ELECTRONICS and Beyond

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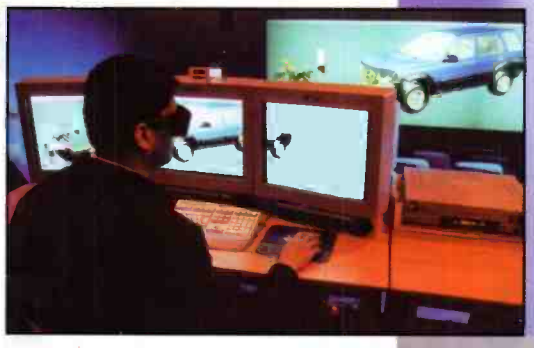
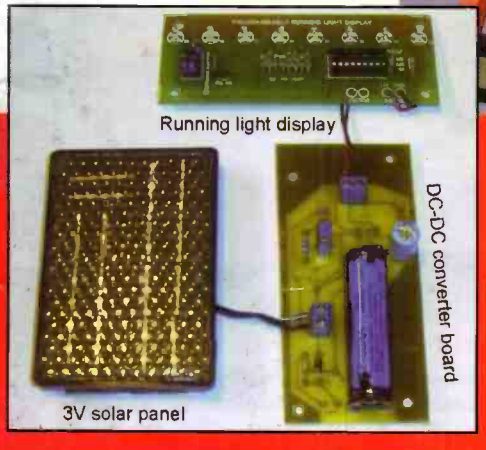
Screenfridge
PC technology in the kitchen

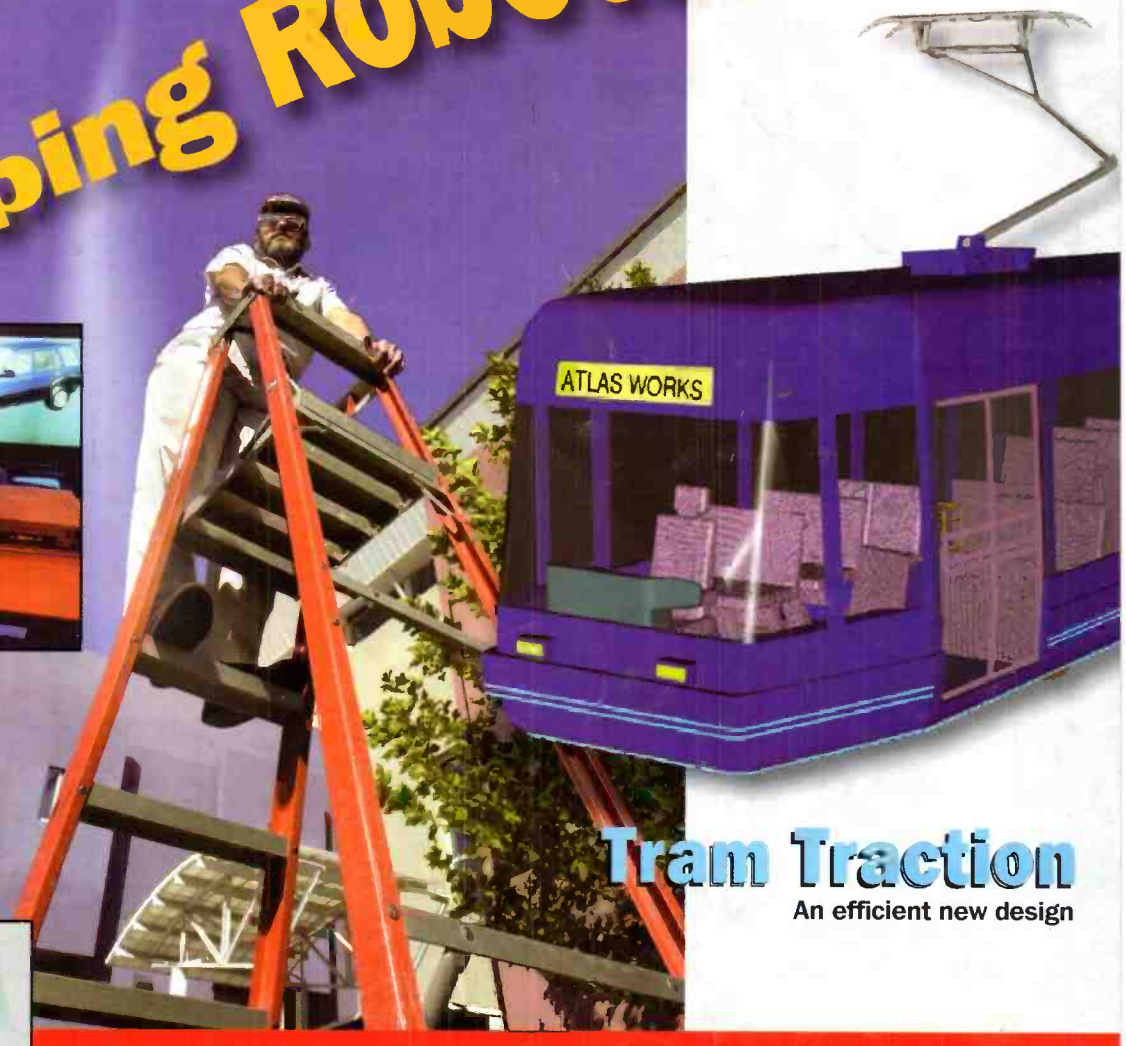
Hopping Robots



3D Cinema

Electronic Circuits of the Future





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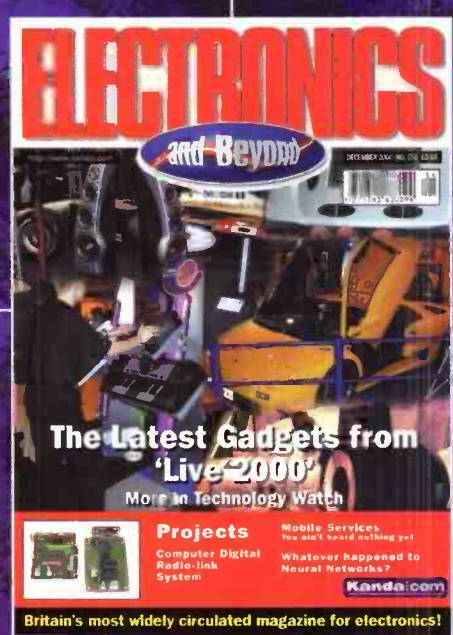

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ELECTRONICS and Beyond

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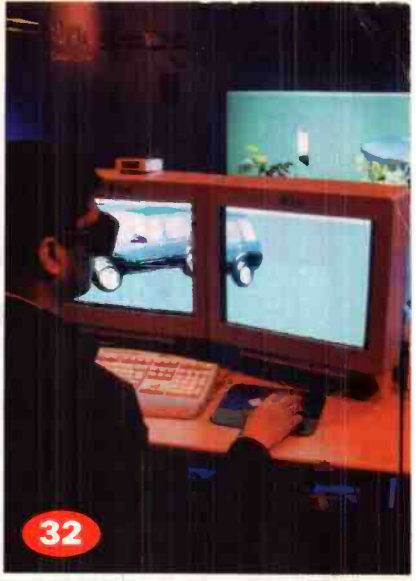
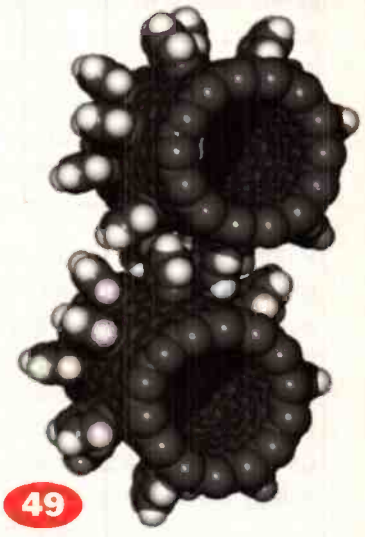




ELECTRONICS and Beyond

Every so often somebody comes up with a radical alternative to a system. In this case it is improving the drive efficiency in motorised rail transport either in trams or trains. For years transmission of rotational energy from power source to wheel has been through a tortuous mechanical route. If you needed a clutch and gearing system there was no other route. But as we know, the longer the mechanical route from power source to traction on the ground or to a rail, the greater the energy losses throughout the drive system and a greater chance of breakdown.

