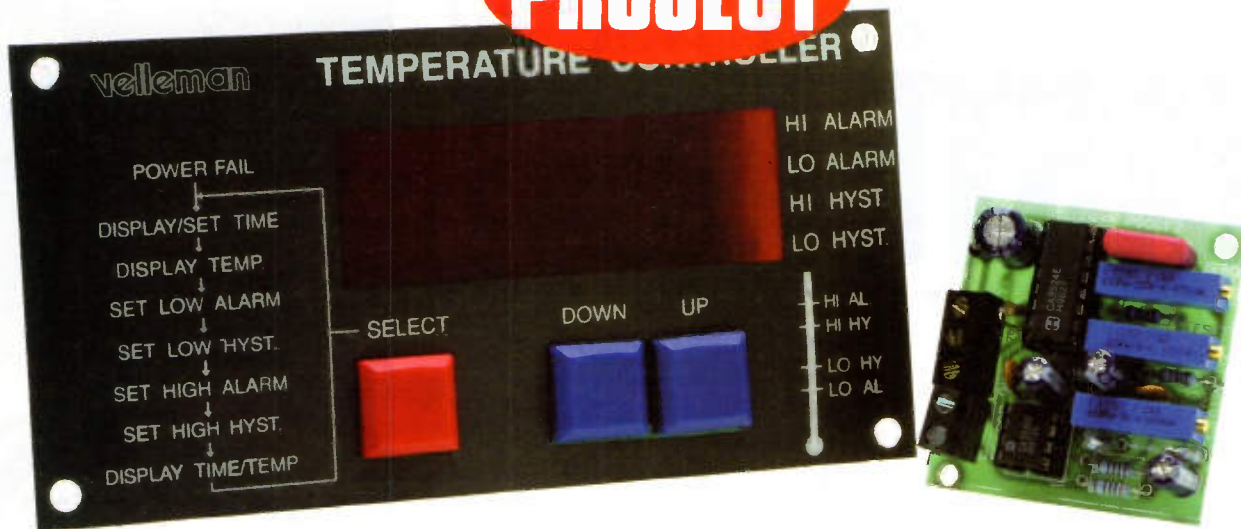
encapsulated in foam insulation with a butyl outer plastic casing. This heat grid links to seven major buildings on the site and will provide plenty of hot water for the buildings. The design will aim to demonstrate how renewable energy resources can be integrated to supply both heat and power to any area where there is a high density of buildings such as industrial centres, villages or towns.

In future careful consideration might well be given to the positioning of any new power station, apart from the usefulness of the heat energy, one has also to consider the expense of pylon and cable installations across the countryside. In the future many more localised generating stations fired by a variety of fuels will provide combined heat and power and so overcome the distance obstacle. Also optimising power lines to the shortest path routes using mathematics with computing power will minimise power losses in cables. One such project is to build a power station at Newbridge on Wye powered by fast growing willow trees, a sustainable biofuel that would be harvested regularly in nearby fields. New willow saplings would be continually planted. The proposal is that it would be a combined heat and power system but more importantly from an environmental point of view, it should be a zero contributor of CO₂. This means that the amount given out by burning should match the amount of CO₂ taken in by the willow in the act of growing.

One thing is certain that in future with ever increasing energy costs, the concept of trading heat will become a more attractive and economic proposition, whether it be for inter-commercial exploitation on industrial estates or at a domestic level on housing developments.



Cross section of Heat Main of CAT, showing the flow and return within foam insulation



The Velleman temperature controller is somewhat unique in that it contains two independently adjustable channels - one that can control a 'high' temperature to turn a fan on for instance, and one that controls a 'low' temperature to control a heater etc. Additionally, each channel has adjustable hysteresis. The outputs are via separate 5A relays so that reasonably heavy loads can be accommodated. For measuring the temperature a separate sensor board kit is included. The actual temperature sensor is off-board and connected to the sensor board by screened cable, where it is converted to a pulse width modulated output to the temperature controller board. This allows the sensor to be some distant from the controller board and not be affected by noise. Additional temperature sensors are available, and if a small switch box is used then several different temperature zones can be monitored. An in-built clock is also included.

As a practical example you may wish to keep a room at 20°C. You can select the high temperature to be 24°C, at which point a cooling fan is switched on. This fan would then be switched off when the temperature falls to 20°C. Similarly, if the temperature falls to say 17°C a heater is switched on which will also be switched off when the temperature reaches 20°C. In passing, our photographer is particularly interested in this project, for he

Microprocessor TEMPERATURE CONTROLLER

John Mosely evaluates the Velleman Temperature Controller and Sensor

Specification

Temperature Controller

- High & low temperature control output with LED indication
- 220V AC/5A relay outputs
- Celsius temperature readout
- $\pm 0.1^\circ\text{C}$ accuracy
- -40°C to $+150^\circ\text{C}$ readout
- 24 hour clock
- Control range from -50°C to $+154^\circ\text{C}$
- Hysteresis available per output
- Separated opto-coupler sensor input
- 9V AC/300mA power requirements

Temperature Sensor

- $200\mu\text{s}/^\circ\text{C}$ pulse width
- pulse width at -40°C is 2ms ($\pm 500\mu\text{s}$ adjustable) and at 150°C it is 40ms ($\pm 2500\mu\text{s}$ adjustable)
- $< 0.5\%$ linearity (-10° to 50°C) $< 2\%$ full range
- 15mA current loop output
- Can be used up to 50m from controller
- 12V/20mA DC supply requirements

needs an accurate method of temperature controlling his processing tank. The sensor head he currently uses has a short life and is expensive to replace - more than the cost of this kit in fact!

Construction - Sensor

This comprises of one small PCB and the sensor, which is mounted on the board, and the circuit is shown in Figure 1. As usual start with the resistors first. Note that two resistors (R2, 7) are mounted vertically and it is recommended that the bodies of the resistors be mounted on the correspondingly marked large circle on the PCB legend. This will make calibration easier, as these resistors are used as monitoring points. Next the diode, small capacitors, IC sockets and electrolytics can be mounted, paying the usual attention to polarity. Finally, the three multiturn pots and the screw connectors can be fitted. Now fit the two ICS in their respective sockets.

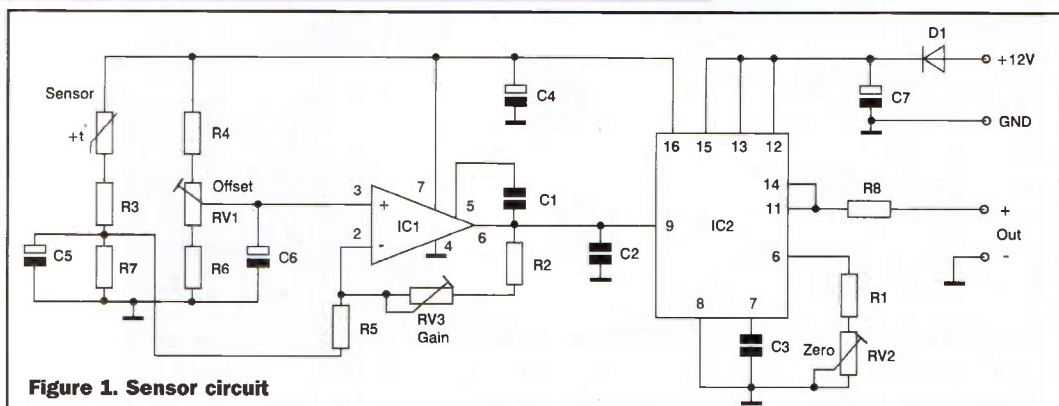
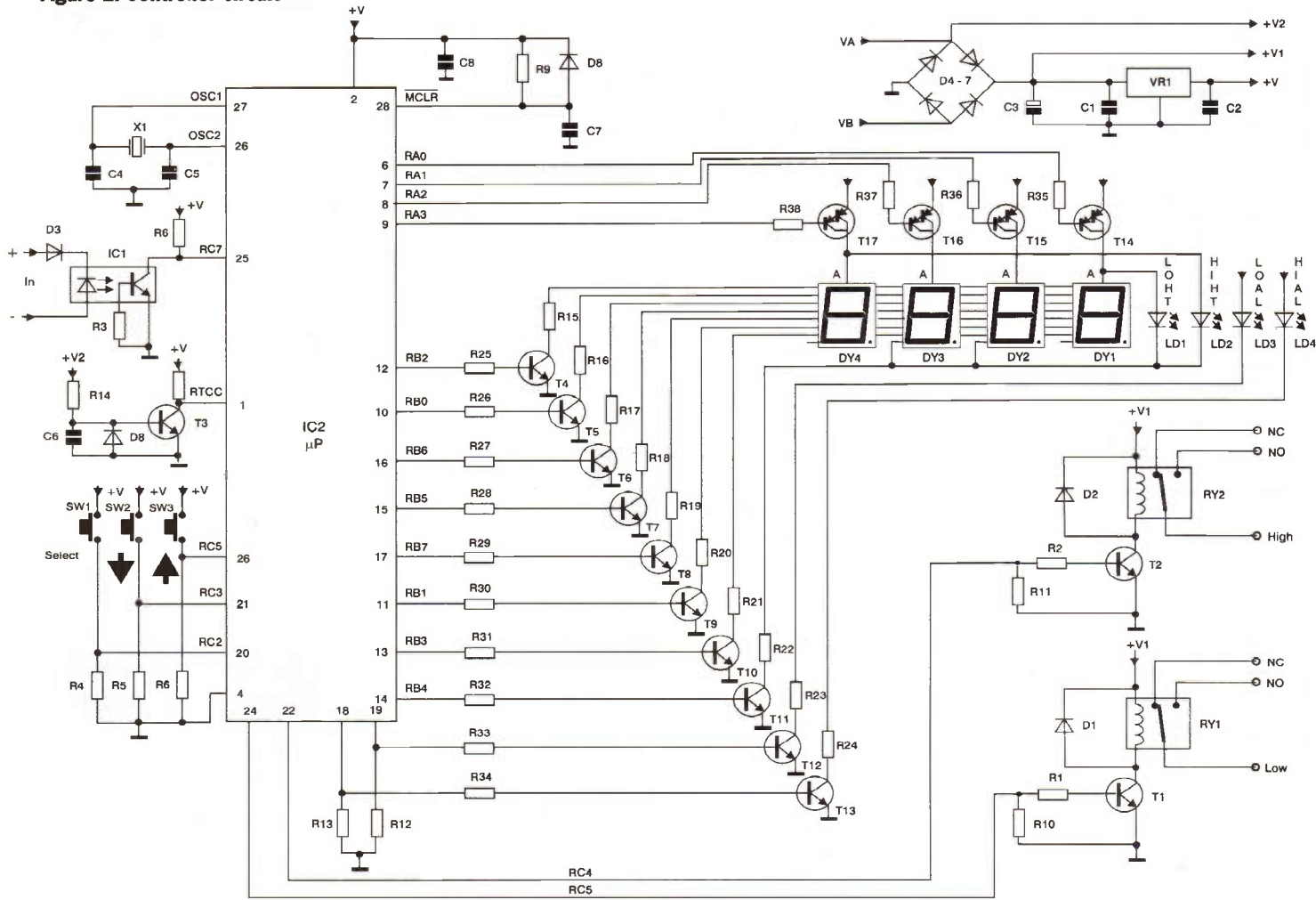


Figure 1. Sensor circuit

Figure 2. Controller circuit



Solder a length of screened wire to the KTY10 sensor - polarity is not important - and suitably insulate the solder joints. A length of heatshrink tubing is included to cover the joints and part of the body of the sensor. This is important because you will need to immerse the sensor in freezing water later.

Construction - Temperature Controller

The temperature controller comprises of three equal sized PCBs - power supply, processor and display boards - that are stacked and secured to an aluminium front panel. This helps to simplify housing and results in a compact final assembly. The circuit diagram is shown in Figure 2. Again, it is advised that the small components are mounted first followed by electrolytics, IC sockets, connectors, relays etc.

It is suggested that the power supply board is constructed

first, which also includes the opto-coupler input circuit and the output relays and driver circuits. Note that the 7805 voltage regulator is horizontally mounted on and bolted to a small finned heatsink, which will require the three IC legs to be carefully bent through 90°.

Now you can move on to the processor module, which requires initially three wire links to be soldered in. The crystal also requires a solder strap to secure it to the board, which is done first before soldering the crystal legs in. The rest of the board is relatively straightforward.

Finally, the display board is constructed, and again several resistors are mounted vertically. The transistors when mounted should not exceed the height of these vertical resistors, otherwise you will have problems stacking the three boards together. Be careful to check the polarity of the displays - the decimal point should line up with legend on the PCB. Similarly, the LEDs should not protrude above the height of the displays.

Now thoroughly inspect and check the boards for any obvious soldering problems, because once the boards are stacked it will be difficult to rectify dry joints etc. When you are happy that all is correct, then you can mount the boards together.

Final Assembly

Firstly, solder the connecting board wire links to the display module. If the links are progressively cut slightly shorter each time then it will

help to align with the holes in the processor board. The display module is attached to the front panel by four 45mm bolts, four 10mm spacers, and nuts. You should now check that the displays are flush with the front of the panel. Now carefully push on another set of spacers followed by the processor module (components facing the display board), and align the connecting links. Secure the processor board with four nuts. Carefully solder the link wires using a small tip

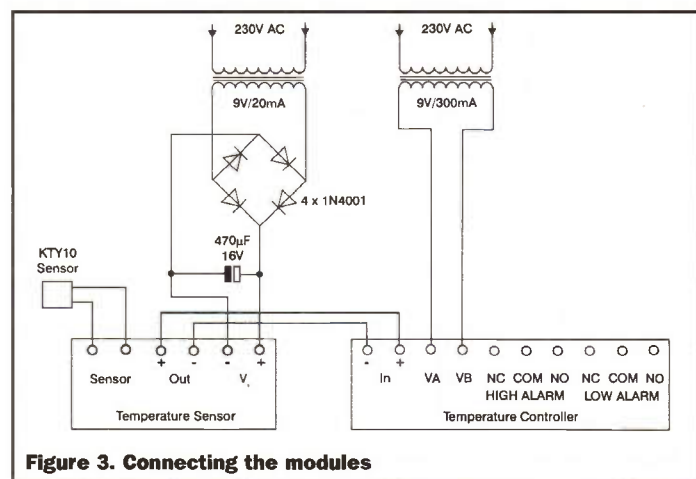


Figure 3. Connecting the modules

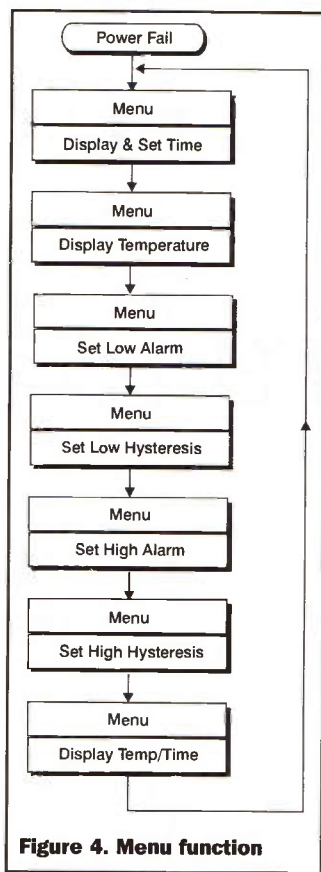


Figure 4. Menu function

soldering iron. Again, use another four spacers and push on the supply board with the track facing the processor board, and secure with four nuts. Push through the link wires on the last two boards and carefully solder in place.

Alignment

The temperature sensor needs to be on for about 10 minutes to allow the circuit to 'warm-up' and stabilise. Note that if you are measuring temperatures below 0°C and above 70°C then you should keep the electronics away from such temperatures, and

connect the sensor remotely. Figure 3 indicates how the modules should be powered. Connect a digital multimeter across R2 and R7, and avoid touching the board during this alignment as it can induce noise and produce an unreliable readout.

While the circuit is stabilising, fill a small glass with ice cubes and water and allow the water to reach 0°C. Place the temperature sensor (KTY10) into the melting water (it is important that the connecting leads are suitably insulated). Now adjust the OFFSET trimmer, RV1, so that the digital multimeter reads 0V - use the most sensitive range possible - and wait for the reading to become stable. Take time and effort to get this right, as it will influence the correct operation of the system.

Now connect the temperature controller board to a suitable AC power supply - see Figure 3 - and you should get a FAIL display, which is correct, and you will see this every time there is a power interruption. The power supply of the sensor must be kept separate from the controller power supply. The controller board can be used to provide power (12V DC) for up to four sensor boards. Note that the controller will not work, and that includes the clock, until the sensor module is connected.

When the two modules are correctly connected and powered, the FAIL indication will be displayed. If you now press the PUSH button you can toggle through the different

modes of display. The time and alarm settings can be selected by the UP and DOWN buttons. Note that there is a slightly delay (0.5s) in the button action to avoid contact bounce. To go through the menu quickly keep the button pressed down. The menu sequence is shown in Figure 5.

Now re-immers the sensor probe into the melting ice again and adjust RV2 so that the display reads 0°C and wait for the reading to stabilise. If you intend to operate the sensor at room temperatures then allow the sensor probe to stabilise at room temperature, and adjust RV3 to read the room temperature. Obviously, it will be necessary to compare readings with a quality thermometer. If you wish to use the sensor above 40°C then the last adjustment should be made in boiling water e.g. a known source at 100°C. It is worth repeating all this alignment procedure to ensure the readings are correct.

In-use

It is very simple to set the controller by just sequencing through the menu and selecting the desired time/temperature using the UP/DOWN buttons. The corresponding LED will light when that function is select.

If you intend to switch AC voltages then you may need to use suppression circuits as shown in Figure 5. The VDR in the inductive load circuit will need to be rated at mains voltage.

Conclusion

This is yet another excellent kit from Vellman that can be used for a variety of temperature monitoring applications. The finally assembly can be tricky, so care is needed at this stage, but the effort is worth it. The whole system can easily be mounted in a small rugged box and a front panel label is supplied to complete the kit.

TEMPERATURE SENSOR

RESISTORS:

R1	240k
R2	18k
R3	3k
R4	4k7
R5	10k
R6, 7	1k8
R8	560R
RV1	1k Multiturn Trimmer
RV2	200k Multiturn Trimmer
RV3	5k Multiturn Trimmer

CAPACITORS

C1, 2	470pF Ceramic
C3	47nF polyester
C4-6	10µF 16V Elect
C7	220µF 16V Elect

SEMICONDUCTORS

D1	1N4001
IC1	3160
IC2	3524
Sensor	KTY10

MICROPROCESSOR TEMPERATURE CONTROLLER

RESISTORS:

R1, 2, 4-8,	25-38	4k7
R3, 10-14		47k
R9		1k
R15-24		270R

CAPACITORS

C1,2,7,8	100nF Ceramic
C3	2200µF Elect
C4,5	18pF Ceramic
C6	10nF Ceramic

SEMICONDUCTORS

D1,2,3,8,9	1N4148
D4-7	1N40001
T1-13	BC547
T14-17	BC516
IC1	4N27
IC2	VK60002 (Velleman)
VR1	7805
DY1-4	TDSR5150
	7-Segment LED Display
LED1-4	3mm Red LED

MISCELLANEOUS

RY1,2	12V DC Coil
	5A/230V Contacts
SW1-3	Push-to-Make
	Heatsink
	Crystal
	Screw Terminal Connectors
	9V/20mA Transformer
	9V/300mA Transformer
	Suitable Box
	Hardware
	Heatshrink Sleeving

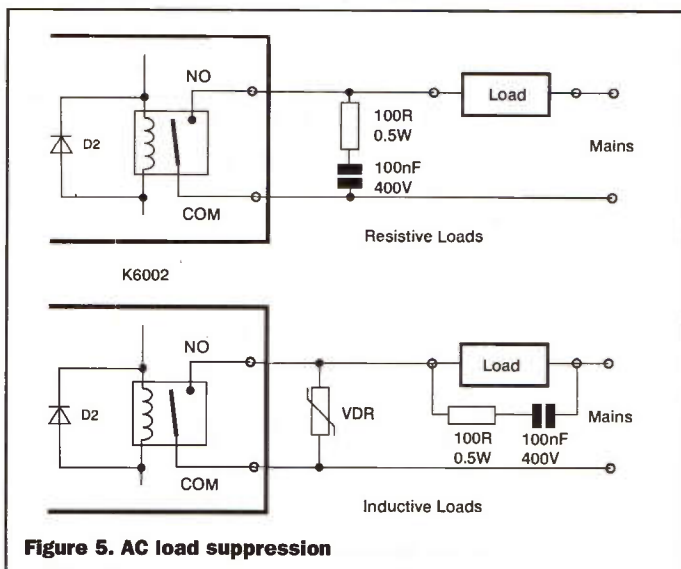


Figure 5. AC load suppression

Type	Order Code	Price
Temperature Controller	VE69A	£59.99 (includes one VE68Y)
Temperature Sensor	VE68Y	£14.99

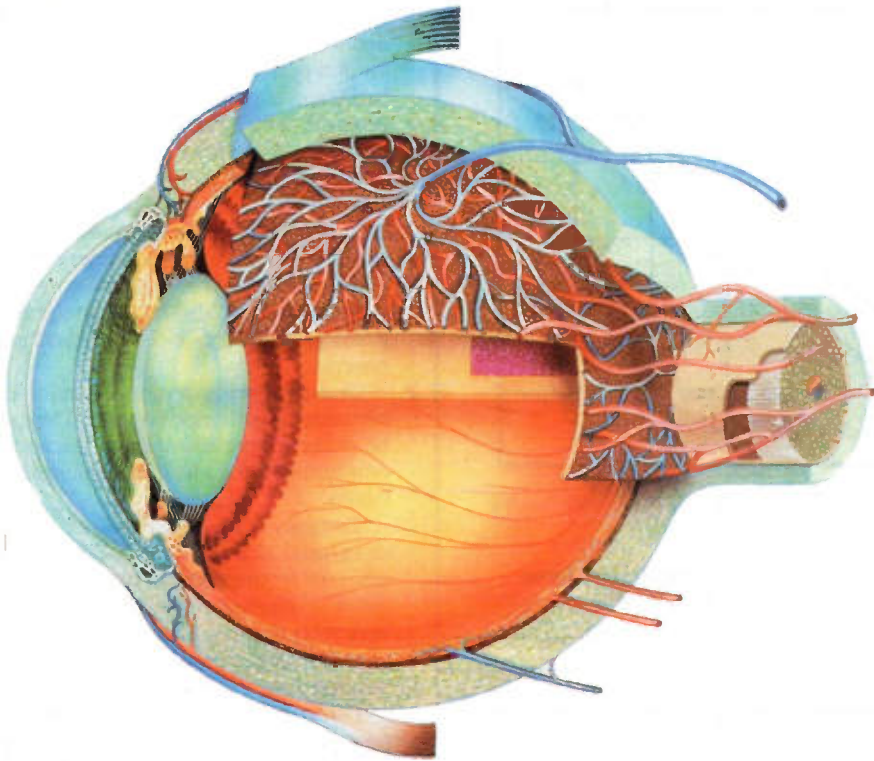


Figure 1: Anatomy of the eye indicating cornea, aqueous humour, lens, vitreous and retina.

Laser Battlefield OF THE FUTURE

Douglas Clarkson reports on the eye damage that can result from current and future laser warfare

Introduction

Since the laser was first invented its incorporation in technology has been rapid and highly significant. While we have open access to information in the area of telecommunications, industrial and medical use of lasers, the level of data regarding

military applications is as expected much more limited.

Laser technologies, however, continue to increase in significance in modern theatres of war. We all perhaps still remember clips of the Gulf War and then the Kosovo conflict where laser guided

devices or munitions were targeted with so called pin point accuracy. There has been, however, increasing anxiety over various weapons programmes around the world which use lasers as counter measures against installations and directly/indirectly against personnel.

As a result of the deployment of such systems, there is the real risk that casualties of future wars will include those whose vision is impaired due to interception of such beams. This would have considerable significance for the provision of medical care of such casualties who would invariably require to be evacuated to receive appropriate specialist treatment. Also, for more severe retinal injuries, treatment is very limited.

Nature of Risk

It is relevant to consider aspects of the nature of interaction of laser radiation on the eye. The eye, as indicated in Figure 1, consists of key components of the cornea, aqueous humour, lens, vitreous and retina. Figure 2 indicates the relative transmission of light within these various components. Within this context, light is taken to mean electromagnetic radiation within the range 400nm to 1500nm. Naturally the eye is most receptive to visible and near infra red radiation. With ultra violet radiation, there is increased absorption in the cornea/lens and with infra red, the cornea becomes more highly absorbing.

Laser energy incident on the retina can readily damage its delicate structures. Wavelengths of longer values tend to penetrate more deeply into its various layers. The normal focusing action of the cornea/lens can in fact increase the energy density at the retina by a factor of 100,000 compared to the levels incident at the cornea. In regard to the hazard of battlefield laser systems, the use of binoculars etc can also act significantly to increase the risk of associated ocular injury.

International standards (such as BS EN 60525-1) have classified the degree of risk that laser radiation currently presents. There is, however, a lack of information on the risks of laser pulses of ultra short duration - of pulse lengths shorter than a nanosecond and behaviour is extrapolated from data at longer pulse durations.

A key term is the MPE or maximum permissible exposure and is the level of exposure that the eyes can safely tolerate. Figure 3 indicates the value of MPE at the cornea for single exposures of laser radiation within the wavelength range 400nm to 700nm and 1050nm to 1150nm for a range of pulse durations. Normally the MPE will be a function of both wavelength and pulse duration but for these specific wavelength ranges, the MPE is only a function of pulse duration. For the range 400nm to 700nm, for example, the MPE value is constant for pulse durations less than 0.1µs. With increasing pulse duration beyond this value, the MPE increases, presumably as the laser energy is more readily conducted out of the incident area. This indicates that for a given value of laser pulse energy, this will tend to be more damaging if delivered in pulse duration

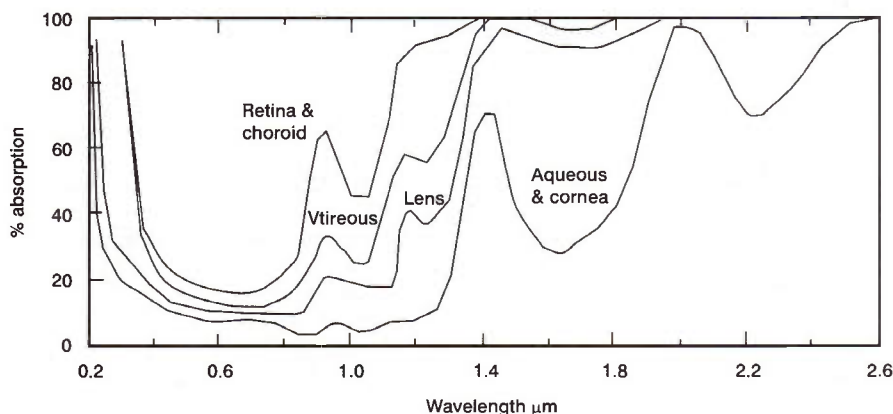


Figure 2: Relative transmission of light through components of the eye.

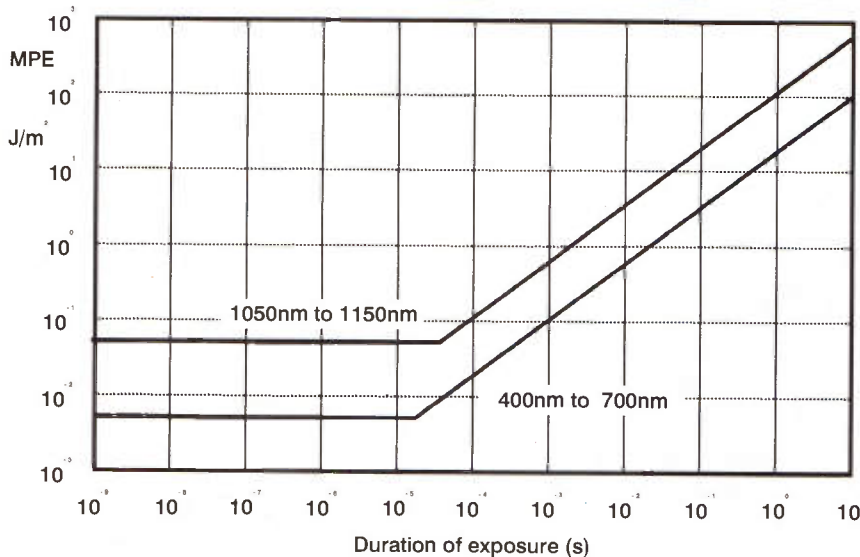


Figure 3: Values of Maximum Permissible exposure for single exposures of laser radiation in wavelength ranges 400nm to 700nm and 1050nm to 1150nm

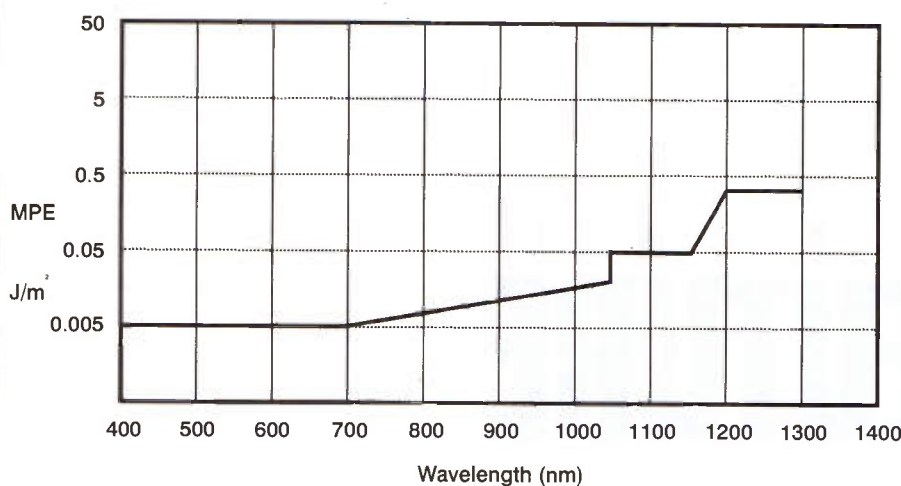


Figure 4: Variation of Maximum permissible exposure with wavelength at a nominal pulse duration of 1µs.

shorter than a specific limiting value.

Also, Figure 4 indicates the variation of MPE with wavelength at a specific pulse duration of 1 micro second. This indicates that the eye, for the wavelength range presented, is most vulnerable in the optical range. Where non-visible laser weapons are being developed to deliberately impair the vision of targeted personnel, the wavelength range around 800nm would be particularly dangerous. The Alexandrite laser with a wavelength of 755nm, is just on the limit of vision. These estimations, moreover, give indication of values of MPE associated with single pulse exposures. Multiple exposures fired closely together in time would carry additional risk - and associated with reduced values of MPE.

The threat of use of such devices is not restricted to future areas of conflict. Already, for example, pilots of commercial air flights have been deliberately exposed to dangerous levels of laser radiation. Such data is, for example, recorded in the NASA Aviation Safety Reporting System database. At least 50 such incidents have been reported to date in the USA.

Classification of Battlefield Systems

A committee of experts convened by the International Committee of the Red Cross

met in 1990 to develop a classification system for battlefield lasers. Category A was defined as systems not primarily designated for anti-personnel use but which under battlefield conditions might present an ocular hazard. Systems included within this group are range finders, target designators, laser target markers, optical laser systems (LIDAR) and large, non portable or vehicle mounted systems. Even range finders are probably not eye safe and target designators utilise more powerful laser sources.

A sub category also relates to sighting, training, simulation and other small portable systems.

Thus category A devices are intended as information gathering systems, They should be designed, preferentially, to discrete monitoring using low levels scanning beams.

Category B systems, however, are designated as anti-sensor systems and have inherent requirement to have sufficient 'clout' to damage optical detection systems. Personnel in the vicinity of targeted installations will be at very high risk if not wearing appropriate eye protection.

Category C systems are so called anti-personnel systems. These are deliberately designed to damage the vision of a targetted individual. Information on such devices is classified, though some snippets of data are available. The British Navy, for example, developed the Laser Dazzle Sight (LDS) which was first deployed during the Falklands War but its development was stopped in May of 1995.

Category D systems are described as anti-material systems. These include at one end of the spectrum the so called 'Star Wars' weapons for interception of missiles in space and at the other, systems to destroy munitions such as land mines.

Table 1 gives therefore a broad overview of a limited range of projects known at one time to have been under development. There is, however, considerable lack of data on the status of any specific project and also on its technical specification (not surprisingly). The LCMS system, has in particular attracted most of the recent discussion of such systems in the USA and is primarily a category B system. Development of such systems, however, is not limited to

Code Name	Functionality
Saber 203	Grenade launched shell that produces very intense light flash
Stingray	category B system for detecting and disabling optical scanning systems.
Dazer	Portable rifle like device operating at 755nm (Alexandrite).
Cobra	Portable rifle like device operating at 1064nm (Nd:YAG diode pumped)
Perseus Optical	40 mm rifle grenade projectile produces intense optical flash Munition
Coronet Prince	System for detecting and disabling ground based optical systems
Compass Hammer	Optical countermeasure system - probably deployed on F15E strike eagle aircraft
Cameo Bluejay	Helicopter mounted tactical laser weapon
Laser Countermeasure System	One person, portable shoulder fired, battery powered device mounted on M16A3 rifle.

Table 1: Various laser devices known to have been developed in the USA.

the USA, with developments in particular being undertaken in Russia, various former Soviet Republics, China, France and Israel.

Systems for laser neutralisation of munitions have been successfully tested against devices such as anti-tank mines, anti personnel mines and rifle grenades. Systems known to exist in the USA include MODS (Mobile Ordinance Disrupter System) and Zeus. Beam output powers are anticipated as many hundreds of watts or several kilowatts. The effective range of such systems is designed to be up to 300 km. The use of such systems, however, would present a risk to any personnel in the line of sight of the firing beam. Star Wars lasers or megawatt class continuous deuterium fluoride laser systems, are being developed as part of 'directed energy' systems.

Development of Protocol IV

It comes very much as a surprise to learn how long ago the effort was first made to limit the arsenal of war in an attempt to limit devices which would cause 'unnecessary human suffering'. The Declaration of St. Petersburg of 1868 was the first such resolution to seek to limit the use of specific weapons and was successful in prohibiting the use of exploding bullets which would serve to uselessly aggravate a combatant's suffering.

It becomes clear that if nuclear weapons had been developed within peace time, efforts would have been made to have their development banned within the Hague Convention - in line with its remit for the prevention of 'unnecessary suffering'.

Initial resolutions were further refined at the Hague Peace Conferences of 1899 and 1907 and the so called Hague Convention became the basis for International Law in the waging of war.

The emergence of initiatives to restrict laser blinding weapons emerged out of a series of meetings under the aegis of the International Committee of the Red Cross (ICRC) and the United Nations. Awareness of the threat posed by laser weapons was achieved by a 1980 UN conference though it was some nine years later that a more focused perspective was available on the potential threat from a panel of experts who drew up the series of laser weapons categories.

It was a review conference of 1995 that subsequently drew up the so called Protocol IV to the 1989 agenda and established the banning of specific use of lasers primarily intended to blind.

The recent Kosovo conflict, however, indicated the use of massive air force with prevalent use of laser targeting systems in an effort to resolve a situation without encountering ground based military casualties. This indicates the increasing political identification with high tech weapons systems designed to minimise the direct engagement of ground based forces.

The Pentagon Speaks

On September 1, 1995, the secretary of Defence William J. Perry, endorsed the international Ban on Futuristic Laser

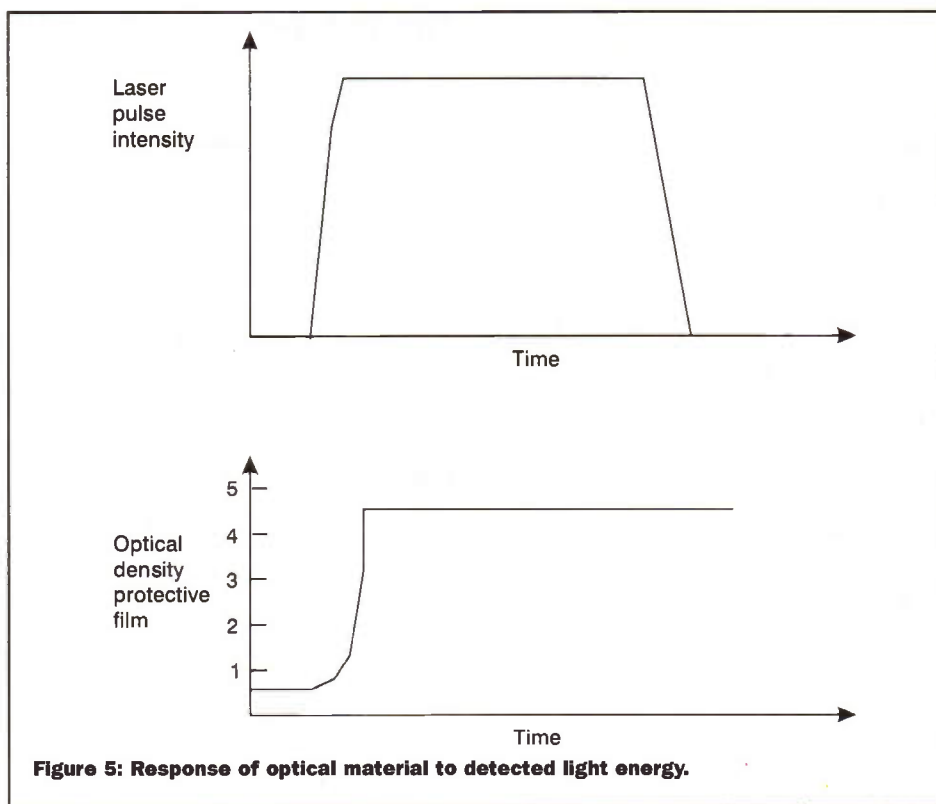


Figure 5: Response of optical material to detected light energy.

Weapons that were intended to cause permanent blindness. While giving encouragement to Human Rights Groups, there was at the same time indication given that the USA would seek to develop and maintain its perceived technological edge in all permissible categories of laser measure/countermeasure. Human rights groups, however, anticipate that Category B systems may be increasingly deployed in the future - giving rise to concern of infliction of severe eye injuries on personnel in the vicinity of targeted installations.

Enter The Dragon

A worrying feature of the proliferation of category C laser weapons has been the open development and marketing by China of laser devices openly claimed to be an effective anti-personnel laser device. The ZM-87 portable laser disturber was first displayed in November 1994 and has been supplied to various countries around the world. The nominal distance over which the device is effective is two to three miles. The device operates by transmitting 15 MW pulses at two different wavelengths simultaneously. The availability of such a device is working directly against the directives to ban the development and proliferation of such devices. There is even more concern that China has also assisted various countries such as Pakistan in the development of their own nuclear weapons programmes.

The recent debate on the apparent ease with which China can steal US military technology is also touching upon the development of laser weapons. China is already known to have considered development of anti-satellite laser weapons. Also, category D laser devices are considered by China to be the most effective countermeasure against Cruise missiles. Presumably as countermeasures,

military satellites are probably already designed to withstand hits from such directed energy weapons.

Countermeasures

One of the hottest topics within the military sector at present is effective countermeasures against category B (and category C) laser devices. Since around 1970, in the US air Force, visors have been available which have provided protection against various fixed wavelength laser radiation. Initially, problems encountered were the fact that such devices introduced distortion into the visual field, or so reduced visible light transmission that night flying was rendered more hazardous while wearing such devices.

Improvements in quality of such devices, e.g. low distortion, better visible light transmission, etc have however significantly increased the cost of such devices, so much so that their deployment has been restricted - even for those in charge of an \$100 million aircraft. The current state of the art visor provides protection against four visible laser wavelengths and three near infra red wavelengths.

The greater threat of ocular damage is associated with the so-called 'agile' laser, which can operate at many different wavelengths within a fraction of a second. The countermeasures against such a device are consequently more complex and are a key area of current military research and development. There is the perception, however, that in the escalation of technology, active threat and adequate countermeasure will be successively locked in a process of continuing and expensive linkage.

It is interesting to speculate on the possible options available to develop such devices. One comparable use of eye protection relates to safety visors used with arc welding units. Automatic devices can

detect the presence of the arc and electronically increase the optical density of the visor material to the appropriate level of filter protection. For industrial applications the transition of light to dark can take place in 0.3ms. The reaction time is faster if the temperature of the filter material is increased. Figure 5 indicates in general terms how such a device operates. The application of such technology to the military sector, however, would be much more challenging, particularly where the duration of laser pulses could be too short to allow deployment of such 'active' protection devices.

There is perhaps an option, however, to develop some sort of intermediate device for the protection of, for example, air craft personnel who are already being targeted by ground based laser devices in the hands of thoroughly irresponsible individuals.

However, the area of so called optical switching, of the interaction of light/electric fields on the optical properties of materials has advanced significantly in recent years - especially in the area of 'optical' computers and spatial light modulators.

Development of countermeasures against so called agile lasers can be imagined to be high on the priority of military strategists and the technology accordingly highly classified.

The Future

We are very much in the dark regarding the specifications of devices in current categories of laser weapons. While the key element may be considered to be the delivered beam power or pulse energy, a great part of the effectiveness of any such system is going to be its detection and targeting capability. It is not unreasonable, however, to anticipate an increase by a factor of 5 in a period of 10 years in delivered power energy. This will serve to make such systems more lethal within existing ranges and also extend the range of delivery beyond existing values.

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Laser Hazards and Blinding Weapons
 School of Biosciences; University of Westminster

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HRW (Human Rights Watch) questions US laser programs as blinding laser weapon ban becomes international law
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Israel acquiring banned laser that 'melts eyeballs' of enemies
<http://www.washington-report.org/backissues/0796/9607036.htm>

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<http://www.icltd.org/laser-weapons.htm>

Lasers and Radiation Hardened Chips for Russia/China
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A great deal of work has been conducted in recent years by NASA directly into medical sensing, with their desire for telemedicine (medical procedures that might need to take place in space remotely involving personnel with little or no specialist medical background). In addition NASA's wealth of scientific instrumentation and experience has often resulted in technologies spinning off benefits into completely unexpected areas.

Medicine today already has an undreamed off available range of body-scanning equipment and techniques available to create images inside the human body to aid physicians in diagnosis, treatment and surgery than even twenty years ago. Perhaps surprisingly a significant amount of this scanning ability has grown out of a space data analysis technique known as Digital Image Processing. This was developed as a means of assembling planetary pictures from streams of digital data bits sent to Earth by distant spacecraft sensors, which by today's standards were at appallingly slow data rates! Image processing technology has been employed in X-rays techniques via Computer-Aided Tomography (CAT) scanners, diagnostic radiography, brain and cardiac angiograms and ultrasound body scanning (routinely used in pregnancy ante-natal care).

With the help of innovative

RESEARCH

NEWS

by Dr Chris Lavers

NASA's Remote Sensing Contribution to Medical Sensing and the Chemical Sensing Environment!

Over the last year or so and certainly the last few months there has been considerable press and recent public awareness on the issue of successful early cancer detection, breast cancer in particular, and we have tried to follow some of the current developments in this area.

technologies from the Hubble Space Telescope breast biopsies to detect cancer may now be performed virtually pain-free and very importantly scar-free with a small needle rather than scalpel. Breast tissue can be imaged more clearly than conventional X-rays, using sensitive silicon

chip devices and the patient can rapidly resume the normal activities of daily life.

Charged Coupled Devices (CCDs) are basically silicon chips that convert light directly into electronic or digital images. Goddard Space Flight Centre headed the development of the advanced, supersensitive CCD installed

into the Hubble Space Telescope in 1997.

Subsequently the LORAD Corporation of Danbury, Connecticut, USA adopted this new CCD for its breast biopsy system (Figure 1). Through this system, the patient lies face down with one breast protruding through an opening to

pinpoint the area in question. LORAD's new CCD based procedure saves the patient time and pain, and leaves only a small needle mark rather than a large scar.

In the mid-1960's the Jet Propulsion Laboratory (JPL) in California developed Digital Image Processing to allow for computer software image enhancement of Moon photographs with the aim of finding a suitable lunar landing site before the decade was out. Physicians use digital image processing now to record images of organs in the human body and with the advent of the internet and digital data transmission, to transfer this information rapidly between specialists with no loss in image resolution and clarity. Magnetic Resonance Imaging (MRI) uses a magnetic field and radio waves to create an image and then a computer will reconstruct the image. MRI is preferable for soft tissues whereas CAT scanning is used for bone, and the two systems should be seen as complementary and not excluding the other. Data specialists are currently working on data fusion systems to combine the best aspects of both systems to create a high quality composite image. Clear, accurate three-dimensional images as those in Figure 2 are made from a series of breast and tumour MRI scans, combined with reconstruction software developed at the Ames Centre for Bioinformatics. A breast image from a MRI scan following a contrast medium injection of gadolinium to detect the tumour shows the position of the mass within the breast (pictures middle and right).