Putting the power source, in this case an electric motor, directly in the wheel and making the wheel part of the motor has many advantages. Motors have the ability to be directly controlled in speed and direction through electric current drive and with fewer mechanical links, the result means better reliability and a much higher efficiency of energy transmission. Also Physics tells us about many reversible actions, in this case the motor acts like a generator and so the motor can also provide electrical braking. It also means that placing motors in each wheel provides traction to the rail at any time when the need is greatest like having wet leaves on the line. All this adds up to a remarkable development that is now being headed by a company called Stored Energy Technology Ltd. in the UK. The energy saving aspect has been applied to many parts of the vehicle and reading this fascinating account leads us to one conclusion – that this design is a great contribution to the environment.

Hope you enjoy your read.

Paul Freeman-Bear

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

Space Camera With a View

The first images to show the invisible portions of an aurora from space have been released by a team of University of California scientists operating the far-ultraviolet camera on board NASA's Magnetosphere-to-Aurora Global Exploration (IMAGE) spacecraft.

These views shown of the aurora borealis were captured during a violent magnetic storm in earth's upper atmosphere during the summer. The onslaught of particles produced sparkling halos of electrified particles writhing, thickening and thinning to wispy streaks of light during four hours of observations.

Many light shows - caused when huge eruptions of fast-moving, multimillion-degree gas from the sun crash into earth's protective magnetic shell - are expected to occur through the middle of 2001 as earth experiences the sun's fury at the height of the 11-year solar cycle.

Regions of these iridescent halos were invisible to scientists before launch of the IMAGE space weather satellite. IMAGE performs its sentry duty by photographing the glow caused when light or particles coming directly from the sun, or nearby particles whipped up to high energies, smash into atoms in the upper atmosphere.

Launched in March 2000, the spacecraft follows a highly eccentric orbit which takes it far enough from the Earth that, at times, the whole planet, and its fluorescing plasma, can be captured within the camera's photographic frame.

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

think3 Brings 3D to the Desktop

think3 has released a 3D design application called think design 6.0, which it believes will change the way industrial and mechanical designers and engineers interact with software for product development, from conceptual design through engineering and manufacturing.

think3's R&D team has brought 3D functionality and ease of use to the desktop with thinkdesign 6.0, making it easier than ever for a full spectrum of users to tap into the power of 3D design.

think3 has worked with Microsoft to build speech functionality into thinkdesign 6.0 with using Microsoft's speech application programming interface.

For further details, check: **<www.think3.com>**

Quantum Leap in Internet Security

Information flooding the ever-evolving Internet will increasingly take the form of light pulses streaming through fibre-optic cables. But fibre optics brings both solutions and problems.

Conceivably, hackers could use beam splitters to divert streams of light and access confidential information without being detected. But if a message were carried by a lone photon - the smallest discrete quantity of light, called a quantum - it would be easier to detect intruders.

"If you have only one photon per pulse, you would immediately know that an eavesdropper had penetrated the system because the receiver at the opposite end could tell that the data had been disturbed," says Stanford chemistry Professor W. E. Moerner.

He and visiting research associate Dr Brahim Lounis, now at the Université Bordeaux in France, were the first to use lasers to get single molecules to emit single photons on demand at room temperature.

While quantum communication is still futuristic, Moerner says, it aims to provide the ultimate in secure information transfer. In the next five or 10 years we may use quantum information technology to send messages over channels one photon at a time. Or we may employ quantum cryptography, which uses signals from a single photon to transmit an electronic key to decode encrypted messages.

For further details, check: **<www.stanford.edu>**

IBM to Receive US Award Technology Innovation

IBM is to receive the US Medal of Technology - which recognises lasting contributions to competitiveness and standard of living in the US - for the company's leadership in developing and commercialising data storage technology.

IBM invented the magnetic hard disk drive in the mid-1950s and is responsible for virtually every major breakthrough in disk storage technology over the past four decades.

Over the past 20 years IBM innovations have increased the storage density of disk drives more than 4,000-fold. Today, annual worldwide production of hard disk drives by IBM and others exceeds 170 million units.

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

NEWS BYTES

MGI Software Announces VideoWave 4

MGI Software has announced the latest release of its popular PC video software for Windows, MGI VideoWave 4. Expanding on version 3's powerful functionality, VideoWave 4 provides a complete suite of features to capture, edit, mix and produce video in any format. New, easy-to-use Web publishing capabilities also allow users to share their videos with family or colleagues on the Internet or by email.

MGI VideoWave 4 is available from Electronics Boutique, Dixons, PC World, WH Smith, Staples, Jessops, Dabs.com, jungle.com, Dream Direct, Simply Computers and other leading software retailers at £79.99.

In addition, a host of new features have been included, such as automatic scene detection, Timewarp for the creation of fast or slow-motion video, a dedicated Web publishing function, and two complete CDs of media content for users to try out or include in their own projects.

In recognition of the growing popularity of video on the Internet, MGI VideoWave 4 includes support for RealNetworks streaming format, and continued support for Microsoft Windows Media, allowing users to create movies in the two most popular Web video formats.

For further details, check:

<www.mgisoft.com> and **<www.videowave.com>.**

SyChip Announces Smallest Global Positioning System for Mobile Phones

SyChip, a Lucent Technologies venture, has developed the smallest fully integrated global positioning system (GPS) module.

Designed for wireless Internet appliances, the GPS2020 chip-scale module enables navigation and location-based services in cellular phones and personal digital assistants. It measures only 11mm by 14mm.

Wireless location services enable people to receive navigation, traffic, weather, other information services, and advertising based on their location.

For further details, check: **<www.sychip.com>**

NEWS BYTES

AIWA Introduces Portable MP3 Player

AIWA has introduced its first portable MP3 player, an SDMI-compliant model that features 32MB of internal memory and includes a 32MB memory card.

The new Windows-compatible AIWA MM-VX200 comes with RealJukebox software for converting music into MP3 files, and for easy setup and fast downloading it connects to a PC through a USB interface.

To expand the player's memory, and so allow more music to be stored, the MM-VX200 has a SmartMedia card slot, and comes with a 32MB SmartMedia ID card. In addition, a built-in microphone allows voice recording of up to two hours, and these recordings can be stored in up to 99 different files.

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

Experimenting with the PIC16F877

Brunning Software has announced the fourth release in their "Experimenting with..." series. The latest system centres on the book and it comes into its full potential when the upgraded software suite is used with it.

The book follows a similar pattern to Experimenting with PIC Microcontrollers by the same author and allows anyone with no prior knowledge to start programming the PIC. The book shows you how to experiment with LEDs using very simple programmes. Then it goes on to experiment with the 16bit timers, and examine the techniques required to create lookup tables, send messages to the liquid crystal display, create a simple frequency counter, use a keypad to send numbers and letters to the display, produce a security coded message machine, and experiment with the 10 bit A/D converter.

Ideally the book and software suite should be used with the Brunning Software programmer module.

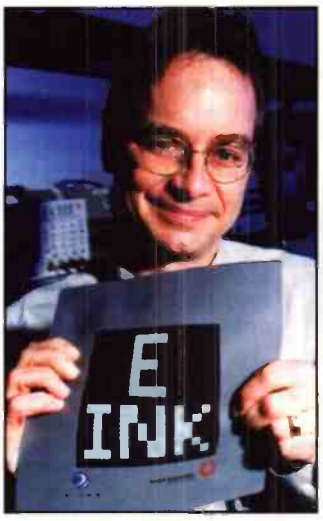
For further details Contact Brunning Software
Tel: 01255 862308.

E Ink and Lucent Demo Flexible Display

E Ink and Lucent have announced a major milestone in their effort to develop a flexible, paper-like electronic display, as they jointly demonstrated working prototypes built on thin sheets of plastic.

Produced just one year after the development project was announced, these devices prove that electronic ink, driven with printed plastic circuits, is a compelling design for electronic paper and other next-generation displays.

The prototypes consist of a 25 sq. in. display area made up of several hundred pixels. The displays were constructed using two ground-breaking developments: E Ink's electronic ink, and Lucent's active-matrix drive circuits



printed on plastic, which were developed by Bell Labs, Lucent's research and development unit.

The transistors in these circuits are made of plastic materials and are fabricated with a low-cost printing process that uses high-resolution rubber stamps. Their switching properties are similar to typical thin film transistors made with silicon and conventional fabrication methods, but they are mechanically flexible, rugged and lightweight.

The electronic ink enables the display's paper-like qualities: extraordinary brightness and contrast under a wide range of lighting conditions; easy viewing from all angles; low power consumption; and plastic film construction.