The Bioinformatics Centre at NASA Ames is part of a much larger national Biocomputation programme established in Palo Alto, California. This national facility will be used to further virtual reality in medicine and hopes to accelerate the use of 3 dimensional and virtual environment technologies in science and space, as well as in medicine. The US Government aims to establish a virtual hospital, which in the not so distant future will link the best medical minds together from around the world to treat patients. Surgeons can use a

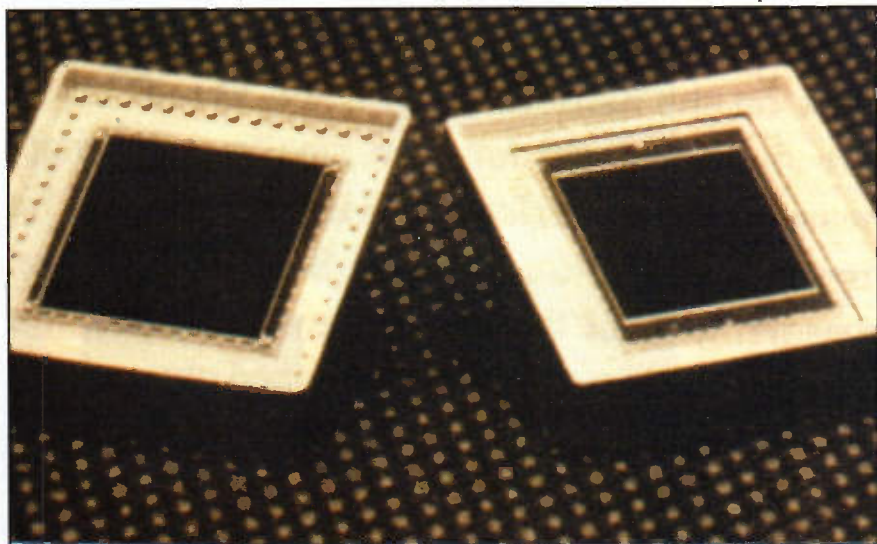


Figure 1. The CCD chip based breast biopsy system commercialised by LORAD Corporation. The CCD on the left is the extrasensitive device developed for the Hubble Space Telescope. The virtually identical CCD on the right is used by LORAD Corporation. Courtesy NASA.

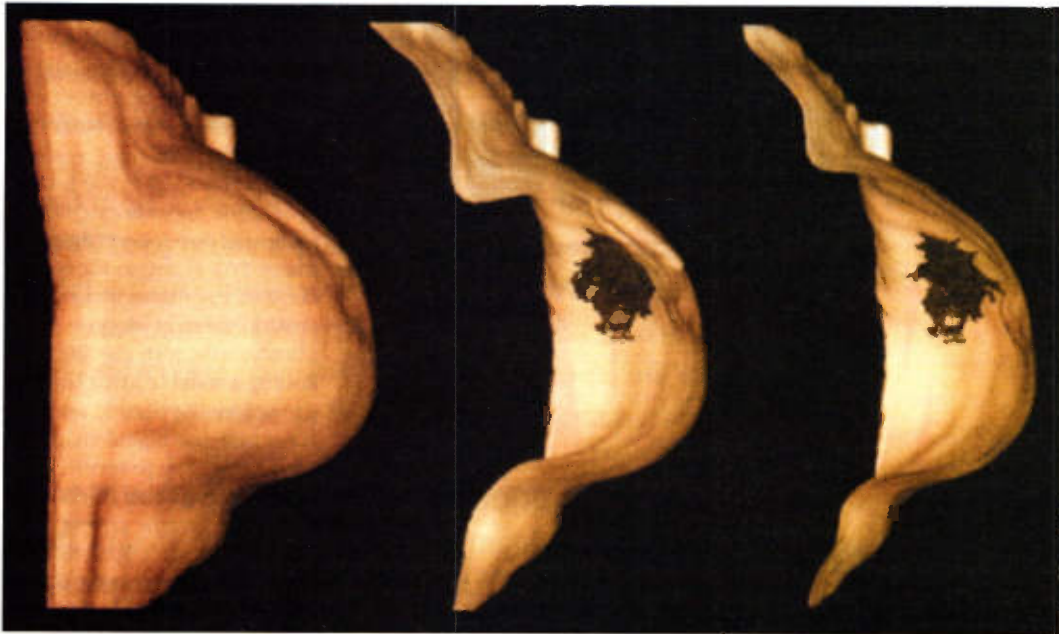


Figure 2. 3-dimensional MRI scan images from a breast with a tumour, combined with reconstruction software developed at the Ames Centre for Bioinformatics. Courtesy NASA.

variety of devices to manipulate 3D computer images of the patient. According to Dr Muriel Ross, director of the Centre for Bioinformatics at Ames "The physician can go in the night before surgery and use the computer in a virtual environment to actually walk through the operation." In the case of facial surgery, the surgeon can even use the virtual reality environment to replace soft facial tissues and see what the patient will be likely to look like after facial reconstruction. If the surgeon doesn't like what he or she sees, it can be repeated in a slightly different way.

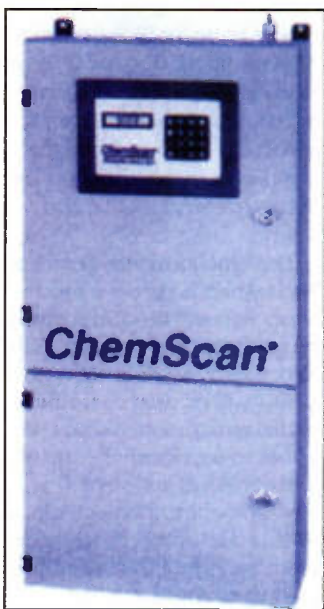


Figure 3. ChemScan, able to detect any chemical substance that absorbs light in the ultraviolet or visible wavelength range. Courtesy NASA.

A new commercialised chemical sensor has come out of NASA's need for a water chemistry analyser for monitoring hydroponic plant nutrients. NASA has a program to support developing systems which must resupply food, water and air, from the carbon dioxide the crew expels, from plants on long in-flight missions, e.g. to Mars. Water analysers originally designed under a contract sponsored by Kennedy Space Centre in Florida, are currently being commercialised. In 1998 Applied Spectrometry Associates (ASA), Inc. of Waukesha, Wisconsin added a new model to its ChemScan® product line. The UV-2150 Process Analyser is now being used to measure chemicals at public drinking water treatment plants and public wastewater treatment plants (sewage works!)

ChemScan (see Figure 3) can detect any chemical substance that absorbs light in the ultraviolet or visible wavelength range. Heavy metal compounds in water, nutrients, unsaturated hydrocarbons (double bonded or tripled bonded carbon-carbon atoms) and aromatics (benzene ring derivatives) are generally unwelcome but fortunately are usually good candidates for analysis using ultraviolet or visible spectrometry. Chemicals that possess natural absorbance characteristics can be detected directly. Reliability for these systems is high whilst at the same time the maintenance costs are low with only a few

hours servicing required per month. Real-time chemical analysis, combined with modern communications could possibly have resulted in a very different outcome of the Camelford incident in North Cornwall 12 years ago. Unfortunately large quantities of Aluminium Sulphate (12

tons) which should have been added in very small quantities worked its way into the water chain and consequently affected about 20,000 people as well. Documented symptoms included cases of rashes, chemical burns and diarrhoea. The long-term health effects of this incident cannot be underestimated. Data linked devices such as ChemScan may very well help prevent similar future incidents occurring.

For further information contact:

NASA has a number of sites involved in virtual medicine activities:
www.hq.nasa.gov/office/olmsa/aeromed/telemed/welcome.
www.hq.nasa.gov/office/olmsa/aeromed/telemed/centers.

Optical DNA Analysis Biochip Reader for GP Desktop Medical Applications.

Following on from sensors for early detection it would be even better to detect a problem

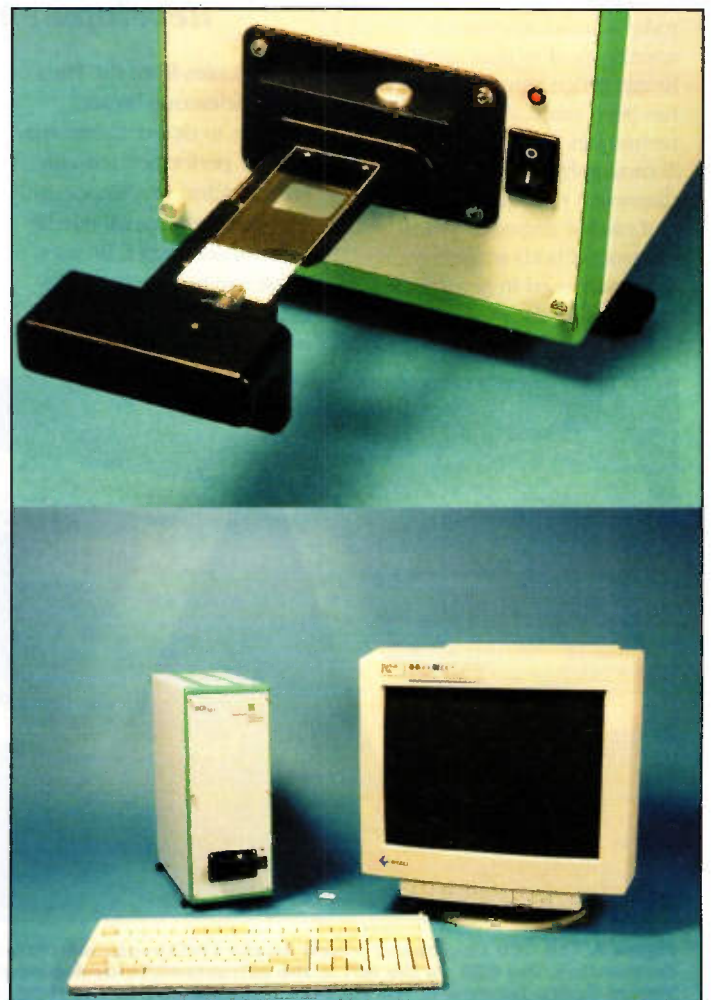


Figure 4. Optical Biochip Reader, Courtesy of IPM Freiburg

	Laser Reader	Multi-Colour Reader
Excitation Wavelength	640nm	400 to 800nm Up to 4 wavelengths possible
Emission Wavelength	682 (+11)nm	400 to 800nm Up to 4-wavelengths possible
Pixel array	762 x 512	762 (512
Chip Size	1/2"	1/2"
Diameter of each dot	50-90 microns	50-90 microns
Detection Limit	6 x 10 ⁴ molecules per dot	5 x 10 ² molecules per dot
Maximum detection area	14 x 14mm ²	14 x 14mm ²
Maximum number of dots	5000	5000
Size of device	180 x 470 x 380mm	180 x 470 x 380mm
	length x height x width	length x height x width

Table 1 Technical data on Optical Biochip reader

before it has begun. Workers at the Fraunhofer Institute for Physical Measurement Techniques (IPM) have developed a DNA analysis biosensor that could analyse blood samples in just a few minutes while you wait in the doctor's surgery. Their optical biochip could allow the rapid determination of hereditary genetic disorders, bacteria and even unauthorised genetic modification of food supplies.

A group led by Dr Hans-Peter Lehr and Marketing Manager David Hradetzky at the Fraunhofer Institute have been working in this area since 1998 targeting the development of various rapid optical biochip readers. Dr Lehr discussed their hopes for the future with me and explained that currently about ten people in total are involved in this work. "Currently we are working with the fluorescent dyes Cy5, Cy3 and FITC," he revealed, "but the multi-colour reader," planned for the future, "can be adapted to any wavelength between 400-800nm".

Key DNA components linked to possible genetic problems, will fluoresce under intense illumination or irradiation and could be detected in this way. Weak levels of fluorescent radiation may be captured 'on-chip' in optical waveguides which allow these DNA fragments to be detected without more complex amplification processes. Their first reader (see Figure 4a) is a single fixed stimulation wavelength of 640nm, but a second reader is being developed that uses a white light source between 400-800nm. Because the 4 wavelengths can be chosen freely the detection system can be adjusted to specific

requirements. The complete kit with user interface is boxed up in Figure 4b.

The optical device uses a microscope slide glass and DNA material is added over a small area. Treated DNA samples in an aqueous solution are then sprayed onto the optical chip. Once inserted into the reader the attached dye molecules, irradiated with laser light, fluoresce at several characteristic wavelengths which a sensitive camera then detects.

The Biochip Reader detects and processes the information in a very short time, and is designed to be both user friendly, at low cost and with a sensitive lower detection limit. The practical clinical implications to the GP or doctor in hospital are clear. The doctor will be better able to meet laid down targets for seeing patients in a minimum duration of time, which is also a benefit from the patients' point of view, as they wait to hear what their problems are, or the results of any predictive screening.

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**New Superchip
Fabrication Plant
Co-operation**

Latest news from STMicroelectronics and Philips Semiconductors is that they are set to expand their existing

cooperation agreements by building a new pilot-line fabrication plant for deep-submicron CMOS production onto 12-inch wafers. As discussed in previous Research News on microelectronics there is a continual drive to smaller and smaller wafer features, which increasingly requires the cooperation of the existing players in the field, driven unsurprisingly by the cost of developing these new technologies. Individual companies are increasingly unable to meet these production line costs all on their own. Apparently Philips Semiconductors, an affiliate of Royal Philips Electronics (NYSE:PHG), and STMicroelectronics (NYSE:STM) will invest up to \$700 million to build together an advanced 12-inch (300mm) wafer pilot-line fabrication plant in Crolles, France.

This new agreement expands upon their existing technology cooperation agreements that has been in place between these two leading semiconductor companies since 1992.

By developing deep sub-micron semiconductor processes to 0.10 micron and below, this new 12-inch pilot line will keep both companies at the leading edge of semiconductor technology worldwide. The pilot line will be designed initially to produce up to 1,000 wafers per week, with the potential to increase up to 2,000 wafers per week. Site preparation and building of the pilot fabrication plant will commence this month, with the first 12-inch wafers expected to be processed in around two years time.

"STMicroelectronics has a long track record of successful cooperation in several areas of

activity with both customers, public research institutes and competitors, particularly in the frame of European R&D programs like Jessi and Medea," commented Pasquale Pistorio, President and Chief Executive Officer (CEO) of STMicroelectronics. "Our cooperation with Philips is an excellent example of the advantages of alliances in leading edge R&D activities: it has certainly contributed to the technological leadership position of both companies and has helped ST to gain new positions in the highly competitive semiconductor market."

The decision to build the new facility follows several years of highly successful cooperation between the two companies, which has already given both of them access to 0.18 micron logic CMOS technology and manufacturing at ST's existing wafer fabrication facility in Crolles, France. The new 12-inch pilot-line fabrication plant will also be located in Crolles, with each company having equal access to both its research and development and manufacturing capabilities. Both companies intend to develop shared CMOS processes at 0.12 micron, 0.10 micron and below. The cooperation will include advanced process technologies such as copper, low and high-k dielectrics, new transistor structures and other state-of-the-art process steps.

ST is already involved in a productive cooperation program with France Telecom R&D (formerly CNET) and with Leti (the research lab of the French Commissariat l'Energie Atomique - CEA). Philips will also contribute research results it obtains as a result of its recently agreed cooperation with IMEC of Louvain, Belgium.

For further information

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Further news of Philips latest research may be found at:
http://www.news.philips.com

Intelligent MACHINES

In this article David Clark examines how biomimetics and artificial intelligence are being used to make intelligent machines and systems.

Introduction

The new science of biomimetics is enabling engineers to develop materials and systems, based on the mechanisms of the natural world, that have an effectiveness and energy-efficiency previously unobtainable. A positive side effect is that this benefits all in terms of the potential for minimising the damage to the environment caused by the manufacturing and use of these commodities. The dramatic advances in the understanding of biological systems that have led to this have also made possible some new devices to add to the list of tools available to scientists to analyse both the natural and the man-made worlds. By using sensors that mimic the biochemical processes of living systems much greater sensitivity and accuracy is now available to monitor the environment and gauge the impact the industrial world is having upon it. These sensors also make possible more detailed study of the living systems from which they are copied - and this includes human biochemistry.

The development of these biosensors as they are called is being accompanied by the development of 'biomimicked' versions of the devices that appear at the 'other end' of

any system, biological or otherwise. These are the actuators, and the actuators of the natural world are the muscles. The effectiveness of borrowing from the natural world and making these powerful and efficient devices in smaller versions than has been possible in previous man-made efforts is opening up new areas for progress in two fields that might initially be thought unrelated - bionics and space exploration. Add to this the capabilities of 'smart' materials and the advances made in artificial intelligence during the latter part of the twentieth century, combine these into 'intelligent' machines and systems, and an exciting twenty-first century beckons.

This article looks at some of the techniques, devices and materials that exist in these fields right now.

Input

Any useful machine of course takes some input, processes it and produces some output. Electrical and electronic engineers have for many years used sensors for monitoring physical parameters, temperature and pressure being two of the most common. The particular transducer converts the input energy to an electrical

output, for example a thermocouple generates an electro-motive force between two wires of different metals due to the thermoelectric effect (see Figure 1).

Here there is usually no need to isolate the quantity being measured from the transducer. The temperature directly 'creates' an electro-motive force that can be measured. The relative straightforward monitoring of these physical parameters in conjunction with some 'intelligent' software is the basis of now routinely available engine management systems for instance.

However physical parameters are also vital in the biological world, information about pressure being particularly vital in allowing the human hand to gently and safely hold delicate things or tightly grip large or heavy objects. The sensation of hot and cold contributes to the prevention of the damage that can occur to biological materials and also gives further subtle information about the nature of an object being handled. Sensing of this type is something that has been lacking in previous attempts at not only artificial limbs but also remote arms for sampling in hazardous environments for example, nuclear materials being an obvious case in point. Perhaps a less obvious need for this sensing is in the tools that are being developed to allow 'remote surgery'. This will allow surgical procedures to be performed by 'robots', under the control of human operators of course, but operated and monitored via remote 'manipulators' and viewing devices passed through small incisions in the skin. This removes the need for major invasive surgery, reduces trauma and allows shorter recovery time with less scarring. The remote surgical instruments will ideally be operated via a glove-like device. The concept of wearing a glove fitted with transducers that translates movement to a remote mechanical 'hand' is no longer new and has seen use in several 'virtual reality' systems.

However, the requirements for Minimally Invasive Surgery as this technique is called are especially demanding (imagine trying to tie stitches inside the abdomen for example by remote control) and research is underway to develop devices with sufficient flexibility to make this possible. Other specialist systems are needed in conjunction with this, accurate three-dimensional imaging being especially important, but particularly relevant in a discussion about sensors is the development of tactile sensors that will transmit a sense of 'feeling' from a remote location. Devices are being developed at the Universities of California at Berkeley and San Francisco that incorporate an array of capacitive sensors that respond to force hence deformation and transmit information to a corresponding array of pneumatically operated pins to provide a related profile. A system with sensors fitted to a remote mechanical hand and actuators attached to the operator's corresponding fingers would give the closest approach yet to achieving something as remarkable as the human hand and wrist. (See Internet site <http://robotics.eecs.berkeley.edu/~mcenk/medical/>)

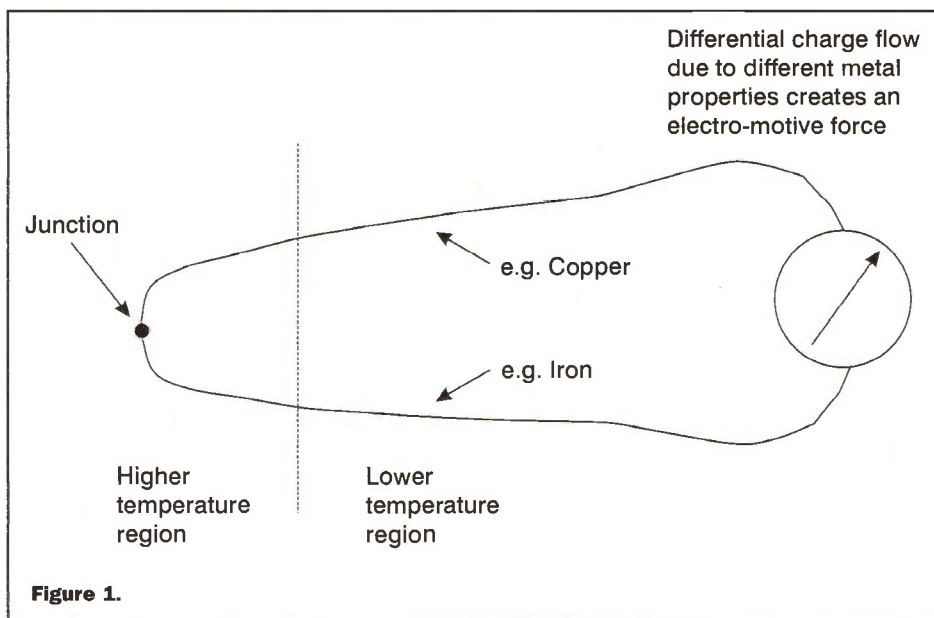


Figure 1.

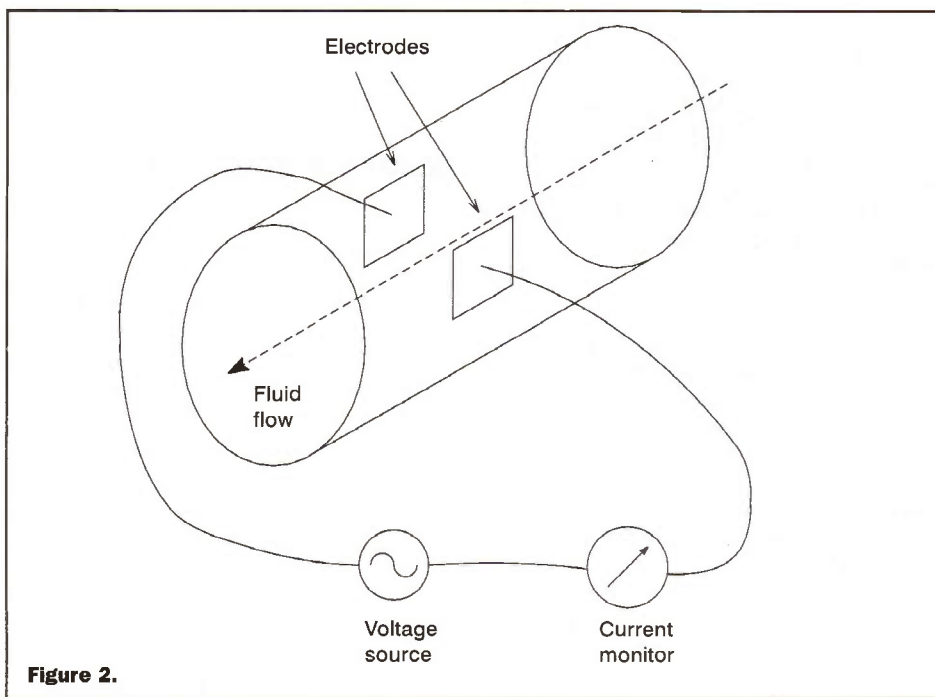


Figure 2.

Electrochemical Sensors

Chemical parameters have also been measured electrically for almost as long as physical parameters. Perhaps the simplest example of this is the case of electrical conductivity being used as a measure of the concentration of a chemical substance in solution (see Figure 2).

This has uses that vary from measurements of the effectiveness of water purification systems (absolutely pure water does not conduct electricity, it is the ions dissolved in it that conduct), through mapping of the oceans by means of the varying salinity of different regions and depths, to medical treatments. (Haemodialysis machines, employed in the treatment of kidney failure, use the electrical conductivity of the dialysing fluid to measure and control the concentration of the ions within the fluid in order that this matches the concentration of

the same ions in the blood). The determination of the acidity of a solution (which is measured in pH units) is also an electrochemical measurement - the acidity of a solution is directly related to the concentration of hydrogen ions in that solution. This measurement too has widespread use in industrial processes, laboratory measurements and again medical diagnoses. The rate at which many chemical processes occur (or even if they occur at all) is dependent on the pH of their environment, and this is particularly true of living systems. Blood pH for example is maintained at a value of 7.4 by the chemical reactions of the body and any variation from this causes severe symptoms and even death if uncorrected. For pH measurements the electrodes need to be isolated from the solution and the interaction occurs via for example a glass membrane - see Figure 3.

The glass membrane is permeable to hydrogen ions and so these ions can diffuse

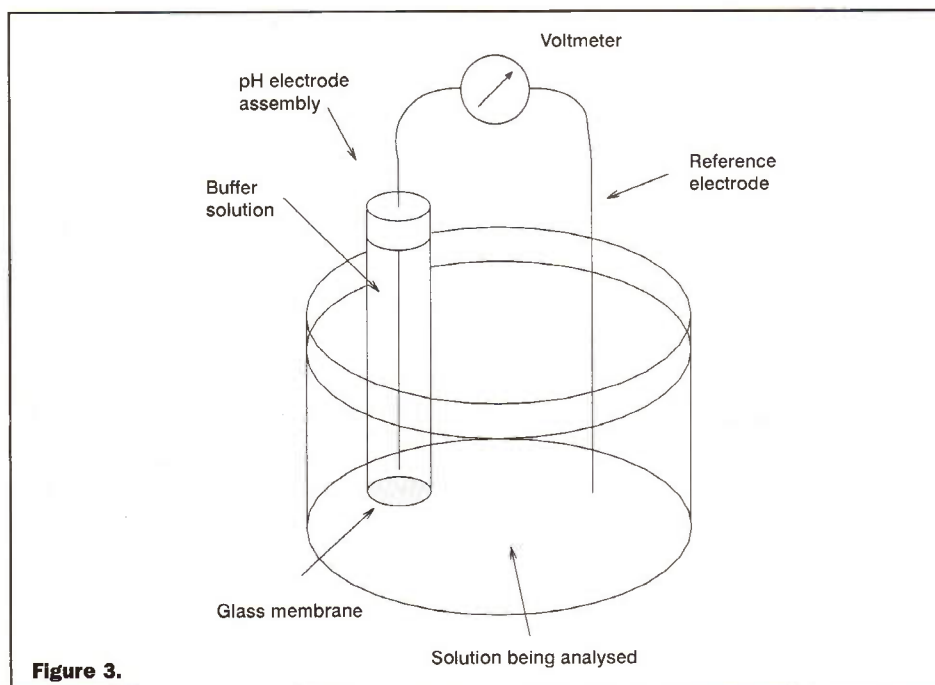


Figure 3.

into and out of the electrode assembly and cause a change in voltage between this electrode and another reference electrode. This type of sensor enables analysis for the presence of different types of ions as the electrodes can be designed to respond selectively to different ions. Other forms of ion selective electrodes available in addition to the permeable glass membrane ones include liquid-ion-exchange, solid-state ion-selective, and neutral-carrier ion-selective types. The liquid-ion-exchange types operate on the same principle as the ion-exchange water softeners often found in the laboratory and home in hard-water areas. In a water softener a 'soft' ion (usually sodium) bound to a resin substrate is exchanged with the 'hardness' ion (usually calcium) as it passes through the resin. In the ion-selective electrode however the ion-exchange material is in the form of a liquid held inside a membrane that is porous but repels water. The ion of interest passes through the membrane, is selectively exchanged, and the exchanged ion generates the electrical output from the internal electrode, which is sensitive to that ion. Solid state-ion selective types perhaps not surprisingly have a solid ion-permeable material acting as the membrane. The neutral-carrier type replaces the liquid ion-exchanger with a substance that selectively combines with the ion under analysis, and this is where the sensor action begins to come closer to that of the latest device in the development of transducers for monitoring biochemical processes - the biosensor.

Biosensors

Biosensors take advantage of the very specific activity of a biological component such as an enzyme, an antibody, a nucleic acid, a complete biological cell or even a complete micro-organism, to monitor the concentration or activity of a very specific substance. (See the box text on enzymes.)

The biological component is made to be in close contact with a transducer that uses the product of the biological component, usually hydrogen ions, electrons or electrical charge, to generate or control an electrical signal. The biological component is 'fixed' in a gel or 'behind' a permeable membrane. See Figure 5.

The by-product then causes a measurable electrical effect by a secondary process, for instance if the by-product were hydrogen ions then the transducer would be a pH electrode. In the case of electrical charge being the by-product the transducer might be a Field-Effect Transistor (FET) with the gate being in intimate contact with the biological agent so that it directly controls the current through the transistor. This highlights another aspect of biosensors - the increasing integration of biological agents with electronics. Furthermore electrical and electrochemical effects are not the only methods of linking the biosensor to its associated analytical system. The optical qualities of biological substances can also be exploited where they change when the substance reacts, as can temperature changes. Biosensors have enormous potential for analysis from a wide range of

Enzymes

Enzymes are the catalysts of the biological world, in other words they speed up reactions that otherwise would be very slow or not take place at all. As with physical and industrial catalysts, enzymes are unchanged at the end of the reaction that they facilitate and are ready to take part in the catalysis of yet more reactants. Unlike most physical catalysts though enzymes are extremely specific in which reactions they enhance, usually only catalysing a single reaction of a single substance. This is because their action is based on the physical shape of the protein molecule which makes up the enzyme (all enzymes are proteins) and the physical shape of the reacting molecule. This is often called the 'lock and key' hypothesis, and Figure 4 shows how this works.

Enzymes work by reducing the energy needed for a reaction to take place. A stable molecule has a certain 'energy level' associated with it as a result of all the bonds between the atoms within the molecule. If the molecule can break down into say two other molecules the sum of the energy levels associated with the 'product' molecules will be less than the original molecule. But there is an energy 'barrier', which is called the activation energy, that the molecule must overcome for the reaction to take place (otherwise the molecule would spontaneously break down anyway). When the enzyme and the molecule 'lock' together the energy associated with the bonding within molecule is reduced and bonds can be broken ie the reaction takes place. The products are then released and the enzyme is ready to catalyse the reaction of another molecule.

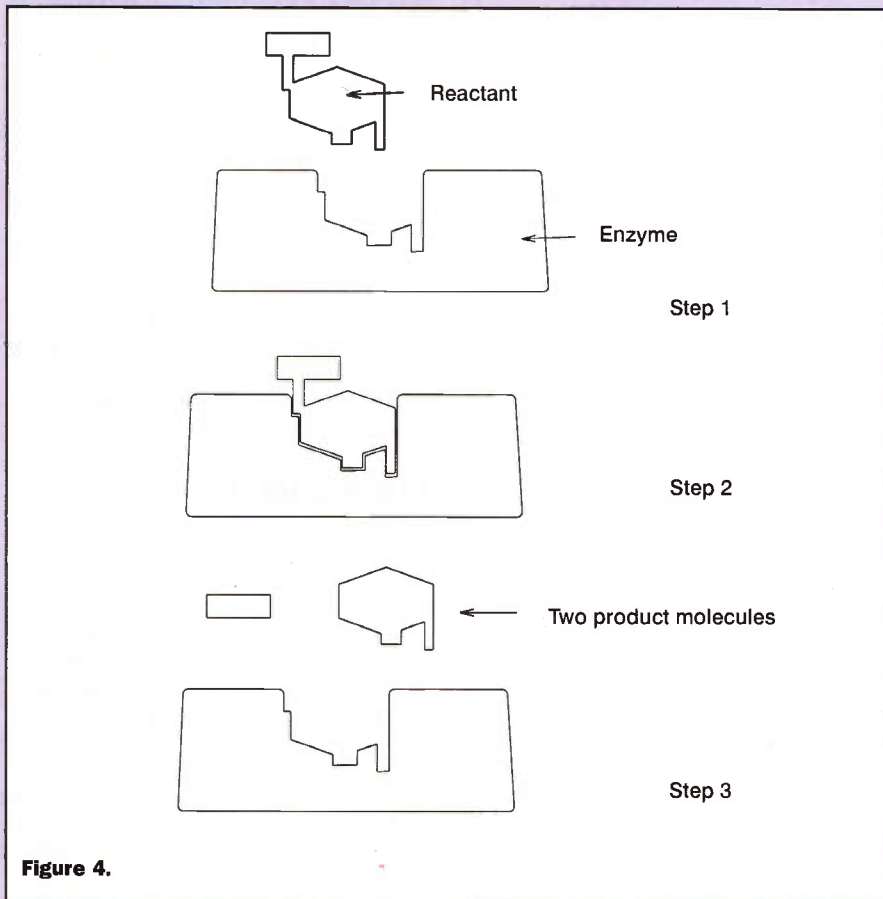


Figure 4.

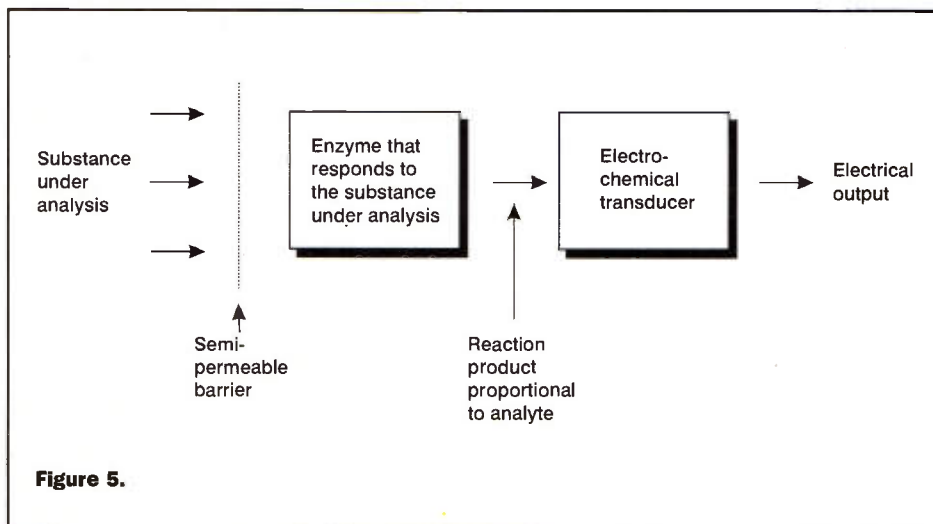


Figure 5.

substances in devices that are becoming increasingly miniaturised and capable of operating in increasingly remote and unattended locations.

Analysis Systems

As with other sensors, biosensors are used in two ways; in 'one-shot' measurements and in continuous monitoring. One-shot measurements are perhaps most frequently used in medical situations, for example a biosensor based on the enzyme glucose oxidase is at the heart of a hand-held device used to monitor blood sugar levels in diabetes sufferers. 'Throw-away' electrodes that measure up to sixteen substances, including glucose, lactate and urea, are increasingly being used in hospital critical-care and ward environments. Continuous monitoring electrodes are more frequently found in environmental monitoring situations for quantifying levels of hydrocarbons, halo-organic compounds and insecticides. (See

<http://www.cranfield.ac.uk/biotech/chinap.htm>)

Output

A fascinating area of development at the 'other end' of the system is the interest in the use of artificial muscles as actuators in place of motors. In many applications, and again the improvement of artificial limbs is a significant domain, the poor ratio of power to size, weight and energy consumption of motors plus gears and hydraulic systems is a major drawback. In another triumph for biomimetics, science is again looking to copy nature to obtain improved performance in this area by employing artificial muscles. The improved characteristics of these are also of great interest to those involved in the sending of remote explorers into space and onto the surface of planets, their moons and in the near future asteroids.

One example of an artificial muscle is in fact extremely simple in principle. It consists of two electrodes separated by a compressible polymer film or polymer hydrogel, a structure known as an Electroactive Polymer (EAP). See Figure 6.

When voltage is applied to the electrodes the electrostatic forces of attraction cause the electrodes to move towards each other, squeezing the polymer outwards in all directions. When the voltage is removed the polymer automatically regains its original dimensions. The electrodes too are made of a flexible material and by rolling and folding the structure into a cylinder a linear actuator can be obtained. Interestingly this action mimics the behaviour of simple creatures that have soft bodies of fixed volume. Circular muscles around the body cause the body to thin and elongate when activated and when relaxed the body assumes its normal dimensions. In these creatures this allows simple movement. See Figure 7.

A more 'state-of-the-art' material being looked at, as a possibility for use in artificial muscles, is a carbon 'nanotube' based type. This material consists of 'cylinders' of carbon molecules only a nanometre in diameter that expand under the influence of

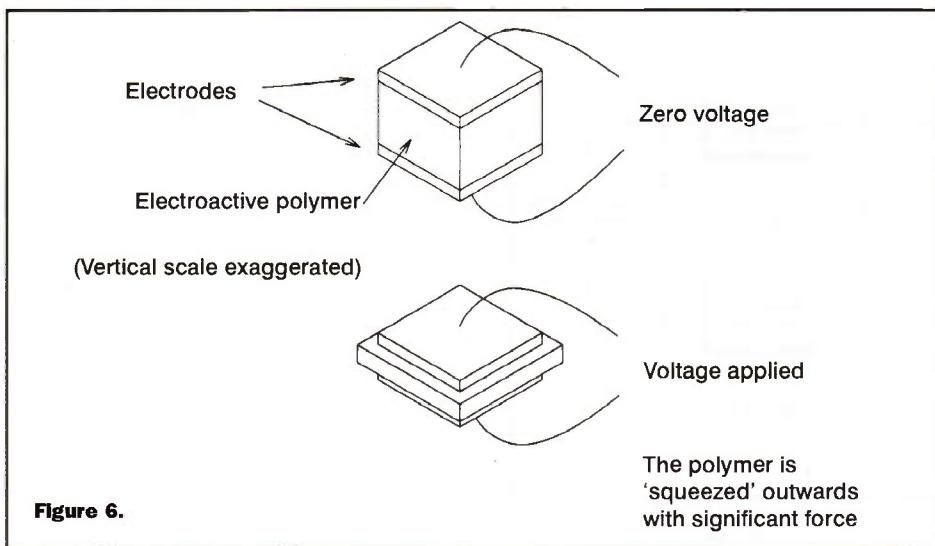


Figure 6.

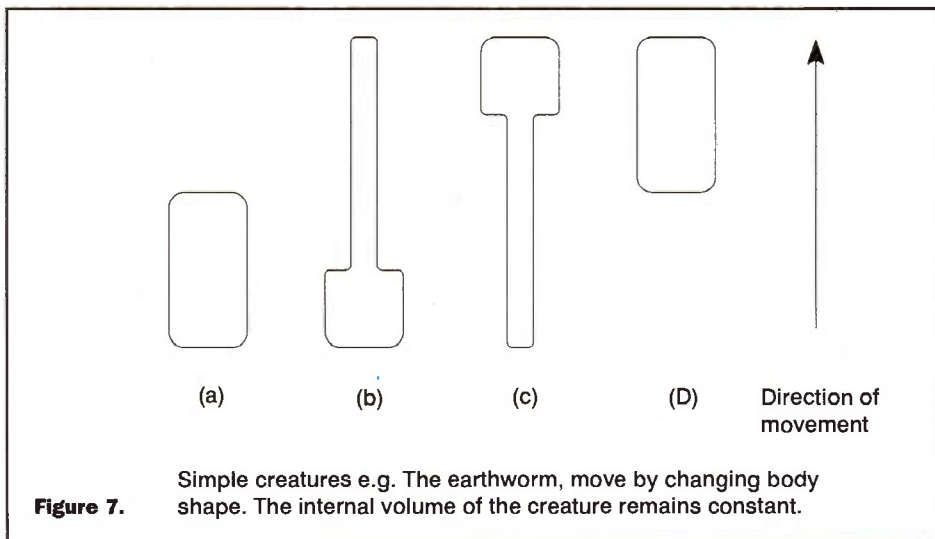


Figure 7.

Simple creatures e.g. The earthworm, move by changing body shape. The internal volume of the creature remains constant.

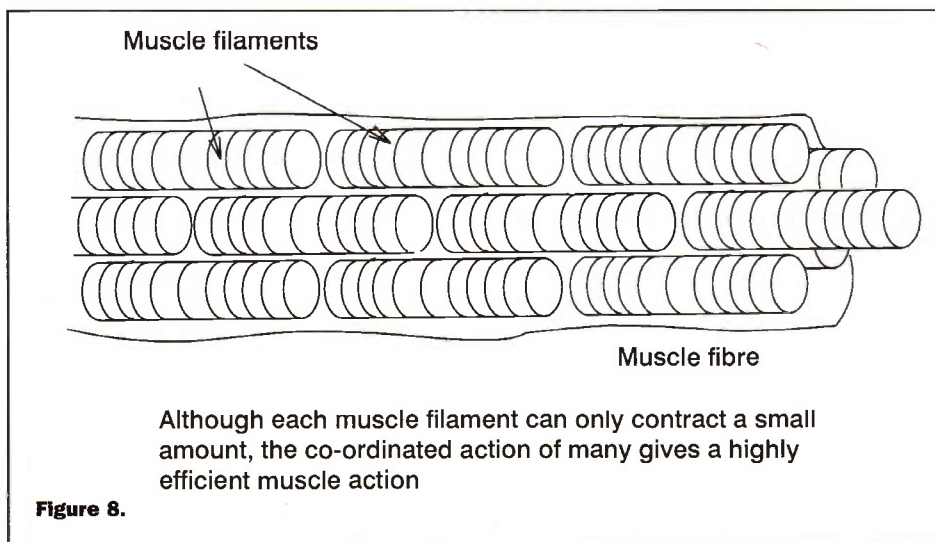


Figure 8.

Although each muscle filament can only contract a small amount, the co-ordinated action of many gives a highly efficient muscle action

an electric charge and contract when it is removed (BBC News Online May 20 1999). Although the expansion is only by around 1%, if the nanotubes could be formed with a higher degree of organisation they could perhaps be made to behave like human muscle. The phenomenal contraction and strength of the human muscle is a consequence of the behaviour of the innumerable muscle molecule filaments around $1\mu\text{m}$ in diameter of which it consists. Although each filament only changes in size by a very small amount

when the molecule changes shape, they are all highly organised within the muscle and act in a co-ordinated manner when the muscle is stimulated by its nerve cell. See Figure 8. This gives the highly effective action so envied by engineers.

Processing

It is perhaps the processing that goes on between the input and output that will make the most dramatic contribution to the developments in bionics and space

exploration. For example one of the characteristics of artificial intelligence is its ability to 'learn' by experience. In machines or robots for exploration this might mean that the device could learn to find its way around an unmapped terrain. In artificial limb research, investigation is underway into using artificial intelligence to turn around completely the conventional approach in which the user has to learn to control the upper arm muscles in order to cause tiny (microvolt) signals to appear on the skin surface as a consequence of muscle activity. Electrodes pick up these signals and are used to trigger motors and gear systems in the replacement limb. For the artificial intelligence approach the limb would 'learn' what the user wanted to do and use the muscle voltage signals detected on the skin surface accordingly, directing the signals to the appropriate actuator. It can easily be seen how this is a much more natural approach, in some ways mimicking how a infant learns to use its new limbs by a sophisticated trial and error routine.

Even the seemingly most simple tasks can benefit from the inclusion of a degree of artificial intelligence - detectors that can learn to recognise defective products on a production line for example through pattern recognition techniques, or machines that can find their own way around a factory, transporting materials. The ultimate processing goal will be to develop devices that exhibit autonomous behaviour. These devices will not only learn from their 'experiences' but will also be able to react to unknown and expected situations. Exploration of the further reaches of the solar system will require just such systems.