For further details, check:
<www.lucent.com> and **<www.eink.com>**.

Logitech's Trackball Provides Optical Freedom

Logitech is setting new standards for innovation and style with its latest trackball - Cordless TrackMan FX.

Based on digital radio technology, Cordless TrackMan FX is free from the limitations of unattractive, entangling cables, sending signals instead to a small receiver that connects to either a USB or PS/2 port.

The combination receiver means that the product is suitable for both PC and USB-enabled Macintosh environments, while digital radio technology means that it is free from line-of-sight requirements.

Logitech's marble optical tracking technology, used in all of its trackball products, delivers superior precision, reduced wear and smooth tracking. Because there are no moving mechanical parts to collect dirt, the device requires virtually no maintenance.

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

Xircom Unveils Smallest Full-Function MicroPDA

Xircom is attempting to redefine the personal digital assistant (PDA) category with its introduction of the new credit card-sized REX 6000 MicroPDA.

Claimed to be the world's smallest, lightest, full-function MicroPDA, the REX 6000 device keeps mobile users in touch with essential information at any time, from any location.

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

Boeing Satellite is Most Powerful Yet

The most powerful communications satellite built to date, 17.5kW Anik F1 satellite built for Telesat Canada, was launched on an Ariane rocket from the Guiana Space Centre in French Guiana in mid-November.

Anik F1 takes full advantage of the technological advances incorporated into the Boeing 702 model spacecraft. The powerful 17.5kW satellite will operate in geosynchronous orbit at 107.3 degrees West longitude. To generate such high power, the two five-panel solar wings employ high-efficiency dual-junction gallium arsenide solar cells developed by Spectrolab, another Boeing company. When fully deployed, the wings span 132.5 feet.

The Anik F1 payload consists of 84 transponders providing broadcast services to North America, and tele-communications, Internet services and broadcast services to South America. The Ku-band carries 48 active transponders with 115W traveling wave tube amplifiers (TWTAs) and the C-band carries 36 active

transponders with 40W TWTAs.

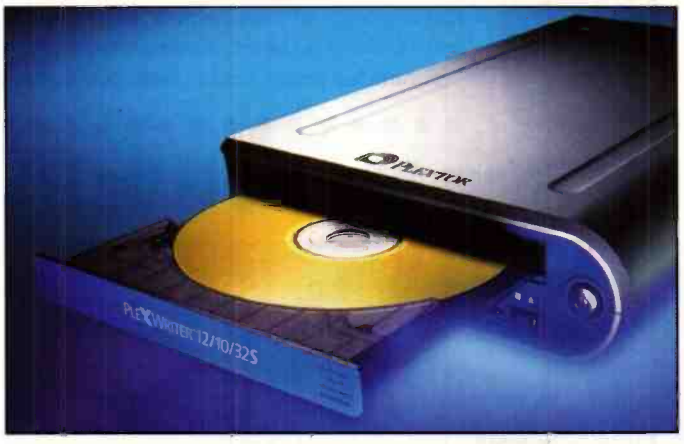
Two nadir antennas will provide Ku- and C-band coverage for South America. Services to North America in Ku-band will be provided by one west antenna, and in C-band by one east antenna. When fully deployed, the spacecraft measures 29.5 feet in width. At liftoff, Anik F1 will weigh 10,384lbs. Once on orbit, the satellite will weigh 6,647lbs.

For further details, check: **<www.boeing.com/satellite>.**

Plextor SCSI External CD-RW Drive

Plextor has launched the external PlexWriter 12/10/32S CD-ReWritable drive with an Ultra SCSI (SCSI-3) interface. The Ultra SCSI interface delivers very fast SCSI-bus burst transfer rates for higher performance.

The external PlexWriter 12/10/32S features 12x write, 10x rewrite, and 32x max playback speeds, making it the fastest SCSI CD-RW device available on the market today. The 10x-rewrite speed leaps over conventional 2x and 4x



CD-RW speeds, enabling end users to rewrite an entire 650MB CD in just over seven minutes (CD-RW).

A stylish silver-and-blue enclosure sets the external PlexWriter 12/10/32S apart from competitive product offerings. The high-speed drive provides both professionals and power-users with the ideal solution for such advanced applications as recording audio CDs, archiving small and large data files, or creating multimedia productions.

For further details, check: **<www.plextor.com>.**

Iomega Bundles Film Trailers on Jaz Disks

Independent Pictures is set to become the first film to pre-load movie trailers on blank high-capacity computer disks manufactured by Iomega.

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

NEWS BYTES

3Com Launches HomeConnect PC Digital WebCam Lite

3Com has announced the launch of the 3Com HomeConnect PC Digital WebCam Lite, the newest member of 3Com's growing line of digital cameras and accessories.

With the PC Digital WebCam Lite, 3Com makes it radically simple to enjoy the benefits of video communications for people who require less flexibility and mobility in their video needs, but still want a high-quality webcam at a lower price.

For further details, check: **<www.3com.com>**

Hauppauge WinTV-PVR Hits Shops

A software video recorder from Hauppage clumsily named videoWinTV-PVR-pci, hit shops in time for Christmas.

WinTV-PVR allows PC users to watch TV in a window on their PC screens, plus can pause live TV, create instant replays, record TV shows to disk, and create Video CD's from television programs.

The pause and record functions of the WinTV-PVR make use of a high quality MPEG2 hardware compressor, which can store studio quality video on a PC's hard disk. MPEG2, the same advanced technology used to create satellite TV broadcasts and DVD movies, provides high quality video and audio while minimising hard disk usage.

While displaying live TV, WinTV-PVR can pause the TV show using a feature called Program Pause. The TV program can later be continued from where it was stopped without missing any of the show. Also, any portion of the paused show can also be replayed, giving the user their own instant replay.

TV shows can also be recorded to disk using the built-in MPEG hardware compressor. Once recorded to disk, they can be played back either on the PC in a window or full screen. Since the built-in MPEG compressor does not require the CPU, recording can be done without affecting other PC applications. For example, a PC user can surf the net at full speed while the WinTV-PVR is recording a TV show to disk.

For further details, check: **<www.hauppauge.com>.**

NEWS BYTES

Stanford Resources Forecasts Steady CRT Growth

Stanford Resources' Monitor Market Trends 2000, the longest-running publication covering the global cathode ray tube (CRT) monitor market, predicts that CRT monitor growth will remain strong through to 2006, as production of 17in. computer monitors continues to accelerate.

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

Symantec Brings Security and Firewall Technology to the Mac

Symantec has announced Norton Internet Security and Norton Personal Firewall for the Mac.

Norton Internet Security for Macintosh is the first Internet security suite for the Mac OS to offer a comprehensive solution with protection against Internet threats such as hackers, illegal access and viruses.

Norton Internet Security for Macintosh provides an essential Internet security suite for the Macintosh platform, combining Norton Personal Firewall for Macintosh 1.0, Norton AntiVirus for Macintosh 7.0 and iClean 3.5 by Aladdin Systems.

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

Sony Upgrades Notebook Engine

Sony Electronics has integrated digital entertainment with the essentials of personal computing and the new mobile Intel Pentium III 750MHz processor to create both the lightest and the slimmest new VAIO PCs with Intel's SpeedStep technology.

Unique in not only form and weight, but in its versatility, the less-than-three-pound, one-inch-thin VAIO SR17 notebook gives those desiring stylish, ultra-portable notebooks the option of either a consumer-oriented Microsoft Windows Millennium Edition operating system or a more business-focused Windows 2000 Professional operating system.

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

HP Launches Sleek PC

Hewlett-Packard (HP) has introduced the HP Pavilion 2755C home PC featuring a space-saving form factor. Available via <www.hpshopping.com>, the new HP Pavilion home PC offers a dramatically re-designed chassis that is about the size and shape of a cereal box.

Standing at 13in. by 15in. by 4in., the HP Pavilion 2755C home PC marries compact size and style with performance.

The HP Pavilion 2755C home PC comes equipped with an Intel Pentium III 800 MHz processor, 128 MB SDRAM with up to 11 MB for video memory, a 20 GB hard drive, CD-RW, 10/100 BT Ethernet card, v.90 56K modem, Polk Audio stereo speakers and a one-touch, back-lit keyboard.

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

Nokia Phone Takes Personal Approach

Nokia has launched a mobile phone aimed at the next generation of wireless users demanding a phone that reflects their lifestyle.

The all-new Nokia model 3390 phone comes with more personalisation options than ever. It brings the style of Nokia phones to the entry-level segment and makes a bold fashion statement with smooth, flowing lines, backlit metallic keys and a contrasting bezel treatment that sets it apart.

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

Intel Brings Wireless to the PC

Intel has introduced a family of wireless PC peripherals that frees consumers to use their PCs and the Internet more comfortably and allows them to add multiple devices to their PCs without messy cord clutter.

Called the Intel Wireless Series, the product family includes the Intel Wireless Series Gamepad, Intel Wireless Series Mouse and the Intel Wireless Series Keyboard.

At the heart of the series is the Intel Wireless Series Base Station, which lets consumers add up to eight Intel Wireless Series devices.

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

Multiple Function Phone From Ericsson

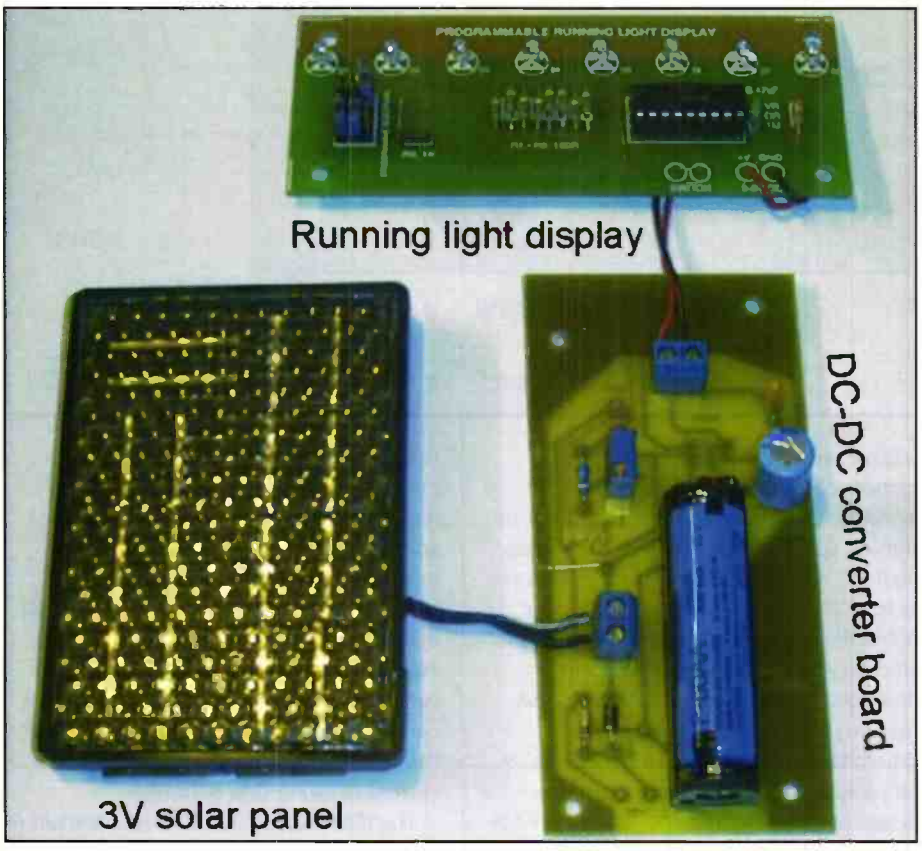
Wear it the way you want to. The Ericsson T20 lets you show who you are. It lets you chat with whoever you want, whenever and wherever via SMS or WAP. Attach the FM radio or MP3-player to it and dig your favourite beats. And of course you can make phone calls.

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

EXPERIMENTAL +5V solar-powered supply

PROJECT

By Dr Pei An



Solar electricity is a technology of converting sunlight directly into electricity through the use of solar cells. Solar electricity does not rely on burning fuels and emits no hazardous or greenhouse gases into the environment. It has been widely used around the world and it will become more and more popular in the future.

The present project is not the power source for your homes and offices. It is a low-power experimental system demonstrating how solar electricity can be used (see Figure 1). During daylight, a solar cell charges a 1.2V rechargeable battery. If the surrounding becomes dark enough, an on-board light sensor automatically activates a step-up DC-DC converter to produce a +5V DC supply with a maximum deliverable current of 50mA.

You will find that the present system is very useful as a power source for low-power devices such as security lights, security sensors, standalone data acquisition systems and remote control receivers.

How it works

Figure 2 shows the workings of the system. A 3V solar panel is used to charge a single cell 1.2V AA size Nickel-Cadmium (Ni-Cd) rechargeable battery.

A single-chip voltage step-up regulator, ML4875, is used to boost the battery voltage (1 to 1.2V) into a +5V DC voltage. The IC requires only three passive components to form a complete DC to DC converter. Conversion efficiency is up to 90%. The minimum voltage input could be as low as 1V.