Smart Homes

Slightly more commonplace intelligent systems are the 'house management' systems that monitor environmental conditions. In conjunction with 'smart materials' that can automatically change properties with their changing environment these will make future housing more comfortable yet also more energy efficient. Perhaps the simplest material that qualifies as 'smart' is photochromatic glass that becomes darker the more intense the light to which it is exposed. However, automated systems and networking within the home will allow better control over heating and ventilation, power load and domestic appliance control, for example, and this becomes more and more effective as greater levels of 'intelligence' are included with the system. This will range from straightforward timing operations to computer controlled systems that incorporate artificial intelligence and 'learn' the habits, requirements and lifestyles of the home's inhabitants. Entertainment of course is a growth area particularly with the rise in digital services, and 'intelligent' systems can for example learn viewing habits and monitor upcoming TV programs and hence advise or even automatically set a video recorder to record favourite programmes or programmes on a particular theme of interest. 'Cutting edge' (and inevitably controversial) architects have even designed homes that take biomimicry almost to the limit. One example is a home

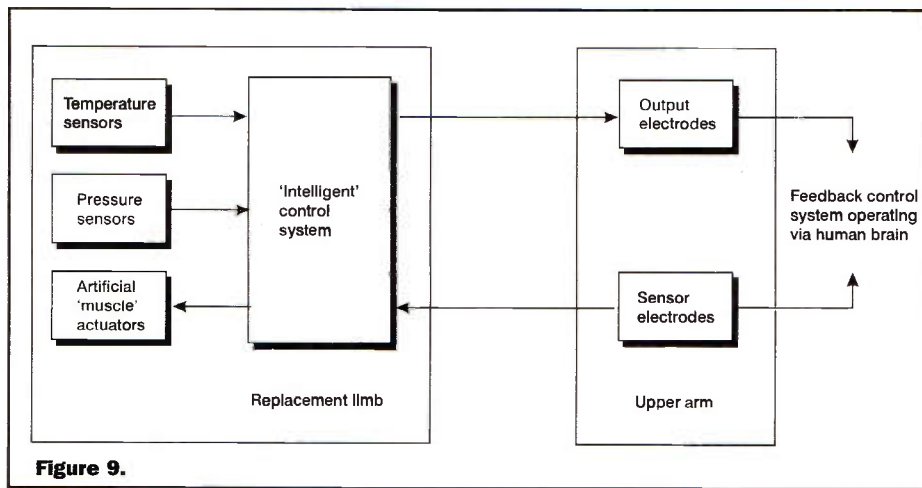


Figure 9.

built around rooms having the form of the chambers of the shell of the sea-creature the nautilus, and ventilation openings based on dragonfly wings (see http://www.stephensonstrategies.com/tips/product_marketing_tips/evolutionary_architecture.html).

Bionics

As already mentioned, of particular importance here is the development of replacement limbs, and a particularly complex function is that of the hand, a beautifully delicate yet complex and sophisticated tool capable of a huge range of tasks, sensations and movement. The hand has forty-four muscles and twenty-seven bones and even state-of-the-art technology cannot yet come remotely close to matching its performance. Future progress may rely on alternatives such as tissue engineering where cells, tissues, bones and even complete structures can be 'grown' in 'bio-reactors'. Artificial muscles may provide part of the answer eventually but as yet, although they can provide equivalent speed and force to living muscle, they cannot match the natural muscle's ability to contract to around 50% of its relaxed length. At the moment artificial muscles can only achieve a change in dimension of around 10%. Nevertheless electro-mechanical devices can provide a great deal. As seen they can be operated from the voltages that appear on the surface of the upper arm due to muscle activity, and as with the Minimal Invasive Surgery robot devices, pressure and temperature sensors can be added to the tips of the 'fingers' and 'thumb'. These generate signals that can be manipulated by a small computer system also contained within the limb to give voltages that appear on electrodes also on the upper arm that stimulate nerves to give the sensation of pressure and heat and cold. This completes the feedback system that allows to some degree the sensitivity of grip and sensation of the living limb. (See Figure 9).

Space Exploration

An interesting space exploration project under development is the Nanorover. This is a small (the prototype is around 20 cm long) four-wheeled device designed to operate on low gravity bodies such as

asteroids. It will carry two scientific instruments - a camera capable of 'seeing' in several frequency ranges (including visible light) and a spectrometer for analysing the material in its field of view. It has four wheels each at the end of a strut, and all the wheels and struts are independently operable.

This allows the rover to cope with its positioning needs (i.e. to point its scientific instruments at mineral samples, to keep the centre of gravity low for climbing slopes, and to cope with accidentally flipping over - see Figure 10).

A relevant detail about the control of the rover is that there is a 'low-level' system for the motion control that autonomously deals with controlling the actions of the wheels and struts following high level commands from a remote operator. This demonstrates the latest approach to 'intelligent' robotic systems. There is a 'hierarchy' of function that albeit in a very simple way mimics a living system with a brain in that the lower levels quietly get on with the job of co-ordinating muscles and so on while the higher levels deal with vision for instance, and decision-making. (Detail about the Nanorover can be found at http://robotics.jpl.nasa.gov/tasks/nrorover/nrt_main.html) A further interesting point is that the Nanorover was intended to carry a wiper arm (used to clean the lenses of the scientific cameras) operated by an electroactive polymer 'muscle'. However it

appears that even this lightweight actuator has been abandoned due to weight restrictions. (See <http://eis.jpl.nasa.gov/ndeaa/nasande/lommas/aa-hp.htm>)

The rover for the planned visit to Jupiter's moon Europa will require much more in the way of autonomy, intelligence and decision-making ability than this however. It is generally believed that if there is life anywhere in the solar system it is likely to be in an aqueous environment such as that thought to be present under a layer of ice on Europa. A rover sent in search of this life, having been landed on the icy surface, will need to cut or melt its way through the ice to the ocean below. Isolated from even the delayed contact possible between Europa and the rover's controllers on Earth, it will then need to become a submarine. Using sensors to detect heat and minerals and perhaps organic substances it will need to find its own way to possibly an underwater geyser there - the likely energy source for any such alien life, avoiding extremes of heat and pressure - to find who knows what?

Conclusion

During the last century the disciplines of engineering and life sciences were seen as almost mutually exclusive, except in a few specialised areas of medical research. Under the umbrella titles of biomimetics and artificial life these fields are now working together in a way that should provide enormous benefit both in terms of what is possible and the effectiveness and efficiency of the processes.

Ultimately this might include the possibility of routinely incorporating these devices into the human body for replacement or even improvement of normal body function. Less attractively perhaps these might be the first steps towards the distant future realisation of that much used and abused stalwart of science fiction and fantasy the android. Wherever it leads, and some argue it is not the job of science to worry about where its discoveries might end, this is a fascinating area of much groundbreaking scientific work.

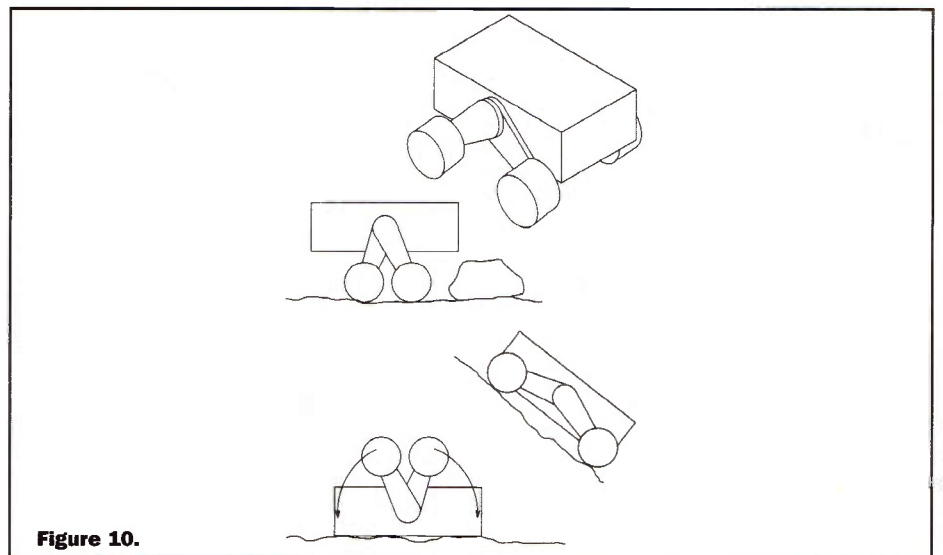
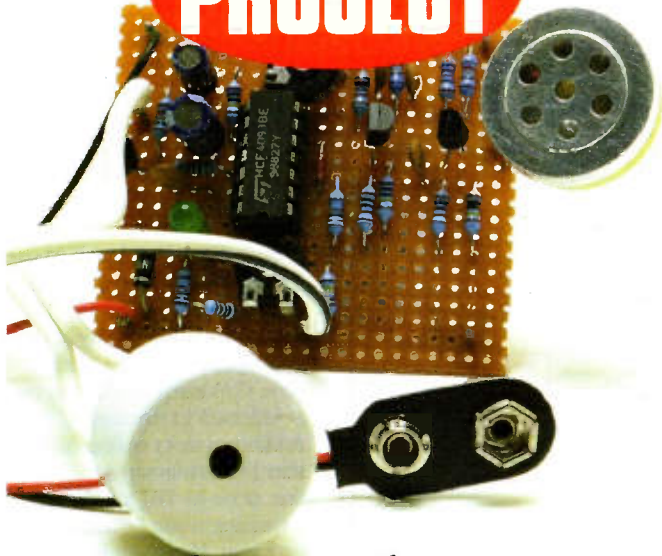


Figure 10.

PROJECT



Telephone ALERT

Gavin Cheeseman describes a versatile 'add-on' to your telephone that lets you know the telephone is ringing when you're in the garden..

Introduction

The idea for this project came when working out in the garden during a recent spell of warm weather. I thought, it would be possible to hear the telephone ringing from the garden even though it was at the other end of the house. Of course, I didn't allow for the cacophony of noise from passing cars, aircraft, lawnmowers, wildlife etc present in the suburban environment. In the dead of

night, the sound of my telephone ringing in the house would be as clear as a bell from the garden (pardon the pun) but at any other time, hearing the phone is almost impossible. As a result, I later found I had missed a number of important calls. The simple project described in this article is designed to detect the sound of a telephone ringing, switching on a remotely wired buzzer. The circuit also provides an optical indication.

There are several ways to detect the ringing sound from a telephone. Of course you could use a microphone and a simple audio amplifier to pipe the sound of your telephone around the house but unless carefully arranged, such an arrangement could also relay conversations in the room where the phone is located for everyone to hear. Also, the quiescent current drain of an audio amplifier can be relatively high calling for the provision of a fixed power supply. For these reasons, the use of a buzzer controlled by the sound of the telephone is probably a more suitable option.

In order to trigger the buzzer, it is necessary to detect the ringing sound of the telephone whilst, so far as possible, filtering out other sounds in the ambient environment. A phase locked loop may be used. This responds to frequencies within a limited range. The phase locked loop is tuned to respond to the frequency produced when the telephone rings. Sounds at other frequencies are ignored. This system can be quite effective when correctly set up but does have its problems. Of course, with the wide range of different telephones available these days there can be considerable variation in the type and frequency of the ringing sound produced. One point that may not be immediately obvious is that the ringing sound often consists of more than one frequency and may not be continuous. This can complicate circuit design considerably.

Another way to approach the problem is to use a circuit that switches on the buzzer when the sound level exceeds a specific value. This can work quite well if the detector circuit is placed in close proximity to the telephone and is not too sensitive. Excess sensitivity results in the buzzer sounding when other loud noises are detected in the room. The design described here is based

on this concept with some additional circuitry to reduce the degree of false triggering.

Figure 1 shows the block diagram. Sounds picked up by a microphone are initially amplified and fed to a voltage level detector. When the sound level exceeds a specific value, the output of the circuit momentarily changes state. The arrangement is such that in standby condition, the circuit will only respond to sounds that exceed the switching threshold for a given time. Shorter, transient high level sounds are ignored. The sound of the telephone ringing is long enough to activate the circuit. Once activated the output switches state in time with the telephone ringing. A simple transistor switch is used to drive the output buzzer. One small drawback of using this type of circuit is that it does not respond to the first ring but in practice this does not usually present a problem.

Circuit description

The circuit is effectively a mixture of analogue and digital technologies. The circuit diagram is shown in Figure 2. The power supply is connected between terminals P1 (+V) and P2 (0V). Capacitor C6 helps to de-couple any high frequency noise from the power supply rail and C8 provides a degree of filtering close to the output switching stage. Ambient sounds are detected by a crystal microphone connected between terminals P3 and P4. A crystal microphone was chosen as it provides a relatively high output level into a high impedance. The signal from the microphone is amplified by a two-stage transistor amplifier comprising Darlington transistors TR1 and TR2. The Darlington transistor is well suited to low current operation, as it only requires a relatively small base current when compared to a single bipolar transistor. It can be

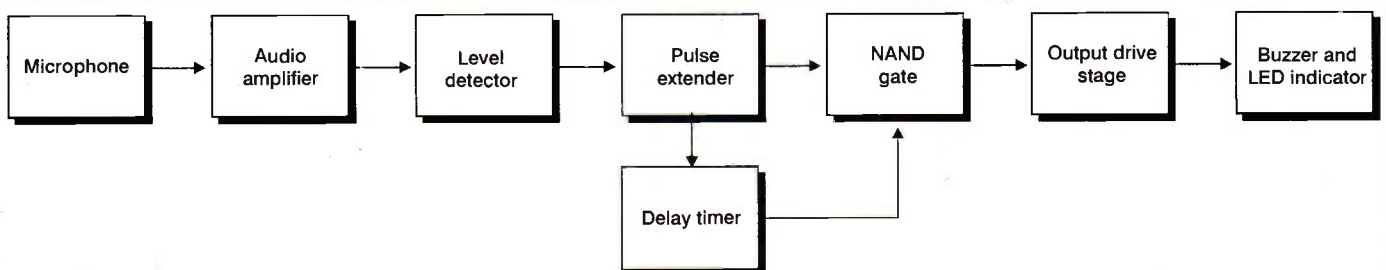


Figure 1. Simplified block diagram.

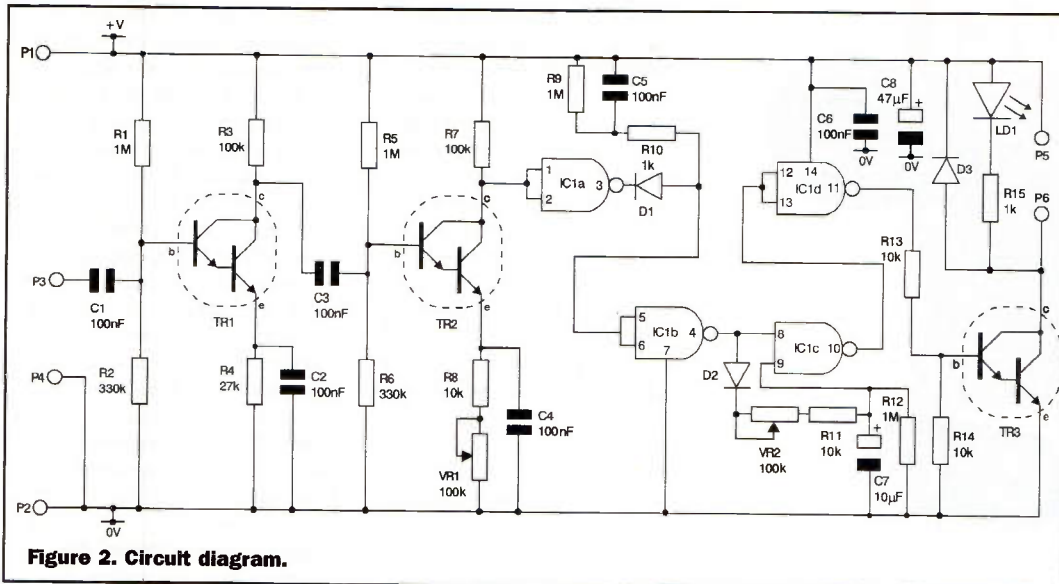


Figure 2. Circuit diagram.

seen that both stages are somewhat similar. Resistors R1, 2, 5 and 6 are bias resistors. Interstage coupling is performed by capacitor C3. Variable resistor VR1 allows the quiescent DC level at the collector of TR2 to be adjusted affecting the final sensitivity of the circuit. The amplified audio signal is fed to the input of IC1a, a quad 2 input Schmitt NAND gate IC. This device operates in the same way as a standard NAND gate but features a degree of hysteresis. As a result, the switching action is clean and predictable. In normal operation, the DC level at the input of IC1a sits below the switching threshold of the IC and only traverses above the threshold when a high level audio signal is present. Consequently, the output at IC1 pin 3 remains in a logic high condition when no sound is present. D1, R9, R10 and C5 form a simple 'charge pump' circuit. This acts as a kind of pulse extender. If a sound of sufficient volume is detected by the microphone, the level at the input of IC1a rises above the switching threshold on audio peaks resulting in pin 3 momentarily switching low. When pin 3 switches low, diode D1 is forward biased rapidly charging C5. In between audio peaks the output of IC1a switches back to the logic high state. This reverse biases D1, preventing C5 from discharging via IC1a. The capacitor still discharges but at a slower rate via R9. The output of the charge pump circuit is connected to IC1b. As with IC1a the inputs of the gate are connected together forming a simple Schmitt inverter. The high impedance inputs of the CMOS device are ideal as they present

very little load on the preceding circuit. The output of IC1b is connected directly to one input of IC1c (pin 8) and also to a second charge pump circuit comprising D2, VR2, R11, R12 and C7. The output of the charge pump is connected to the other input of IC1c on pin 9. The time taken to charge capacitor C7 is controlled by VR2. It is important to note that although the configuration of the charge pump circuits are similar, the charge and discharge times of the second circuit are considerably longer. Because IC1c is a NAND gate, pin 10 will only switch to logic low when both inputs are in a logic high condition. High level sounds of short duration such as a hand clap result in IC1 pin 4 momentarily switching high; however, if the duration is not long enough to charge C7 to the appropriate switching threshold, the output of IC1c will remain high. Sounds of a duration long enough to charge C7 to a voltage exceeding the switching threshold result in a low condition on IC1 pin 10. The output remains in this state as long as both of the gate inputs are high. Once charged, C7 holds IC1 pin 9 above the switching threshold for some time after IC1 pin 4 has switched low whereas the level on IC1 pin 8 changes immediately. The overall result is that after the initial period, during which C7 is charging, IC1 pin 10 will switch low with every ring of the telephone. In this state the circuit will also respond to a host of other sounds but this is not generally a problem unless the telephone is sited in a very noisy environment. After the phone stops ringing C7 slowly discharges to a level below the switching threshold of the IC.

The output of IC1d is an inverted version of that at IC1c. This results in a high transition on IC1 pin 11 when a telephone ring is detected. The output at pin 11 drives output-switching transistor TR3 and this in turn drives LD1 and any suitable load connected between terminals P5 and P6 (usually a buzzer).

Construction

The circuit may be constructed on matrix board, printed circuit board or any other suitable medium. Although layout is not generally a problem, it should be borne in mind that the transistor amplifier stages exhibit relatively high gain, so

the usual rules for laying out audio circuits should be adhered to. Although the audio output is not intended to be listened to, noise pick-up can still present a problem as it can result in continuous false triggering of the circuit. Therefore all wiring runs should be kept as short as possible. It is probably a good idea to use separate supply leads for the analogue and digital sections of the circuit joining only at the appropriate supply terminal pins. Capacitor C6 should be positioned in the area of IC1. Additional de-coupling capacitors may be connected to the supply line close to TR1 and TR2 if switching noise becomes a problem. However, in most cases this will probably not be necessary. A crystal microphone is used to detect the sound of the telephone ringing. It is recommended that the microphone is connected directly to terminals P3 (signal) and P4 (microphone case) and is not extended. It is better to extend the lead to the output buzzer than extend the microphone lead, as the latter will inevitably result in unwanted noise pickup unless extreme care is taken.

Take care to connect all components correctly when constructing the circuit. This is particularly important with polarised components such as TR1-3, IC1, D1-3, C7 and C8.

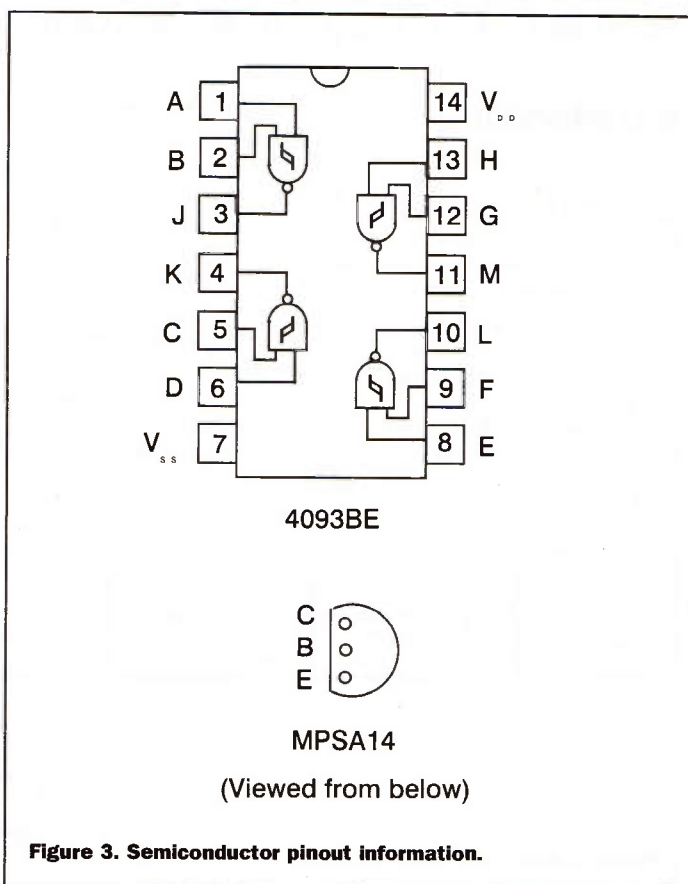


Figure 3. Semiconductor pinout information.

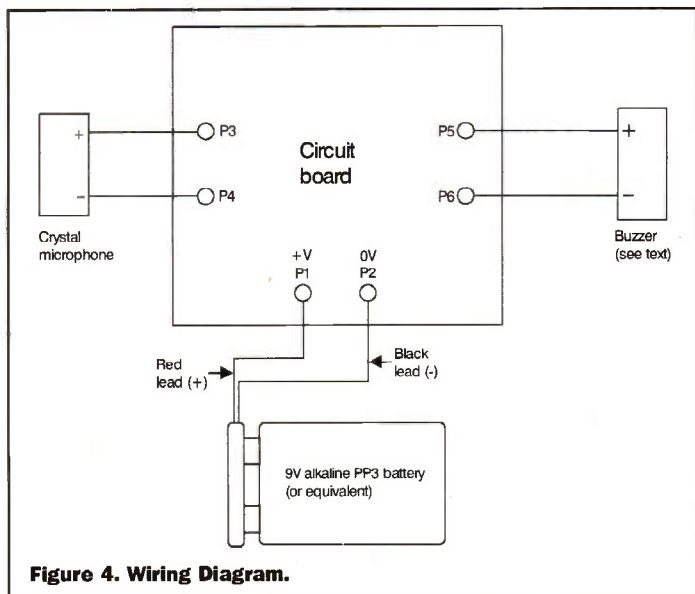


Figure 4. Wiring Diagram.

Incorrect connection of the components will result in faulty operation of the circuit and some components such as the electrolytic capacitors may even explode! Figure 3 shows semiconductor pinout information. The polarity of electrolytic capacitors is usually indicated by markings on the side of the capacitor case. Often a negative (-) symbol will be shown adjacent to the negative lead which is also usually shorter than the positive lead. If you are unsure, always double check before applying power to the circuit. A suitable DIL socket should be used for IC1 and the IC should not be inserted until all other construction is complete. CMOS IC's are prone to static damage and the relevant handling precautions should be taken. Static damage is often insidious and may not result in immediate failure.

In addition to the components shown on the circuit diagram there are also off-board components. It is recommended that suitable terminal pins are used to connect off-board components to the circuit board as direct connections may result in excessive strain on the component leads. Figure 4 shows the wiring diagram for the circuit. Light emitting diode LD1 may also be mounted off board if required. Do not use a longer lead than is necessary as this may couple unnecessary noise onto the supply rail. The use of very long leads for the output connections (exceeding a few metres) is not recommended. The buzzer should not be mounted in close proximity to the microphone. If the microphone picks up the sound of the buzzer at high level the circuit will tend to latch up.

Unless you are sure where you want to finally position the buzzer, it is probably best to make a temporary connection using a couple of metres of hook-up or loudspeaker wire to allow the circuit to be tested. In fact the basic operation of the circuit can be tested using just the LED if required. Take care to observe the correct polarity when connecting the buzzer.

The battery clip is soldered to terminals P1 (red lead) and P2 (black lead). Please ensure that the correct polarity is observed as reverse connection of the power supply may result in irreparable damage to the circuit. Do not connect the battery until you are ready to test the unit.

Testing

The circuit is relatively simple to test and no special equipment is required to complete the basic procedure. If available, it may be useful to connect a multimeter set to read current in series with the positive battery lead, to allow current levels to be monitored. Similarly if you have access to an oscilloscope, you can check the correct operation of each stage of the circuit. It is sensible to use a x10 oscilloscope probe as some parts of the circuit are very high impedance and are easily loaded. If you do not have access to the above equipment, this is not a problem. The general operation of the circuit can be checked without any test gear.

Before applying power to the circuit double check your work to ensure that all components are correctly connected. Pay particular attention to the soldering, looking out for any dry joints or solder short

circuits. When you are happy that everything appears OK, set VR1 to the minimum resistance position and VR2 to maximum resistance. Connect a suitable alkaline 9V PP3 type battery to the battery clip. In standby condition, the supply current should not exceed a few hundred microamps. If the output buzzer is connected, make sure that it is positioned as far away from the circuit board and microphone as possible. If you have not connected the buzzer, LD1 can be used to indicate the output state of the circuit (a quieter option). Clap your hands once, loudly within a few cm of the microphone (do not touch the microphone as this may result in the circuit picking up mains hum). The circuit should not respond. LD1 and the buzzer should remain off. If you whistle into the microphone or make other sounds of longer duration this should trigger the circuit. Once the circuit has been triggered, it should respond almost instantly to any high level sound in close proximity. Allow a few seconds of silence for the circuit to reset and try the same test a second time. Once again the circuit should become insensitive to single short duration sounds such as a hand clap but sounds of longer duration should switch on LD1 and the buzzer. General background noise in the room, unless very loud, should not trigger the circuit.

Adjusting VR1 should change the effective sensitivity of the unit. Monitoring the quiescent voltage level at the collector of TR2, clearly shows the effect of varying the preset control. As the resistance of VR1 is increased, the DC voltage level at the transistor's collector also increases. As a result the circuit responds to lower level audio signals until, past a certain point, the output circuit is

permanently switched on. It should be noted that although adjusting VR1 creates the effect of varying the sensitivity of the unit, the gain of the transistor stage is comparatively unchanged at high frequencies. This is because the emitter resistance is effectively bypassed by capacitor C4. In practice, the effect of varying VR1 on sensitivity is relatively subtle.

The setting of VR2 determines the delay time before the circuit will respond to a telephone ringing. The preset resistor controls the time taken to charge C7. Setting VR2 to a lower resistance position will result in the circuit responding more quickly. However, in practice this will also make the unit more prone to false triggering particularly in a noisier environment. Conversely, setting VR2 to maximum resistance means that the circuit may miss the first couple of rings. The most appropriate setting is probably best determined empirically.

Check the operation of the circuit with the controls set to various positions to ensure that they produce the appropriate effect. Once testing is complete the circuit may be installed into a suitable housing. Almost any suitable plastic case may be used. Holes should be drilled for external wiring and close to the position of the microphone to allow sound to enter.

Using the Telephone Alert

How and where the circuit is used is very much dictated by individual circumstances. The housed circuit board together with the attached microphone needs to be positioned as close as possible to, but not in contact with the telephone so that the sound of the telephone

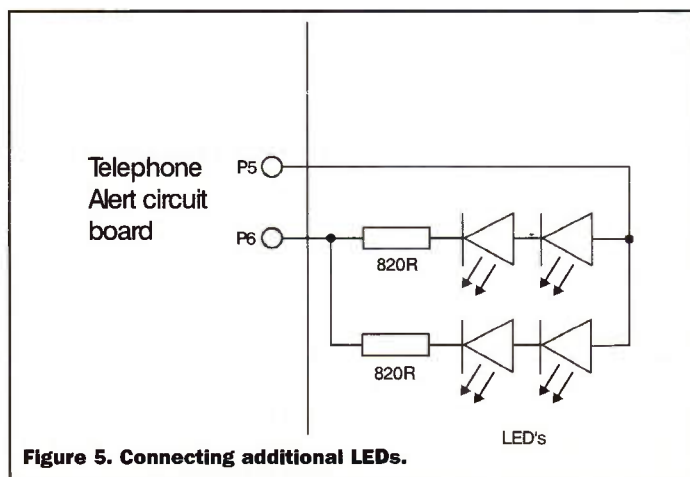


Figure 5. Connecting additional LEDs.

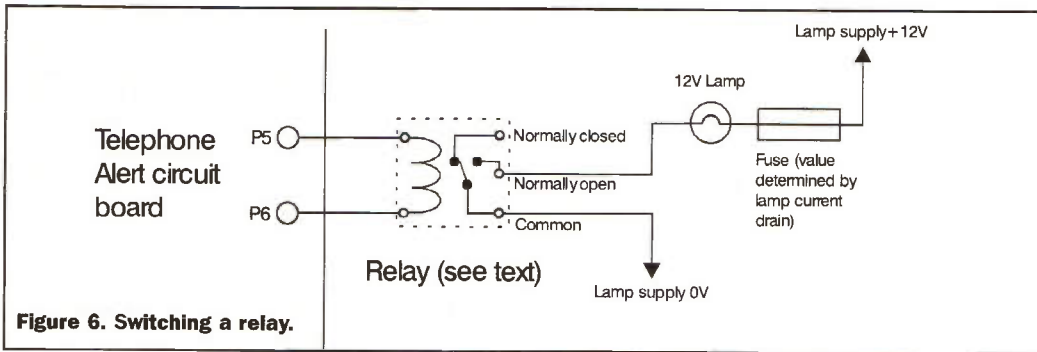


Figure 6. Switching a relay.

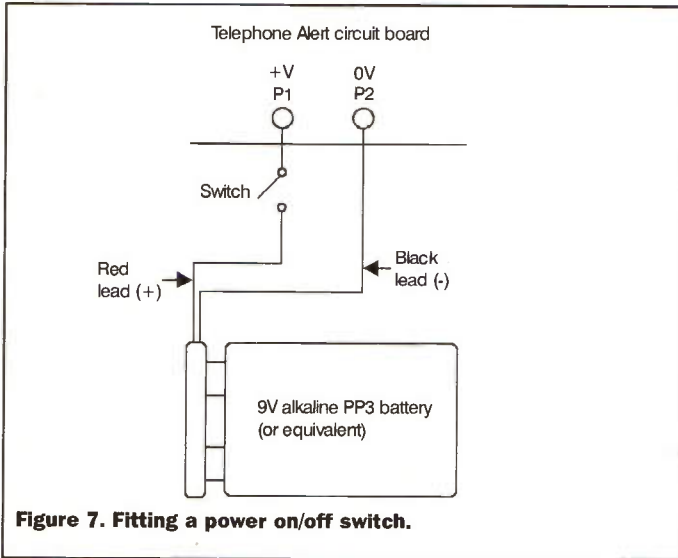


Figure 7. Fitting a power on/off switch.

ringing is as loud as possible. It is best if the telephone is loud enough to trigger the circuit when it is adjusted to the most insensitive setting as this helps to minimise unwanted false triggering. The buzzer would normally be wired off to a remote location (another room, garden shed etc). It should be pointed out that the buzzer is not waterproof and so should not be mounted in a location where it is likely to be exposed to the elements.

If required, a number of LED's may be connected to create a more visible optical indication. This may be useful in noisy situations where it is not possible to hear the buzzer; for example when operating power tools, wearing headphones etc. Figure 5 shows an example of how to connect additional LEDs. Low current LEDs provide good performance.

The output may also be used to switch other small loads such as a suitable relay. An example of how to do this is shown in Figure 6 for reference although in practice arrangements may vary. It is recommended that the output (coil) current is limited to 100mA maximum to avoid damage to TR3. The relay may then be used to switch a

higher current load such as a light bulb. A separate supply would be required for the load connected to the relay contacts and suitable fusing must be used. For safety reasons it is recommended that only low voltage supplies (less than 50V) are switched via the relay contacts using this arrangement. In the example 12V DC is used.

Battery life varies depending how often the circuit is triggered. The battery will last longer in an environment where the phone rings only occasionally. Connecting additional loads to the output will tend to reduce battery life. If necessary, a power on/off switch may be connected in series with the positive battery lead to allow the unit to be switched off when it is not needed. Figure 7 shows how to fit an on/off switch.

False triggering

In most cases the unit should perform well without any problem. However, because of the simplicity of the circuit, false triggering may be experienced under some conditions. Loud noises other than the telephone may sometimes trigger the unit. The occasional beep sound from the buzzer is not

generally a problem as the repetitive ringing sound of the telephone is clearly recognisable. Longer beeps may, however be annoying. It may be useful to increase the delay before the circuit responds by increasing the value of R11. Removing C2 should reduce the gain of the input circuit at audio frequencies making it less sensitive. However it should be pointed

out that if the background noise in the room where the telephone is located is continuously louder than the phone, the circuit will simply latch on permanently.

The circuit may also be false triggered by strong RF fields and in some cases it may be necessary to add additional filter components or screening to the unit to prevent this. Radio frequencies are typically be picked up on external leads. The problem can be reduced using simple ferrite choke or bead arrangements as illustrated in Figure 8. The output leads are shown in the diagram but a similar arrangement can be used on the other external leads if required.

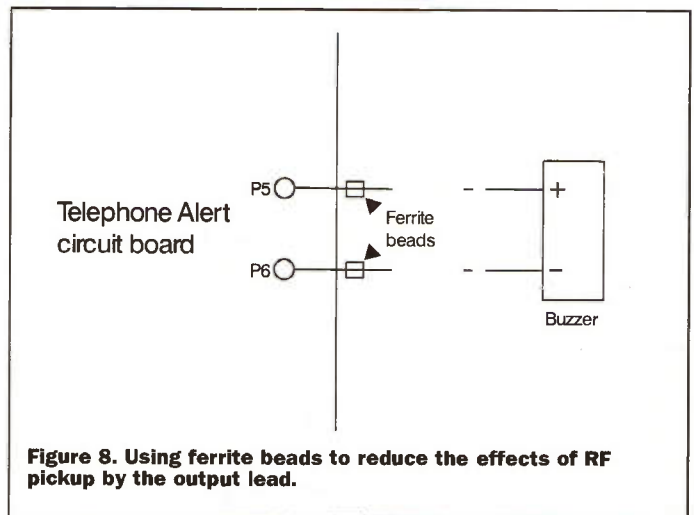


Figure 8. Using ferrite beads to reduce the effects of RF pickup by the output lead.

PROJECT PARTS LIST

RESISTORS: All 0.5W 5% Metal Film (Unless Stated)

R1, 5, 9, 12	1M	4	M1M
R2, 6	330k	2	M330K
R3, 7	100k	2	M100K
R4	27k	1	M27K
R8, 11, 13, 14	10k	4	M10K
R10, 15	1k	2	M1K
VR1, 2	Hor Encl Preset 100k	2	UH06G

CAPACITORS

C1-6	Minidisc 0.1µF 16V	6	YR75S
C7	GenElect 10µF 63V	1	AT77J
C8	GenElect 47µF16V	1	AT39N

SEMICONDUCTORS

D1, 2	1N4148	2	QL80B
D3	1N4002	1	QL74R
TR1-3	MPSA14	3	QH60Q
IC1	4093BE	1	QW53H
LD1	LED Green	1	WL28F

MISCELLANEOUS

DIL Socket 14-Pin	1	BL18U
Pin 2145	6 Pins	FL24B
PP3 Clip	1	HF28F
Crystal Mic In Metal	1	HY33L
DC Piezo Buzzer	1	KU56L



SVG

SVG stands for scalable vector graphics, a brand-new form of image creation language that's tailored for Web pages. Based on the same principles that make PostScript graphic images so popular - the ability to allow re-sizing of images without losing graphical clarity, while maintaining a small file size - SVG looks set to become an instant hit with Web page creators worldwide.

The SVG language has been developed by the World Wide Web Consortium (W3C) and its members, who include numerous technology industry leaders like Adobe, Apple, Corel, Hewlett-Packard, IBM, Kodak, Macromedia, Microsoft, Netscape Communications, Quark, Sun Microsystems, and Xerox. It has been designed as an open language, and actually describes two-dimensional graphic images using Extensible Markup Language (XML), the technology destined to replace the currently more usual HTML method of creating Web pages. Because it expresses vector graphics in XML and is compatible with other related W3C initiatives, SVG's impact is expected to be profound. For example, SVG meets the challenge of e-commerce Website problems by solving several complex design issues.

Currently the language is in its final draft stages but SVG images are already being used in Websites, and all that users need to view the images is a plug-in viewer in their Web browser. Viewers are available for both Windows and Macintosh versions of Microsoft Internet Explorer and Netscape Navigator. Only recent versions of the Web browsers are compatible, as they are required to view XML pages anyway, and currently only static SVG images are viewable in the Macintosh version of Microsoft Internet Explorer.

The SVG Viewer can be downloaded from Adobe's Website, at: <http://www.adobe.com/svg/viewer/install/>, but it is also bundled in the latest release of Adobe's best-selling illustration application Illustrator (version 9.0), and will be included in forthcoming versions of other illustration applications.

The World Wide Web Consortium has detailed information about SVG, on its Website, at: www.w3.org/Graphics/SVG, and the Adobe Website has links to several example pages which feature SVG graphical images.

Mac Music Maker

Panic Software has recently released version 1.5 of its high-quality mp3/CD audio player for Macintosh computers. Audion uses playlists to store favourite track ordering, and playlists are as easy to use as dragging tracks into and out, with deep playlists - folder-based hierarchies of music - and full CDDB (CD database) support across the Internet for track and album checking and listing.

But all these features and quality is not Audion's most rewarding ability. Like many music players these days, Audion support the use of different appearances - called skins by some players, but known as faces in Audion. And Audion has some of the best around, and certainly a very wide selection.

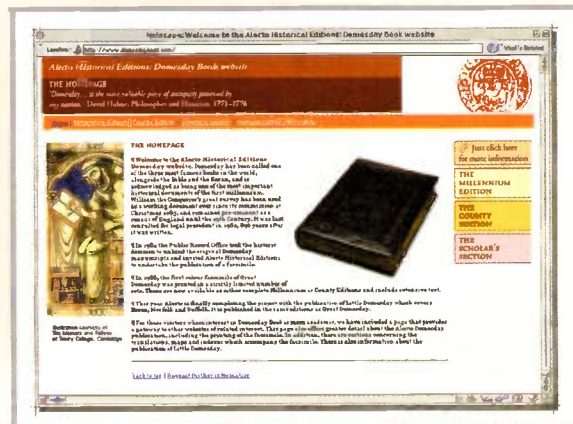


Aerial Reception

The whole country is being photographed from the air, in an ambitious project called the Millennium Map, which allows you to locate anywhere that's been mapped and purchase the photograph and other details about the area. The Website, GetMapping, at: <http://www.getmapping.com> isn't quite complete yet, but many places (over half the country at a guess) are already online, and the others will be following shortly. You can enter location details by name or preferably by postcode, and roam around the area until you get the view you want for your photograph. A downloadable plug-in for your Web browser also allows zooming in and out of the photograph (although we couldn't actually find a link to download it when we tried).

The project started in April 1999, and four Rockwell Aerocommander aircraft, complete with computer-controlled camera equipment to the value of £250,000, have since been systematically flying the length and breadth of the country. Detail of the photographs allows objects of a minimum size of 25cm to be seen. Around 90% of England has been photographed, and Scotland and Wales will be done so after England has been completed. To date, over 56,000 photographs have been taken on 9-inch film, and each roll of film is 500 foot long. Scanning of each photographic image then takes place, and the final image is map accurate, which means that it can be used in conjunction with conventional 1:10,000 scale maps.

A nice touch is that, when you've located the area you want for your photograph, an option to view the Domesday Book entry for that area takes you to the Domesday Book Website, at: <http://www.domesdaybook.com>.



BT SurfTime Goes Live



SurfTime at www.bt.com/surftime, gives BT customers unlimited telephone calls to the Internet for a fixed fee. It means that BT customers will be able to subscribe to one or more Internet Service Providers whilst retaining absolute control over the telephone charges they pay.

Two SurfTime options cater for different needs:

- Customers can get unlimited calls to the Internet at weekends and on weekday evenings for £5.99 a month.
- Heavier residential users can get round the clock unlimited calls to the Internet for £19.99 a month.

But significantly, BT's SurfTime will provide access to all Internet Service Providers that offer service on the 0844 04 telephone number range. ISPs are likely to make further charges for the use of their services, and BT will provide optional billing services to ISPs.

ISPs who have already announced that they will provide access via the 0844 04 SurfTime number include: Affinity Internet Holdings, BT Internet, BT Click for Business, Freeserve and PlusNet.

America Online Unveils AOLTV



AOL at www.aol.com has launched the AOLTV service, that it believes will fundamentally transform the Internet television experience.

AOLTV combines television with the Internet to allow AOL members and other consumers to take advantage of

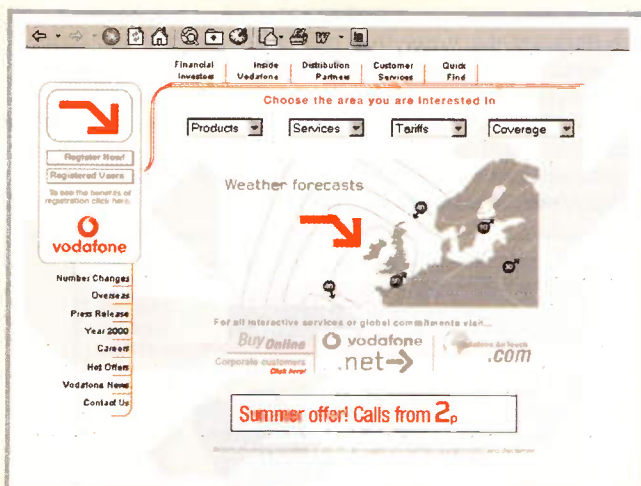
convenient AOL features like e-mail, instant messaging, and chat with AOL's worldwide community of nearly 23 million members - at the same time that they watch their favourite television shows.

AOLTV enhances the TV experience by:

- Giving consumers access to familiar, convenient AOL features and AOL's worldwide community of nearly 23 million members.
- Responding to viewer demand for an easier way to choose programs from the hundreds of available channels with the AOLTV Program Guide - an easy-to-use menu that organises channels by category and provides brief descriptions of three days worth of shows.
- Creating a new platform for broadcasters and cable networks to provide innovative interactive programming to complement their TV shows - everything from in-depth background accompanying news and sports programming, as well as interactive polls and e-commerce opportunities linked directly to the shows on screen to local information on community-wide events or emergencies.

AOLTV also provides access to AOL's 'You've Got Pictures' feature, allowing members to organise and view their family pictures on the television screen. The AOLTV Program Guide allows users to change channels by clicking on words and graphics, rather than scrolling through channels one by one.

Vodafone Starts Groundbreaking GSM Internet Trial



Vodafone at www.vodafone.co.uk has commenced trials of GSM on the Internet, a new service for corporate customers which will enable simultaneous voice and data calls using a combination of GSM technology and Internet Protocol.

Developed by Ericsson, it is the first version to support multi-network connectivity, which allows voice calls to and from a range of internal and external networks, and also the first version to support the use of a PC.

GSM on the Internet will offer customers the ability to access IP-based applications whilst on a voice call, via the new generation of mobile devices or a PC. Applications could include internal and external databases, company intranets, personal information management applications (such as Microsoft Outlook) and the Internet.

For example, when a voice call is received from a customer, account details for that customer could be sent automatically from an intranet database to the receiving PC or mobile device and viewed simultaneously with the voice call. Two-way data transmission will enable, for example, electronic invoices to be signed, issued and returned in real time whilst both parties are still on the original call.

Trials of GSM on the Internet are currently taking place at Vodafone's headquarters in Newbury, Berkshire. Further development and customer trials will take place before the launched version - compatible with WAP and GPRS - will be commercially available at the end of next year.

Web Surfers Stuck on Duck Tape Web Site



Can you believe it? A Web site dedicated to duck tape. No April Fools day is long gone. Web surfers are truly getting stuck on a Web site devoted to duck tape.

The press release claims that the site at www.ducktapeclub.com inspires visitors with animated characters, sound effects and content as it spreads the duck tape story to diehard fans and those who are newly converted to its uses. What next?

Recipeweb is a Melting Pot for the Kitchen



Tired of the same old recipes? Worried about the long term affect of your diet but don't know how to improve it? Now there is a Web site that could see a change in the way you eat forever.

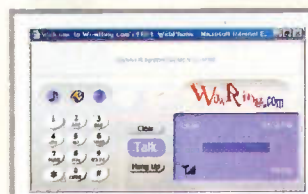
RecipeWeb.co.uk at www.recipeweb.co.uk, the UK's first specialist on-line source of recipes, related features and culinary and nutrition advice.

Eliminating the need to wade through endless cookbooks to find the dish you crave, RecipeWeb.co.uk gives you all the information you need at the touch of a key.

All the recipes on the site are accredited to leading chefs and nutritionists such as Anton Edelmann of The Savoy, Richard Coates of The Belgo Group and Thane Prince, the renowned culinary writer.

RecipeWeb.co.uk has the answer whether you're looking to prepare a quick snack or a dinner party for twelve. You can currently search by ingredient, cooking time, cuisine and experience - appealing to the culinary expert and the kitchen novice alike. The site will also soon offer the ability to search by calorie content for those looking to watch their weight.

WowRing.com Portal for Free Long-Distance Calls



WowRing.com has announced the launch of its 'Web-to-phone' portal that will allow Internet users anywhere in the world to make free long-distance phone calls.

The service, which is supported by advertising, is now available free to anyone who completes a simple registration form at www.wowring.com.

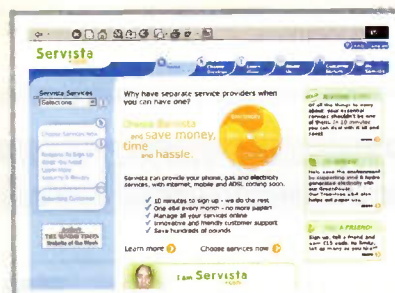
A recent study by International Data Corporation (IDC) shows that 'voice-over-IP' (VoIP) traffic is tripling on an annual basis, compared to 12% to 16% yearly increases in traffic over conventional phone networks.

After a user registers at the WowRing.com site, a keypad will appear on the screen. Callers enter the telephone number simply by clicking on the numbers on the keypad or by entering the number directly from their keyboard.

Each time a registered user visits WowRing.com to make a call, the site automatically checks the user's system for the latest version of the keypad. If a new one is available, it is downloaded automatically.

Customer support is available directly from the WowRing.com site, which offers a comprehensive 'frequently asked questions' (FAQ) section and a tutorial on how to make calls.

Save £152 on Household Bills in Just Ten Minutes



When it comes to gas bills alone, research shows that: half the population know they can change their gas supplier but less than one in four have actually switched; and 5.5 million adults do not know whether or not they are paying too much.

Servista.com at www.servista.com promises to save the average household £152 a year on their combined phone, electricity and gas bills. The company is Britain's first Internet-based provider of telecoms, gas and electricity and is the first to introduce a single eBill for however many domestic services.

Thanks to open competition, Servista's formula brings home the benefits of deregulation to consumers as intended by the government's regulatory bodies. Until now, consumers have known they can save money by switching service provider, but less than one in four have switched because it is such a hassle.

Now, consumers can save money by switching one or all of their essential services to Servista in just ten minutes. The company aims to save millions of UK households hundreds of pounds, and Servista's combined eBill for telecoms, gas and electricity aims to cut out both the hassle of receiving separate bills, and the time wasted having to manage relationships with separate service providers through unhelpful call centres.

Zoom in for a Closer Look



Ginger Online has introduced MGI ZOOM technology on its three Web sites <www.virginradio.co.uk>, <www.theprioryshow.com> and <www.tfifriday.com>, which will allow fans of the radio and TV shows to zoom in for a closer look at their favourite moments and take virtual tours around the studios.

Ginger Online's most popular site, <www.virginradio.co.uk>, includes 'zoomable' pictures of Chris Evans and his Breakfast Show Team in action, together with a fully navigational, zoomable virtual tour of the studio created in conjunction with MGI's 360° panoramic software, PhotoVista.

On The Priory Show's Web site, the viewer can take a close-up peek behind the scenes of the hit series, nose around on Jamie Theakston's desk, zoom in on Zoe Ball interviewing top guests, and even spy on the audience.

TFIFriday online shows photos of Supergrass and other major artists on stage, plus a virtual panoramic tour of the studio, with 'hotspots' that automatically transport you into different rooms and locations.

24-7 Freecall Offers Unmetered Internet Access



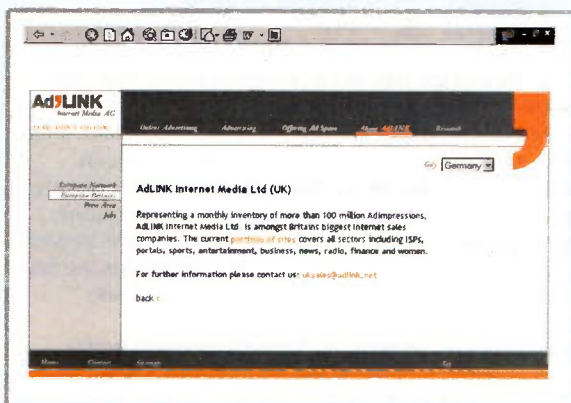
24-7 Freecall at <www.24-7freecall.net> has announced the launch of its unmetered and unlimited Internet access service. The cost is a flat rate charge of £24.70 per month with no contracts to sign, or set up costs incurred.

The service is based on quality and value for money, and will initially only be available to a limited number of users who are looking for a reliable service that is unhindered by restrictions and conditions. 24-7 Freecall also plans to offer a range of services such as WAP and ADSL.

Contention Ratios, the number of users who can simultaneously use the same modem line to access the Internet, average 65/1 in the UK with many Internet Service Providers (ISPs) operating at a much higher level.

24-7 Freecall is offering one of Europe's lowest contention ratios which means that users will have no difficulty in assessing the service even during busy times of the day.

Death of Internet Banner Advertising Exaggerated



In spite of their comparatively small share of the total advertising market, Internet banners adverts do convey brand and content very clearly to Internet users - and just under half of online consumers believe that banner advertising is the advertising medium of the future.

These are just some of the key findings of the Banner Brand Impact Study undertaken in five European countries by <[conwebmax.com](http://www.conwebmax.com)> GmbH on behalf leading of AdLINK Internet Media at <www.adlink.de>, Europe's leading independent

Internet advertising network.

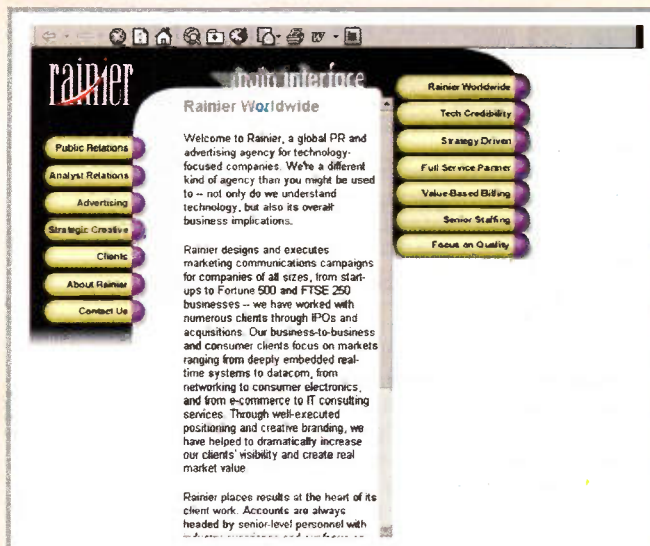
In this primary study, 500 online users from the UK, Germany, France, Sweden and Spain were interviewed in person and asked to assess the advertising impact of a variety of Internet banners. Two banners from nationally known branded companies were tested in each country, selected from the following industries: automotive, travel, information technology and information services.

In addition a single, uniform banner from the automotive sector was tested in each country to act as a control mechanism. The study showed that in many cases, banner advertising was perceived as having informational value to Internet users rather than merely trying to sell them something.

This was particularly the case in Germany, where 47% did not regard banner advertising as a pure selling tool. The research also showed that banners are often viewed as a source of information and as a means of accessing the advertiser's Web site.

Between 79% (UK) and 93% (Sweden) of those questioned click through a banner 'occasionally to frequently' because it catches their attention or helps users to obtain additional information. Up to 48% of the Internet users questioned described banner advertising as the advertising medium of the future.

Study Reveals International Internet Communication Breakdown



More than 40% of the leading UK and US public companies are failing to take the Web seriously as a communication channel and are not using it as a direct communication medium with customers, investors and other target

audiences. Some are even in the precarious position of failing to deliver on promises they make on their sites to customers and investors.

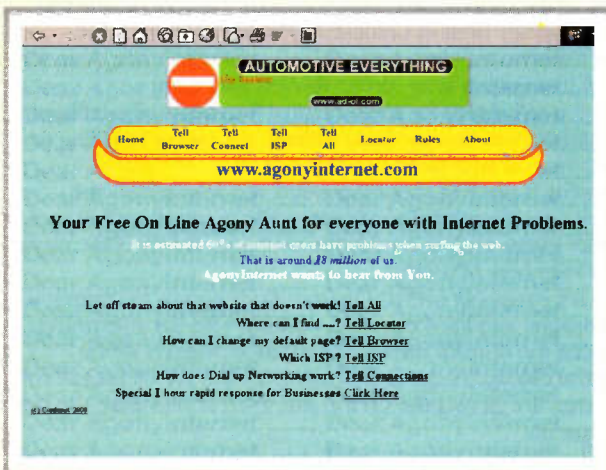
This is the conclusion of the second Rainier Web-Index study into the use of the Web by the FTSE 100 and the top 100 Fortune Rainier at www.rainierco.co.uk, the international technology marketing communications consultancy. The results demonstrate a clear requirement for large corporates to adjust their global Internet strategies to ensure that their public Web response capabilities are at the very least as effective as telephoning, faxing or writing to their national or international headquarters.

The Rainier Web-Index study found that in Britain only 71 of the FTSE 100 companies could be contacted by e-mail via their Web site and of these more than 20% including, National Grid, P&O and Telewest failed to respond to multiple requests for basic investor information after a wait of three months.

A total of 29 of the FTSE 100 companies including Bass, Marks & Spencer and Thames Water could not be reached by e-mail via their Web site or did not have a Web site.

By comparison, 77 of the Fortune 100 companies in the US could be contacted by e-mail and of these a third, including American Express, Motorola and Walt Disney failed to respond to a request for basic investor information after a wait of three months. Additionally, 23 of the Fortune 100 companies including GTE, Hewlett-Packard and Intel and could not be reached by e-mail via their Web site.

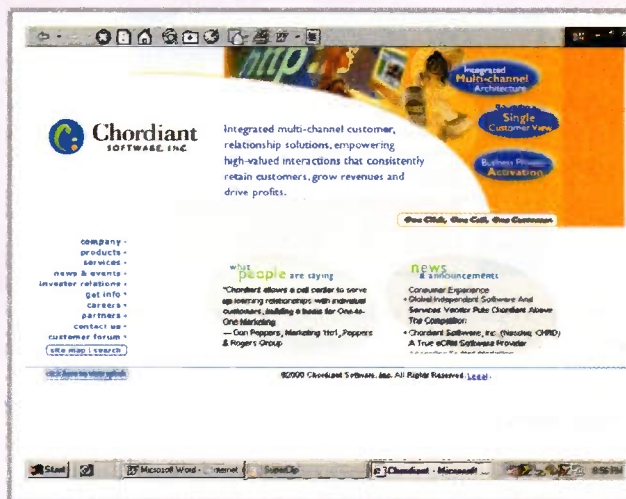
AgonyInternet for Internet Unknown



AgonyInternet www.agonyinternet.com is now on line. The site is a haven for anyone who is unsure about any aspect of the Internet can ask their question and get a no-nonsense reply everyone can understand.

AgonyInternet is a simple site designed for the user to easily browse, find the subject they want, and send a question. Agony Internet replies are usually online within 24 hours, many quicker. And are available for everyone to see.

First-Generation 'Clicks And Mortar' Fail at Customer Service



UK blue-chips are more eager to adopt a 'clicks and mortar' strategy than continental counterparts, according to a qualitative survey of 171 British, German and Dutch organisations published in June by Chordiant Software at www.chordiant.com.

However, of the companies surveyed, the UK had the worst record when it came to sharing customer information between existing departments. The combination of these two factors suggests that the UK is developing e-commerce divisions in technical isolation from existing operations, severely compromising quality and consistency of customer service.

Scout Gets the Loot



Scout at www.scout.com has acquired Loot at www.loot.com in a deal worth £189.8 million.

The combined company is set to form the UK's largest market place for buyers and sellers, one unique company where sellers can publish their offer not only in print and on the Internet but also via mobile and fixed line telephones and through digital TV.

The deal will create the largest destination site for classified and directory services in the UK. Scout's strength in the business to consumer market place and Loot's expertise in the consumer to consumer arena makes a powerful exchange where buyers can find exactly what they need, where they need it, using whatever media they choose.

Money Makes the Web Go Round



SevBanners.com at www.sevbanners.com, a new service set up by Northants based Internet marketers, Severina Publications, aims to help small and medium sized business owners make money from their Web traffic by selling banner advertising on their sites.

SevBanners.com aims to help sites large and small sell their banner advertising, with a dedicated team of telephonists finding the right buyers for the right site.

With companies such as UK Banners at www.ukbanners.com, Tapaz at www.tapaz.com and Shoutloud.com at www.shoutloud.com already signed up, Nikki and her team have sold almost a million banner impressions in the first month of the service, with more to come.

Top of the Swaps - Webswappers 'Swap 10'



A new report published in June exposes for the first time the weird and sometimes bizarre swapping habits of the UK population.

The 'Top of the Swaps report' published by webswappers.com at www.webswappers.com, the UK's leading online swapping site, is based on data compiled from the 7000 plus swaps placed on the site since January, by the increasing number of people who have discovered the latest phenomenon to hit the net - online swapping.

Some of the more bizarre swaps include 1.2kg of bovine gall stones (allegedly used in Chinese medicine) or there is the person with two training canoes who is willing to trade them for a pair of mannequin arms, preferably left and right.

Or if you're longing for some original fragments of the Blarney stone, direct from County Cork, Ireland, the owner is willing to be 'surprised' at your offer.

Swapping is not just about the weird and wonderful - the whole of the UK population appears to be going swapping mad. The posh swaps top ten reveals the swapping habits of the more affluent members of society.

They are swapping everything from Rolls Royces to magnums of champagne and for the man in your life who has everything how about the domain names 'the2002worldcup.co.uk' or 'the2006worldcup.co.uk', or perhaps a life like 6ft tall Laura Croft statue, they are all on offer on the site. Even homes have the 'for swap' sign up.

Leading the kids 'Swap 10' are Pokemon cards, being swapped in vast numbers, with Nidoking and Charizard the most popular cards. Computer games and CDs are following closely behind in popularity.

Three Hours a Day Wasted on Irrelevant E-mails

Recent research from The User Group has shown that information overload is growing at such an alarming rate that it could impact on the economy.

In a survey which spanned a number of different business sectors and included responses from companies such as Arthur Andersen and PriceWaterhouse Coopers, respondents claimed to spend almost three hours a day dealing with unnecessary and irrelevant e-mail.

In a similar survey conducted two years ago, the average was 90 minutes. Should the trend continue at this rate, the average next year could rise to as much as four hours per working day sifting through irrelevant e-mail - unproductive time which could lead to lack of productivity and loss of revenue.

MusicStore Jukebox Stores 200 Audio CDs in MP3 Format

DigMedia at www.dig-music.com a digital music distribution company has released the MusicStore, a consumer electronics device that incorporates a CD player, digital jukebox and a portable MP3 player/docking station that can record, store and manage up to 200 conventional audio CDs using a rights secure MP3 format.

With command of more than 2,400 songs, the MusicStore cannot only replace an entire CD collection, but is poised to redefine how music is managed and enjoyed. Consumers don't need to be computer literate or MP3 savvy to use the MusicStore.

As conventional audio CDs are played, MP3 audio is created automatically and stored to the unit's on board 6.4 GB hard drive. The MusicStore connects to any hi fi system or powered speakers and is among the first digital music systems to recognise Digital Rights Management in order to protect the original content owners from piracy.

When songs are transferred to the MusicStore's built-in portable SoulMate MP3 player, they are no longer available on the jukebox until the SoulMate is returned to its base. The transfer of songs to and from the MusicStore is also astoundingly fast - each track transfers in about a half a second.



Internet.com Acquires PDAStreet.com and Thinkmobile.com



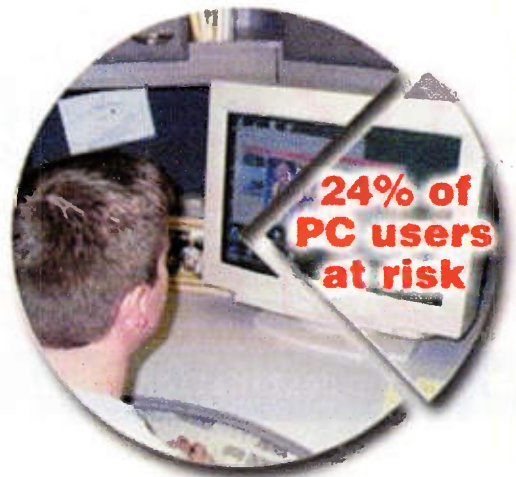
Internet.com at www.Internet.com, the Internet Industry Portal, has acquired the PDAStreet.com at www.pdastreet.com network of Web sites and Thinkmobile.com at www.thinkmobile.com, the Mobile Computing Portal.

These Web sites provide comprehensive coverage of the Wireless Internet marketplace serving the mobile community of personal digital assistant (PDA) and mobile phone users and will become the backbone Internet.com's soon to be launched Wireless Internet Channel.

The PDA Network, provides targeted mobile computing coverage for users of specific types of PDAs including: Windows CEcity at www.winccity.com covering the Windows CE market, PalmBoulevard at www.palmbld.com for Palm Pilot users, PsionPlace at www.pSIONplace.com for Psion users, and VisorVillage at www.visorvillage.com for Visor users.

Thinkmobile.com meanwhile is a premier news and information portal for the mobile communications community. Content found on Thinkmobile.com includes: daily news and information about mobile computing and wireless communications, editorials, specifications and reviews of mobile products and services.

Nearly 25% of PC Users Unprotected from New Viruses



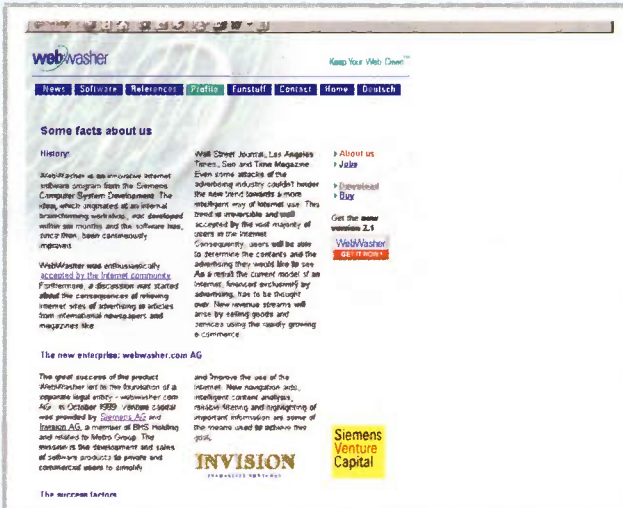
Nearly a quarter of home and office PC users running anti-virus software don't update their anti-virus software at least monthly, leaving themselves vulnerable to newly minted viruses, according to a survey conducted by Central Command, a leading supplier of anti-virus software at www.avp.com.

This is despite the high awareness of Internet viruses following outbreaks of the Chernobyl and Melissa viruses and the LoveLetter worm, which disabled millions of PCs around the world. The survey e-mailed to nearly half a million PC users, investigated people's encounters with computer viruses and their computer security habits.

The survey revealed that in the previous 12 months the majority of PC users (65%) had experienced at least one virus, and 57% of infections resulted in a loss of data. In addition, over 18% of respondents said they lost 'moderate' or 'large' amounts of data, and 14% reported more than five virus attacks in a year.

The survey found that 24% of respondents said they do not update their anti-virus software at least monthly.

That virus encounters are common came as no surprise, but the fact that so many PC users so infrequently update their anti-virus software may indicate a weakness in the community's defenses against cyber attacks.



webwasher.com at <www.webwasher.com>, a global developer and marketer of advanced, enterprise-friendly ad filtering

software, has released WebWasher 2.1 with a function that provides automatic, two-way cookie filtering. With WebWasher 2.1, individuals and enterprises can take privacy into their own hands by getting rid of the cookies that third parties use to follow them around the Internet.

Cookies are short text files placed on a user's hard drive by Web sites the user visits. Internet marketing companies use some cookies to develop profiles of individual consumer browsing and buying behaviour.

Other cookies do not represent personal information leaks and are, instead, necessary for speedy page views and efficient shopping on the Internet.

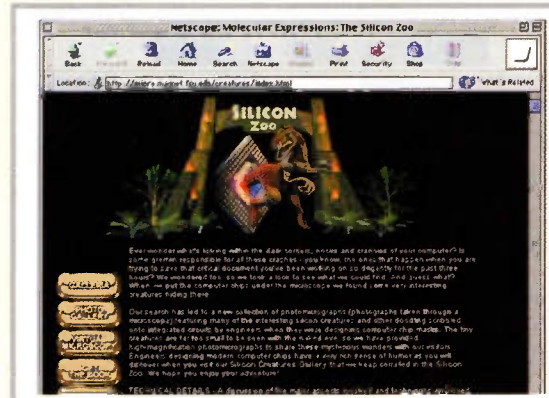
WebWasher 2.1 uses an algorithm to automatically filter out bad cookies that leak personal information about the user to third parties. Good cookies that are required - for example, to execute an e-commerce transaction - can pass by. If the cookie cannot be rated good or bad, it will get a finite life span, after which it will cease to exist.

Another unique aspect of WebWasher's cookie function is that it works in both directions, filtering both incoming cookies from a Web server and outgoing cookies called forth by an external server when a Web site is re-visited.



If you need information on how disabled people can use computers, AbilityNet will likely have the information you need. AbilityNet is a charity set up specifically for the purpose of assessing disabled people and showing them what computer-based equipment they need to enjoy the technology. Located at: <<http://www.abilitynet.co.uk/>>, AbilityNet's Website is a well-organised and easily accessible database of help.

When kids are ill, it's often the parents who suffer most - mentally, at least - with worries about how little Johnny is, and what can be done to help. Parents Encyclopaedia is a good Website that can give short easily understood answers to



common questions that arise with children's illnesses. The definitions and answers are not meant to be definitive, textbook style discussions. You can find it, at:

<<http://www.sleepight.com/EncyMaster>>

Short text messages (SMS) sent to mobile phones can be very useful if you could only do it via email or over the Internet. Well, you can with Genie from BT Cellnet. You can send a text message to any digital mobile phone user direct from the Website, at: <<http://www.genie.co.uk>>. Also, if you're a digital mobile phone user, you can register with Genie and have a personal Genie email address that anyone can use to send you messages. Beats pressing your mobile's number pad over and over again to write a message.

While computers appear quite bland boxes (unless they're made by Apple, of course), far under their skin developers inevitably leave their signatures in some form or other. To be truthful, real signatures aren't common, and most often developers include some oddball way of ensuring that the computers they make are just that little bit different. But you've got to look closely - most of these things are etched minutely into the integrated circuits and aren't visible with the naked eye. The Silicon Zoo, at:

<<http://micro.magnet.fsu.edu/creatures>> is a Website that's been put together to show some of the things that developers get up to, and features a marvellous collection of high-magnification photomicrographs of developers work to look through.

COMMENT



by Keith Brindley

Technology for All?

This technology is a great thing. It allows us all to surf the Internet, it allows us all to have powerful computers and do things with them that couldn't be attempted just a few years ago. It means that we can communicate with others just about anywhere else in the world, it means we can view pictures and listen to music in our homes, in our cars, and on the move, all with no barriers.

Or does it? Well, yes, of course, technology does mean that some people can do all these things. And some people can do some of these things. But, and this is a big but, not all of us can do all of this.

That last point appears about to be stressed over the coming months as interested parties look set to challenge those technology providers that don't do more to help us all. Key to all this is the Disability Discrimination Act (known as the DDA), which has been partially phased in from 1995 and will be in force completely by 2004. The DDA specifies that providers of goods and services must make sure that appropriate goods and services are available to the UK's disabled people.

In particular, the goods and services that look set to be targeted by proponents of the DDA are Websites, as most Websites are inaccessible to blind people. It's looking increasingly likely that a high-profile test case will be initiated against a prominent Internet-based UK shopping site soon. The Disabled Rights Commission (DRC) is on record as saying that there needs to be a test case on the issue, and is planning to take action in some way. If the right disabled person complained that a Website was inaccessible, then the process would start and the case would be brought to court.

But what can Websites do to provide disabled access? The World Wide Web Consortium (W3C) has recently launched the Web Accessibility Initiative (WAI), in which it considers the ways to make Websites more accessible by all people, including the disabled. The Initiative's

Website at: <http://www.w3.org/WAI> is quite informative, and gives several examples and suggestions. It points out that a Web page needn't necessarily in itself be accessible by disabled people, but that it should allow them easy access to equivalent pages that disabled people can access. These equivalent pages should be maintained with at least the same frequency as the main page. To give easy access to pages specifically for disabled access, meta information can be used within the page, to automatically relocate the users browser to the equivalent pages. For example, the LINK element can be used within an HTML page to link to the equivalent pages if the user's browser is identified as supporting aural or braille rendering.

The Initiative also makes the point that Web pages designed properly for keyboard access (in addition to mouse access) will generally be accessible to users with any type of input device.

Access to Websites is just the start, of course. Disabled people aren't able to do some things that non-disabled people often take for granted. In effect, the odds are against disabled people. The DDA aims to counteract this and even up the odds in some small way. Nevertheless, there's much that cannot be redressed. The key word in the DDA is appropriate. Inappropriate goods and services can't be expected to be provided - blind people, for example, can't expect to be able to drive cars; paraplegics can't expect to be refuse collectors.

But there's a world of difference between driving or emptying trashcans, and surfing the Internet. Cars and rubbish have been around in their present forms a long time. Yes, adapting them so that blind people can drive them, or paraplegics can empty them is possible, but it's just not appropriate! Well, in the short term at least - as more and more electronics and computer-control goes into cars, it's feasible that long-term cars could be so automatically driven that drivers needn't actually need to see.

The Internet, on the other hand, is new technology. It's developing constantly; it's

being developed constantly because it's basically software-driven. It's also the ideal medium to build accessibility for all into it - the Web is all about tailoring content to suit users after all, more so than any other information medium has been in the past.

It's easy to write a Web page, it's only marginally more difficult to write that Web page so that it's accessible by disabled people. Website producers merely need to add a few lines of HTML code to add aural or Braille links, and quite rightly they should be made to do so by law, as in the case of the DDA.

Indeed, unless Web pages are developed properly and most likely in the ways the W3 Consortium's Web Accessibility Initiative suggest, there's an increasing likelihood that a sort of digital divide will occur, between those who have access to the Internet, and those who have none. Where there already is such a divide between the richer and the poorer of us who do and don't use the Internet, the divide will widen if disabled Internet access (or, more pertinent) lack of it, is thrown into the question.

Despite this, awareness of the DDA is poor. Most companies with Websites wouldn't know what the initials stand for, let alone what they should be doing to improve their Websites. A high-profile test case will highlight the new act, the issue, and the way forward. It seems a pity that a lawsuit will be necessary, but at least it will focus the minds of Website producers, and that can only be good news for the future.

In the end, as disabled people number some 8.5 million in the UK, with - get this - an estimated £40 billion a year disposable income, technology providers have to ask themselves if the market they are missing out by not providing appropriate access to disabled people is worth the cost of missing. In short, Web access by disabled people is an opportunity that Websites themselves shouldn't miss out on.

The opinions expressed by the author are not necessarily those of the publisher or the editor.

The Very LONG WAVES

PART 5

In this final part, George Pickworth explores high frequency alternators and submarine antennas

High frequency alternators

High frequency alternators were the most successful of all very low frequency, pre-thermionic valve continuous wave transmitters. But high frequency (HF) alternators were difficult to build and their construction taxed the ingenuity of both electrical and mechanical engineers. I therefore hope that this study will give readers an insight to the ingenuity of the pioneers and an understanding as to how those remarkable and innovative, superstation-alternators worked.

Only a handful of superstations were constructed and as far as I have records, there were only three makes of HF alternators:- Alexanderson machines made by the American General Electric Company (GE), the Osnos machine made by the German AEG company and the German Goldschmidt alternator. In their time these machines were at the leading edge of both electrical and mechanical technology.

By-product of the Arc Lamp

Like the quenched arc oscillator, the high frequency (HF) alternator, was a by-product of the arc lamp. Arc lamps provided the only practicable way to produce light from electricity before the turn of the last century and were widely used for street lighting.

Locally generated DC originally powered arc lamps but following the adoption of Tesla's polyphase power distribution system, streets lamps were generally powered by AC. Then, expansion and contraction of the arc plasma caused the lamps to produce a sound that corresponded to the frequency of the supply current. The 50/60Hz tone produced by numerous arc lamps could be intolerable.

Tesla realised that the annoying sound problem could be overcome by feeding the lamp with high frequency AC, i.e. in the order of 20kHz, so that the sound was above audibility. He also reasoned that HF current would not only solve the arc noise problem but would allow power distribution systems to use iron free transformers, which

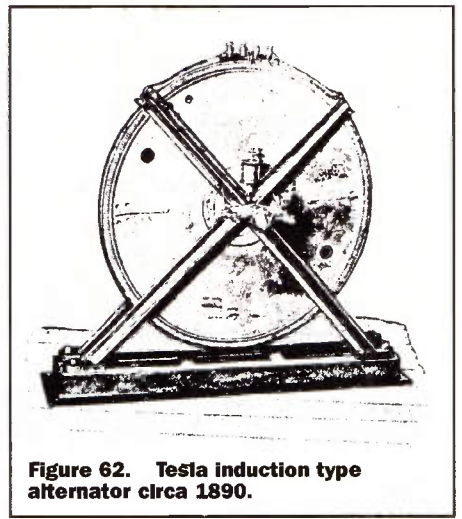


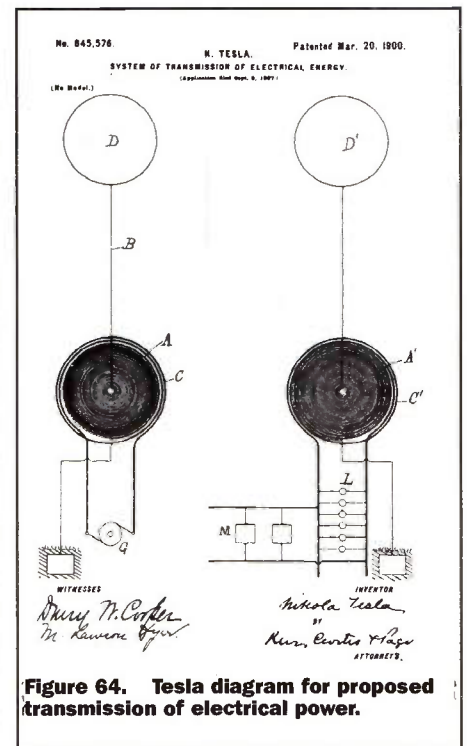
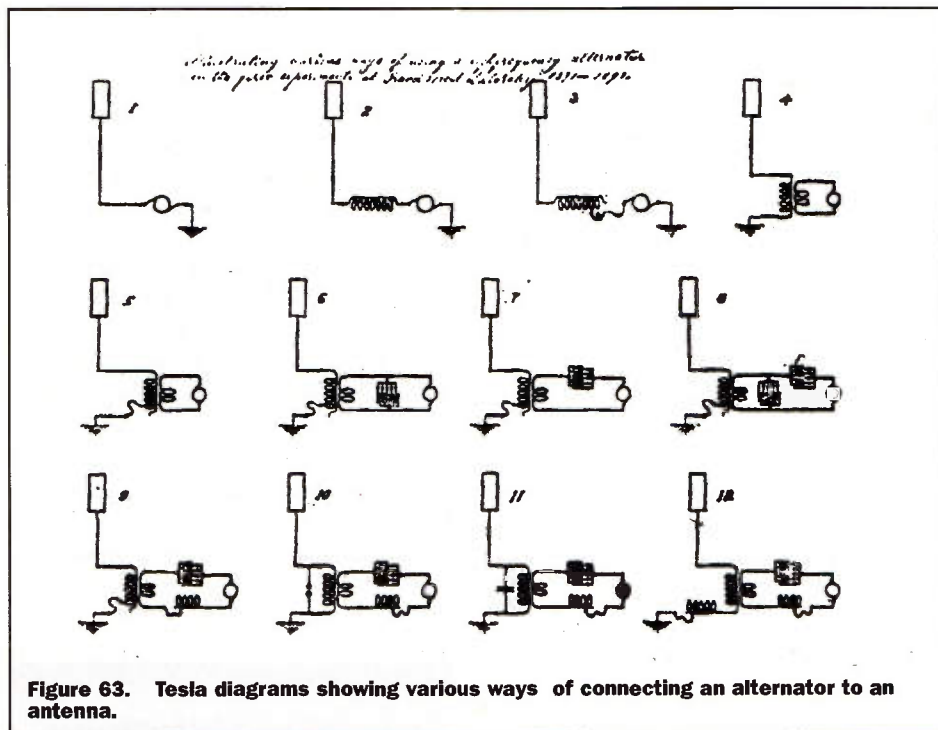
Figure 62. Tesla induction type alternator circa 1890.

would result in considerable savings in the costs.

But, Tesla abandoned the concept of a HF power distribution network in favour of employing rarefied air of the upper atmosphere as the conductor for long distance transmission of HF electrical power generated by the Niagara Falls power station. This involved elevating electrodes to an altitude of about 15km by means of hydrogen filled balloons. The earth would serve as the return conductor. See Figures 31 & 33 Part 3

In 1890, Tesla succeeded in building a 10kHz alternator (Figure 62) followed by a 20kHz machine and between 1891 and 1892 produced diagrams showing virtually every possible configuration for connecting an alternator to an antenna - see Figure 63. Yet, Tesla did not subscribe to electromagnetic (em) waves and describes diagrams as means of transmitting electrical energy via natural media - see Figure 64.

The irony is that Tesla had elevated his antennas to a height of 15km and he actually made plans for such an attempt, and if he energised it with his 10kHz alternator he would have had a very efficient



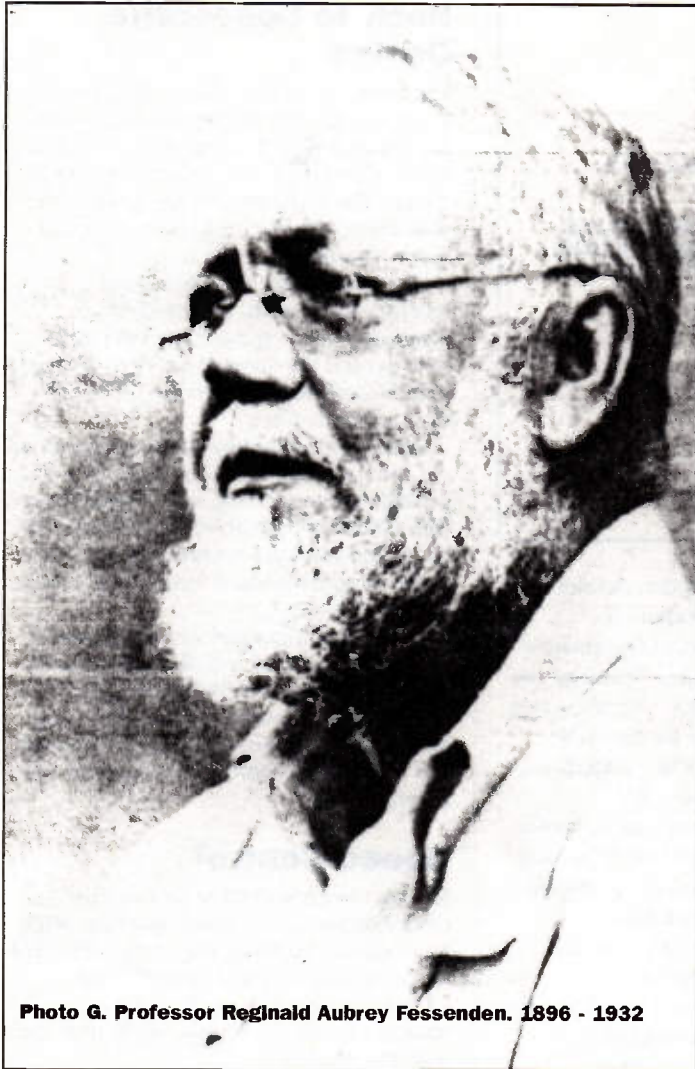


Photo G. Professor Reginald Aubrey Fessenden. 1896 - 1932

began to develop alternator systems from where Tesla had left off. His first HF alternator was given patent No 706,737. See Photo G.

By 1905 Fessenden had established his very long wave Brant Rock, USA to Machrihanish, Scotland link with his rotary, synchronous-spark-transmitter. Indeed, Fessenden was well ahead of Marconi with high power spark systems but was intent on upgrading his stations to alternator continuous wave systems.

Marconi and indeed many others would not accept that em radiation was possible by apply alternating current directly to an antenna, it was believed that a spark was essential. Many believed that radiation was from the actual spark! Yet, even Marconi had no option other than to ultimately adopt alternators.

Even more remarkable, J. A. Flemming referring to Fessenden's patent, asserted in his book *Electromagnetic Waves* that no such alternator-existed and if it did, it is doubtful if any appreciable radiation would exist. But shortly afterwards, on the 24th December 1906, Fessenden, employing an 88kHz alternator confounded Flemming by making the first transatlantic broadcast. Modulation was inserting a power microphone in the antenna circuit. The rest was history.

Tesla Alternators

Tesla had described construction of HF alternators as difficult and complicated. Unfortunately, space only allows a brief description of their construction, however as pioneers called the armature the rotor complemented by the stator, these terms are used in this study.

Tesla made several variations to the design of his alternators but a typical machine had a stator that consisted of a ring of wrought iron with 348 internal pole projections. The field winding was wound axially in a groove around the outside of the ring and was energised by either a battery or a small DC generator - see Figure 62.

The armature, in which the oscillatory current was induced, rotated concentrically inside the stator. It was a steel disc with a wrought rim with 348 short, radial, bronze pins i.e. corresponding to the number of stator projections. The armature coils were wrapped around these pins. In some machines the armature windings were around teeth cut out of the periphery of the rotor. The projections, teeth or indeed the bronze pins are referred to as pole pieces.

Output frequency is set by the number of pole pieces multiplied by the rotational speed of the armature. So with 348 pole pieces and to produce 10kHz rotor speed was therefore 2,304rev/min. Very high peripheral speeds were essential for high frequencies, so the rotor was of large diameter. Moreover, a large diameter allowed more space for pole pieces. Nonetheless, constructional factors limited both the diameter of the rotor and the number of pole pieces.

The obvious way to further increase frequency was to increase rotor speed but there was a limit as to how this could be increased before centrifugal force caused its windings to fly out off the pins or out the slots as the case might be. So, Tesla, incorporated both magnetising and armature windings on the stator; the rotor was then simply a toothed disc; this was known as an inductor type alternator and was the basis of virtually all HF alternators - see Figure 65.

$1/2\lambda$ antenna and an em transmitter that theoretically would have had worldwide range. But he would only have needed to elevate the antenna to a height of 7.5km ($1/4\lambda$) which many believe would have been possible.

In fact, during an early study of the Sanguine submarine signalling systems it was proposed to employ balloons to elevate antennas that would have been energised in exactly the same way as shown in Tesla's diagrams. But balloons were considered impracticable so radiating earth loops were ultimately adopted. Refer to Figure 29 Part 2.

Radio Telephony

When financier Morgan withdrew his support for Tesla, his HF alternator projects were terminated and for some time afterwards HF alternators attracted little interest. Remarkably it was developments with radiotelephony (RT) that brought about a renewed interest in these machines. The reason was that continuous waves were necessary for RT. Attempts to produce CW by means of high-speed interrupters and high-speed spark systems had proved unsatisfactory. Quenched arc oscillators were partially successful but waveform was not really good enough for RT. See Part 4

Fessenden foresaw the potential for alternator systems not only for radiotelephony, but radio broadcasting and last but far from least, as an attractive alternative to spark systems for transoceanic telegraphy. So he

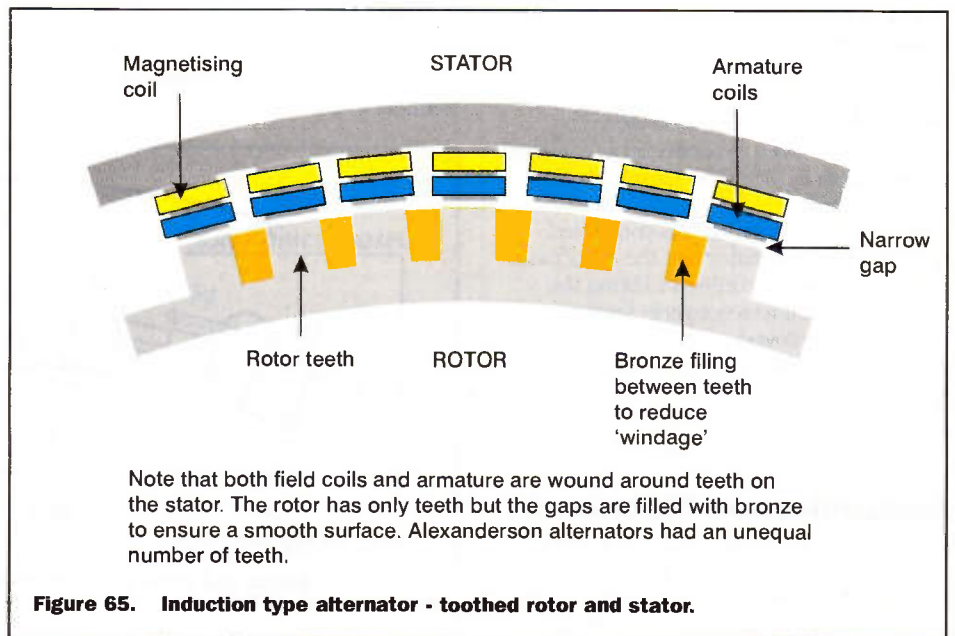
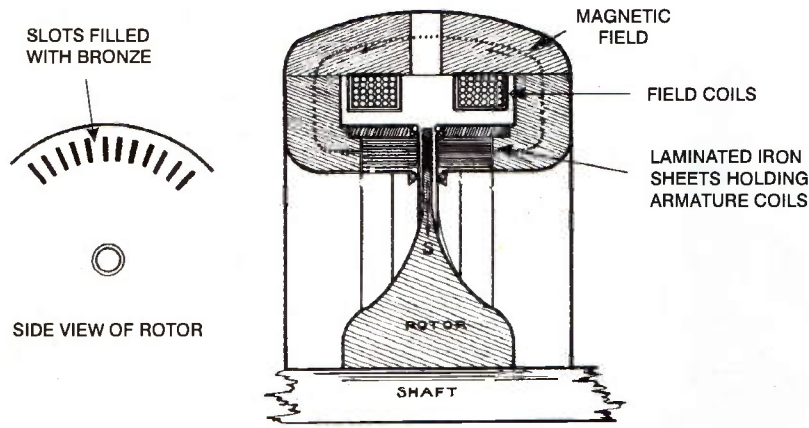


Figure 66. Section of Fessenden alternator, calliper type.



Fessenden Machines

However, the drawback with the concentric toothed stator and rotor was that the gap between these two components had to be very small. But at high rotational speeds the diameter of the rotor increased as a result of centrifugal force and this made it difficult to maintain the required degree of gap width.

So Fessenden employed a disc rotor with slots around its periphery that ran between the calliper shaped cross section stator that held both magnetising and armature windings. The calliper design allowed the rotor to increase in diameter, without the danger of it coming into contact with the stator. Moreover, the calliper design allowed the gap between the sides of the rotor and the calliper to be very narrow; indeed this was vital for efficient operation of the machine - see Figure 66.

A Balance

As we have seen, for his Brant Rock/Machrihanish link, Fessenden opted for a frequency of 88kHz and this enabled a reasonably sized antenna to give good radiation. On the down side, the alternator had to run at very high speed. Whilst lower frequencies were found to be better suited to transoceanic signalling, a balance had to be struck between wavelength and antenna radiation efficiency.

Fessenden's 88kHz, 50kW machine had 360 pole pieces so the machine ran at 14,640rev/min. However, little difficulty seems to have been experienced in running the machines at such high speeds via a simple flat belt.