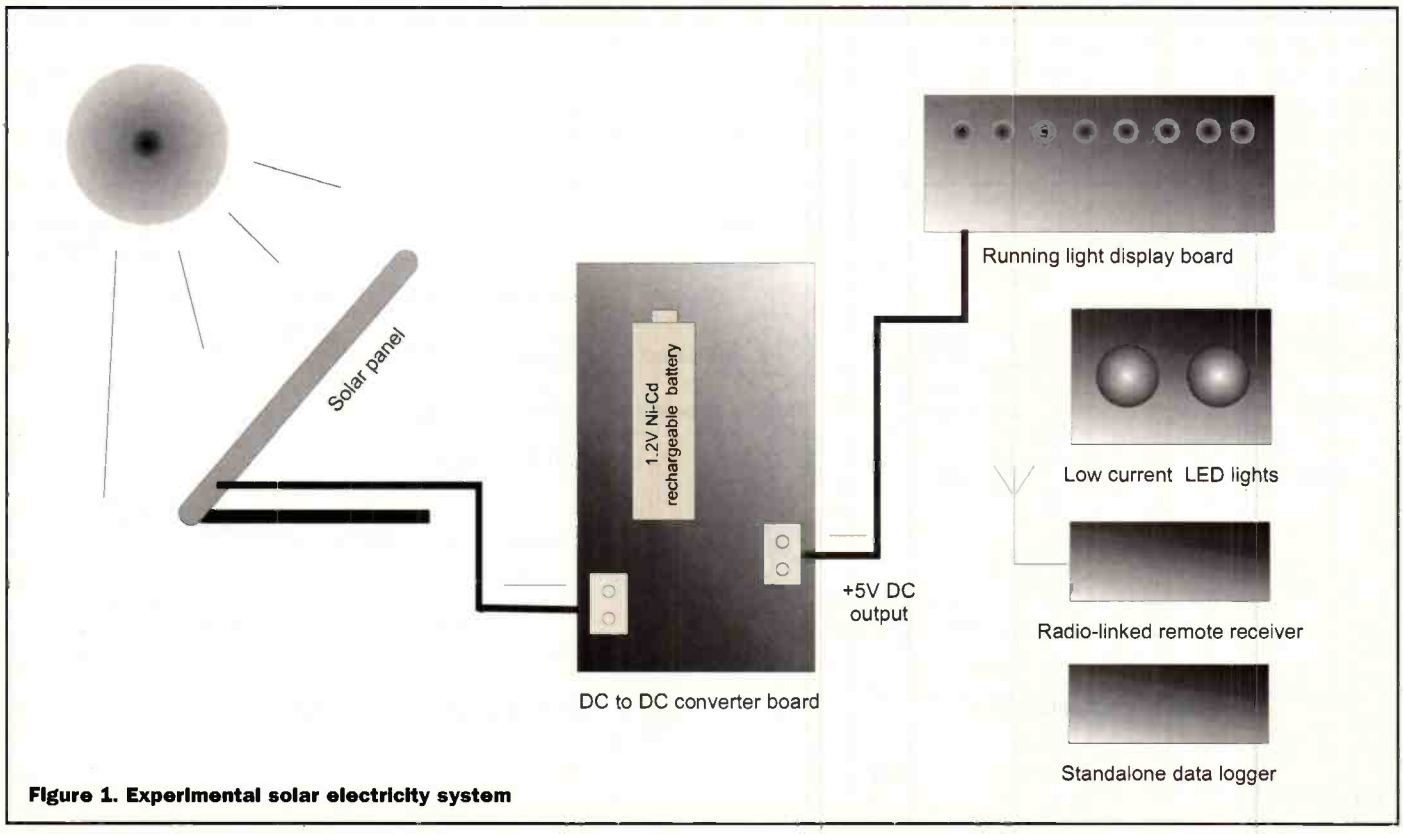


Figure 1. Experimental solar electricity system

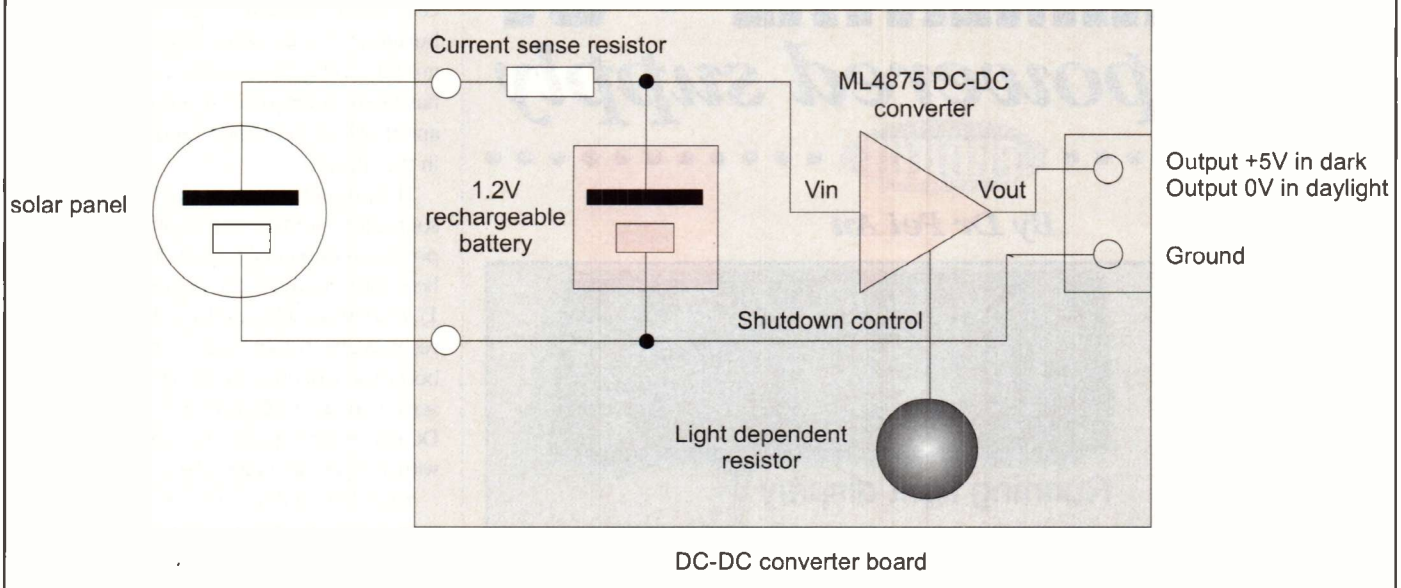


Figure 2.

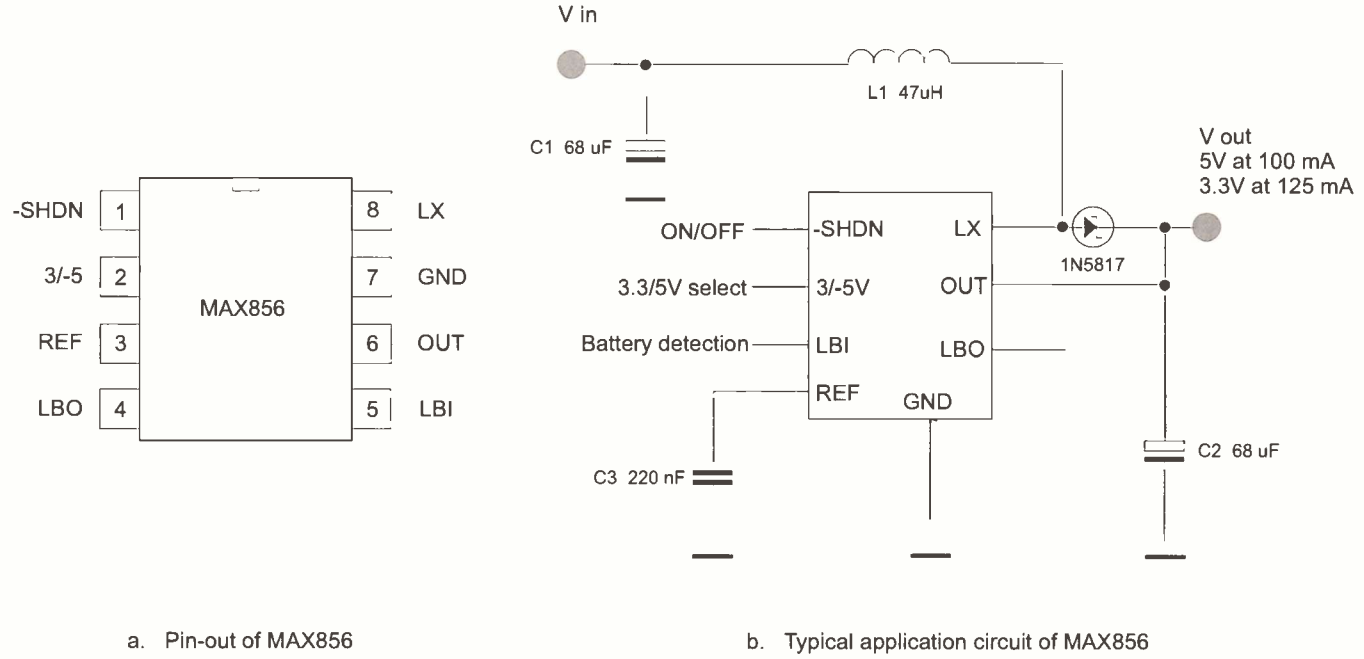
A light dependent resistor controls the on/off of the DC-DC converter. If the ambient light intensity is higher than a pre-set threshold, the DC-DC converter is switched off. During switch off, the battery is isolated from the load completely so that there is no current flowing through the load. If the ambient light intensity is lower than the threshold, the DC-DC converter is switched on, outputting +5V DC voltage.

DC to DC converters

In most cases, 1.2V DC supply is too low to be used to power up any devices. The voltage must be boosted up to much higher voltages such as 3.3V or 5V. Nowadays, there are a variety of state-of-art step-up voltage regulators which generate high DC voltages from low voltages as low as 0.8V. They feature ultra-low quiescent operating current with a typical conversion efficiency of 90%. Here two chips are described briefly. One is the MAX856CSA (Maxim) and the other is the ML4875 (Micro Linear). Both of them have SOIC 8-bit package. Reference 1 and 2 give the details of these two ICs.

MAX856 is a +3.3/+5V output step-up regulator designed for an input voltage range 0.8V to 6V. Supply current 500mA maximum. Two capacitors, one inductor and one diode are all the components needed to form a complete DC-DC converter. It has a guaranteed start-up and operation voltage of 0.8 V DC with efficiency up to 85% (at 100mA output current). It features an ultra-low quiescent current consumption of typically 25mA. If the device is in the shut down mode, the current consumption is 1mA.

The device has a shutdown control pin (-SHDN). Shutdown will turn off the DC-DC



a. Pin-out of MAX856

b. Typical application circuit of MAX856

Figure 3.