Originally, the antenna was connected directly to the alternator and the inductance of the armature was utilised to bring the antenna circuit into resonance. Later, Fessenden employed antenna coupling transformers similar to those shown in Tesla's diagrams; this allowed the alternator impedance to be matched to that of the antenna - see Figure 63.

Alexanderson Machines

Fessenden handed over production of his alternators to the American General Electric Company (GE) where they were built under the supervision of Alexanderson. Hence the

name. The fact that Fessenden developed the prototype was soon forgotten.

Early GE machines were of Fessenden's calliper design, but to reduce 'windage' the slots in the rotor were filled with phosphor bronze. The first machine had 300 pole pieces. So in order to produce 100kHz the rotor ran at 20,000revs/min! Not surprisingly, such high rotor speeds caused the bearings to become extremely hot and operation at this speed was unsustainable.

But as we have seen, such high frequencies were unnecessary even for telephony. Indeed the original radiotelephone link between Rugby and the USA was only 30kHz. Transoceanic superstations also opted for a lower frequency where poorer radiation efficiency of practical sized antennas was offset to some extent by lower attenuation of the transmissions. Lower frequencies also allowed alternators to run at lower speeds and this was a very important consideration.

Indeed, the only compelling reason for adopting a higher frequency, i.e. in the order of 50kHz, was to find a 'slot' in the limited a space of the very low frequency band, or for better radiation where physical restraints limited antenna size. But frequency raisers could be employed to increase the alternator fundamental frequency by a factor of four.

Back To Concentric Design

The drawback to the calliper design was that it was less efficient than the toothed rotor and stator design. So Alexanderson reverted to the toothed rotor and stator concentric design. The gaps between the rotor teeth were filled with bronze so as to present a smooth surface - see Figure 65.

Moreover, as the machines ran at relatively low speeds, the effect of centrifugal force on the rotor was much reduced and this allowed a very narrow gap to be maintained between the stator and the concentric rotor.

Later, it found that by having 300 teeth on the rotor and 400 teeth on the stator it was possible to produce the same frequency as with 600 teeth on both rotor and stator. So, compared with earlier machines with 300 teeth on both rotor and stator, drive speed could be halved.

Two 200kW Alexanderson alternators of the above type were installed at Marconi's Caernarvon station in 1921; one was operational and one in reserve. They were driven by 300kW two-phase electric motors and ran at 2,100 revs/min so frequency was 21kHz.

Speed Control

As frequency is set by the speed of the rotor, precise speed control was vital. With Alexanderson machines, one of the alternator's armature coils supplied current to an inductance/capacity circuit having a resonant frequency slightly higher than the required frequency.

By operating at the bottom end of the resonance curve, changes in the speed of the rotor and therefore frequency caused the current in the resonant circuit to rise or fall. Some of the current was rectified and used to operate relays that in turn operated a magnetic amplifier that controlled current to the drive motor.

Briefly, the operation of magnetic amplifiers involves saturation of the core of a 'transformer' by applying DC to its primary winding. An increase in DC causes a proportionate fall in the inductance of the secondary. A small direct current can therefore control a large alternating current, hence the name magnetic amplifiers.

Keying was by means of a magnetic amplifier

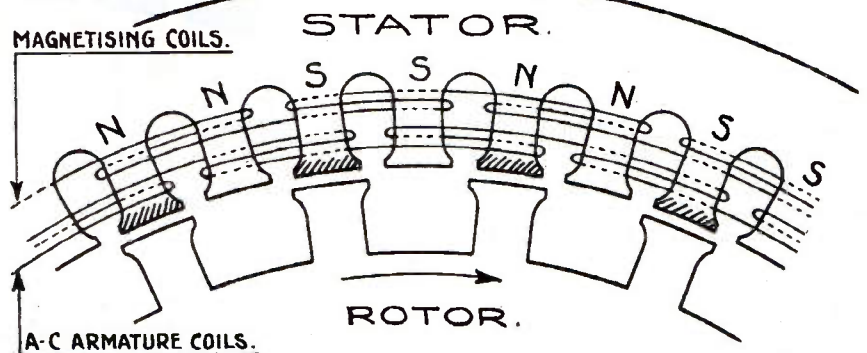


Figure 67. Stator and rotor of Osnos alternator, note that stator has two pole pieces to one on the rotor.

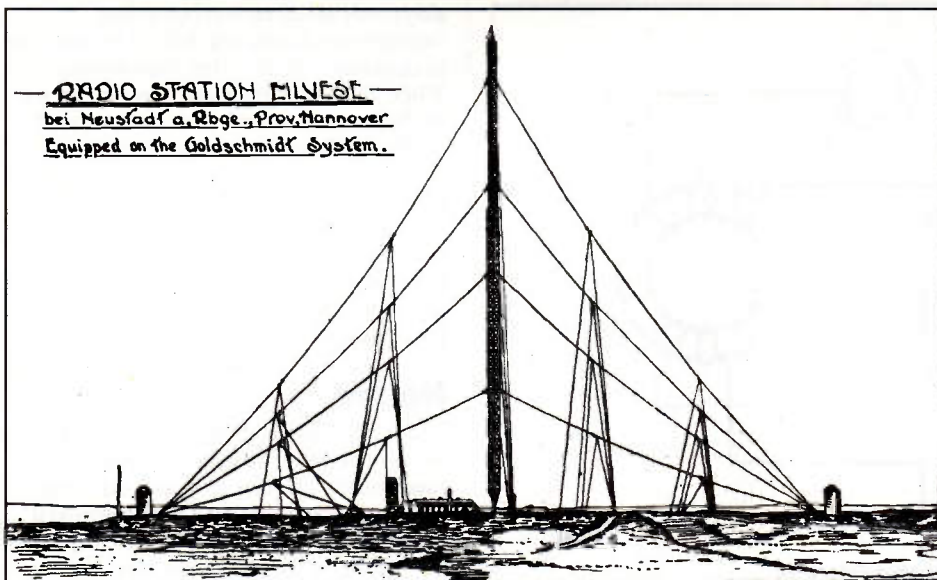


Figure 69. The antenna: Eilvese superstation Germany. The station worked Tuckerton USA on 60kHz, and employed the Goldschmidt transmitter of Figure 68.

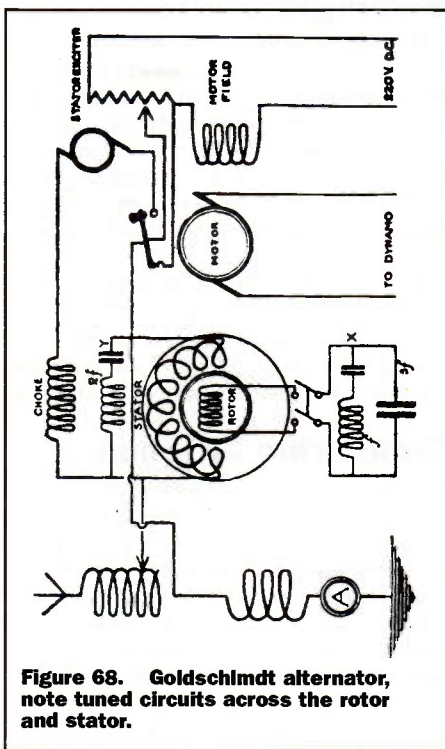


Figure 68. Goldschmidt alternator, note tuned circuits across the rotor and stator.

between the alternator and antenna. However, in order to compensate for the changes in load on the drive motor, a relay working synchronously with the signalling key cut out a load resistor in motor's rotor circuit when the key was pressed.

Osnos

M. Osnos's alternator was similar in design to the Alexander machine but each stator pole had two teeth per pole whereas the rotor had only one tooth per pole. The effect was that of increasing the number of pole pieces - see Figure 67.

Typical machines were rated at 15kW at 50kHz but I have no record of the drive speed or the number of actual pole pieces. The design was patented and adopted by the AEG Company of Berlin and machines were used widely by the Telefunken Company.

Goldschmidt

These machines did not run very high speeds so fundamental frequency was low. However, resonance circuits across both the rotor and stator enabled the machine to deliver current at four times its fundamental frequency - see Figure 69.

The feature of the Goldschmidt alternator was that the stator coils were joined up, so an alternating current passing through these coils caused a magnetic field to rotate around the inner periphery of the stator at a speed set by the frequency of the current, i.e. similar to the stator of an ordinary induction motor.

When operational, the magnetising current was induced in the stator. So when the stator coils were joined up such that the direction of the magnetic field rotated opposite to the rotor, the output frequency was double that compared to a stationary magnetic field.

By connecting several machines in cascade very high frequencies could be attained but then serious losses occurred. However, Goldschmidt achieved a similar effect with one rotor and one stator. A simplified explanation of its operation is as follows - see Figure 68.

Magnetically Coupled

DC initially energised the stator field coils but when the operational frequency of

15kHz was reached, choking coils isolated the DC energiser from the field coils. Now, as both the rotor and stator were magnetically coupled, the rotor induced a current in the stator but as a result of the magnetic field rotating in opposite direction to the rotor, the frequency of the induced current was 30kHz. It will be seen that the rotor is connected to a tuned circuit that resonates at both 15kHz and 45kHz.

Rotor/stator interaction now caused the stator to induce a second current with a frequency of 45kHz in the rotor and this is accentuated by the resonant circuit. Then, the rotor induced a second current of 60kHz in the stator and this frequency was selected by the antenna's tuned circuit.

Goldschmidt 150kW transmitters were employed at the Eilvese superstation in Germany and at its complementary station at Tuckerton USA. The antenna was supported by a steel tower 250m tall and was a combination of an umbrella and double cone; it was made up of 36 bronze cables extending over a radius of 500m - see Figure 69.

Frequency Raisers

M. Joly and M. Phobi developed 'frequency raisers' based on the non-linear saturation characteristics of the cores of toroidal transformers. Briefly, operation is as follows.

With reference to Figure 70, when an iron cored inductor is magnetised by DC, the magnetising force is represented by H and the resulting magnetic flux by B. The curve shows how magnetisation varies with the magnetising force. The upper flat portion of the curve corresponds to saturation.

If the core of a toroidal transformer is magnetised with DC so that the magnetic flux is at the point A on the curve and the alternating current is in separate winding, the resultant magnetisation is shown by the dotted 'a' 'b' 'c'.

Telefunken System

The Telefunken Company system employed two 'transformers' with toroidal cores magnetised almost to saturation by DC through the windings 'D'. The choking coil L prevented high frequency (HF) current flowing into the battery circuit. The alternator was connected to the primary circuit, coils 'P' via its resonant circuit, coil L and capacitor K. Output was from the secondary circuit, coils 'O' - see Figure 71.

When HF current flowed through the primary circuit, the HF current and DC

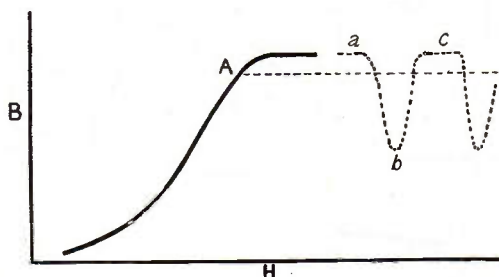


Figure 70. Non-linear saturation of the core of a toroidal transformer

H - magnetising force, B - resulting magnetic flux. Dotted area see text.

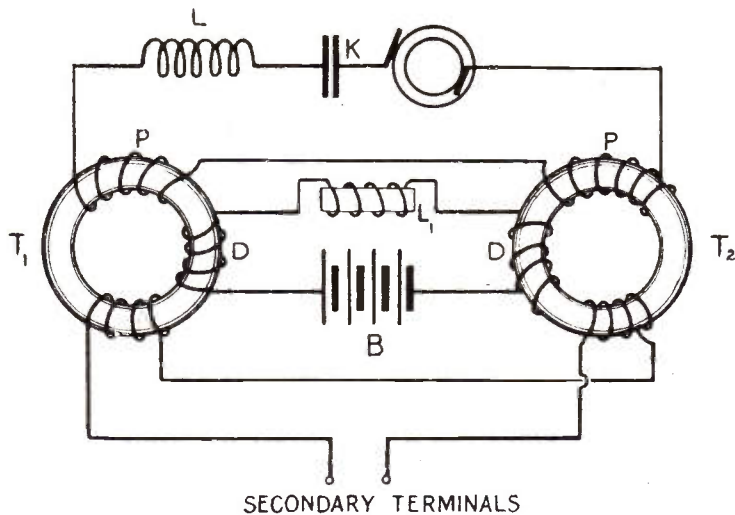


Figure 71. Telefunken frequency raiser - see also Figure 72.

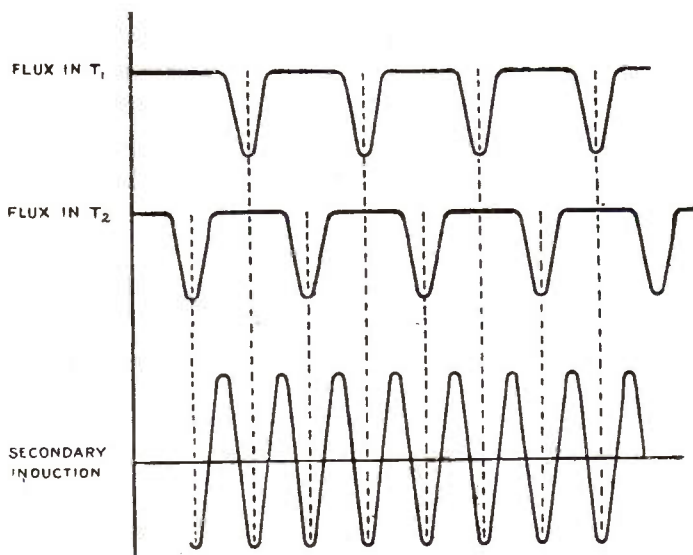


Figure 72. Representation of operation of the Telefunken frequency raiser - see also Figures 70 & 71.

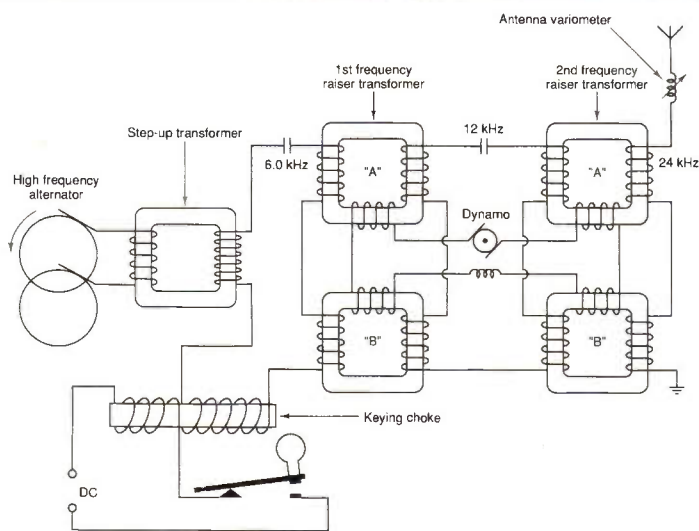


Figure 73. Schematic of frequency raisers of Nauen superstation.

alternately aided each other in one 'transformer during one half cycle' but were in opposition in the other 'transformer'. When aiding, the magnetic flux did not rise as the iron was already near saturation, but it falls significantly when opposing.

The result is shown in Figure 72 where it will be seen that current frequency in the secondary circuit is double that of the primary circuit. Output from the secondary circuit was delivered to a tuned circuit. This accentuates higher frequency and suppressed lower frequency.

Nauen

The 1914 German strategic transmitter at Nauen employed an alternator with a fundamental frequency of only 6kHz but frequency raisers employing four toroidal 'transformers' increased output to 24kHz. Keying was by saturating the core of an inductor in series with the step-up transformer and the first pair of frequency raiser 'transformers' - see Figure 73.

Strategic

Following the British navy's successful submarine signalling trials shortly before WW1 it is almost certain that during the war, operational signals were transmitted to British submarines by the commandeered Caernarvon very long wave superstation. So, there seems to be no reason why 'U' boats should not have received signals from Nauen.

In 1925, Britain commissioned its first true strategic station, GBR at Rugby. The role of GBR in signalling to submarines during WW2 has already been mentioned so let us now move on to submarine antennas.

Submarine Antenna

Like the Sanguine radiating earth loop, (refer to Figure 29 Part 3), submarine antennas had their roots in pre-Hertzian signalling systems. As we have seen, before the turn of the last century, Preece had shown that his 'earth current signalling system' could induce a current in submersed antenna. Preece employed an insulated wire, terminating with an exposed electrode, trailing behind a tugboat in the Bristol Channel. The hull of the tugboat formed the second electrode - see Figure 74, and refer to Part 2.

Early submarine antennas consisted of insulated wire terminating in an electrode that gave the necessary buoyancy so that the antenna trailed upwards to the ocean surface. The submarine's hull formed the second electrode.

More sensitive receivers developed during WW2 enabled signals from GBR to be received by submarines over most the world. But the antenna had to be towed fairly close to surface of the ocean. However, because of noise generated within the submarine the antenna was connected to the end of the transmission line - see Figure 75.

Post War Period

During the post war period, submarines were required to operate at ever increasing

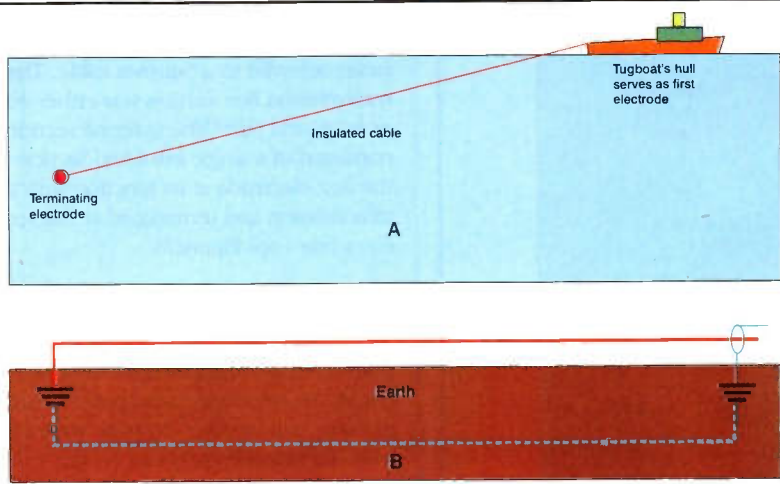
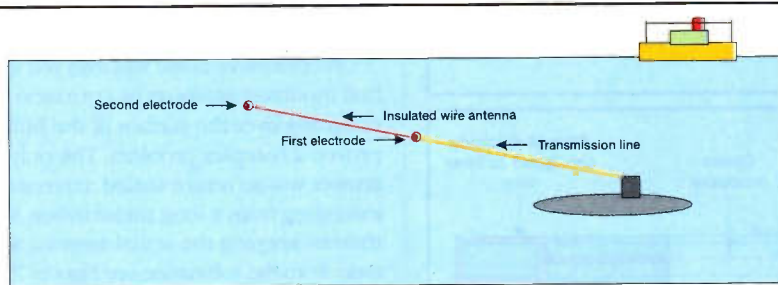


Figure 74. a) Preece's underwater antenna' used during the Bristol channel trials. b) Equivalence of the underwater antenna with an earth loop antenna.



The actual antenna is similar to Preece's underwater antenna except that the first electrode replaces the tug boat's hull

Figure 75. Submarine antenna and transmission line.

depths where reception was beyond the capabilities of WW2 equipment.

So, during early 1960, when the Sanguine project was launched, a study was made of other physical phenomena such as sound pressure waves in water and electromagnetic induction that might be employed as an alternative to VLF em systems. Esoteric systems were considered that included modulation of dynamo currents flowing in the ionosphere. See Part 1.

But ultimately, extremely long em waves

(ELF) were selected as these were known to penetrate seawater to a much greater depth than VLF. Moreover, the generation of current in the ELF range could be achieved by means of well-established audio frequency techniques. Alternators would have seemed the logical choice, but signalling involved complicated waveforms that audio techniques were best able to handle - see Figure 79.

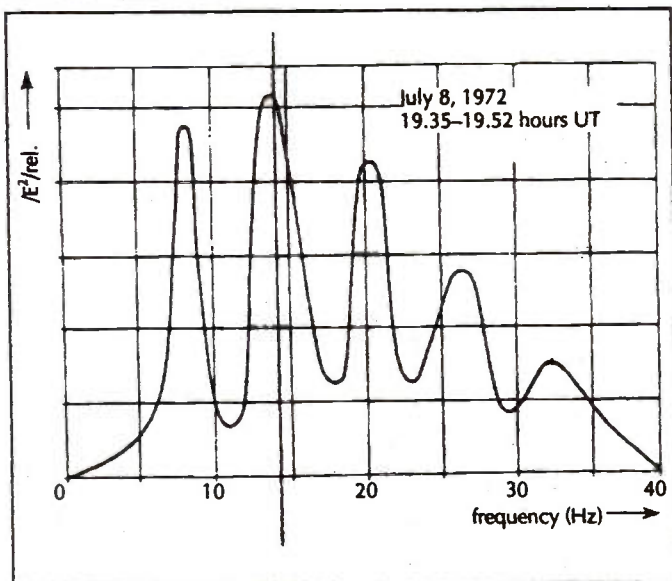


Figure 76. Schumann resonances.

Sferics

Before 1962, no radiating system existed to enable the propagation and attenuation of ELF waves to be actually measured. So researchers had to rely on data obtained from sferics (atmospherics) and the best known being 'whistlers' generated by distant lightning discharges; they were heard by both Preece and WW1 earth current signallers. Indeed this accounts for the otherwise unexplainable interest in 'Whistlers' at that time.

Whistlers cover a broad band of audio frequencies and were of particular significance because they propagate through the earth ionosphere/waveguide. In fact Schumann employed 'whistlers' to determine the frequency at which em waves resonated within the earth ionosphere/waveguide; these became known as Schumann resonances see Figure 76.

Sferics served as a good signal source against which to compare noise levels caused by submarine machinery, surface potentials, water motion and bubbling. The next matter was to design and construct an antenna to actually radiate ELF waves.

Satellite Trailed

Horizontal wires trailing from aircraft were commonly used as radiators of medium and long waves, but for good radiation of extremely long waves the length of the wire needed to approach $\lambda/10$, i.e. many km. This was out of the question with aircraft. Moreover, vertical antennas producing vertical electric (E) fields were necessary to excite em waves in the earth/ionosphere waveguide. Refer to Figure 45 Part 3.

Consideration was given to trailing a wire many miles long from an orbiting satellite. But the idea was discarded not only for practical reasons but it was believed that like the aircraft trailing antenna, it would not excite the earth/ionosphere waveguide.

Elevated By Helicopter

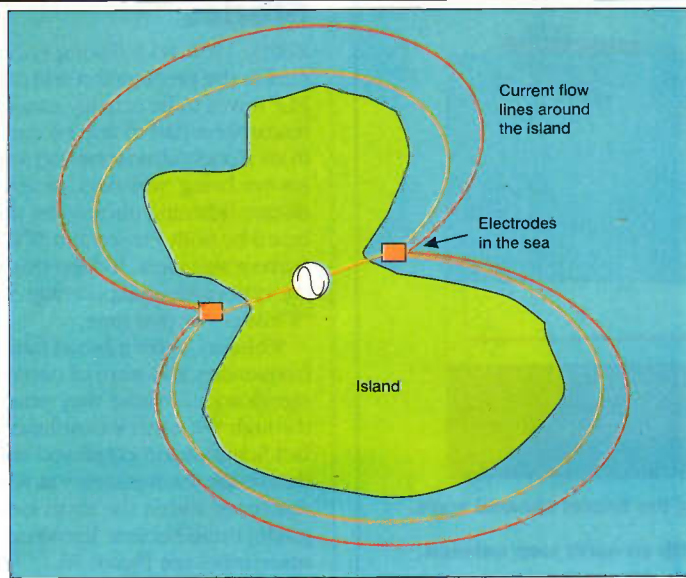
A long wire suspended from a helicopter would produce a vertical E field (Shades of Tesla's concept of balloon elevated antennas) but the problem was weight and tensile strength of the wire. A wire strong enough to be suspended from a height of several miles would be too heavy to be carried by a helicopter. Moreover the operational height of helicopters was limited. Balloons were considered, but this approach was not considered to be operationally feasible.

Island Slot

Its concept was that the seawater surrounding the island would provide a lower resistance path, but of longer distance than that directly across the island - see Figure 77. Early tests across Long Island showed that a current path through the water could not be relied upon and the idea was abandoned. Nonetheless, this antenna was the precursor of the earth loop radiator. Refer to Figure 29 Part 2.

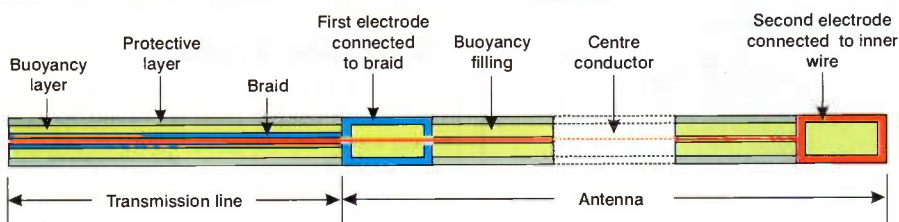
Parallel

Developments in transmitting antennas paralleled developments with submarine antennas and various types and configurations



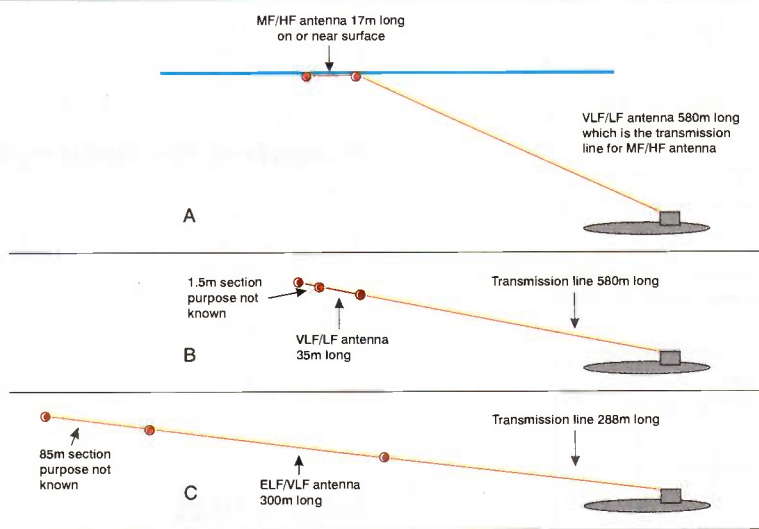
Compare with current flow lines in the earth loop antennas Figures 15 & 16, issue 150.

Figure 77. Island slot antenna



Early machinery inside the submarine for deploying and retrieving the antenna could only handle rigid electrodes. Later versions used much longer flexible electrodes including segmented metallic or carbon tubes, helical wires or conductive polyethylene

Figure 78. Buoyant submersible antenna and transmission line



Typical towing configurations for buoyant-cable antennas

were tried.

In the search for a low noise underwater receiving antenna, orthogonal loops and insulated wires with exposed electrodes were evaluated. However, tests showed the best receiving antenna to be one with widely spaced electrodes, (identical to Preece's underwater antenna). But the submarine itself produced spurious signals so the antenna was connected to the submarine via a long transmission line so as to keep the antenna well away from the

submarine and thereby reduce noise levels - see Figure 75.

Loops to sense the magnetic field were also tried but noise levels were greater than with the electric field, probably because of the magnetic fields produced by on-board electric motors.

Buoyant.

Since the early 1960's, US, and presumably also British submarines, employed a trailing

wire antenna that was simply a conductor encased in a buoyant polyethylene foam jacket referred to a buoyant cable. The transmission line section was either coaxial or a 'twisted pair.' The antenna section consisted of a single insulated section with the first electrode at its junction with the transmission and terminated at the second electrode - see Figure 78.

Hull Mounted

The drawback with buoyant cables was their short life and susceptibility to being cut by the submarine's propellers during extreme manoeuvres. So trials were made with the antenna mounted on the submarine's hull. A further advantage of this arrangement was that crossed electrode pairs could be used to obtain omniazimuthal antenna response patterns as opposed to the figure of '8' pattern with the buoyant cables.

Unfortunately, noise was injected into hull mounted antennas by corrosion occurring over the surface of the hull; this proved a complex problem. The only real answer was to return trailed antennas but extending from a long transmission line thereby keeping the actual antenna well away from the submarine see Figures 75 & 79.

However, the electrodes of trailed antennas were noise generators especially below 100Hz and this increased with towing speed, but by careful choice of electrode material, i.e. carbon fibre this noise was reduced to an acceptable level.

Digital

In recent years developments in communications have continued apace, especially with regard to digital systems, (see Figure 80) but antennas obey physical laws and whilst their design is continually being improved I cannot see how they could have significantly changed from the already tried and tested systems.

But alternative signalling methods mentioned in part 1 that were not based on em waves, were considered during the Sanguine project; these may well have been developed and now be operational. Presumably they would employ esoteric sensors. And there I must end this study.

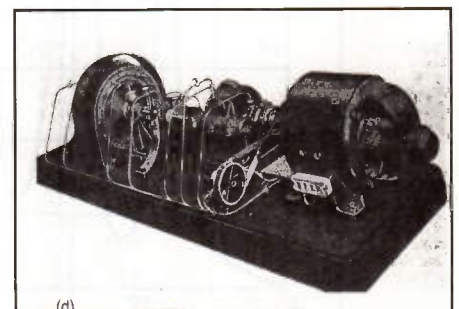


Photo H. Fessenden/ Alexanderson alternator. The alternator is on the left, drive motor on the right. Note gear drive, belt drive oil pump and feed lines to bearing

Fuel Cell DEVELOPMENTS

Reg Miles looks at how the desire for zero and ultra low emission vehicles is spurring on the development of fuel cells

The fuel cell is one of those technologies that is perennially going to solve the problems of this, that or the other industry, but never actually does. This is partly the fault of manufacturers overstating the capabilities of the state of the technology, and partly media hype. But the progress of development is accelerating, due mainly to the impetus in the USA for zero emission and ultra low emission vehicles (ZEV and ULEV) and, at the other end of the scale, the multiplication of portable products using small batteries - mobile phones, camcorders, PDAs notebook computers, etc. So 161 years after William Grove discovered the fuel cell principle it finally looks as if it is on the verge of solving at least some of the power and related pollution problems.

Limited Production

At present their production is limited. They also tend to be used in mundane roles, such as backup generators, or combined heat and power generation (CHP) in which the fuel cell generates electricity and the heat from oxidation goes to a heat exchanger for hot water and/or space heating in applications from domestic to local power stations (Figure 1). The roles that attract headlines, such as their use in cars, buses and boats, and the replacement of batteries in consumer items, are generally just a one-off to demonstrate progress (and to gain financial backing) or are part of on-going projects. Because the

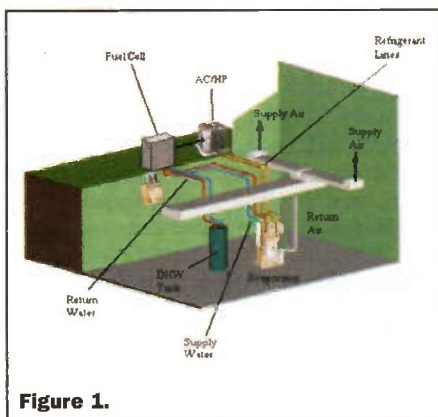


Figure 1.

numbers of those that actually are being manufactured is limited they are expensive and quite likely to be subsidised by those with vested interests or that want to prove their 'green credentials'.

The year 2001 seems to be favoured by a number of companies for either beginning the manufacturing of those fuel cells that will have some of the headline attracting roles or to increase production of those that are already being manufactured. Realistically, however, the expansion of the technology into a wider variety of roles and the reduction in prices that will make it attractive to both the customers for those and the existing roles are likely to be spread over the first decade of this century - and, in some cases, the following decade. Whatever the media and investors want to believe, or want others to believe, the technology is a long term one. If electric generators and batteries are going to be replaced by fuel cells it will be later rather than sooner.

Fuel Cell vs Battery

Although fuel cells and batteries have similarities - they both produce electricity by electrochemical means, the two technologies are actually quite different. A fuel cell is not a storage device like a

battery; electricity is only produced when fuel, normally hydrogen, is flowing through it - stop the flow and the current stops. Obviously there are both advantages and disadvantages to this. It does not become exhausted like a primary battery and need to be replaced, or need to be recharged in the case of a secondary battery. When the fuel runs out it is refuelled - always assuming that you are in a place where it is widely available or you have a supply with you. The fact that it is not self-contained has always counted against the fuel cell: the need to carry hydrogen in some form provides cause for concern, as well as adding to the overall weight and volume. However, the only other requirement is for an oxidant - and that is normally taken from the air. The process of oxidation does produce some heat; and, unlike a battery, there is some emission of vapour - which, if the fuel is pure hydrogen, is only water: but one or both could render it unsuitable for some uses, while making it particularly attractive for others.

There are five basic types of fuel cell; and these are generally known by the electrolyte that is used.

Polymer Electrolyte Membrane

One that was first used by NASA for the Gemini space programme and is growing rapidly in popularity due to its potential for not only small scale CHP, power generation and electric cars but a replacement for rechargeable batteries is known variously as the proton exchange membrane or polymer electrolyte membrane (PEM), or sometimes the polymer electrolyte or solid polymer fuel cell (PEFC/SPFC). Whatever, it employs a thin film (membrane) as the electrolyte that separates the anode from the cathode (Figure 2). The electrodes are typically 5-50µm thick and are coated onto the membrane that will vary in thickness from 50-175µm - this is known as the membrane/electrode assembly. The electrodes are made of porous carbon, and

CROSS SECTION OF POLYMER ELECTROLYTE FUEL CELL

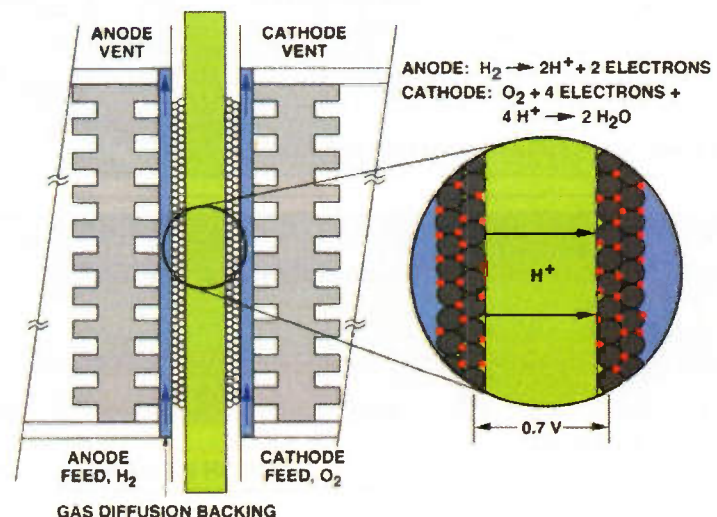
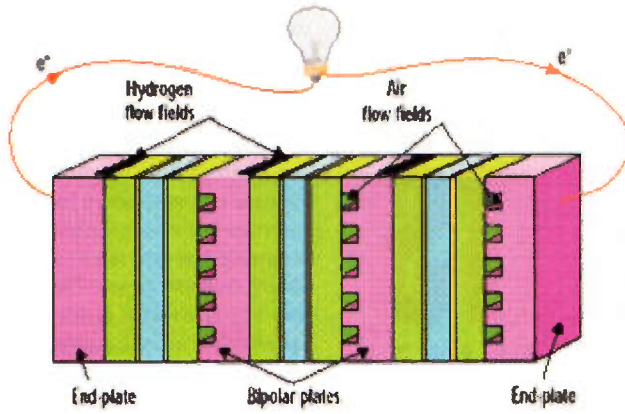


Figure 2.

Figure 3.



A 3-cell fuel cell stack with two bipolar plates and two end plates.

contain a catalyst of dispersed platinum (Pt) particles to expedite the anode and cathode reactions at the comparatively low operating temperatures of 50-100°C; the membrane is generally made of a perfluorocarbon sulfonic acid ionomer. Oxidation occurs at the anode, producing hydrogen ions (protons) and electrons from the hydrogen gas. Only the positive ions can pass through the humidified membrane, the electrons that are left behind thus produce a potential negative voltage. On the other side of the membrane the hydrogen ions mix with oxygen, but for reduction to occur electrons are needed. This creates an electrical potential between the negative anode and the positive cathode. The electrons that were left behind flow through an external

circuit from anode to cathode, providing the electrical power, and combine with the hydrogen ions and oxygen to complete the reduction and produce water. This may then be used to humidify the membrane, or be carried away if humidification is provided by water introduced into the hydrogen and air. The membrane, incidentally, is also the barrier that prevents the hydrogen and oxygen mixing (the oxygen may be neat or taken from air, in the latter case supplied either by a compressor or from the ambient air depending on the design).

On either side of and in contact with the membrane/electrode assembly there are gas diffuser or backing layers. These are typically 100-300µm thick, and are generally made of either porous carbon paper or

cloth: carbon, in order to conduct the electrons out of the anode and into the cathode; porous, to spread the hydrogen and oxygen as uniformly as possible over the electrodes and so maximise catalysation. They also perform the task of balancing hydration: if they hold too much water it will reduce gas diffusion through the layers, while if they hold too little the membrane will dry and its conductivity will fall.

The cell is completed by current collector plates at either end. These may be made of either graphite or metal, although composite materials are finding increasing favour. They generally serve a dual role: firstly, as a gas flow field distributing the hydrogen and oxygen evenly over the backing plates through machined channels (which also control hydration); and secondly, conducting the electrons from the anode backing layer out of the cell through an external circuit to the load and back into the cell to the cathode backing layer. Because a PEM only operates at about 0.7V they are usually arranged side by side in what are known as stacks; and then the current collector plates become bipolar plates with flow fields on both sides (Figure 3). In this case the electrons are then conducted from the anode of one cell to the cathode of the adjacent cell, and the stack is completed by end plates that are connected via the external circuit. Stacks can also be connected - in series or in parallel.

Incidentally, 0.7V represents about 60% efficiency, with the remaining energy turning into heat. The theoretical maximum voltage obtainable is 1.23V; although under typical operating conditions this declines to 1.16V; and present day PEMs are unlikely to operate at more than 0.9V.

PEM Variations

There are also a couple of variations on the PEM 'direct hydrogen' fuel cell. One is the reformat hydrogen cell, that uses fuels such as natural gas, methanol, ethanol, even petroleum now, that have been converted into hydrogen by an external reformer. The other variation is the direct methanol fuel cell (DMFC), where the anode catalyst extracts the hydrogen from the methanol. This latter type obviously has considerable potential for small to medium size applications where carrying pure hydrogen in some form or reforming other fuels would prove a barrier to success in consumer driven markets. Much of the work on PEM types has been done by the Los Alamos National Laboratory in the USA, and companies are licensing the technology for commercialisation.

Although there are different types of fuel cells, they all follow the same general arrangement.

Alkaline Fuel Cell

The alkaline fuel cell (AFC) was the type that finally showed the potential of the technology after more than a century of experimentation with limited success. In

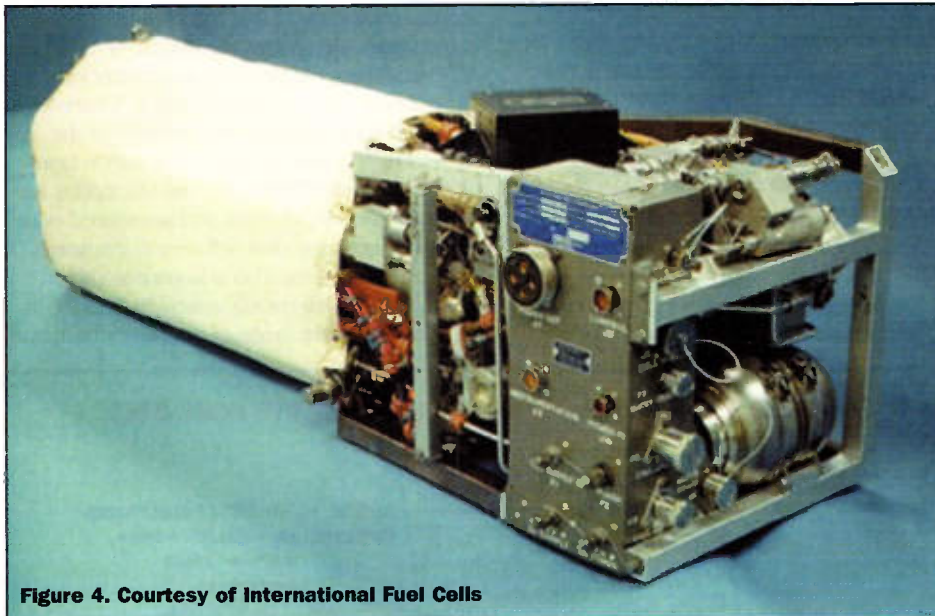


Figure 4. Courtesy of International Fuel Cells

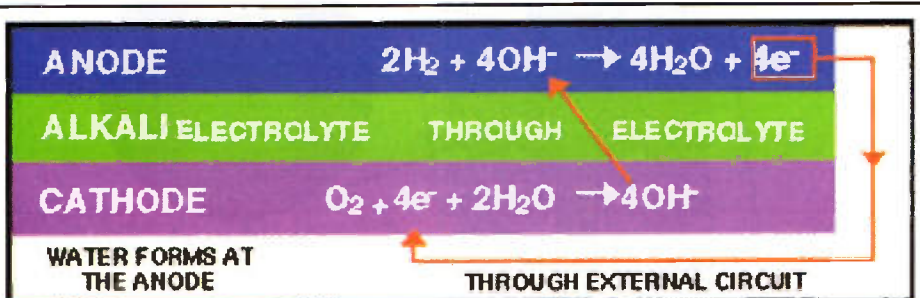


Figure 5.

Figure 6.

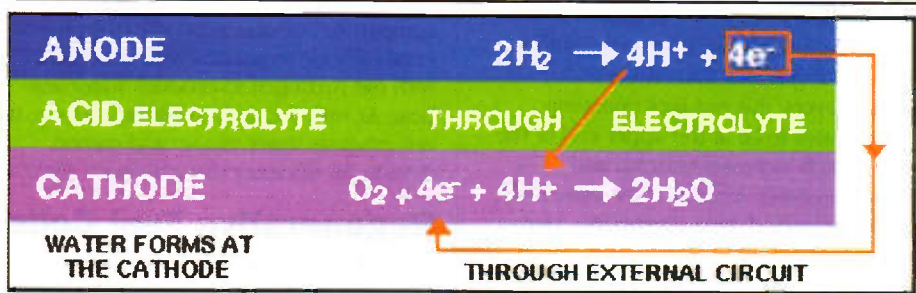


Figure 7.

1959 Francis Bacon and his team at Cambridge University demonstrated their fuel cell powering a forklift truck and a welding machine. This led International Fuel Cells to develop AFCs, which NASA chose to use for the Apollo, Apollo-Soyuz and Skylab programmes (all based on the Bacon technology). The same company has supplied all the second generation AFCs for the Space Shuttle Orbiter. Three 12kW cells are installed under the payload bay (Figure 4), using hydrogen and oxygen from cryogenic tanks. Not only do they provide all the power for the shuttle, but also water for drinking and cooling. No backup batteries are provided, nor needed - for just one AFC can guarantee the shuttle's safe return. And they have proved very reliable over the years.

The electrolyte in an AFC is usually potassium or sodium hydroxide; and the electrodes are normally carbon with a nickel catalyst. Hydrogen at the anode reacts with hydroxyl ions from the electrolyte producing water and releasing electrons (Figure 5). These go via an external circuit to the cathode, where they react with oxygen and water to produce more hydroxyl ions that pass through the electrolyte to replenish those used at the anode. Twice as much water is produced at the anode as is used at the cathode, so it must be drained off.

AFCs operate at temperatures of 50-250°C. They can also be made to achieve an

efficiency of up to 80%, and those used for the Space Shuttle achieve over 70%, although much depends on the design.

In addition to being used by the Space Shuttle, AFCs are being used in vehicles, boats and stationary applications. One company that is involved in all three areas, and one of the few UK based companies to be manufacturing fuel cells, is ZeTek Power. Their Millennium Taxi is running in London (Figure 6) and they have provided fuel cells for a canal narrow boat, among other projects. The company is also building the

world's first fully automated fuel cell production plant in Cologne; with the first of four production lines expected to be operational this July.