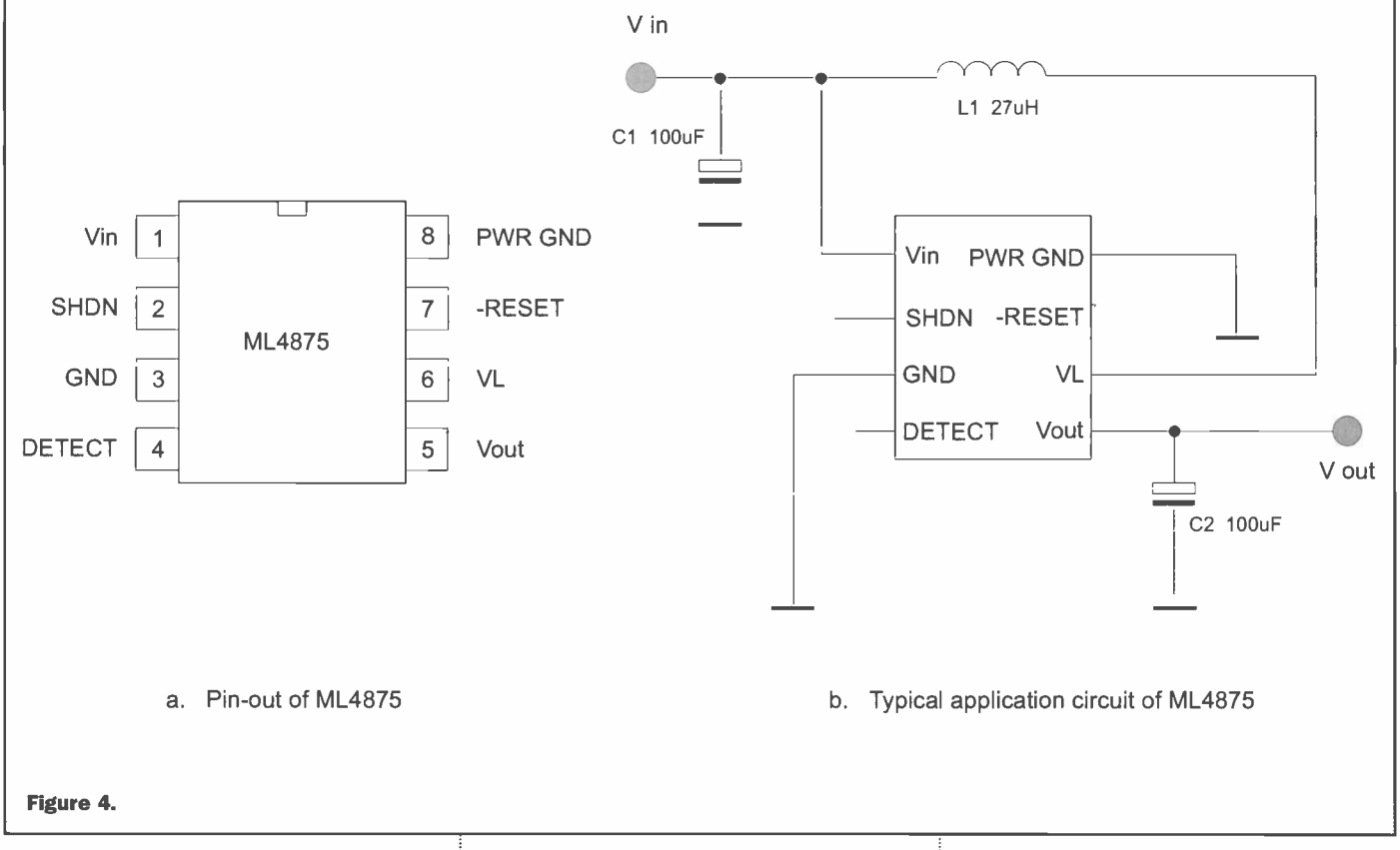


Figure 4.

converter only. It does not isolate the battery from the load. That means that although the DC-DC converter is switched off, battery will still supply power to the load through a diode.

A 3.3V/5V select pin allows the output voltage level to be selected either at 3.3V or at 5V. A low-battery detector output is available to indicate if the battery voltage is too low.

Figure 3 shows pin-out functions and a typical application circuit. Pin-out function is given in Table 1.

ML4875-5 is a +5V output step-up regulator designed for 1 to 3 cell battery powered systems. Two capacitors and one inductor are all the components needed to form a complete DC-DC converter. It has a guaranteed start-up and operation voltage of 1 V DC input with efficiency in excess of 90%.

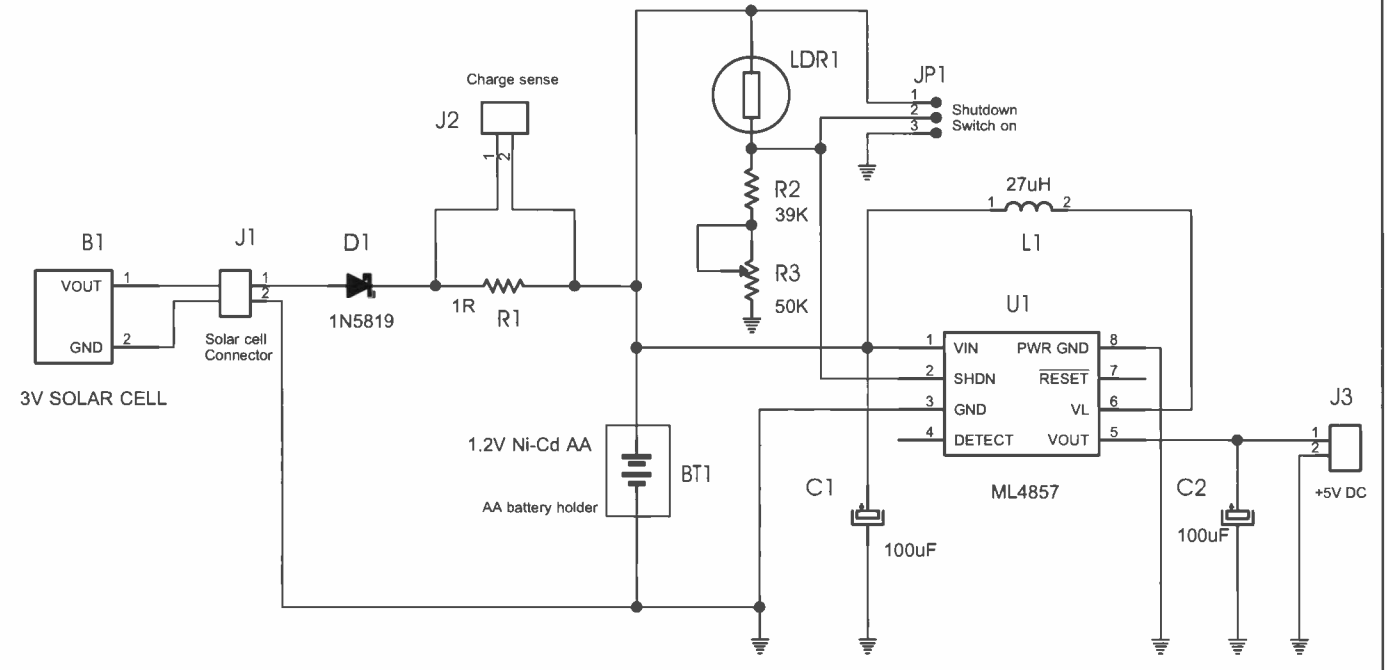


Figure 5.

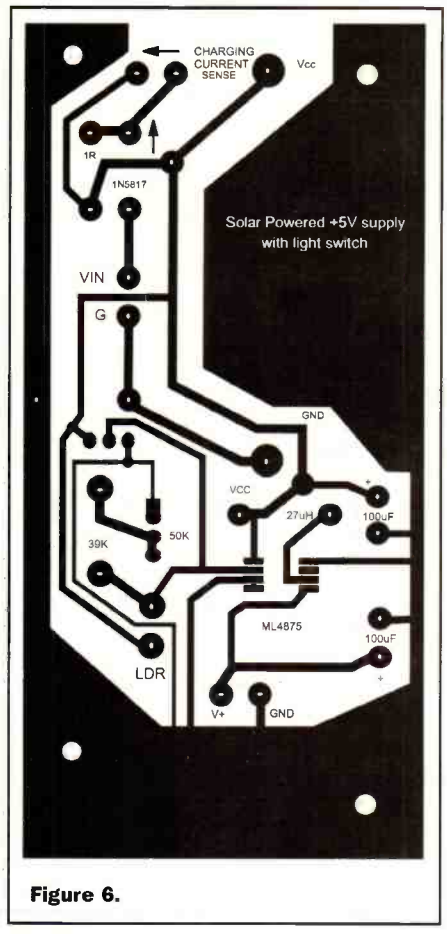


Figure 6.

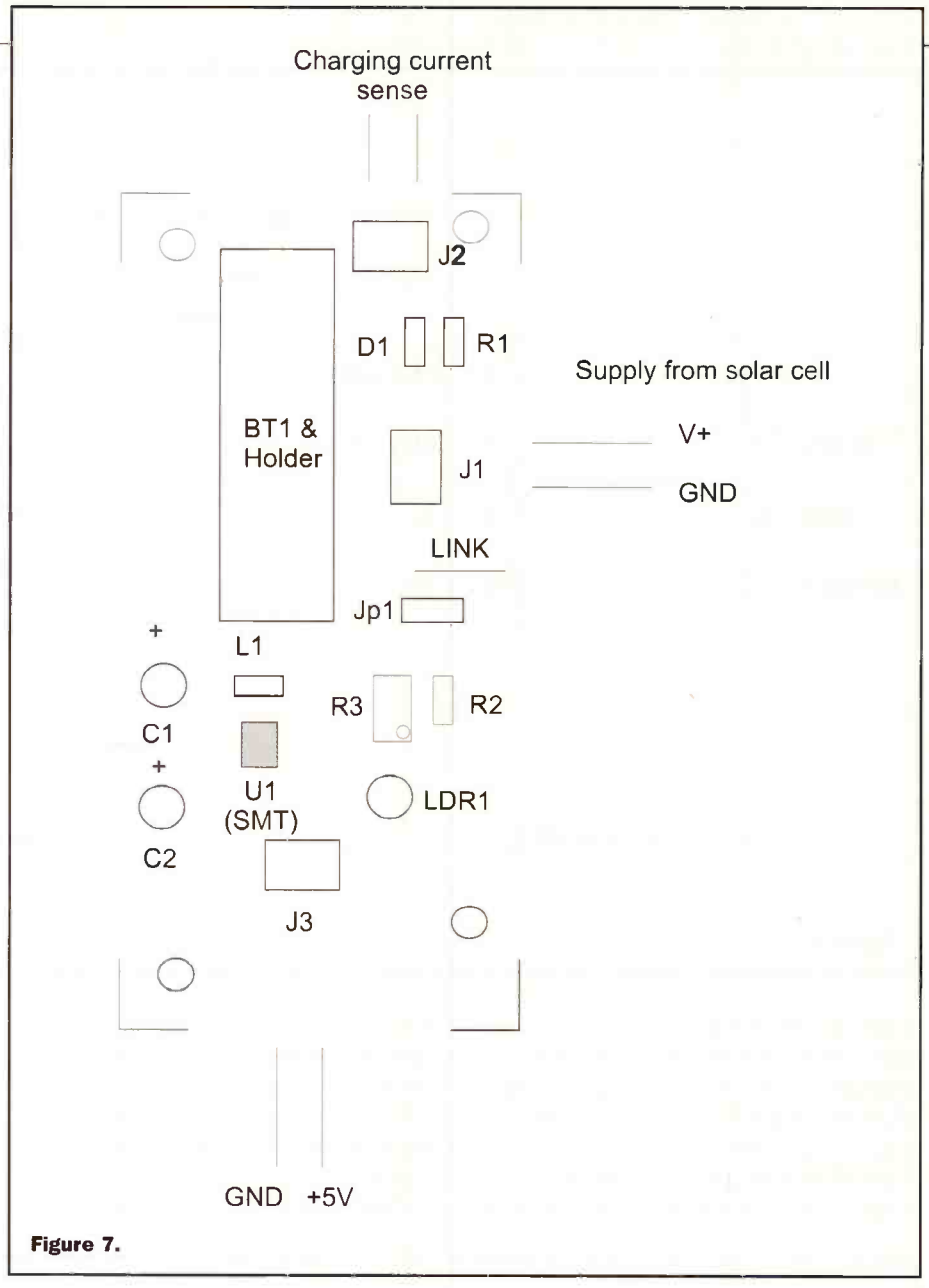


Figure 7.

It features an ultra-low quiescent current consumption of typically 50mA. If the device is shut down, the current consumption drops to 20mA.

A unique feature is that by shutting down the device (SHDN pin held high), the battery is completely isolated from the load. This feature is very useful in applications where complete shutdown of power to loads is required.

Figure 4 shows pin-out functions and a typical application circuit. Pin-out function is given in Table 2.

Pin	Name	Function
1	-SHDN	Pulling high to enable the regulator. To shut down the IC, -SHDN should be held below 400mV.
2	3/-5	Logic high to select +3.3V and low to select +5V output
3	+REF	1.25V reference voltage
4	LBO	Low battery output. An open-drain N-channel MOSFET sinks current when the voltage at LBI drops below 1.25V
5	LBI	Low battery input. When the voltage on LBI drops below 1.25V. LBO sinks current. If not used connect to Vin
6	OUT	It provides bootstrap power to IC
7	GND	Power ground
8	LX	N-channel power-MOSFET drain

Table 1 Pin functions of MAX856

Sealed Nickel-Cadmium batteries

The battery used in the system is an AA size Ni-Cd rechargeable battery. A typical AA size battery has the following electrical characteristics. Nominal capacity is 700mAh. Maximum charging current is 200mA. This implies that the solar panel used should not generate a current that is higher than the charge current. A typical charge and discharge cycle is at least 700 times.

Solar panel

The solar panel used in my design is a 3V, 100mA solar panel, measuring 95mm × 65mm × 7.5mm in size. It produces a full current of 100mA in bright sunlight. Bigger solar panels can be used, provided that the maximum deliverable current is smaller than the maximum allowable charging current.

The circuit

The circuit diagram of the system is given in Figure 5. We see that the solar cell is connected to J1 and charges the 1.2V battery. D1 is a diode and R1 is the current sensing resistor. From J2 you can use a voltmeter to measure charging current.

The DC-DC converter is the ML4857 IC.

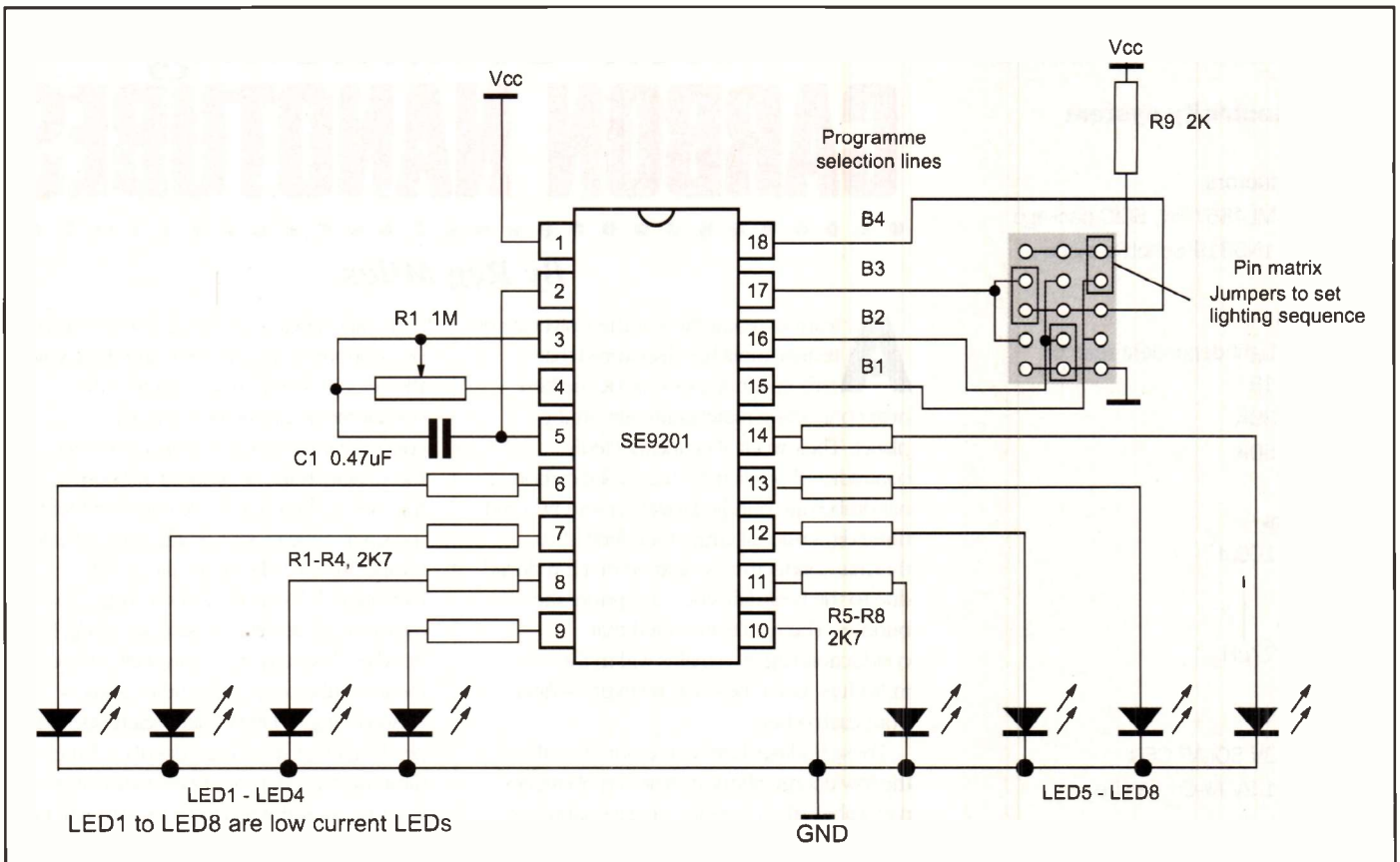


Figure 8.