Phosphoric Acid Fuel Cell

The phosphoric acid fuel cell (PAFC) is the most commercially developed type at present. It is being used in a variety of stationary applications for medium scale power generation and CHP, and is also suitable for larger vehicles such as buses and railway locomotives. The operating temperature range is higher than the two previous types at 160-220°C. This higher temperature produces steam that can be used for cogeneration of electricity, which roughly doubles the efficiency to about 85%.

The electrolyte is orthophosphoric acid. The cell is similar in operation to the PEM: hydrogen ions and electrons are produced at the anode, the ions travel through the electrolyte where they recombine with the electrons that have travelled via the external circuit, they mix with the oxygen and produce water (Figure 7). The cells can use hydrogen that is contaminated with carbon dioxide, so that the hydrogen can be produced from various fuels - they can also be used for direct methanol applications.

Molten Carbonate Fuel Cell

The molten carbonate fuel cell (MCFC) takes a jump up the temperature scale to around 650°C. And has an operating efficiency of 50-60%. It is being used for medium to large-scale power generation and CHP, including local and larger power stations.

The electrolyte is molten potassium lithium carbonate. Because of the higher operating temperature the cell can run on a mix of hydrogen and carbon monoxide from fossil-based fuels. This combines with the carbonate electrolyte, and then with the

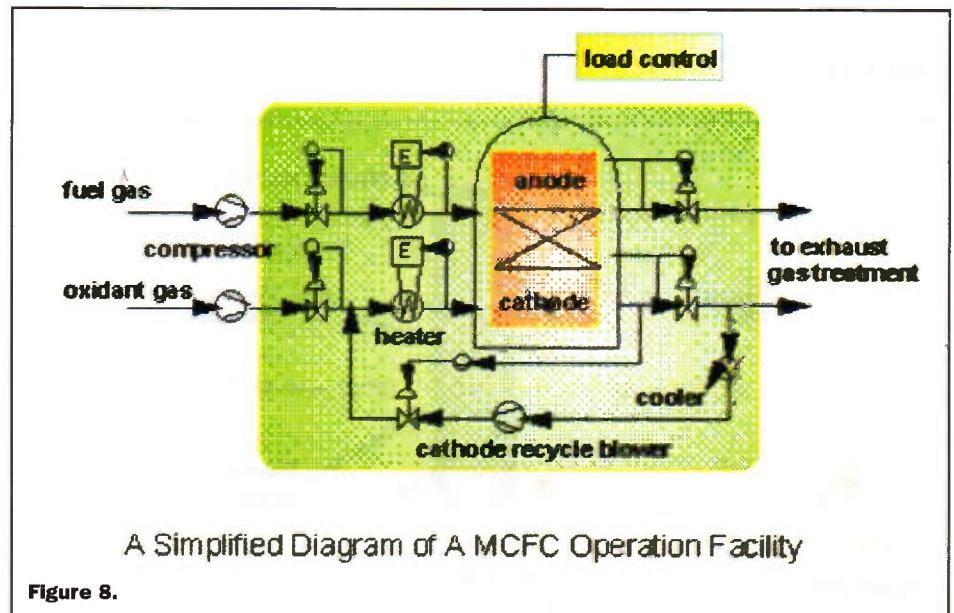
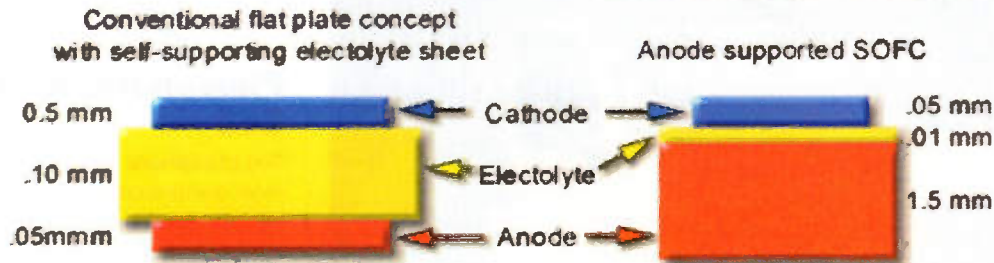


Figure 8.

Single Cell Structure



Figures 9a & 9b.

oxygen to produce water vapour and carbon dioxide (Figure 8).

Solid Oxide Fuel Cell

Right at the top of the fuel cell temperature scale is the solid oxide fuel cell (SOFC), with a range of 800-1000°C. It is the least developed type, but has the potential to provide stationary applications from small to large; and to be used for auxiliary power in vehicles with internal combustion engines, as well as recharging the batteries in a hybrid electric vehicle. The fact that the SOFC can operate using a wide variety of fuels - natural gas, propane, petroleum, etc - adds to its versatility. This is possible because it is the oxygen ion that migrates through the electrolyte, rather than the hydrogen ion, giving a greater choice of chemical to be oxidised. An additional

advantage of the SOFC is that the high operating temperature allows the SOFC to directly reform the fuels.

The electrolyte is an ion-conducting oxide, such as zirconia treated with yttria. The electrodes are also ceramic, with nickel for the catalyst. A combination known as the ceramic PEN element (positive electrode, electrolyte, negative electrode). The 'traditional' type of SOFC is known as 'electrolyte supported' (Figure 9a) with a thick electrolyte and thin anode and cathode layers; this requires operating temperatures to be at the upper end of the range, which increases material and production costs. A recent alternative is the 'anode supported' type (Figure 9b). Here a thick anode provides the supporting structure and the electrolyte and cathode are thin, allowing reduced operating

temperatures, reduced production costs and increased life. Other configurations have also been developed, with their own advantages and disadvantages.

Fuel is supplied to the anode where it undergoes an oxidation reaction, and releases electrons to the external circuit. On the cathode, oxygen becomes reduced by taking electrons from the external circuit. The electrolyte, which separates the two gas compartments, conducts only oxygen ions - from cathode to anode - which combine with the hydrogen to produce water and heat. As with the molten carbonate type, the cell exhausts water vapour and carbon dioxide. Its efficiency varies between 45-60%.

Regenerative Fuel Cells

Those are the basic types of fuel cell. However, the fuel cell process is basically electrolysis in reverse, and it is possible to make a cell that can operate in both modes (Figure 10- a, fuel cell mode; b, electrolysis mode). Applying electricity to the cell's electrodes produces hydrogen and oxygen gases from retained water; these are then stored under pressure until they are required to power the cell again. Regenerative fuel cells (RFC) are usually combined with solar panels.

The electrolysis of hydrogen is being promoted on a much larger scale in California, with Hamilton Sundstrand Space Systems International and HyGen Industries signing a Memorandum Of Understanding to develop and commercialise renewable hydrogen generation and vehicle fuelling systems using water electrolysis powered by sun, water and wind. Sun alone is being used by the Solar Hydrogen Energy Corporation - concentrated by reflectors, the heat is apparently sufficient to produce hydrogen and oxygen. As an alternative, scientists at the University of California have persuaded algae to produce hydrogen gas by keeping them in an anaerobic environment. Just some of the ways that hydrogen might be produced for fuel cells.

And there is going to be a lot of it required if fuel cell powered electric cars are going to be accepted in the next few years. All the major car manufacturers are developing prototypes (Figure 11). Generally obtaining the fuel cells from specialist companies, such as the Canadian Company Ballard Power Systems - which has been particularly active in supplying its PEM

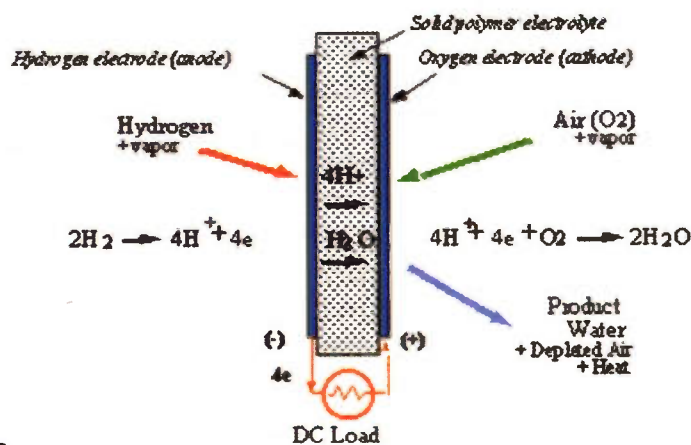


Figure 10a.

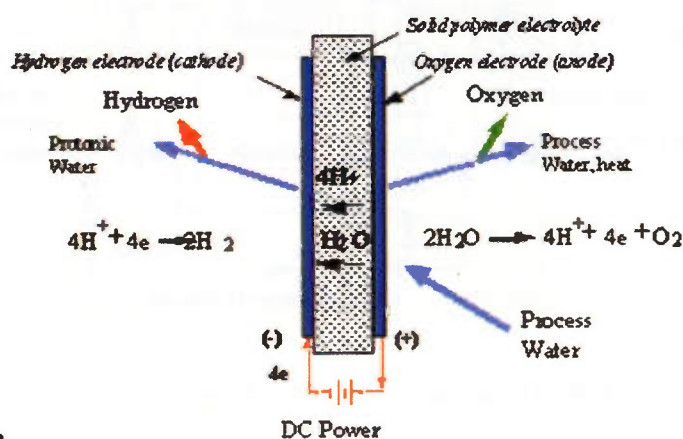


Figure 10b.

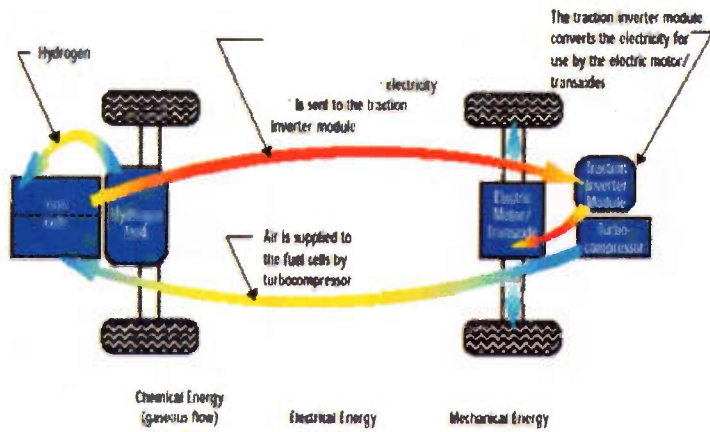


Figure 11.

cells for cars. Fuel cell powered cars have a performance and range more closely approximating that of conventional cars than do battery powered ones, because fuel cells are generally more efficient for a given size and weight.

On a much smaller scale, researchers at Case Western University have developed a fuel cell with a volume of just 5m³. This has been achieved by printing layers of components onto a substrate. A hydride is used at present, but methanol is planned for the future. Los Alamos National Laboratory and Motorola have designed a methanol fuel cell that is small enough to be used for

mobile phones. The methanol would be made available in small, plug-in cartridges. Staying on the subject of mobile phones, Manhattan Scientifics recently acquired the rights to the MicroFuel Cell being developed by Energy Related Devices. They plan to launch it next year as a holster which will take the mobile phone and constantly recharge its battery (replacing the battery will come later), with a methanol cartridge to fuel it.

Try It Yourself!

If all this has got you interested in fuel cells you can obtain an experimenters kit from

Electro-Chem-Technic (Figure 12). The URL is www.i-way.co.uk/~ectechnic/; or they can be e-mailed at: ectechnic@patrol.i-way.co.uk. You can also make your own fuel cell: J. Bull Electric has the details at www.bull-electric.com (workshop facilities are required, so it is not a project for beginners).

We shall have to wait and see whether we are on the verge of a fuel cell future or not. A lot of money is being put into the technology, so I cannot imagine it going to waste.



Figure 12.

<http://www.maplin.co.uk>



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Evolvable CIRCUITS

This month Mike Bedford looks at 'Genetic Algorithm', a phrase well known in software engineering - but what does it mean?

Genetic Algorithms

In the realm of software engineering, the phrase 'genetic algorithm' is well known. Although it would be wrong to suggest that the technique is now in widespread use, there's been much research into genetic algorithms and a reasonable amount of press coverage. Such software is developed in a manner that mimics biological reproduction and the Darwinian theory of evolution by natural selection.

The basic principle is that the exact operation of a piece of software depends on various parameters or genes. Each gene controls a particular aspect of the software's operation and the sum total of all the genes is referred to as a chromosome. Initially the

chromosomes are set randomly, the software is run, and a score is compiled to indicate how successful the software had been at accomplishing its task. This is repeated a number of times and the top two chromosomes, perhaps, are singled out. Now, the chromosomes of the two leading programs are combined in a way that is akin to breeding in biological organisms. In other words, combining the genes of the 'parents' in different ways creates a number of new chromosomes. Specifically, a technique called 'crossover' (see Figure 1 for a clarification) is used in which the two chromosomes are split at a random point - albeit on a gene boundary - and the two broken chromosomes spliced together. And

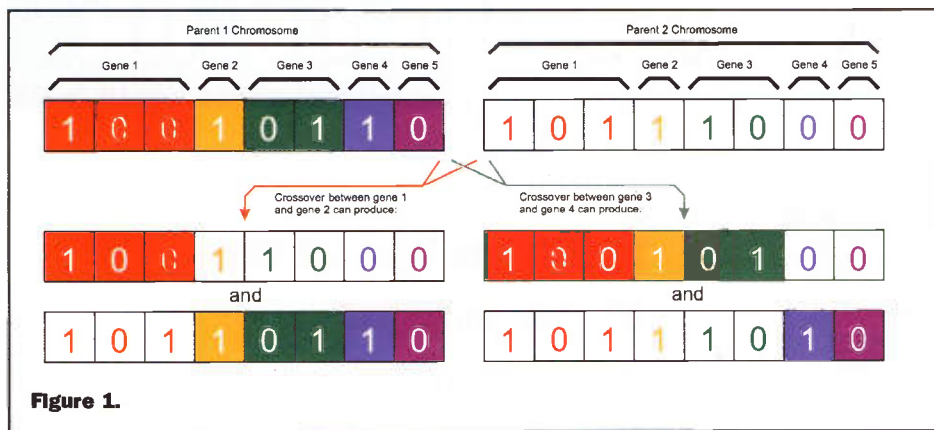


Figure 1.

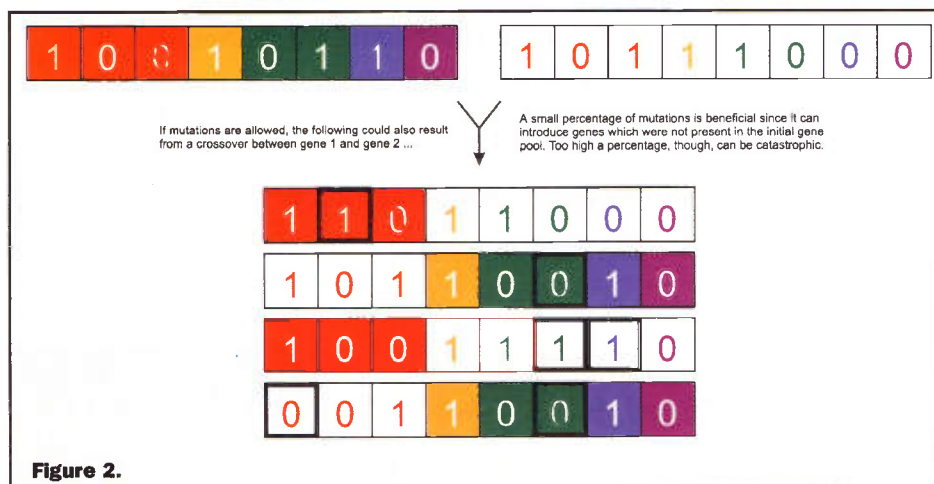


Figure 2.

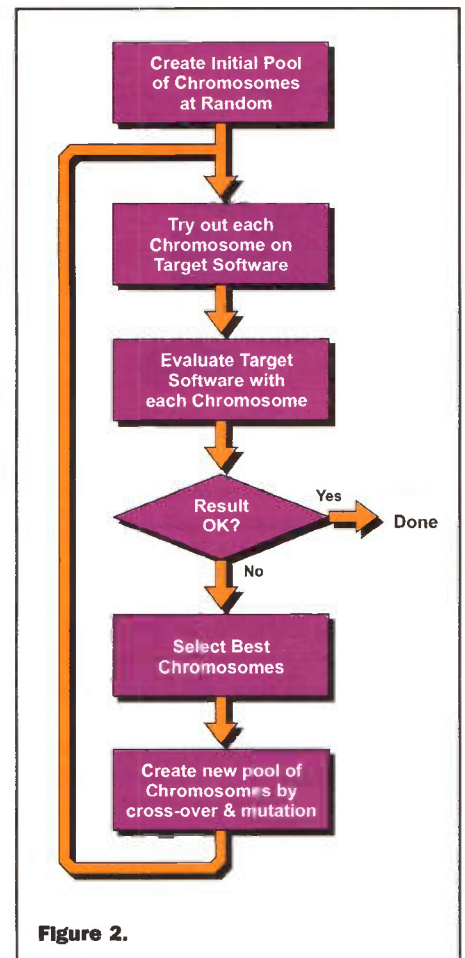


Figure 2.

occasionally, random mutations - flipping individual bits (see Figure 2) - are forced, once again, to mimic biological processes. Programs with these new chromosomes are then run and the process is repeated for another generation. The process stops when the score indicates that a solution has been achieved or the experiment is abandoned. This cycle is shown as Figure 3.

A few words of explanation about crossover and mutation are appropriate. Whereas the rationale behind the crossover is fairly easy to appreciate - to produce a hybrid of the two parents - the reason for mutation might not be quite so obvious. The philosophy is that this allows, during the evolution process, genes that hadn't been represented in the initial random sample to be tried out. Clearly it is a random process and the result could be disastrous, indeed if too high a proportion of mutations is allowed then almost definitely the result will be catastrophic. However, a small amount of mutation can have a beneficial impact on the evolving software.

The results have been impressive both at a demonstration level and in real world applications. Demonstrations are often of the A-life or artificial life type. For example, A-life organisms, each represented by a dot on the screen, are placed on a grid containing a replenishable food source. The organisms will consume any food they come across, breed to produce a new organism if they encounter a mate, and eventually die, their life duration depending on their success at finding food and various other factors. Genes control characteristics such as the organism's speed of travel, its eyesight (i.e. the distance over which it can see food or a

Figure 4.



problem should be solved. Furthermore these will be applications in which the number of parameters is large, the number of combinations huge, and the time taken to try them all out in sequence would be prohibitive. By their very nature, though, genetic algorithms perform a directed search through the gene space and hence can often come up with an acceptable solution in a reasonable time period. Some of the best known examples of genuine applications have been in the arts. Computer artist William Latham, for example, specialises in visualising other-worldly life forms

potential mate), its general state of health (and hence its life duration), and its motivations (e.g. whether it moves toward a potential mate or is repelled by one). After a period of evolution, the vast majority of organisms are the ones with favourable genes, i.e. ones which allow a reasonable speed of motion, good eyesight, and a sensible motivation, that is being drawn toward rather than away from food and a mate.

Searching the Gene Space

This sort of program, of course, is just a proof of concept and, in the simplest of cases, it is perfectly obvious what combination of genes would give the A-life organisms the best chances of surviving and passing their genes on to the next generation. In reality, of course, genetic algorithms would be used in applications where it's far from obvious how a particular

and has exhibited his work in prestigious galleries world-wide. A classic example of his work is shown as Figure 4. The life forms are generated automatically using software written by the artist in which the characteristics are defined by parameters or genes to use the biological parallel. But the number of genes and their permissible values are such that searching through them using conventional techniques would be prohibitive. And since the visual effect of genes in combination is not always obvious, pleasing works of art could remain hidden forever. Latham has solved this problem using his Mutator program. A selection of random life forms is displayed on screen and the artist selects the two that he finds most aesthetically pleasing. The chromosomes of these life forms are then used as the basis for the next generation and the process continues until a final result is achieved. Latham has now turned his attention to computer games and is using genetic algorithms to control the action of characters within the games. His first game

to employ genetic techniques is called Evolve and has just been released by Virgin Interactive (www.viv.co.uk). Figure 5 is a screen shot from this game and whereas this might look like any other action game of the shoot 'em up genre, the game play is, apparently, quite different due to the use of the genetic algorithm engine.

So far we've looked at applications where the basic algorithm is known and evolvable chromosomes are used to fine tune the operation. However, there are problems in which nobody has even managed to figure out what the basic structure of the algorithm should be. And in this case it's clearly not possible to write a program for which a genetic algorithm simply optimises various parameters. However, a similar technique has been used in which the actual algorithm, and not just the parameters, is allowed to evolve. Clearly this isn't achievable with a conventional computer program. Although a program is a sequence of zeros and ones, this really can't be likened to the chromosome that we've talked about. Instead these zeros and ones correspond to instructions that are executed in sequence, and any attempt to perform a crossover, let alone a mutation, on two programs would, more than likely, produce a program which would crash at some point. Even if, by some coincidence, a valid program resulted, its operation would almost certainly not be a better solution than its parents. Instead, a so-called classifier system has to be used to allow evolution. This is a system in which the logic is represented by a string of ones and zeros but these ones and zeros aren't the op-codes of instructions that are executed in order. Instead, the ones and zeros represent how the system should respond to particular combinations of its inputs. This is too complicated a subject to describe fully in this brief introduction but, suffice it to say, any program which could be written in a conventional computer language such as Basic or C, could be re-written as a classifier system. Since the operation of the system is controlled entirely by that sequence of ones and zeros, this code can be considered the system's chromosome and our technique of breeding the most successful systems by crossover and mutations can be applied.

One particularly successful application of an evolved algorithm using a classifier system was devised in the University of Illinois for the control of a gas pipeline. This is an example of a control system for which manual operation had previously been the only solution. But even this was by no means easy, primarily because of the long time lag between making a change and the effect of that change becoming evident. This just wasn't intuitive so operators required a long apprenticeship in order to master the system. The fact that genetic algorithms have proved successful is particularly interesting since evolving the algorithm is a close analogy to the training of human operators - the only other option that is currently viable.

Figure 5.



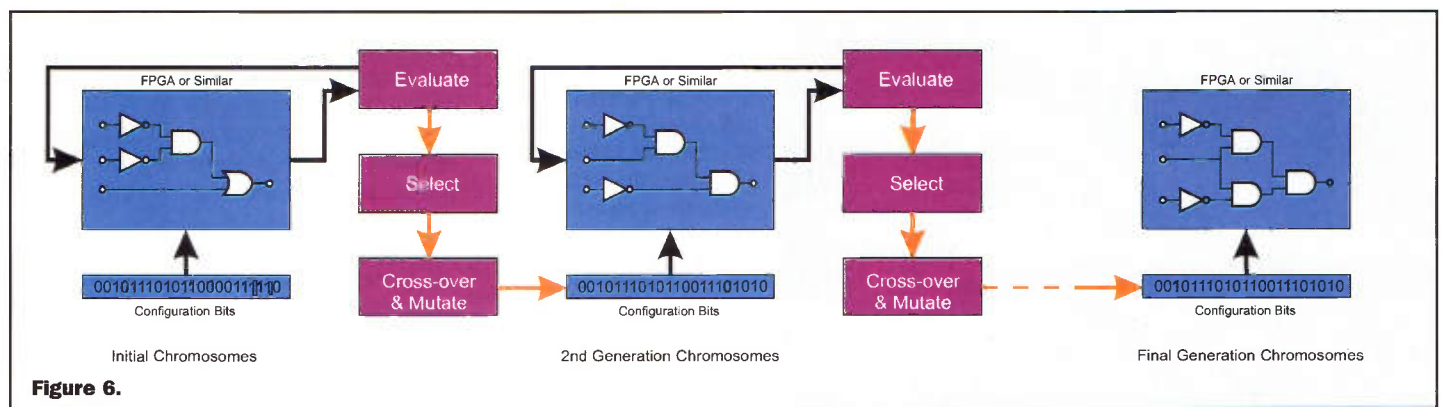


Figure 6.

Evolvable Circuits

OK, that's as much as I intend to say on genetic algorithms - that is software that can evolve. This was really just to set the scene for the main subject of this article, the lesser-known field of evolvable hardware. Increasingly, equipment is being designed so that its function is not set in concrete the moment it leaves the production line. A classic example is anything containing a microprocessor. By changing the software stored in ROM new features can be added, and if flash memory is used then this upgrade can be carried out by the end user. But it's important to stress that this is changing the software (well, firmware actually) rather than hardware and there's a limit to how much can be achieved with changes to the software alone. But upgrades to the hardware are also possible if use is made of reconfigurable components such as field programmable gate arrays or FPGAs (see box out for details) and, once again, this would allow the end user to upgrade the equipment.

Impressive as all this may sound, though, this is not what is meant by evolvable hardware. In order to upgrade a piece of equipment containing an FPGA an electronic design engineer first has to figure out how the circuitry should be changed. If the new functionality is to be made available to existing customers, the new configuration then has to be distributed and the customer has to follow the upgrade procedure. However, to quote Xin Yau of the University of Birmingham and a pioneer in the field, "Evolvable hardware refers to one particular type of hardware whose architecture, structure and functions change dynamically and autonomously in order to improve its performance in performing certain tasks.". Note his use of the word autonomously - this is hardware that reconfigures itself. Note also Yau's use of the word dynamic, even though other researchers also talk about a slightly different concept - that of static evolvable hardware. In the static approach, the iterative process required to automatically generate the required functionality is performed as part of the design process. And once the circuit leaves the factory its functionality is fixed. With dynamic evolvable hardware, on the other hand, the evolution continues when the product is in use. As conditions change, therefore, the hardware reconfigures itself to cope with the changing environment and so ensures continued optimum performance. Figure 6 shows the iterative cycle of

evolvable hardware and this is clearly very similar to the way in which the evolvable software operates. In static evolvable hardware, the processor that runs the genetic algorithm is external to the final product, in dynamic evolvable hardware it is integral.

Success Stories

Let's now jump straight in by looking at some success stories - some applications in which evolvable hardware has already reaped benefits or in which research is looking promising. In the main, these applications involve allowing the circuit to evolve within an FPGA although analogue evolvable hardware, which can't make use of the essentially digital nature of the FPGA, has also been produced.

Tetsuya Higuchi, of the Evolvable Systems Laboratory at MIT's Electrotechnical Laboratory in Japan has developed a chip with evolvable hardware to handle data compression and decompression in top-end colour printers used in the printing and publishing industries. These printers typically output to A4 at 1200dpi with a throughput of 100 pages per minute, thereby requiring data transfer at a rate of 300MB/s, significantly in excess of that achievable from standard hard disks. Data compression is, therefore, integral to the operation of such a printer, but conventional software techniques are not able to provide either the necessary speed or the compression ratio. Conventional hardware, on the other hand, is faster but is even less flexible and therefore achieves an even lower compression ratio. Clearly a hardware solution is needed but only by using evolvable hardware can the necessary flexibility be provided. Whenever the compression ratio falls, due to changes in the types of pattern in the document being printed, the circuitry reconfigures itself to improve its performance. Results have been encouraging - the compression ratio achieved is almost double that obtainable using conventional software compression algorithms and, furthermore, the necessary speed of operation has been reached. The chip - which contains both the reconfigurable hardware and a 32-bit RISC processor which runs the genetic algorithm - is going into production for use in commercial printers.

A major research project undertaken at NASA's Jet Propulsion Laboratory and elsewhere involves the development of fault-tolerant hardware for use in deep space probes. The electronic equipment

used in missions to the outer edges of the Solar System and beyond may be required to operate for decades yet the environment in which it's placed really isn't too conducive to long-term operation. The hardware is subject to ageing, to wide temperature variations and, perhaps most importantly, to ionising radiation which can cause permanent damage to individual elements within integrated circuits. One common conventional approach to fault-tolerance is to provide redundant circuitry - circuitry that, under normal circumstances, plays no part but which is switched into circuitry should a fault occur. Needless to say this is an expensive proposition. Not only does this impose a cost associated with duplicating all the critical systems, but the increased size and weight of the hardware will also impact the size of the vehicle and hence the launch and operational costs too. The hope and expectation is that evolvable hardware will be able to provide an acceptable level of fault-tolerance without going to the expense of duplicating everything. Perhaps the most obvious way of achieving fault-tolerance is to use evolvable hardware dynamically. And although some groups are working on this solution - causing the circuitry to reconfigure itself on the fly as and when faults occur - the major drawback is the time taken for a repair to be effected. Unlike those dynamic evolvable circuits that are designed to reconfigure themselves under gradually varying conditions, a fault is a step function that could result in many thousands of iterations before a new solution is obtained. Clearly this would result in a long down time. The alternative approach is to use the evolvable approach statically in order to design a circuit that has an inherent immunity to faults. The drawback here is that the circuit will only be guaranteed to show tolerance to particular faults - the ones that were injected during the training process. Some researchers are attempting to improve on this technique by using a pair of genetic algorithms - one to optimise the circuit to cope with faults and the other to devise faults to try to catch out the evolving circuitry. This has been described as the 'arms race' approach to fault tolerance.

The applications of evolvable hardware which we've seen so far are ones in which the entire circuit topology is allowed to grow using a non-committed, programmable integrated circuit such as an FPGA or a FPTA (field programmable transistor array). However, useful results have also been

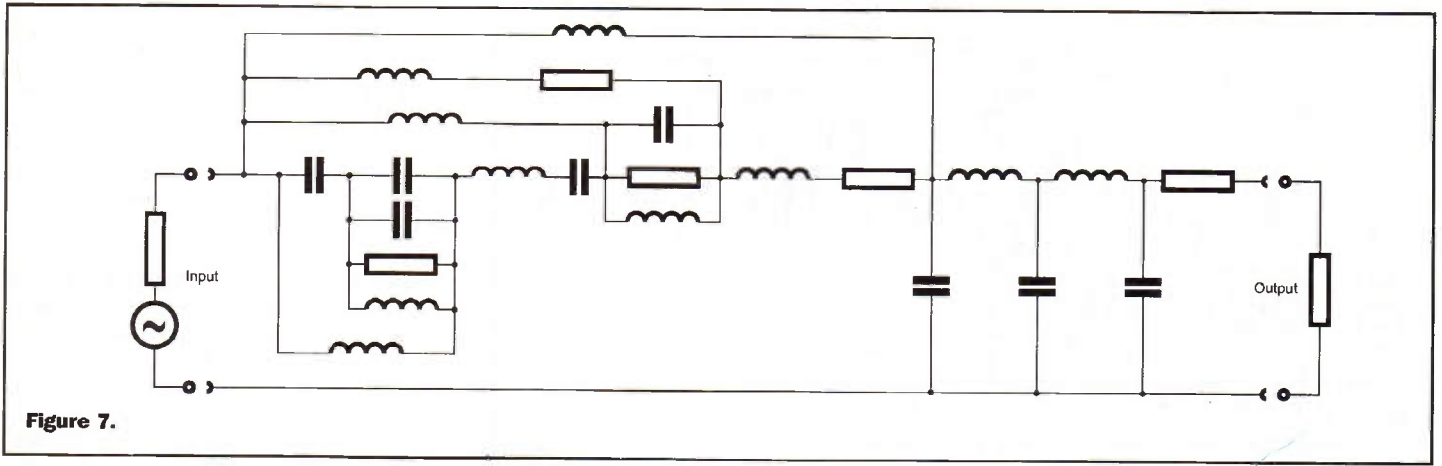


Figure 7.

achieved by using genetic algorithms to fine tune circuits with a fixed topology. This is especially common in analogue electronics - for example, the RF circuitry used in mobile phones. In another project at MIT's Evolvable Systems Laboratory, evolvable hardware is being used for IF filters, components which need to adhere to very tight tolerances. Because of variances during the manufacturing process, the conventional approach is to test all the devices coming off the production line and discard those which are outside of their specification. This is a wasteful process. The chip developed to overcome this problem contains 39 transconductance amplifiers whose characteristics can be set genetically. The chip went into production in late 1998 resulting in a dramatic increase in yield. Despite the fact that each amplifier may differ from its target value by up to 20%, and despite the fact that a 1% error in the filter's centre frequency is unacceptable, evolution has allowed 95% of all chips manufactured to meet the overall specification.

Designing by Evolution

So far we've looked at evolvable hardware, that is, hardware such as the FPGA in which the functionality can be controlled or modified automatically either at the manufacturing stage or during operation. Closely related to this is the work being carried out by Jason Lohn and others at

NASA's Ames Research Center. Here, hardware which, in itself, is reconfigurable isn't employed. Instead, standard hardware consisting of ordinary resistors, capacitors, inductors and transistors is used, but the way in which those components are connected together is determined by genetic algorithm software. The rationale here is different. Clearly this approach doesn't permit a piece of equipment to adapt to changing conditions, nor does it allow different products to be generated from the same basic hardware, simply by using a different goal to configure the circuit at the design stage. The reason for experimenting with automated design is simply that analogue design engineers are now so thin on the ground, despite the fact that the majority of products still require some analogue circuitry.

The design system has three basic elements. First of all there is the circuit builder which configures the topology of the circuit depending on the parameters fed to it. These parameters include the type of component (i.e. transistor, resistor, capacitor, inductor etc.), its value, and how it should be connected (e.g. to ground, to the supply rail, to a previous node, or to a new node). Secondly there is an analogue circuit simulator such as SPICE that determines what output the circuit would produce for a given set of inputs. And finally there is the genetic algorithm engine that compares the simulation results of each

circuit with the design goal and generates the parameters for new circuit variations based on a success score and the principles of crossover and perhaps mutation. Let's now look at a couple of the circuits that have been designed using this novel approach.

The first circuits to be evolved were passive filters. These were chosen as a first step since they used just two-terminal devices - i.e. resistors, capacitors and inductors, they had no power connections, and filter design is well-understood and documented. In one exercise, the design of a low-pass filter, the specification called for a cut-off frequency between 1kHz and 2kHz, a pass-band attenuation of 0.01dB, and a stop-band attenuation of 60dB. Figure 7 is the circuit that has been produced using the system, and Figure 8 compares the actual performance of the filter with the target characteristics. The circuit that achieved these requirements evolved after about 930,000 circuit evaluations taking many hours on six workstations. Having proved the system with passive filters, attention turned to amplifiers. Now, of course, transistors were needed with the added complexity of coping with 3-terminal devices and power supplies. Figure 9 is an 85dB amplifier that was produced and, as with the low-pass filter, the performance is acceptable.

According to Jason Lohn, the circuits are of about the standard that would be expected of a first year student on an electronic engineering course. However, the circuits certainly don't look like anything a first year student would have come up with, nor an experienced design engineer for that matter. In fact the circuit topology would be quite unrecognisable to an analogue design engineer. These unconventional circuits have some interesting properties. For a start, many of the evolved circuits will only operate over a narrow range of conditions. For example, some of them will work only within a narrow band of temperatures centred around the temperature specified in the simulation. Presumably the evolution process would have to be carried out over a wide range of temperatures in order to overcome this drawback. Another strange feature of many of the circuits is that they have redundant components. Basically the circuit will continue to operate correctly even if these extra components are cut out. Lohn explains this phenomenon by

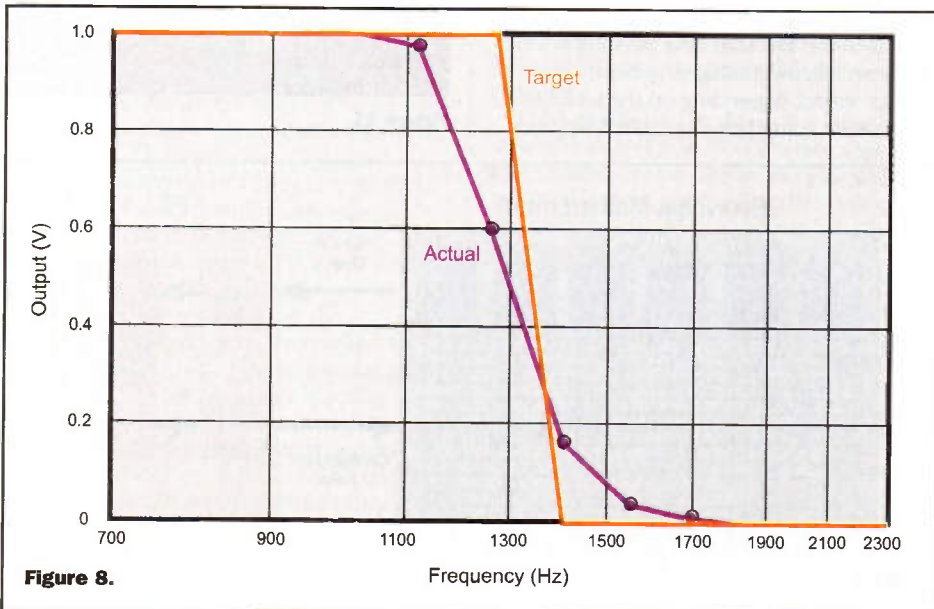


Figure 8.

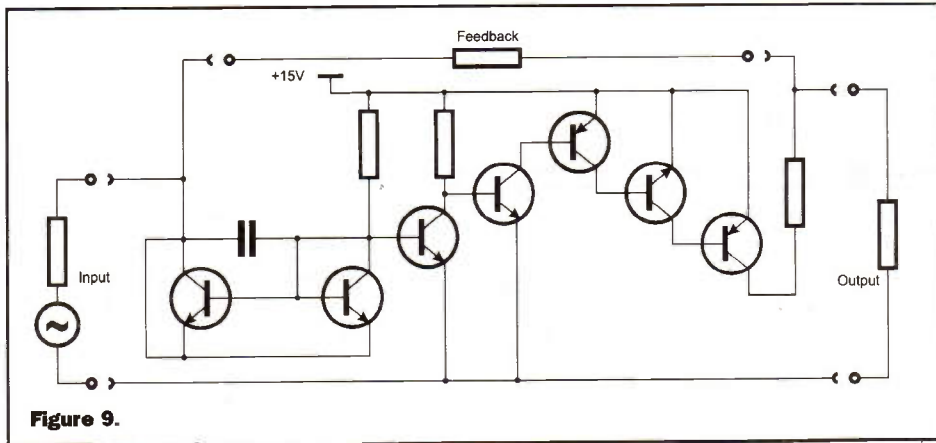


Figure 9.

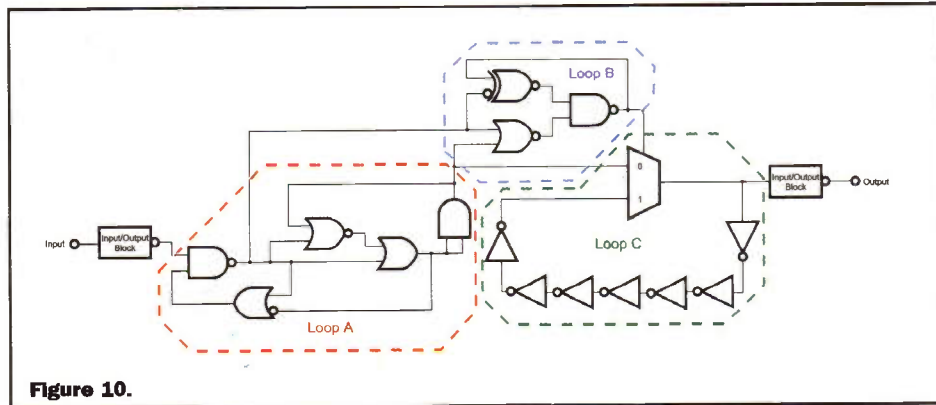


Figure 10.

describing the redundant components as the vestiges of evolution - elements that had originally served some purpose but which fell into disuse as better circuitry evolved. Clearly there are drawbacks of the evolutionary approach to designing hardware, but there are some potential strengths too - the circuit topology isn't constrained by conventional thinking. Instead, the system is allowed to search the whole of the gene space and can, as a result, come up with some truly innovative solutions, solutions that, in some cases, might outperform conventionally designed circuits.

How Does It Do That?

Despite the fact that the analogue circuits developed by a genetic algorithm in the previous section were described as quirky, any competent analogue design engineer would recognise that the circuits will, indeed, do what they purport to do. To put it another way, the circuits are easy to analyse even though they're somewhat unconventional. But the same isn't true of all evolved hardware.

In an exercise carried out by Adrian Thompson and Paul Layzell at the University of Sussex's School of Cognitive and Computing Sciences in Brighton, a circuit was evolved on an FPGA to differentiate between two frequencies - specifically audio tones of 1kHz and 10kHz. The researchers were interested in how an FPGA - normally considered a logic device - could be pressed into service for continuous time problems. The hardware was allowed to evolve in a 10 x 10 cell corner of an FPGA and a working circuit emerged using just 16 of the cells - far less hardware than was expected from a knowledge of conventional circuits. The \$64,000 question, though, is "how does it

work?" - a question which still hasn't been adequately answered. Indeed some characteristics of the circuit are bizarre. Figure 10 is a circuit diagram of the evolved circuit. It's shown as a collection of logic gates although the researchers point out that "the system's behaviour is unlikely to be fully captured by this Boolean level of extraction". Not shown on this diagram are a number of cells that, although not connected to the main part of the circuit, affect its operation. Specifically, if the outputs of these cells are clamped then the circuit behaves less reliably. The mechanism by which these cells affect the circuit has yet to be discovered. But this is just one of the mysterious aspects of the circuit. Tests have proved that the loops indicated A and B on the circuit diagram lock into an inactive state within 20ns of the start of a high going pulse. Nevertheless, as the input pulse returns to the low state, the circuitry which had been inactive is able to generate a correct output depending on the width of the positive going pulse - i.e. the frequency

of the input tone. Researchers have described this as "astonishing".

So we have a circuit, utilising just 21 cells of an FPGA which, so far, has defied analysis. And even if this circuit eventually gives up its secrets, what of more complicated evolved circuits? It seems highly likely that a large proportion of future evolved circuits will defy all attempts to understand their workings. And this is a cause of some concern to many of those working in this field. Does it really make sense to rely on circuitry that we can't understand? You might take the view "if it works then why not?" and at first sight this seems reasonable. However, how can anyone know if it works - under all conditions, that is. With no knowledge of how the circuit is supposed to work the only information available is empirical. In other words, all that can be guaranteed is that the circuit will work under the conditions it was tested under. For circuits with large numbers of inputs, though, it just won't be feasible to test it under all conceivable conditions and so there will remain nagging doubts as to whether the circuit will produce some nasty surprises. In fact, this is already true of complex conventional circuits, for example the Pentium processor - hence the infamous bug.

Hands-on

If you fancy getting a bit of hands-on experience with evolvable circuits, Paul Layzell has designed something he calls an evolvable motherboard and has made the circuit diagrams, PCB layout and software available on the Web. The board is shown in Figure 11 and Figure 12 is a block diagram illustrating the principle of operation. Basically, the motherboard is a large array of programmable switches which are controlled by a PC. Daughter boards

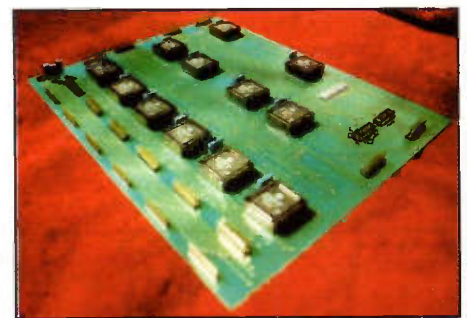


Figure 11.

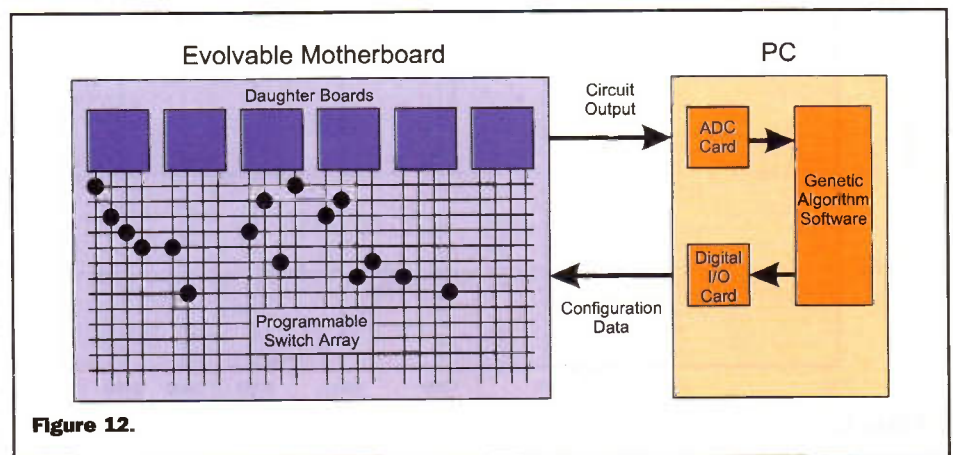


Figure 12.

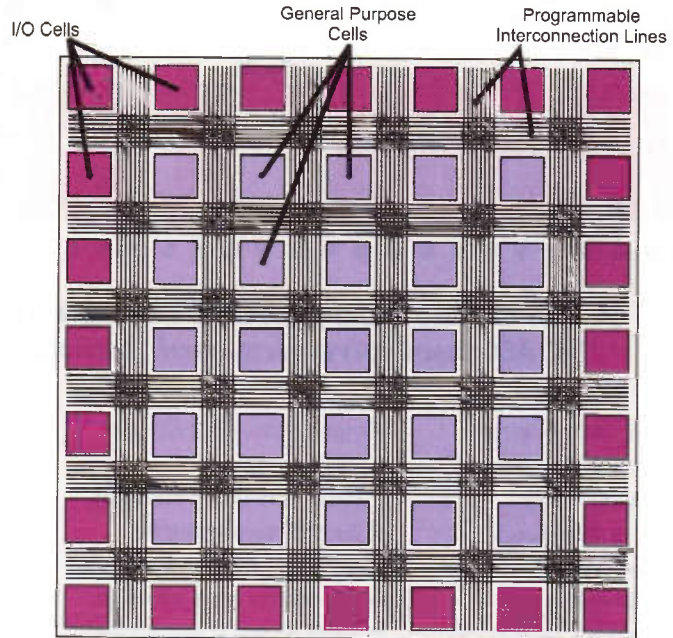
plugged into the motherboard are interconnected by the programmable switches. The daughter boards can contain a wide range of electronic building blocks such as transistors and op-amps so the end result is that these components are connected together dynamically under the control of a PC. And, unlike FPGAs, all the pins are accessible with test equipment so that the evolved circuits can be fully analysed. For full details, take a look at <http://www.cogs.susx.ac.uk/users/paul1a/Motherboard/motherboard.html>. There is also a possibility that PCBs may be available - contact Paul at paulla@cogs.susx.ac.uk if you're interested.

Field Programmable Gate Arrays

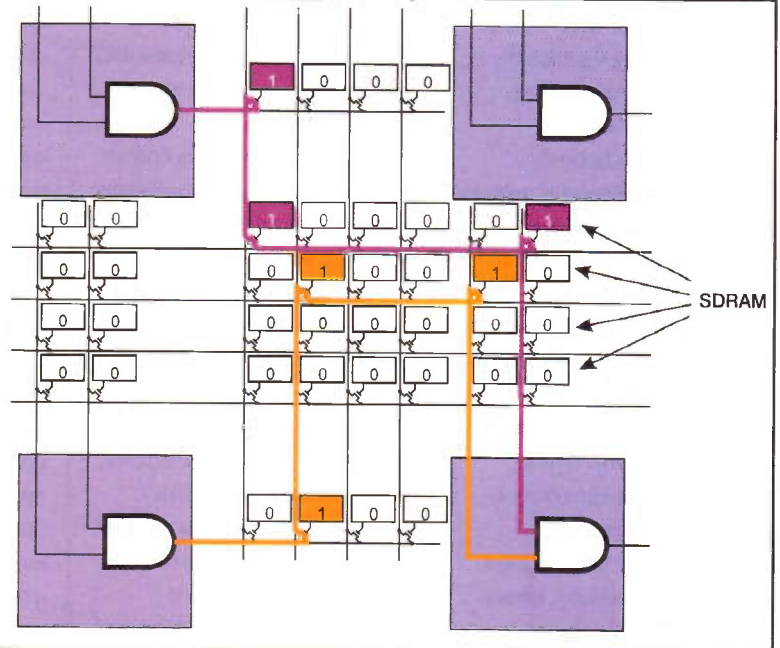
The Field Programmable Gate Array or FPGA is a vital element of many evolvable circuits. However, since it's rarely used in home construction or in low complexity manufacturing, it will undoubtedly be unfamiliar to some readers. This, therefore, is a brief introduction to FPGAs, describing what they are and how they're used.

If you have a need for a VLSI (very large scale integration) chip to perform some specific non-standard job there are two basic approaches. Either you have a custom chip made or you programme a general-purpose programmable chip. The first option involves a massive up-front cost but the unit price is low whereas the second option uses more expensive components but obviates the need to pay a semiconductor manufacturer that initial design and tooling cost. The upshot of all this is that custom chips are economically viable only for large volume production whereas programmable devices are feasible in much more modest production runs. The programmable approach also provides more flexibility in that changes to the functionality can be made without redesigning the hardware. The FPGA is a programmable device and has the additional advantage that it can be re-programmed in the field. In fact, the FPGA is an extension to the masked gate array - a type of chip that comes somewhere between the full custom and the programmable approaches. Whereas a full custom chip requires every single mask in the chip to be defined, in the masked gate array - an example of a semi-custom device - only a single interconnect layer is defined by the customer and so those up-front costs are reduced. The basic chip onto which the customised interconnect layer is applied is a large array of uncommitted logic - the transistors needed to implement logic elements such as inverters, OR-gates, AND-gates and the like. By applying the customised interconnect layer, the individual circuit elements are configured according to the specific requirements and connected together to make a working circuit. The FPGA is similar except that in place of the interconnect layer is an array of electronic switches which can be turned on or off by programming, just as memory cells can be configured to the 0 or the 1 state in a flash memory chip. These electronic switches make connections between the

Figbox 1.



Figbox 2.



uncommitted logic, thereby configuring them to perform a specific task. Since some FPGAs allow the circuit configuration to be redefined a large number of times, they're suitable for implementing evolvable circuitry.

The first illustration shows the basic structure of an FPGA. You'll notice that there are, in fact, two types of cells, the general purpose logic cells in the centre of the chip and the I/O cells around the edge which connect to the pins. The second diagram shows rather more detail around a few cells in a simplified and rather simplistic manner. You'll notice that the configuration is achieved by writing to memory cells that control the switches at the intersections of the interconnection lines. A couple of interconnections are shown as made - these are the ones indicated by coloured lines. The corresponding memory cells have also been coloured. Real FPGAs can have millions of cells and hundreds of pins.

In conclusion it's worth pointing out some of the difficulties of using FPGAs for

evolving circuits. For a start, not all use re-writable memory cells - some use antifuses so are configurable just the once. This is a parallel to the difference between a PROM and flash memory. Even if you get the right type of FPGA, though, it still isn't all plain sailing. Most of the currently available devices allow you to specify configurations that will blow up the chip (e.g. by allowing several tri-state devices connected to the same line to be active at the same time). To get round this, some manufacturers have proprietary validity-checking software but this slows down evolution considerably. Another solution is to encode the chromosome so that these configurations can't occur but this is by no means a simple task. All in all, therefore, evolvable hardware using FPGAs is not for beginners - take a look at Paul Layzell's evolvable motherboard instead.

Controlling DC Motors WITHOUT A SENSOR

*A novel, method of controlling motors from
ST Microelectronics and Kanda Systems*

Electric motors are an essential component of our industrialised society with no less than 5 billion motors built worldwide every year. Brushless DC motors are already used in hard disk drives and many industrial applications, and their market share is growing significantly in automotive, appliance and industrial applications.

A suitable method of controlling brushless DC motors is with a microcontroller.

The ST72141 microcontroller has been developed by STMicroelectronics to control synchronous motors or, more specifically, 3-phase brushless DC motors. The most common applications of this type of motor are industrial control, automotive equipment, refrigerators, air conditioners, compressors and fans, where brushless DC motors are already used due to their high efficiency, silent operation,

compact form, reliability and longevity.

These devices are members of the ST7 microcontroller family designed specifically for motor control applications and includes an A/D converter and an SPI interface. They include an on-chip peripheral for control of electric brushless DC motor either in sensor or sensorless mode.

Brushless DC motors consist of two coaxial magnetic armatures separated by an air gap. In certain types of motor:

The outer part of the motor is called the stator and is fixed. The internal armature is the rotor.

In normal brush DC motors, the internal armature, the rotor, is an electro-magnet. This armature is supplied by a constant current (DC). In a Brushless DC motor, the rotor is a permanent magnet, this type of motor has almost the same properties and physical laws as

a DC current machine. The external stator is polyphased using 3 phases in this case. The current pulses through these coils at a rate given by ω . As it is a synchronous motor then, if Ω is the angular speed of the rotor, we have the relation: $\Omega = \frac{\omega}{p}$, where p is the number of poles.

As we know an electric motor transforms electrical energy into mechanical energy and the two main characteristics of a brushless DC motor are:

- 1) It has an electromotive force proportional to its speed
- 2) The stator flux is synchronised with the permanent magnet rotor flux.

Using the back EMF (electromotive force) of the motor is the basis of one the ways of driving brushless DC motors with the ST72141 microcontroller in sensorless mode.

The ST72141 (ST7 Motor Control) is particularly suited to driving Brushless DC motors as it supports operating modes like:

- Commutation step control with motor voltage regulation and current limitation in Voltage mode
- Commutation step control with motor current regulation, i.e. direct torque control in current mode
- Sensor or Sensorless motor phase commutation in both delta and star connections
- Back-EMF zero-crossing detection with high sensitivity. The integrated phase voltage comparator is directly referred to the full back-EMF

voltage without any attenuation. A clamping function is provided to protect the microcontroller). A back-EMF voltage down to 200mV can be detected (the detection threshold voltage can be selected from 4 different values: 0.2, 0.6, 1.2 and 2.5V) This provides high noise immunity and self-commutated operation over a large speed range Real time motor winding demagnetisation detection for fine-tuning the phase voltage masking time to be applied before back-EMF monitoring.

- Automatic and programmable delay between back-EMF zero crossing detection and motor phase commutation.

The ST72141 is a very powerful and complete technical solution for driving brushless DC motors. It provides a complete digital solution, eliminating the need for analogue filters and potentiometric dividers.

Kanda Systems, a company known for their test and development kits have designed and manufactured the ST7 Motorcontroller development kit. At £435 this kit allows an engineer to learn about Brushless motor control with the supplied motor, test his own motor and even program the ST72141 device for use in real applications.

The kit includes a motorcontroller development board, programming boards, default 24V motor and power stage - which can support 12V-300V.

More details, including a working software download can be found on ST's engineering forum website:

www.st7-forum.com. Also available here is the complete documentation on the ST72141 and a full range of Motor control application notes.



SCR Principles AND CIRCUITS

Ray Marston describes basic SCR principles and looks at practical SCR circuits in this special feature article.

An SCR (Silicon Controlled Rectifier) is a controllable medium- to high-power self-latching solid-state DC power switch. This article explains its basic operation and shows some practical ways of using it.

SCR Basics

An SCR is a four-layer pnpn silicon semiconductor device. It has three external terminals (anode, gate, and cathode) and uses the alternative symbols of Figure 1(a) and has the transistor equivalent circuit of Figure 1(b). Figure 2 shows the basic way of using the SCR as a DC switch, with the anode positive relative to the cathode, and the SCR controlled via its gate. The basic characteristics

of the SCR can be understood with the aid of these diagrams, as follows:-

1. When power is first applied to the SCR by closing S1 in Figure 2, the SCR is 'blocked' and acts (between anode and cathode) like an open switch. This action is implied by Figure 1(b), i.e., Q2's base current is derived from Q1 collector, and Q1's base current is derived from either Q2 collector or the gate terminal; in the latter case no base current is available, so both transistors are cut off, and only a small leakage current flows from anode to cathode.
2. The SCR can be turned on and made to act like a forward-biased silicon rectifier by briefly applying gate current to it via

S2; the SCR quickly (in a few microseconds) self-latches into the on state under this condition, and stays on even when the gate drive is removed. This action is implied by Figure 1(b); the initial gate current turns Q1 on, and Q1's collector current turns Q2 on, and Q2's collector current then holds Q1 on even when the gate drive is removed: a 'saturation' potential of 1V or so is generated between the anode and cathode under the on condition.

3. Only a brief pulse of gate current is needed to drive the SCR on. Once the SCR has self-latched, it can only be turned off again by briefly reducing its anode current below a certain 'minimum holding current' value (typically a few milliamps); in AC applications turn-off occurs automatically at the zero-crossing point in each half-cycle.

4. Considerable current gain is available between the gate and anode of the SCR, and low values of gate current (typically a few mA or less) can control high values of anode current (up to tens of amps). Most SCRs have anode ratings of hundreds of volts. The SCR

gate characteristics are similar to those of a transistor base-emitter junction (see Figure 1(b)).

5. Internal capacitance (a few pF) exists between the SCR's anode and gate, and a sharply rising voltage appearing on the anode can cause enough signal breakthrough to the gate to trigger the SCR on. This 'rate effect' turn-on can be caused by supply-line transients, etc. Rate-effect problems can be overcome by wiring a C-R smoothing network between the anode and cathode, to limit the rate of rise to a safe value.

AC Power Switching Circuits

Figure 3 shows an SCR used in an AC power switching application; alternative component values are shown for use with 240V or (in parenthesis) 120V AC supplies. The AC power line signal is full-wave rectified via D1-D4 and applied to the SCR anode via lamp load LP1. If S1 is open, the SCR and lamp are off. If S1 is closed, R1-R2 apply gate drive to the SCR, which turns on and self-latches just after the start of each half-cycle and then turns off again automatically at the end of the half-cycle as its forward current falls below the minimum holding value. This process repeats in each half-cycle, and the lamp thus operates at full power under this condition. The SCR anode falls to about 1V when the SCR is on, so S1 and R1-R2 consume little mean power. Note that the lamp load is shown placed on the DC side of the bridge rectifier, and this circuit is thus shown for use with DC loads; it can be modified for use with AC loads by simply placing the load on

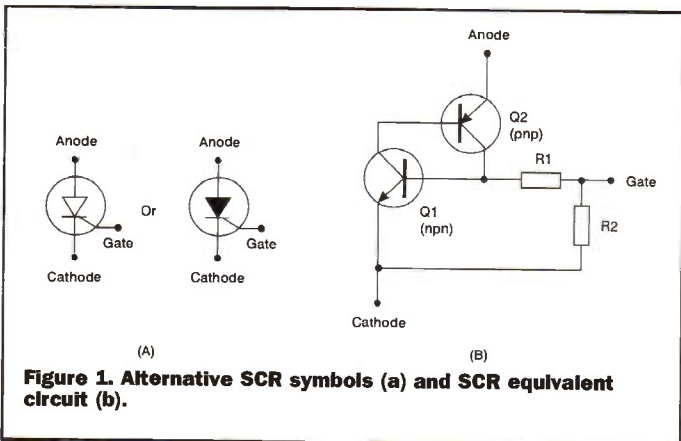


Figure 1. Alternative SCR symbols (a) and SCR equivalent circuit (b).

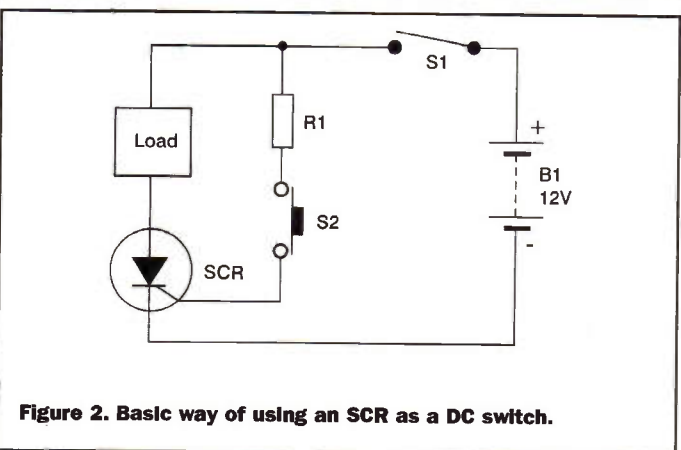


Figure 2. Basic way of using an SCR as a DC switch.

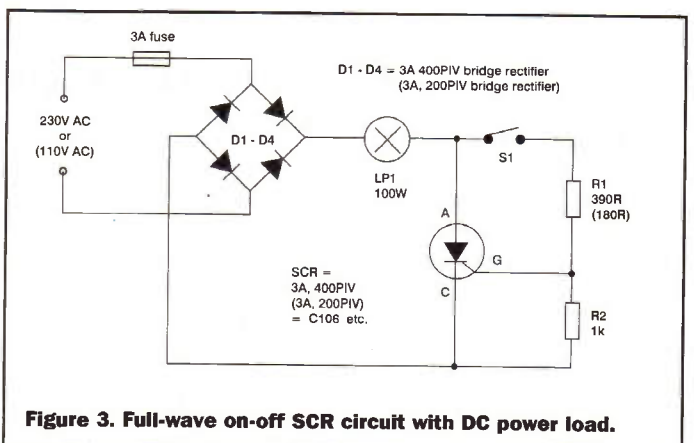


Figure 3. Full-wave on-off SCR circuit with DC power load.

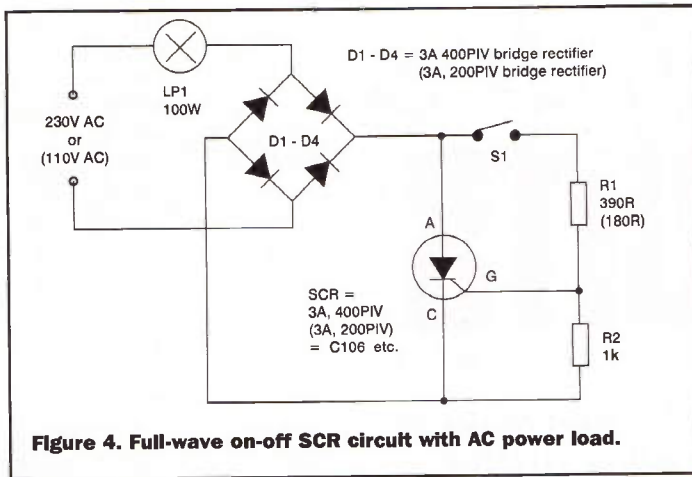


Figure 4. Full-wave on-off SCR circuit with AC power load.

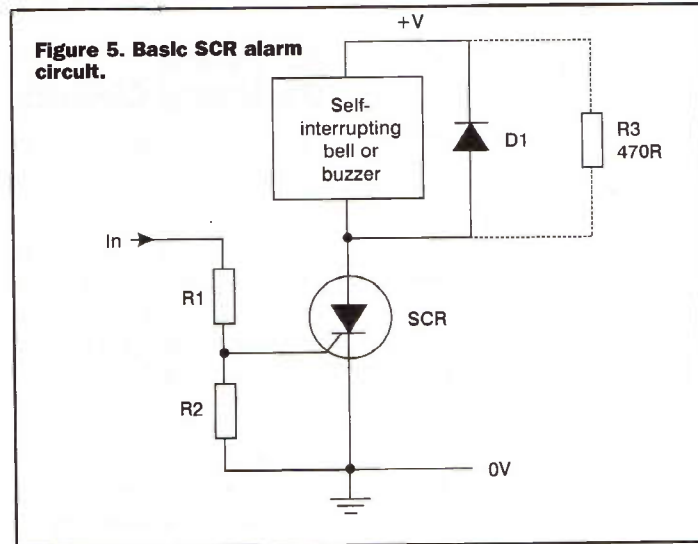


Figure 5. Basic SCR alarm circuit.

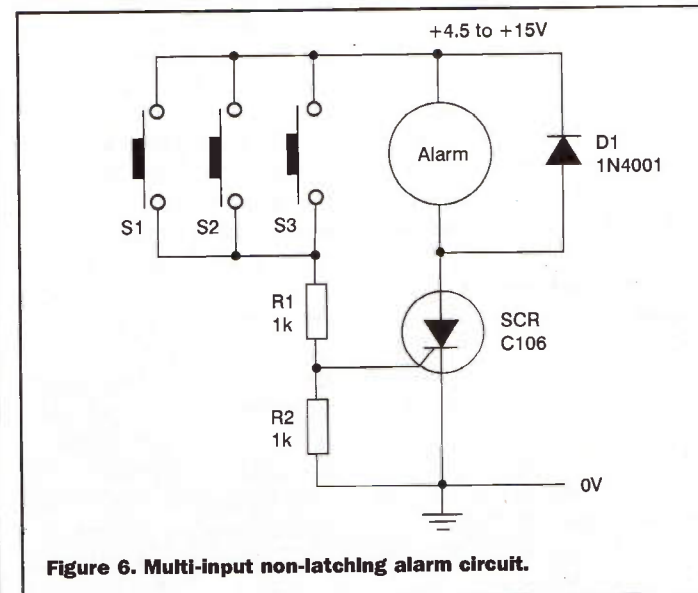


Figure 6. Multi-input non-latching alarm circuit.

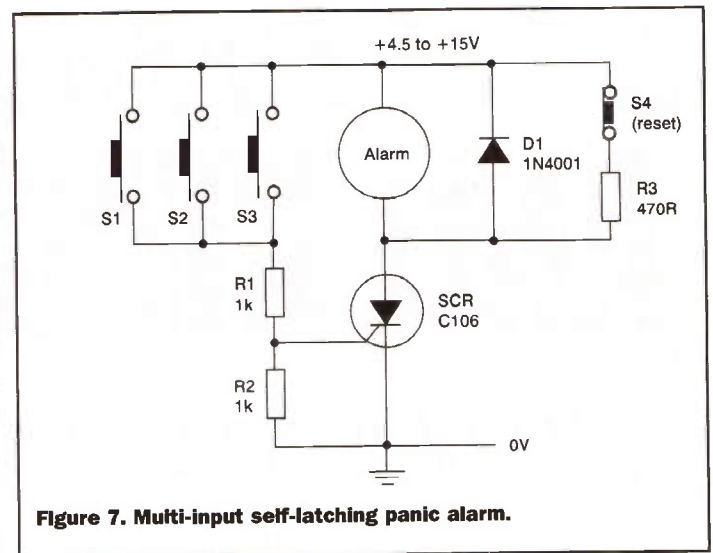


Figure 7. Multi-input self-latching panic alarm.

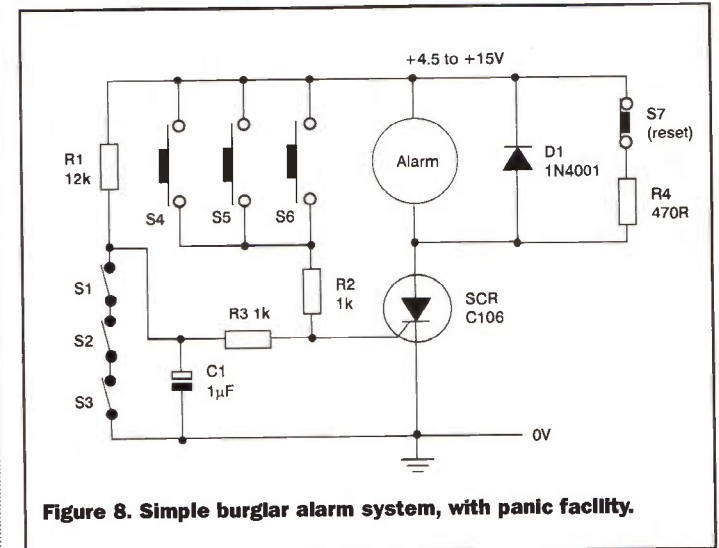


Figure 8. Simple burglar alarm system, with panic facility.

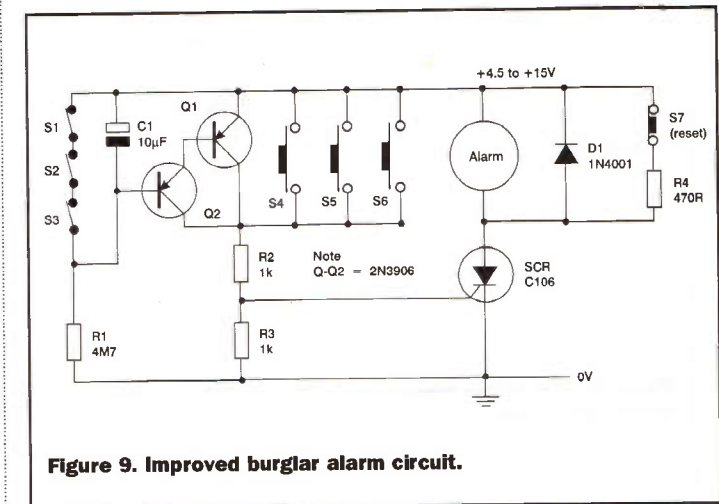


Figure 9. Improved burglar alarm circuit.

the AC side of the bridge, as in Figure 4.

Note that SCRs can also be used, in various ways, to apply variable AC power to various types of load, but that these tasks are usually best carried out by TRIACs, as will be described in a future article. However, two special types of SCR variable AC power control circuits are shown at the end of the present article.

Bell/Buzzer Alarm Circuits

One useful application of the SCR is in DC-powered 'alarm' circuits that use self-interrupting loads such as bells or buzzers. These loads comprise a solenoid and a series switch, and give an action in which the solenoid first shoots forward via the closed switch, and in doing so forces the switch to open,

thus making the solenoid fall back and re-close the switch, thus restarting the action, and so on. Figure 5 shows such an alarm circuit; it effectively gives a non-latching load-driving action, since the SCR unlatches automatically each time the load self-interrupts. The circuit can be made fully self-latching, if desired, by shunting the load with resistor R3, as shown, so that the SCR anode current

does not fall below the SCR's minimum holding value as the load self-interrupts.

Figures 6 to 14 show a selection of alarm circuits of this type. All of these are designed around the inexpensive type C106 SCR, which can handle mean load currents up to 2.5 amps, needs a gate current of less than 200µA, and has a 'minimum holding current' value of less

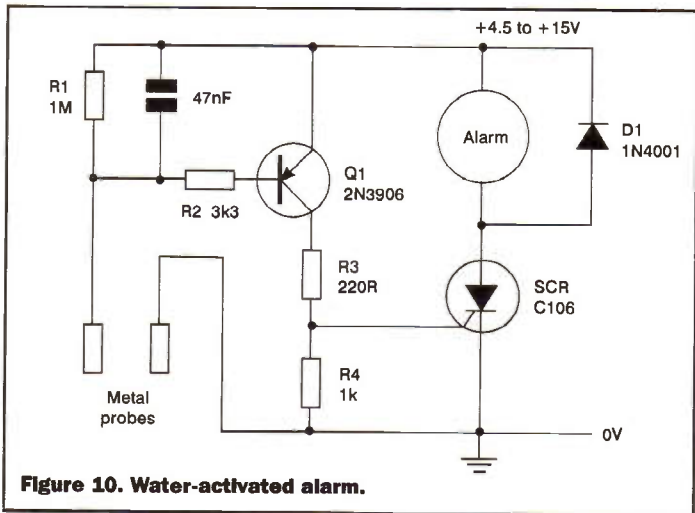


Figure 10. Water-activated alarm.

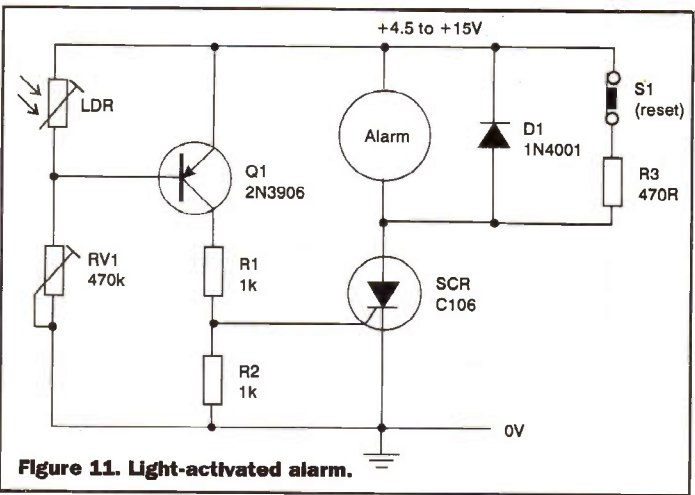


Figure 11. Light-activated alarm.

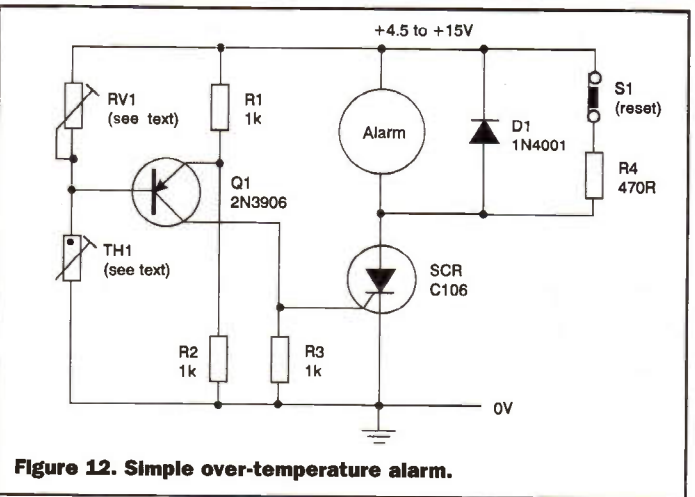


Figure 12. Simple over-temperature alarm.

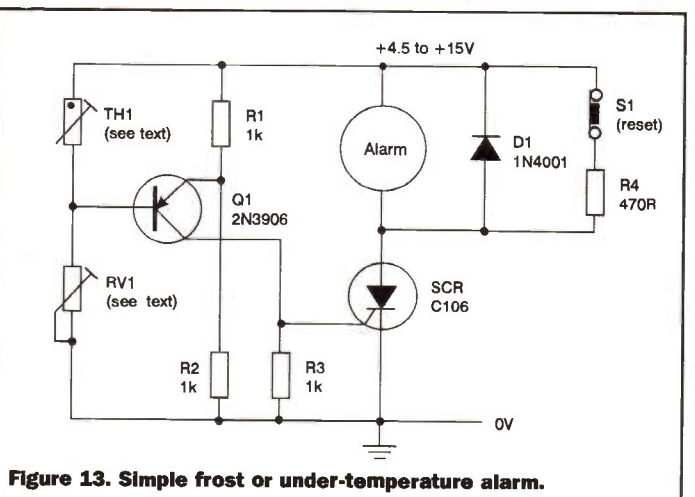


Figure 13. Simple frost or under-temperature alarm.

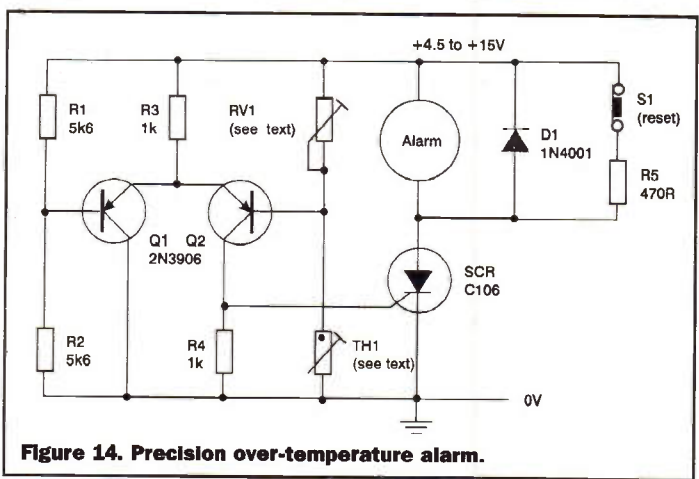


Figure 14. Precision over-temperature alarm.

than 3mA. Note in all cases that the supply voltage should be about 1.5V greater than the normal operating voltage of the alarm device used, to compensate for voltage losses across the SCR, and that diode D1 is used to damp the alarm's back-emfs.

Figure 6 shows a simple non-latching multi-input alarm, in which the alarm activates when any of the S1 to S3 push-button input switches are closed, but stops operating as soon as the switch is released.

Figure 7 shows the above circuit converted into a self-latching multi-input 'panic' alarm by wiring R3 plus normally-closed reset switch S4 in parallel with the alarm device. Once this circuit has latched, it can be unlatched again (reset) by briefly opening S4.

Figure 8 shows a simple burglar alarm system, complete with the 'panic' facility. The alarm can be activated by briefly opening any of the S1 to S3 'burglar alarm' switches (which can be reed-relays or microswitches that are activated by the action of opening doors or windows, etc.), or by briefly closing any of the 'panic' switches. C1 acts as a noise-suppressor that ensures that the alarm only activates if the S1 to S3 switches are held open for more than a millisecond or so, thus enhancing the circuit's reliability. The circuit consumes a typical standby current of 0.5mA (via R1) from a 6V supply.

The standby current of the burglar alarm circuit can be reduced to a mere 1.4µA (at 6V) by modifying it as shown in Figure 9. Q1 and Q2 are connected as a Darlington common emitter amplifier that

inverts and boosts the R1-derived 'burglar' signal and then passes it on to the gate of the SCR. Here, C1 is used as a time-delay component that ensures that the alarm only activates if the S1 to S3 switches are held open for more than a few seconds; the C1 value can be greatly reduced, if desired.

Water, Light & Heat Alarms

The basic SCR-driven alarm circuit can be used to indicate the presence of excess water, light, or temperature levels by driving the SCR gate via suitable sensing circuitry; Figures 10 to 14 show alarm circuits of this type.

The Figure 10 'water-activated' alarm uses Q1 to activate the SCR when a resistance of less than about 220k appears across the two metal probes. It's operation as a water-activated alarm relies on the fact that the impurities in normal water (and many other liquids and vapours) make it act as a conductive medium with a moderately low electrical resistance, which thus causes the alarm to activate when water comes into contact with both probes simultaneously. C1 suppresses unwanted ac signal pick-up, and R2 limits Q1's base current to a safe value. By suitably adjusting the placing of the two metal probes, this circuit can be used to sound an alarm when water rises above a pre-set level in a bath, tank, or cistern, etc.

Figure 11 is a 'light-activated' circuit that can be used to sound an alarm when light enters a normally-dark area such as a drawer or wall safe, etc. The LDR and RV1 form a light-sensitive potential divider

that has its output buffered via Q1 and fed to the SCR gate via R1. This output is low under dark conditions (LDR resistance is high), but goes high under bright conditions (LDR resistance is low) and thus drives the SCR and alarm on; the light-triggering point can be pre-set via RV1. Almost any small cadmium sulphide photocell can be used in the LDR position.

Temperature-activated alarms can be used to indicate either fire or overheat conditions, or frost or underheat conditions. Figures 12 to 14 show three such circuits. In each of these TH1 can be any n.t.c thermistor that has a resistance in the range 1k to 20k at the required trigger temperature; pre-set pot RV1 needs a maximum resistance value roughly double that of TH1 under this trigger condition.

The Figure 12 over-temperature alarm uses R1-R2 and TH1-RV1 as a Wheatstone bridge in which R1-R2 generates a fixed half-supply 'reference' voltage and TH1-RV1 generates a temperature-sensitive 'variable' voltage, and Q1 is used as a bridge balance detector and SCR gate driver. RV1 is adjusted so that the 'reference' and 'variable' voltages are equal at a temperature just below the required trigger value, and under this condition Q1 base and emitter are at equal voltages so Q1 and the SCR are thus cut off. When the TH1 temperature goes above this 'balance' value the TH1-RV1 voltage falls below the 'reference' value, so Q1 becomes forward biased and

drives the SCR on, thus sounding the alarm. The precise trigger point can be pre-set via RV1. The circuit's action can be reversed, so that the alarm turns on when the temperature falls below a pre-set level, by simply transposing the TH1 and RV1 positions as shown in the frost or under-temperature alarm circuit of Figure 13.

Note in these two circuits that if TH1 and Q1 are not mounted in the same

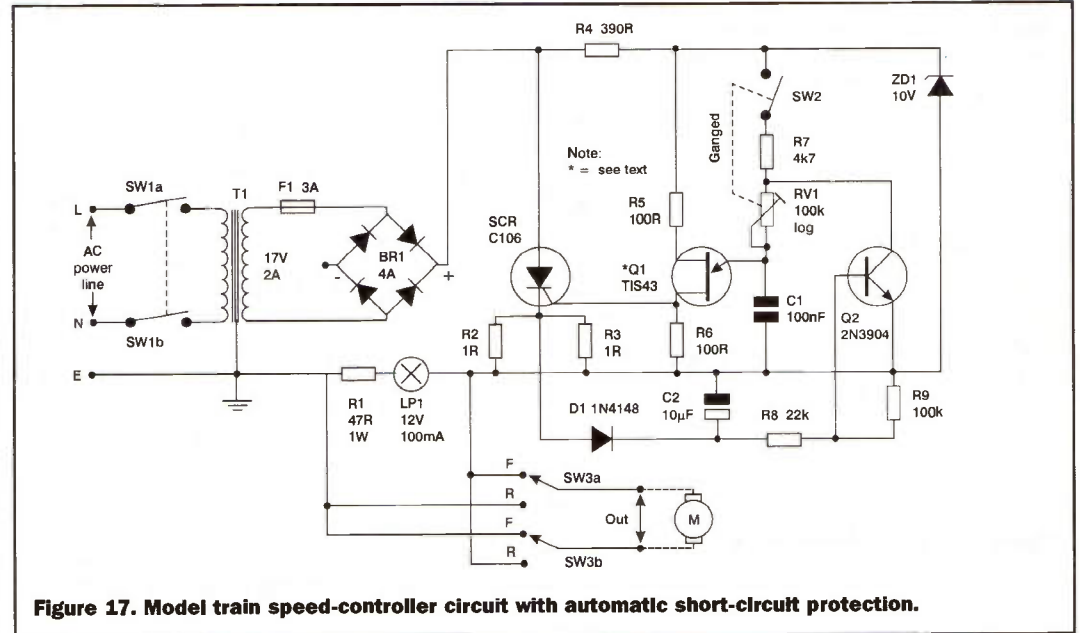


Figure 17. Model train speed-controller circuit with automatic short-circuit protection.

environment, the precise trigger points are subject to slight variation with changes in Q1 temperature, due to the temperature dependence of its base-emitter junction characteristics. These circuits are thus not suitable for use in precision applications, unless Q1 and TH1 operate at equal temperatures. This snag can be overcome by using a two-transistor differential detector in

place of Q1, as shown in the Figure 14 over-temperature alarm, which can be made to act as a precision under-temperature alarm by simply transposing RV1 and TH1.

Variable AC Power Control

All SCR circuits shown so far give an on/off form of power control. SCRs (and TRIACs) can

be used to give variable power control in AC circuits in several ways. One of these is via the 'phase-delayed switching' technique of Figure 15, in which power is fed to the load via a self-latching solid-state power switch that can be triggered (via a variable phase-delay network and a trigger pulse generator) at any point in each power half-cycle, and automatically unlatches again at the end of each half-cycle. The diagram shows the load voltage waveforms that can be generated.

Thus, if the power switch is triggered near the start of each half-cycle (with near 0° phase delay) the mean load voltage equals almost the full supply value, and the load consumes near-maximum power. If it is triggered near the end of each half-cycle (with near-180° phase delay) the mean load voltage is near-zero, and the load consumes minimal power. By varying the trigger signal's phase-delay between these extremes, the load's power feed

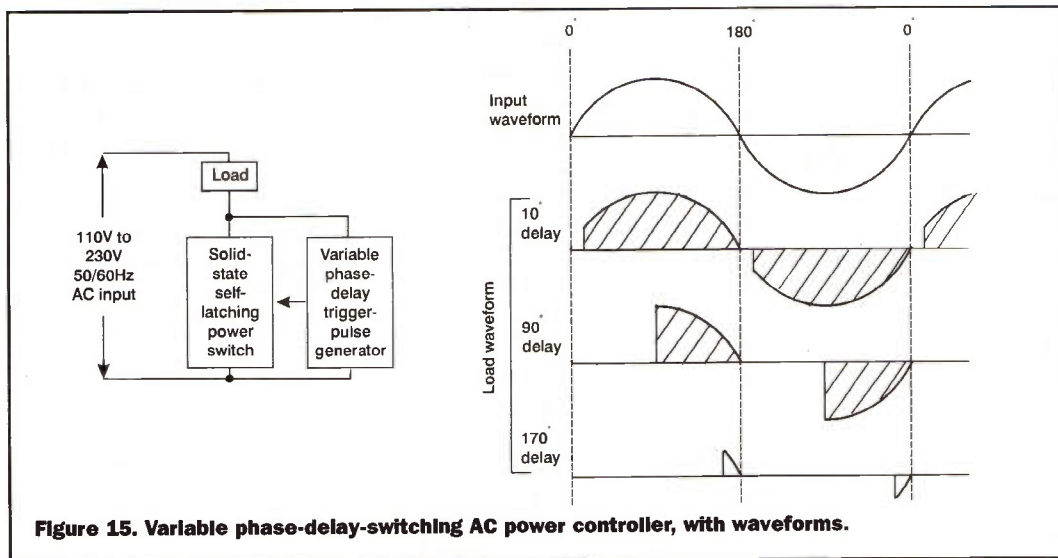


Figure 15. Variable phase-delay-switching AC power controller, with waveforms.

can be varied between zero and maximum. This form of variable power control is very efficient (typically 95%), and can (amongst other things) be used to control the speeds of many types of electric motor, including those of electric drills and model trains (see Figures 16 and 17).

A Drill-Speed Controller

Most electric drills are powered by series-wound 'universal' (AC/DC) electric motors. These motors generate a back-emf that is proportional to the motor speed, and the motor's effective applied voltage thus equals the true applied voltage minus the back-emf. This gives the motor a degree of speed self-regulation, since any increase in motor loading tends to reduce the speed and back-emf, thereby increasing the effective applied voltage and causing the motor speed to rise towards its original value, and so on.

The speed of an electric drill can be varied electronically by using the 'phase-delayed switching' technique. Figure 16 shows a particularly effective yet simple variable speed-regulator circuit. This uses an SCR as the control element and feeds half-wave power to the motor (this causes a 20% reduction in maximum available speed/power). However, in the off half-cycles the back-emf of the motor is sensed by the SCR and used to give automatic adjustment of the next gating pulse, to give automatic speed regulation. The R1-RV1-D1 network provides only 90° of phase adjustment, so all motor pulses have minimum durations of 90° and provide very high torque. At low speeds the circuit goes into a high-torque 'skip cycling' mode, in which power pulses are provided intermittently, to suit motor loading conditions.

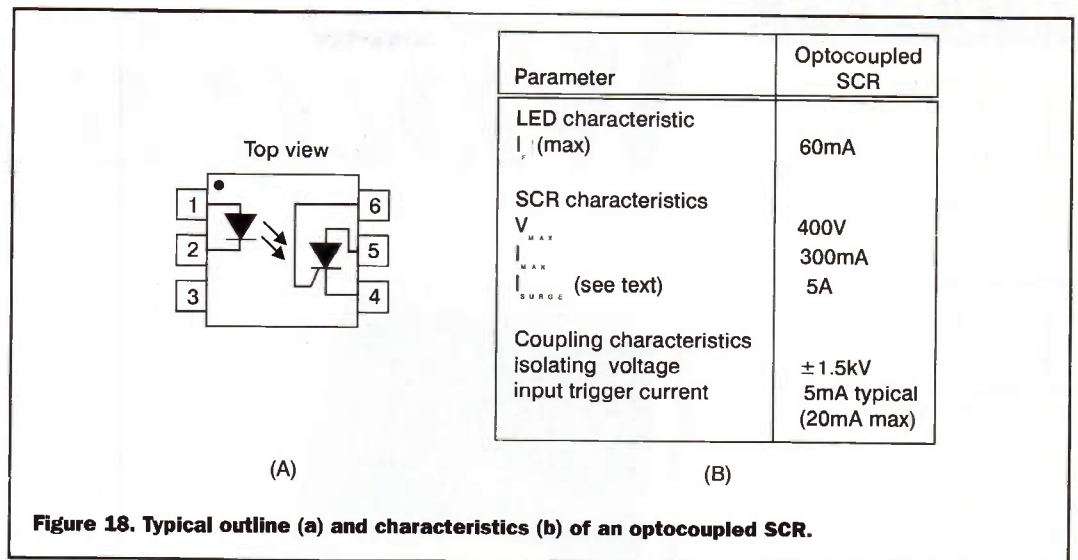


Figure 18. Typical outline (a) and characteristics (b) of an optocoupled SCR.

Model-Train Speed Controller

Figure 17 shows how the 'phase-delayed switching' technique can be used to make an excellent 12V model-train speed-controller that enables speed to be varied smoothly from zero to maximum. The maximum available output current is 1.5A, but the unit incorporates short-circuit sensing and protection circuitry that automatically limits the output current to a mean value of only 100mA if a short occurs on the track. The circuit operates as follows.

The circuit's power line voltage is stepped down via T1 and full-wave (bridge) rectified via BR1, to produce a raw (unsmoothed) DC supply that is fed to the model train (via the track rails) via the series-connected SCR and direction control switch SW3. At the start of each raw DC half-cycle the SCR is off, so DC voltage is applied (via R4 and ZD1) to unijunction transistor (UJT) Q1 and its associated C1-RV1 (etc.) timing circuitry. C1 starts to charge up until eventually the UJT fires and triggers the SCR. As the SCR turns on it saturates, removing power from Q1 (which thus resets) and feeding the rest of the power half-cycle to the model train via R2/R3 (= R2 and R3 in parallel) and SW3. This timing/switching process repeats in each raw DC half-cycle (i.e., at twice the power line frequency), giving a classic phase-triggered power control action that enables the train speed to be varied over a wide range via RV1.

Note that the circuit's output

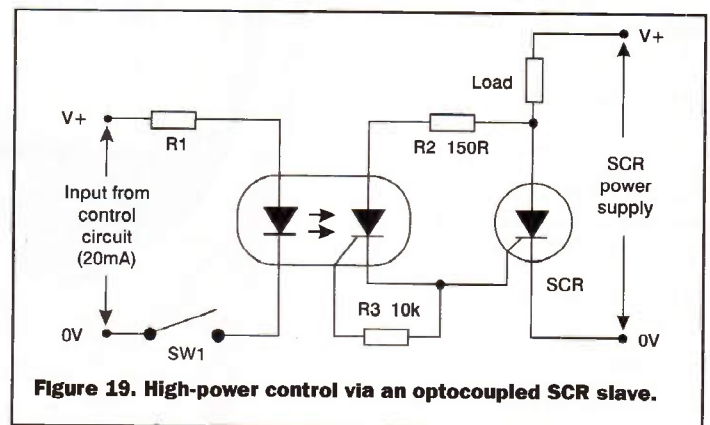


Figure 19. High-power control via an optocoupled SCR slave.

current passes through R2/R3, which generate a proportional output voltage that is peak-detected and stored via D1-C2 and fed to Q2 base via R8-R9. The overall action is such that, because of the voltage storing action of C2, Q2 turns on and disables the UJT's timing network (thus preventing the SCR from firing) for several half-cycles if the peak output current exceeds 1.5A. Thus, if a short occurs across the track the half-cycle output current is limited to a peak value of a few amps by the circuit's internal resistance. The protection circuitry ensures that the SCR fires only once in (say) every fifteen half-cycles, thus limiting the mean output current to a mere 100mA or so. Note that the UJT shown here is an obsolete TIS43 type, but in practice any TIS43 or 2N2646 near-equivalent UJT can be used in its place.

Optocoupled SCRs

SCRs are semiconductor power switching devices that (like transistors) are inherently photosensitive. An optocoupled

SCR is simply an SCR and a LED mounted in a single package and configured so that the SCR's gate current is controlled by the LED's optical output. This enables the SCR to be controlled by a remote input current that is electrically fully isolated from the SCR's output (load) circuitry. Figure 18(a) shows the typical outline of an optocoupled SCR that is mounted in a 6-pin DIL package. Figure 18(b) lists the typical parameter values if such a device, which has a mean output load current rating of only 300mA but has a surge current rating of 5A at a pulse width of 100µs and a duty cycle of 1%.

Optocoupled SCRs are very easy to use. The input LED is driven in the way of a normal LED, and the SCR is used like a normal low-power SCR. The most important application of the optocoupled SCR is a 'slave' device that controls the gate current of a high-power SCR, which can activate a load of any desired power rating; Figure 19 shows an example of this type of application.

Diary Dates

Every possible effort has been made to ensure that information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments, please contact event organisations to confirm details.

September 2000

3 to 5 Sept. European Computer Trade Show (ECTS), Olympia, London. Tel: (0208) 742 2828.

10 to 13 Sept. PLASA - Light & Sound Trade Show, Earls Court, London. Tel: (0207) 244 6433.

13 to 14 Sept. OnBoard - Electronics Assembly Exhibition, Olympia, London. Tel: (01799) 528 292.

13 to 14 Sept. ECIF - Electronic Components Industries Fair, Olympia, London. Tel: (01799) 528 292.

17 Sept. National Vintage Communications Fair, NEC, Birmingham. Tel: (01392) 411 565.

19 to 20 Sept. Call Centre Expo, NEC, Birmingham, Miller Freeman. Tel: (0208) 742 2828.

21 to 24 Sept. Live - Consumer Electronics Show, Earls Court, London. Tel: (0208) 742 2828.

22 to 23 Sept. Leicester Amateur Radio Show, Donington Exhibition Centre, Derby. Tel: (01455) 823 344.

26 to 27 Sept. Business Systems Show G-MEX Centre, Manchester. Tel: (07000) 464 336.

26 to 28 Sept. GIS - Geographic Information Systems Exhibition, Earls Court, London. Tel: (0208) 742 2828.

27 to 28 Sept. Communications for Business, Barbican Centre, London. Tel: 01923 676 867.

October 2000

3 to 5 Oct. Coil Winding 2000, NEC, Birmingham. Tel: (0207) 417 7400.

4 to 5 Oct. Softworld Accounting & Finance, NEC, Birmingham. Tel: (0208) 541 5040.

9 to 11 Oct. TMA33 - Telecommunications Managers Association Exhibition, Stakis, Metropole, Brighton. Tel: (01372) 361 000.

11 to 12 Oct. SIT - Small Business IT Show, Bournemouth International Centre. Tel: (01934) 420 365.

11 to 12 Oct. TEST - Electronic Testing Exhibition, NEC, Birmingham. Tel: (02476) 230 333.

11 to 12 Oct. Webmaster - Web & Internet Show Olympia, London. Tel: (01256) 384 000.

11 to 12 Oct. JAVA - Computer Software Trade Exhibition & Conference, Olympia, London. Tel: (01256) 384 000.

17 to 18 Oct. Property Computer Show, Barbican Centre, London. 01273 836 800.

18 to 19 Oct. PHOTONEX/FIBRE EXHIBITION, NAC, Stoneleigh, Coventry. 01932 866 766.

25 to 26 Oct. Accounting IT, Business Design Centre, London. Tel: (0207) 221 1155.

24 to 25 Oct. OSPMA FieldComms - Industrial Networking Show, Telford International Centre. Tel: (0207) 417 7400.

31 Oct to 2 Nov. Voice Europe Olympia, London. Tel: (01244) 378 888.

Please send details of events for inclusion in 'Diary Dates' to: News Editor, Electronics and Beyond, P.O. Box 777, Rayleigh, Essex SS6 8LU or e-mail to swaddington@cix.compulink.co.uk.

What's On?



Effects of Low Level Electromagnetic Fields Not Proven Says IEE

There is still no convincing scientific evidence showing harmful effects of low level electromagnetic fields on people, according to a statement from the IEE (Institution of Electrical Engineers).

The IEE's assessment is the result of examining over 700 relevant refereed papers published throughout 1998 and 1999, covering five areas: cellular, animal, epidemiological and human studies and mechanisms of interaction.

At low frequencies, recent evidence from major epidemiological studies and the cumulative evidence from the large body of literature built up over the past 20 years suggests that the existence of harmful effects is unlikely.

The IEE believes, therefore, that future proposals for low frequency electromagnetic field research should now be weighed carefully against

other public-health priorities.

At higher (radio) frequencies less data is available. Whilst existing data does not show harmful effects, the Working Party believes that further research, both epidemiological and laboratory based, is needed.

This view is based on public concern and the increasingly ubiquitous nature of our exposure to such fields rather than a likelihood that harmful effects exist.

The statement is the fifth produced by a specialist independent Working Party set up by the IEE in 1992 to consider the possible harmful effects of low level low frequency electromagnetic fields. In January 1998 the Working Party's terms of reference were extended to include frequencies up to 300GHz to reflect public concern over possible health effects of radio frequency energy - from mobile communications systems in particular. For further details, check: www.iee.org.uk. Contact: IEE, Tel: (020) 7240 1871.

Single Message on Professional Development as Engineering Bodies Combine

Three of the UK's engineering organisations have pledged to work together to support the professional development of their members.

The agreement was ratified in June by the signing of a Memorandum of Understanding by the Presidents and Chief Executives of the IMechE (Institution of Mechanical Engineers), the IIE (Institution of Incorporated Engineers) and the IEE (Institution of Electrical Engineers).

The Institutions have agreed a common policy and have already issued guidance to all their members on the best way to undertake a structured programme of development based on assessment of competence.

Together the three organisations represent over 260,000 chartered, incorporated and technician engineers in the fields of electrical, electronic, mechanical and manufacturing engineering. For further details, check: www.iee.org.uk. Contact: IEE, Tel: (020) 7240 1871.

Howells Welcomes Plans For Strong New Energy Consumer Council

Proposals to create a strong consumer body for gas and electricity consumers announced today were welcomed by Consumer Affairs Minister, Dr Kim Howells.

The new proposals for the Gas and Electricity Consumer Council, being set up under the Utilities Bill, were put forward by Ann Robinson, Chair of the Gas Consumer Council and Chair-designate of the new Council following an extensive consultation exercise.

The new Gas and Electricity Consumer Council (GECC) being set up under the

Utilities Bill will merge the existing Gas Consumers' Council and the 14 Regional Electricity Consumers' Committees. This reflects trends where the same company now increasingly supplies both gas and electricity and there have been many new entrants to the market place.

- Suppliers' selling practices
- Processes for transferring customers
- Billing problems Accurate meter readings
- Gas safety
- Problems of the fuel poor

Remit of Gas and Electricity Consumer Council (GECC)

For further details, check:

www.dti.org.uk.

Contact: DTI, Tel: (020) 7215 5000.

Science Enterprise Challenge

Stephen Byers, Secretary of State for Trade and Industry today announced that an additional four Science Enterprise Centres are to be established, these will complement the eight centres announced in September 1999.

The new centres will be Durham (in collaboration with the universities of Newcastle upon Tyne, Northumbria at Newcastle, Sunderland and Teesside), Warwick (in partnership with Birmingham), Ulster (with Queen's University of Belfast) and Oxford.

The centres, which are part of the Science Enterprise Challenge, aim to develop business expertise in science and transfer knowledge from the science lab to the marketplace.

For further details, check: www.dti.org.uk.

Contact: DTI, Tel: (020) 7215 5000.

Lord Sainsbury Launches Investment Programme In Optical Internet Technologies

A multi-million pound Government investment in the future of the UK's optical technology industry has been announced by Science Minister Lord Sainsbury.

The £11 million programme, aimed at encouraging greater links between universities and companies to develop new optical applications, will be matched by the private sector. Overall more than £20 million could be spent over the next five years, helping to keep the UK at the forefront of this high-tech sector.

Optical systems allow massive increases in computing and communications power, transmitting and processing information at the speed of light.

Potential participants should contact Dr Peter Batchelor (DTI) on 020 7215 1342 (e-mail: peter.batchelor@dti.gsi.gov.uk) or Glenys France (EPSRC) on 01793 444319 (e-mail: glenys.france@epsrc.ac.uk).

For further details, check:

www.dti.org.uk.

Contact: DTI, Tel: (020) 7215 5000.

For the last few months, we've been looking at some of the lesser known facilities of Word 97. Generally, I have described how to use these features and suggested how you can delve further. This month, though, I am not going to look so much at what you can do as much as what you should do.

Fonts

It's not much of an exaggeration to say that word processors have now got to the point where just about everything is possible with their capabilities further extended by disks containing vast libraries of clip art and fonts. For many people the temptation to use these products to the full is overwhelming. It's as if some people think "if I've got 1,000 fonts, hundreds of megabytes of clip art and thousands of colours, then I'm going to use them all". I'd like to suggest, though, that you try to exercise some discretion in what you use. Documents which use dozens of fonts and colours on the one page often look dreadful. The 'ransom letter' style generally isn't the way to go. The following makes the point although it is, admittedly, something of a parody.

Less is often more - a



tastefully designed document can be very eye-catching even if it only uses a couple of fonts and a handful of colours. Ironically, it requires more skill to use lots of fonts successfully yet it's often the amateur type setter who is tempted to go overboard. My suggestion, therefore, is to start out with just a couple of fonts, perhaps Times New Roman for the body text and Arial for the headings. And when you do decide to liven things up a bit, how about looking for fonts which are subtly different from these two basic ones rather than the more bizarre fonts. Take the trouble to scrutinise fonts to find ones you find pleasing. You'll probably find fonts which are sufficiently different from Times New Roman to be interesting but not so different as to be difficult to read. The more unusual fonts should be used very sparingly for special purposes and effects.

Before moving on from

Software HINTS & TIPS

by Mike Bedford

This month we argue that less is sometimes more as we turn our attention to designing documents using Word 97.

Subtle differences
Subtle differences

fonts, there are a couple of interesting types of characters you may not be familiar with. First of all let's think about capital letters. The rules of grammar dictate that we have to use them in certain places such as the start of a sentence and for abbreviations. However, using capital letters in abbreviations tends to draw undue attention to them so there's been a recent trend to use lower case letters. An interesting alternative which is grammatically correct yet doesn't cause them to 'shout' is to use small capitals. These can be selected in Word 97 under Format > Font.

Similarly, have you noticed

TLAs tend to stand out, but not with small capitals -- TLA.

how figures also tend to draw undue attention to themselves? The reason is that the figures we're used to are actually upper case (i.e. capital figures). However, there are also lower case figures and these, like the lower case letters, vary in their height and in whether or not they have descenders below the base line. As such they fit in well with lower case letters and don't stand out like the proverbial sore thumb. Unfortunately, there's no way you can select lower case figures like we selected small capitals. It all depends on the font - most have upper case figures but a few have lower case ones. None will have both, though, since the ASCII character set doesn't make provision for both. This is something you may like to consider when choosing fonts.

Figures - 1234567890 - tend to stand out. Lower case figures - 123,4567890 - don't.

Creating Emphasis

Emphasised text is used both in titles and to draw particular attention to a word or phrase within the main body text. As you'll be aware, modern word processors provide lots of ways to emphasise text. A larger point size, a different colour, a different font, underlining, emboldening, italicisation and capitalisation are just some of the methods available and it's common to see all of these in use. However, there are some that I would advise against. Number one on my list of pet hates is underlining. This has never been a mainstream typographic convention, the only reason it came into use is that it was one of the few methods available on the typewriter and later on the dot matrix printer. Now we have inkjet and laser printers there are much better methods - the ones which have been used by professional publishers for centuries and which readers expect to see.

Emphasise by emboldening or italicising, not underlining.

Obviously personal preferences come in here but my suggestion would be to use emboldening, italicisation or both to emphasise body text and to use a larger font size, probably in a different font and emboldened for titles. A different colour could also be used here although do keep to something subtle.

Colour

Since we have now touched on colour let us consider its use in documents and, as with most things, don't go overboard with it. With the exception of photographs which will, of course, be in every imaginable colour, devise a colour scheme using, perhaps, as little as two or three colours and keep to them. If possible, try to use a limited palette of colours in your line illustrations too. And, as I suppose you've already guessed, my suggestion is to avoid loud colours. A document with blue body text and red titles will look incredibly tacky and will rapidly tire your readers - you've been warned!

Use of Colour

This is one good way to get on your readers' nerves.

Using a slightly different colour for the headings, and perhaps for illustrations can look quite attractive. You will notice, for example, how I have used brown text for the various examples in this article. Unfortunately, though, Word 97 isn't especially good with subtle colours. Only sixteen colours are provided and these tend to be either the bright colours or the dirty browns. This is, perhaps, one of the few areas where word processors still lag behind a proper DTP package.

Be Subtle

Using a subdued colour scheme can be effective. Unfortunately, though, Word 97 doesn't give you much choice.

Practice Makes Perfect

Really, design is a subject that can only be taught to a degree. My aim in this column, therefore, is just to raise awareness of the various issues and to suggest, as tactfully as possible, that your documents probably leave some room for improvement (I know mine do). And if you've come to that point it's over to you. The saying that practice makes perfect is as true here as anywhere. So try out different styles and get friends to look at your results with a critical eye. And although I wouldn't suggest plagiarism, do look at books and magazines with a more critical eye to try to get some tips from the professionals.

TECHNOLOGY WATCH



With Martin Pipe

This month, I'm going to comment on some of the latest developments in digital video, audio and broadcasting. If you're a regular reader, you'll know that these are subjects close to my heart. Judging by the number of e-mails I get from 'Electronics' readers, it's clear that I'm not the only one with such interests. There are disadvantages to the technologies - as well as advantages. Take the case of Sky, for example. Through its digital broadcasting service, this broadcaster is responsible for several innovations, including interactive news and sports coverage. It is currently trying to migrate its existing analogue subscribers (myself included) to Sky Digital. One can hardly blame it - after all, the cost of those analogue transponders on Astra 1x run into tens of millions of pounds each year, and it understandably wants to shut them down at the earliest opportunity. It is currently offering free Digiboxes to existing subscribers, but on the proviso that they pay for them to be installed (basically, they swap your existing dish/LNB for the smaller Sky Digital one, and use the existing coax cable run. This way you can't retain your analogue set-up, and thus enjoy the other analogue and digital channels available from 19°E!). As we near the analogue shutdown date (which, at the time of writing, has not been finalised), one can expect that Sky will probably offer incentives of ever-increasing generosity. I can imagine that the installation charge will be waived for a start. I doubt very much that Sky will want to lose subscribers paying upwards of £250 per year when those analogue screens finally do go blank! Sky has already sent around salesmen to try and convince me. No such luck - I'm going to hold on until the bitter end. By then, Sky will hopefully provide the Digibox of my choice. This will be the Sony, which is the only current model to feature a S/PDIF digital audio output. At the present, all free Digiboxes are standard Pace and Amstrad models.

The wonderful new world of digital broadcasting isn't without its drawbacks, though. Take a look at the wonderful Sky TV guide, which is sent to all broadcasters whether they like it or not. The magazine sent to analogue subscribers may be full of gushing puffery (I, for one, cannot recall any letter critical of Sky) but does offer channel listings. The version sent to digital subscribers doesn't have these listings, making it difficult for them to plan their viewing. But then again, Digiboxes don't have event timers, and so you can only time-shift from one channel. This will surely be great fun when analogue terrestrial transmissions are closed down! Just about every analogue receiver

produced over the last five years, by the way, is equipped with one of these event timers, which switches channels at user-defined times. The digital TV guide, which is notably thinner than the analogue one, consists in the main of lightweight articles. There are only cursory previews of what you can expect to see over the coming month. If you want precise scheduling details, then you have to rely on the on-screen electronic programme guide (EPG) instead. This only works over a few days, rather than the entire month covered by the paper guide. Using the EPG - which is rather slow to appear, particularly if you're looking ahead - may well interrupt the viewing of another family member, and will certainly ruin any recordings being made. Not that you should be making recordings, dear me no... Sky Digital, then, isn't the best choice for those who travel periodically - you'll simply have to wait until the programme you wanted to watch is retransmitted. If, of course, it is - and you can find out when...

One of Sky Digital's great advantages is that teletext information carried as part of the DVB datastream which is re-inserted into the TV picture's vertical blanking interval (VBI). It can thus be decoded by any analogue teletext TV. The situation with ONdigital is rather different. Here, the teletext is - or will be, when it finally gets off the ground - transmitted on a separate channel. Utterly ridiculous, because it means you have to interrupt your viewing (or recording) when you want to check up on some information via teletext. As a form of compensation, the terrestrial digital teletext services will offer pretty graphics, still images and other gimmicks - but I know what I would prefer! ONdigital currently has little spectrum, certainly compared to what Sky has available. Although teletext data occupies little bandwidth relative to a MPEG-2 video/audio signal, it soon adds up across the range of channels offered. With UHF spectrum being as scarce as it is, ONdigital has probably decided to invest the bandwidth involved on additional TV channels. I can imagine that when terrestrial TV is shut down, some of the frequencies thus released will be made available to ONdigital. They may choose to piggyback the teletext information

associated with a particular channel in the traditional manner, as Sky does. The chipsets employed within the ONdigital set top boxes will probably support the decoding of teletext packets and VBI-insertion, and the relevant firmware upgrade could be issued to receivers 'over the air'. That's not to say that Sky Digital has it all its own way. Channel 4's teletext is a pale imitation of its analogue terrestrial relative, while Sky One's simply tells you to use the EPG. Why not simply retransmit the services that accompany the analogue channels?

Another problem with both digital services - that of recording and watching different channels simultaneously - will, no doubt, be solved by the time the great analogue shutdown occurs. By then, cheap terrestrial set-top box add-ons should be available, or so the government tells us! These boxes will probably only decode the free-to-air channels. If you want to receive two different pay-TV channels simultaneously, then you'll need two decoders - and two subscriptions! We're used to that with analogue satellite, though. Less easy to address, however, is the issue of picture quality. The Euro2000 football tournament provided me with a welcome opportunity to compare digital with analogue, courtesy of BBC1's coverage. And guess what - analogue came out considerably better, with fewer unpleasant artifacts and greater clarity (note that our free-to-air Digibox was connected to the TV via a direct RGB Scart link). This difference in picture quality is quite worrying, seeing that most of us will need a Digibox (and a heavy subscription) if continued enjoyment of football is envisaged. But then again, there was no ghosting. If you live in an area notorious for its poor terrestrial coverage, the Digibox will give you pictures of a quality that was previously denied to you. As long as they have clear view of the satellite, viewers across the whole country should experience identical results. In terms of sound quality, though, there was little difference. If anything, digital should be better on account of the 48kHz sampling rate, which compares favourably with the 32kHz employed by analogue TV's NICAM stereo system.

Indeed, sound is where the greatest benefit of digital satellite broadcasting is realised. The BBC, and several commercial operators, disseminate their services via the Astra 2A satellite. These stations, which include some unavailable anywhere else, can thus be received on any Sky Digibox. The key services (Radios 1 to 4, Virgin, Heart, Classic FM, etc.) are transmitted with MPEG-1 Layer-2 encoding at 192Kbps, and

a sampling rate of 48kHz. Even with an unmodified Sky Digibox feeding analogue stereo signals to a hi-fi system via its phono outputs, the sound quality is nothing short of revelatory even when compared to the best analogue FM tuners (I've undertaken side-by-side listening tests with a Revox model). As we discovered in the February 2000 issue of 'Electronics', the Digibox's analogue outputs can be modified for improved sound quality. Unfortunately, there's no S/PDIF output. Sky's Digibox, the design of which appears to be largely standardised by the broadcaster, employs an AKM 4319 DAC.

Followers of my series of articles on the MP3 audio system may well recall my description of how an S/PDIF output could be added to the Creative Labs Soundblaster 16 (SB16) soundcard, courtesy of the Cirrus CS8402A IC. Further details can be found in the July and August issues of 'Electronics'. The SB16 is - ironically enough - also based around an AKM chip. Could you carry out a similar modification to the Digibox? For a start, you would need a very steady hand because the surface-mounted 4319 has a very fine pin pitch. Some other work is required - the circuit described is optimised for sample rates of 44.1kHz, rather than 48kHz. Some changes to the circuit are thus required. The frequency of the external clock fed into the CS8402A must be directly proportional to the required sampling rate. Clever divider chains may be necessary, if you can't find suitable clock around the receiver's digital audio circuitry. Some of the option-setting pins described in the original circuit may also be different. The datasheet for the CS8402A can be downloaded from <http://www.cirrus.com/ftp/pubs/>.

It's a Nok-out!

You don't need a Digibox to receive these radio services, which provide a cost-effective and more flexible alternative to DAB. Most are unencrypted, and can be decoded by a 'free-to-air' DVB satellite receiver - which will also pick up many TV channels into the bargain! In the February issue, we described how a S/PDIF output could be added to Nokia's 9200 receiver - similar comments also apply to the company's 9500 and 9600 models, encryption-ready receivers that employ the same basic MPEG hardware. You might be able to modify other DVB receivers along similar lines. The mod works very well, and I have fed the output to Minidisc decks and external DACs without trouble. For some strange reason, I have had very limited success getting it to work

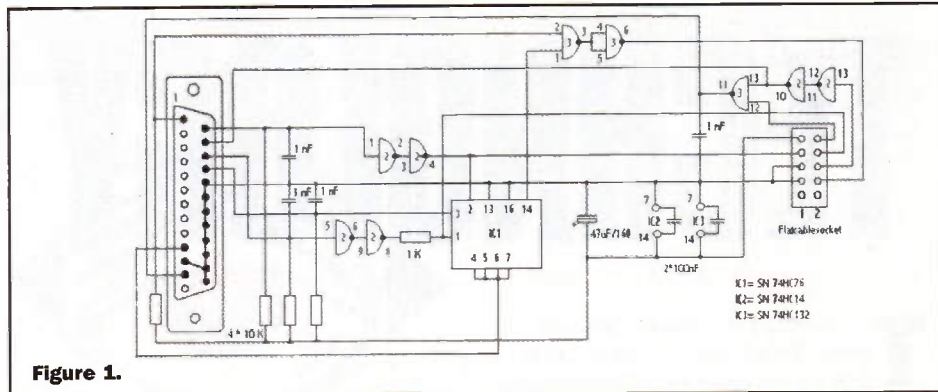


Figure 1.

with a Sony DTC790 DAT recorder - it doesn't, for some reason, seem to like the 48kHz signals. I have found that the link does work well with the 44.1kHz-sampled free-to-air Music Choice channels. There are three of these, by the way, all of which play continuous music back-to-back without interruptions or DJs. Note that DAB multiplexes offer no such channels! They're broadcast on 12.188MHz, with horizontal polarisation, a symbol rate of 27500 megasymbols per second and a forward error correction (FEC) of 2/3.

If you conduct a search with these settings, you'll find several tens of channels, with names like 'Jazz', 'Classic Rock' and 'Opera'. The vast majority of these themed music channels are encrypted with Videoguard, and are pay-radio services available at additional cost to Sky Digital subscribers (if you're interested, check out <http://www.musicchoice.co.uk> for more details). The search will, however, also reveal the trio of free services. They're easy to spot in the list, thanks to their rather odd identification tags. The services, which are found as '1946', '1947' and '1948', are actually called 'Synergy', 'Fidelity' and 'Style' respectively. Between them a wide range of music, from classical to pop, is available. Although free, they're intended only for Sky's subscribers. Odd then that they're unencrypted, but one mustn't complain! Other interesting free-to-air radio services include Core, CNN Radio, Planet Rock and

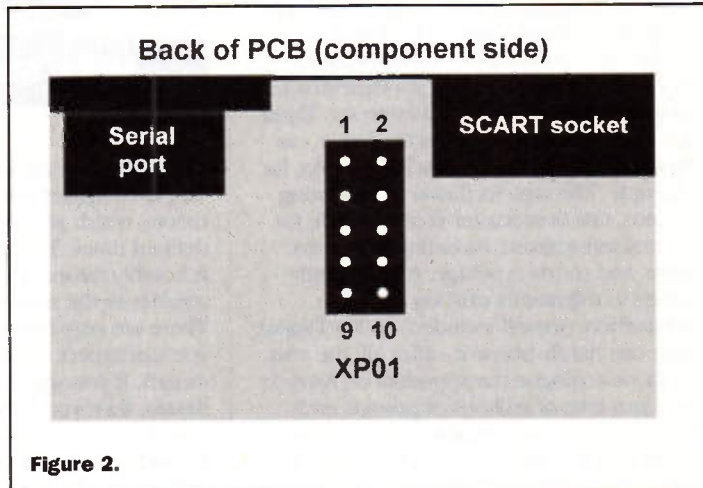


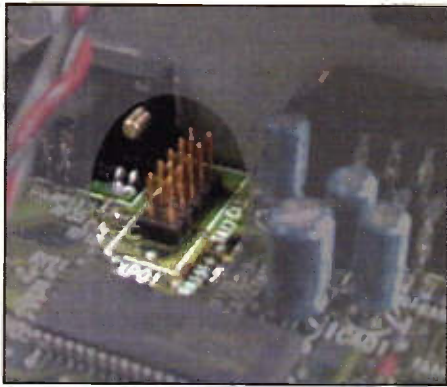
Figure 2.

Premier Christian Radio. You'll also be able to receive channels carried on satellites co-located with Sky Digital's Astra 2A at its orbital position of 28.2°E. One such satellite is Kopernicus F2 - as a result, you can also enjoy listening to radio from the Czech Republic and the Netherlands. More will undoubtedly follow, expanding still further the listening choice!

There is, however, even more - if you have a Nokia receiver, that is! Direct-to-disk recording, free MP3 downloads, and even the display of digitised PC images on your TV set are all possible! Nokia's receivers have proved popular - versions equipped with conditional access hardware are issued to the customers of many European pay-TV operators. Their excellent availability and flexible hardware specifications have appealed to the die-hard enthusiast, some of whom have rewritten the Nokia operating system firmware to provide new features. Nokia has made this easy - the software resides in flash memory, rather than EPROM - so that purchasers of its hardware can keep abreast of DVB developments. Indeed, the 'official' Nokia upgrades can be found on its web site. The original free-to-air operating system didn't cater for single-channel-per-carrier (SCPC) services or the manual entry of audio/video packet identifiers (a necessary feature for obscure channels and feeds). The upgrades provide such features, and others to boot. The same Web page (<http://www.nokia.com/multimedia/downloads/index.html>) also contains links to a PC program that allows you to transfer the new firmware (which is supplied in the form of a .bin file) to your receiver via its serial port. Unfortunately, the process is rather slow - and indeed not particularly



Sony has announced a TiVo-compatible set-top box. And this is what it looks like...



Location of XP01 and XP06

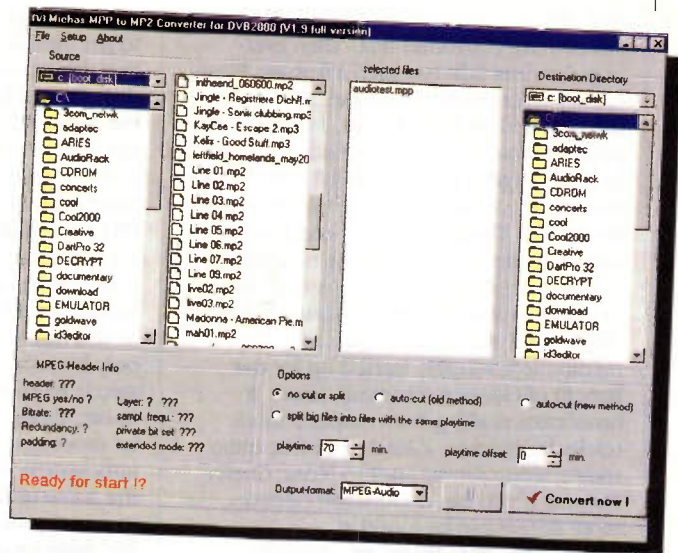
reliable (particularly if you're using an earlier bootloader, more of which shortly). Thankfully, Nokia has provided an alternative - although it requires access to the receiver's innards. Towards the back of the receiver's PCB is a 10-pin header terminal (marked as 'XP01'), which originally intended for factory programming and development. It's possible to interface this connector, using the simple 'BDM', or 'background debug module' circuitry detailed in Figures 1 and 2, to a PC's parallel port.

Programming is now considerably faster, although you'll need different PC software for the task. I use TranxBDM, which can be downloaded from a variety of sites including <http://www.dominance.net/overflow>. The software is easy to use - pressing a single button ('program') invokes a sequential process in which the existing firmware is deleted from the memory, and the new firmware loaded, in 'blocks'. You're advised to back-up the original firmware first, using the 'read' button. The BDM and TranxBDM may also be required to update the 'bootloader - a separate item of firmware that initialises the receiver on start-up, and loads the software into the receiver's RAM. The version of the bootloader currently installed is shown, albeit extremely briefly, on the display at switch-on. Early versions of the bootloader (1.01, for example) result in problems when trying to install new operating system firmware. Replacement bootloaders - a good choice is Nokia's B2.00Uns - can be downloaded from several different websites, including <http://www.satinf.com/nokia/osnokia.htm>. To replace the bootloader, you will need to bridge the protection jumper XP06. You can use a standard 0.1in. jumper of the type often used to set configure PCs - but don't forget to remove it after programming! An advantage of the updated bootloader is that it permits replacement operating systems to

be transferred to the PC across the serial port with greater reliability. The transfer speed is still slow compared to what's possible with the BDM, but then again there's no need to get inside the receiver.

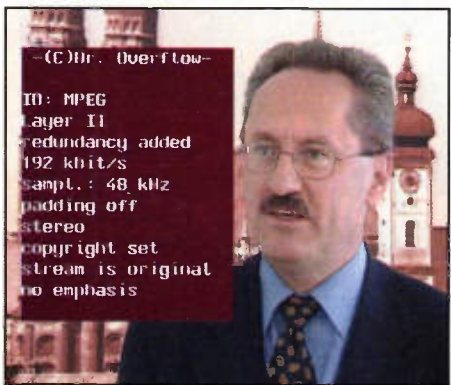
Replace the operating system with a newer Nokia version adds some nifty features that aren't obvious - enable the S/PDIF output pin of the CS4920 MPEG audio processor (refer to the February 2000 issue of 'Electronics'), there are alternatives. Some of the others currently in circulation are capable of more features (albeit at the expense of user-friendliness). The aforementioned satinf.com site provides links to a fair number of these third-party operating systems. One of the best is Dr. Overflow's shareware DVB2000 (<http://www.dvb2000.org>). It makes full use of the hardware, bringing out much of the functionality offered by the core chipset. You're presented with all kinds of parameters that can be adjusted through a battery of on-screen menus. DVB2000 is also capable of providing a considerable amount of information about the received signal - if you want more, you'll probably have to spend thousands of pounds on a professional-grade DVB test set! Much of the added functionality can be attributed to a high-speed PC interface - which has been exploited by various programmers to provide additional functionality. All of this is possible because Nokia decided to endow its receivers with a Fast SCSI-2 interface; the original idea was that users could hook up a CD-ROM drive to the back of the unit, and play Video CDs. With DVB2000 installed on your Nokia receiver, and a SCSI card installed in your PC, the fun can really begin. It's a shame that SCSI ports, or interfaces of equivalent performance, seem to be disappearing from digital satellite receivers. Without them, nothing of what I'm about to describe would be possible.

Let's start with something that will appeal to die-hard scanners of the skies. DVBEedit, also available from the [dvb2000.org](http://www.dvb2000.org) site, features a band scanner. This is very useful since it allows you to spot new transponders and satellites. Its display resembles that of a spectrum analyser. Moving swiftly along, the Dr. Overflow team have written an excellent Windows 9x program - VGrabber - to fully exploit the link between PC and satellite receiver. Turn on the receiver, and then boot up your PC. Run VGrabber (available, once again, from [dvb2000.org](http://www.dvb2000.org)), and the receiver should be appear on the displayed list of SCSI devices. I had problems here until I told Windows to 'detect new hardware' - this presumably gets the ASPI drivers to recognise and talk to the receiver. You don't need a fancy SCSI card - the one in the test PC is a bargain-basement Adaptec 2904. The default SCSI ID given to the receiver is 3 - if this conflicts with other devices on your SCSI chain, you'll be pleased



to know that it can be changed via one of the on-screen menus. Note that the receiver should be the last device on a SCSI chain, because it incorporates a terminator. Most of the program's real functionality is located in the 'SCSI Action' menu. From here, you can transfer new firmware to the receiver, transfer channel databases and grab TV pictures with or without on-screen graphics (great for 'long-distance' TV enthusiasts). You can also send pictures (BMP or JPEG) from your hard disk to the receiver - they're then displayed on your TV screen. I can imagine this feature being of great interest to video editing enthusiasts, because they can now commit title screens, digital photographs and scanned images onto tape with the highest possible image quality!

Of greatest interest to Electronics readers, however, is Vgrabber's 'streaming' feature. Here, MPEG audio and video streams can be saved directly to the PC's hard disk - pipping to the post those forthcoming Sky Digiboxes with in-built mass storage! You can also save other types of datastream (for example, teletext) by entering the packet identifier value - we'll discuss one valuable application of this shortly. At the time of writing, simultaneous capture of video and audio isn't possible. A future version of Vgrabber will, no doubt, rectify this. Capturing audio streams from radio stations is, for now, the greatest application of the software. In other words, you can make recordings with absolutely no quality loss relative to the original broadcast. Audio streams can be saved directly as mp2 files, which can be played by Winamp. Sometimes, however, there are audible 'glitches'. These are caused when some of the transport-related header information (synchronisation and so on) transmitted with the audio datastream isn't removed. A better option is to save audio streams in their 'raw' state (MPP file format) and a converter program that can be downloaded from the DVB2000 web site. This program (mpp2mp2v19a_full_registered.zip) will convert raw captures to MP2 files, stripping away any information that isn't audio-related. The 'Michas MPP to MP2 Converter' also features a track splitter, and the ability to convert those MPEG audio captures into WAV files. The latter will, of course, benefit those who want to make CDs from live concerts and other such broadcasts. Note



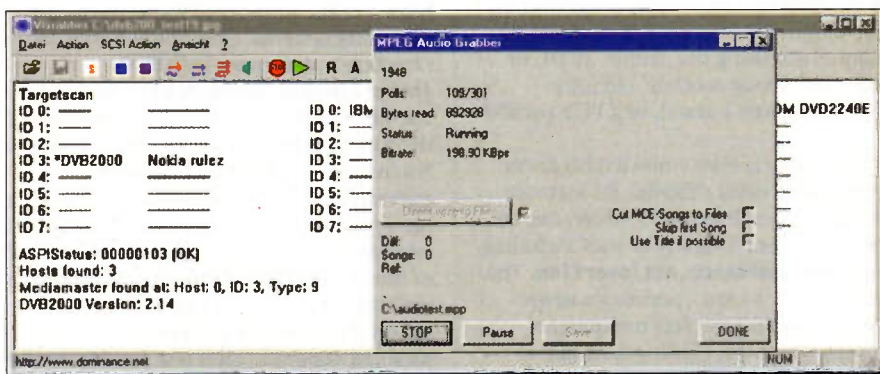
that 48kHz datastreams will need to be sample-rate converted first - then ever-popular Cool Edit has such a feature. Music Choice streams are, of course, already in the required 44.1kHz format. Music Choice plays CD tracks, and you would of course buy the original CDs - wouldn't you? In all, though, the home recordist has never had it so good! The potential for excellent sound quality is unlikely to be bettered.

But there's even more - how does the direct download of MP3 music to your hard disk sound? A service, known as r@dio.mp3, recently started up for the benefit of German cable customers. It broadcasts nothing but complete music tracks and jingles - a kind of DJ-free radio station along similar lines to Music Choice Europe. If you can understand German, more details can be found at <http://www.musicplay.de>. Basically, though, subscribers purchase a PC tuner card that plugs into their cable outlet, and run special software that decodes the transmissions and generates the MP3 files. The transmissions are sent to cable networks via satellite, and because they are not encrypted can be received by all! Well, theoretically at least - although the footprint of the satellite involved (Eutelsat Hotbird, at 13°E) covers the greater part of Europe, getting to those MP3 files is rather tricky and beyond the capabilities of the average domestic satellite viewer. Basically, they're transmitted in the teletext datastream of NBC Germany (11.057 GHz; horizontal polarity; symbol rate 27500; FEC 3/4). The flexibility of DVB2000, however,

makes interception a reality. The first step is to get the teletext packet identifier (PID) so that the stream can be captured to the hard disk. One of DVB2000's menus gives you the audio PID, the video PID - and last, but not least, the teletext PID.

If you go to VGrabber and select the 'read from PID' menu, you can enter the PID value that was displayed by DVB2000. The datastream containing the MP3 files can then be captured to your hard disk as a binary file. Those captures can be as long as you like - they're ultimately restricted only by your hard disk's capacity. One more step is required before you can listen to the music, though - the raw datastream has to be processed so that the header information is removed. Some kind soul by the name of 'Michael R' has written the required program, and placed it on his web site (www.no-access.de). It's easy and quick to use - simply specify the raw capture file, and it extracts all of the MP3

files - complete with ID3 tags - and dumps them in the directory of your choice. Judging by what I have heard, r@dio.mp3 is aimed at a very youthful audience. If you don't like Euro-disco, you're not missing much! As one would expect, German-language pop music is also represented well. As with any radio station, you don't have any control over what's played. What's more, at least one song is guaranteed to be incomplete because you can't hear the music and are thus always capturing 'blindly'. Note that obtaining music in this way is just as dubious as downloading MP3 versions of commercially-available recordings from an obscure FTP site - if not more so. Martin Pipe welcomes comments and ideas. E-mail him at: martin@webshop.demon.co.uk Or look out for him online! His ICQ ID is: 15482544



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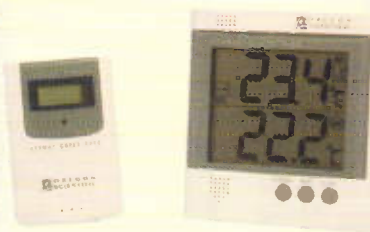


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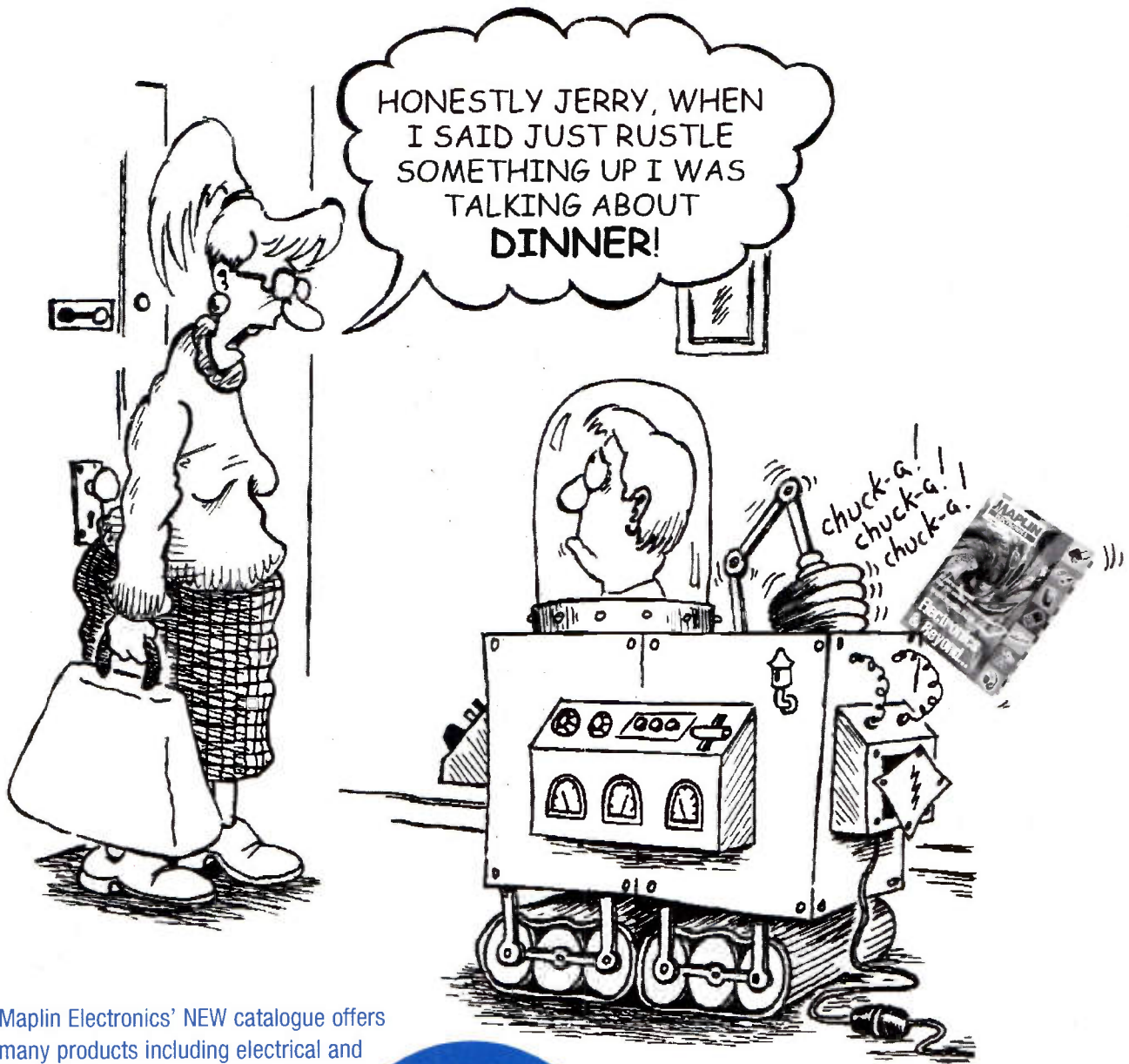
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