Pin	Name	Function
1	Vin	Battery input voltage
2	SHDN	Pulling high to shut down the regulator and to isolate input voltage to load. To turn on the IC, SHDN should be below 200mV.
3	GND	Digital Ground
4	DETECT	When this pin below 200mV, causes the –RESET pin to go low
5	Vout	Boost regulator output, +5V
6	VI	Boost inductor connection
7	- RESET	Output goes low when regulation cannot be achieved or when DETECT goes below 200mV
8	PWR GND	Return for NMOS output transistor

Table 2. Pin functions of ML4875

C1, C2 and L1 are required by the converter. The +5V power is output from J3.

The LDR1 is a photo-conductive cadmium sulphide light dependent resistor. Its peak in sensitivity is around 550nm. At 100lux, the resistance of the LDR is about 5k Ohm. In dark, the resistance becomes 20M Ohm. In daylight, the resistance of the LDR is sufficiently low that makes the SHDN pin high to shut down the DC-DC converter. If the light intensity reduces to a pre-set threshold, the resistance of the LDR1 is high enough that SHDN pin becomes logic low. This switches on the DC-DC converter. R3 sets the threshold.

JP1 provides a manual on/off switch to the ML4875. If pins 2 and 3 are connected together, the ML4875 is switched on all the time regardless of ambient light intensity.

The solar electricity system is constructed on a single-sided PCB board. The PCB artwork is given in Figure 6 and the component layout is given in Figure 7.

Notes

This system utilises an ML4875-5 that produces +5V DC power. 3.3V and 3.0V versions are also available. It is a matter of changing the IC to produce the required output voltage.

The maximum current deliverable by the ML4875-5 is a function of input voltage. If the input voltage is at 1V, the current is around 40mA. If the input voltage is at 2V, the current will be 100mA. If a higher power solar electricity source is required, please have a look at Reference 3.

Bigger solar panels can be also used to reduce charging time. However, care must be taken to ensure the maximum current supplied by the solar panel should be less than the maximum charging current of the rechargeable battery.

Application ideas

For demonstration purposes, a running light display is connected to the solar electricity system that produces a running light show every night. The running light display was featured in the March 1998 issue of Electronics and Beyond [4].

The circuit diagram is shown in Figure 8 as a quick reference. In the circuit diagram, LED1 to LED8 are low-current LEDs, which require a current as low as 1mA to illuminate. The running light display has 27 pre-programmed lighting sequences. Jumpers are used to select a running light sequence.

References

[1] Datasheet for MAX856-MAX859 available from www.maxim-ic.com

[2] Datasheet for ML4875 available from www.microlinear.com

[3] Solar power PSU, Andrew Armstrong, October, 1999, p8-11

[4] A running light display, Pei An, March, 1998, p50-52

PARTS LIST

Solar electricity system

Semiconductors

U1	ML4857-5V, SOIC package
D1	1N5819 Schottky diode

Resistors

LDR1	Light dependent resistor
R1	1R
R2	39K
R3	50K

Capacitors

C1,C2	100μF

Inductors

L1	27μH

Batteries

B1	3V SOLAR CELL
BT1	1.2V Ni-Cd AA size

Others

J1,J2,J3	2-way screwed terminal
JP1	3-way PCB pin header

AA size battery holder

PCB boards

Running light display board

Semiconductors

U1	SE9201 programmable light sequencer IC, DIP package
LED1-8	3 mm low current LEDs

Resistors

R1*	1MOhm linear pot or 1Mohm resistor
R1-R8	2K7 0.25W carbon resistors
R9	1K 0.25W carbon resistor

Capacitors

C1	0.47μF ceramic capacitor

Others

J1	3 way by 5 way PCB pins (made from SIL pins)

PCB board.

Technical support

Kits for the experimental solar electricity system and the running light display are available from the author. Please send your enquiry to Dr. Pei An. The email address is **<pan@intec-group.co.uk>**. Phone/fax number is: 44 (0)161 477 9583.

Heat Conducting CARBON NANOTUBES

By Reg Miles

A team of researchers at the University of Pennsylvania has discovered that carbon nanotubes may be the best heat conducting material known on the planet. Their work also unexpectedly contradicted predictions that when carbon nanotubes are bundled together into two and three dimensional arrays their individual thermal conductivity would be much reduced due to the heat diffusing throughout the bundles. The results indicated that conduction largely remains within the individual nanotubes, and is largely isolated from each other.

These findings have come out of work on the low energy phonon structure of carbon nanotubes (the phonon being a quantum of lattice vibrational energy in a crystal). This is an area that has been largely unexplored experimentally, unlike the electronic structure where the greater energy of electrons has made its study comparatively easy. Knowledge of the phonon structure of single wall nanotubes (SWNT) is necessary because it is related to the mechanical properties and defines the thermal conductivity; additionally, it will elucidate electron-phonon scattering in the nanotubes. Thus, advancing understanding of the physical, thermal and electrical properties of this interesting and potentially very useful material.

The team was led by materials scientist John E. Fischer and physicist Alan T. Johnson; with James Hone, a former Penn postdoctoral researcher now at the California Institute of Technology, Bertram Batlogg of Lucent Technologies and Zdenek Benes, a Penn graduate student.

They synthesised samples by laser ablation in an 1100 degree C oven, with nickel and cobalt catalysts (Ni/Co). The resulting material was then treated with acid to remove the catalysts and amorphous carbon. A suspension was purified, and folded into small pellets that were vacuum annealed. Analysis of these determined that the average tube diameter was 1.25nm. Afterwards, the samples were baked in a vacuum for three days to remove atmospheric contaminants. The heat capacity was then measured over the temperature range 2-300K. A sample was removed from the vacuum under an inert nitrogen atmosphere, loaded into a cryostat (low temperature thermostat) and evacuated. The heat capacity was measured again, and the previous measurement subtracted from the total heat capacity.

In nanotubes the thermal energy is carried by phonons (sound waves); and the greater the velocity, the more complete is the confinement and the better is the conductivity. The researchers discovered that the velocity is in the order of 10,000m/s; and the measured results were consistent with the single tube model, going from 3D at low temperature to 1D and finally to 2D, indicating that conduction was largely one dimensional despite the samples being in bundles. The reason for this seems to be that the intertube coupling is rather weak.

According to Dr. Fischer, 'Scientists had predicted that two dimensional or three dimensional arrays of carbon nanotubes would permit the sound waves carrying heat to scatter in all directions, greatly reducing thermal conductivity. Our experiments showed that even within bundles of nanotubes, sound waves remain remarkably one-dimensional.' To which Dr. Johnson added, 'The sound waves don't fan out and dissipate because the bonds between nanotubes in a bundle are so weak. In terms of bonding strength, you can think of nanotubes in a bundle almost like dried spaghetti sliding freely back and forth when you shake its box.'

So conductivity's gain is strength's loss. While the individual nanotubes are extremely strong, the expectation of unrivalled mechanical strength that bundles of them would bring now seems to be unrealistic - unless their coupling can be improved.

But carbon nanotubes would seem to have a bright future in providing heat dissipation where more conventional methods are inappropriate. These might be: directing heat away from each circuit on a microchip; using them as heat sinks in electric motors to allow the introduction of plastic parts that might otherwise melt under the intense heat. They could also be embedded in materials regularly called upon to withstand extreme temperatures, such as those that form the exterior panels of planes and rockets. They could also be used for highly sensitive bolometers.

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The Big SQUEEZE

A look at compression techniques by Mike Bedford

If it wasn't for data compression, many of todays up and coming technologies could never have come to fruition. Without employing compression, for example, it would have been impossible to cram more than a few minutes of high quality video onto a 120mm diameter disk. Yet, as home cinema enthusiasts are well aware, DVDs are capable of storing a full-length movie at broadcast quality. Much the same argument applies to digital TV. Simply digitising an analogue TV signal would result in a data stream that would require a much higher bandwidth than analogue. When that same signal is subjected to data compression, though, it becomes possible to cram half a dozen programmes into the bandwidth that was formerly required for a single TV station. And for reasons of reducing transmission time, reducing RF bandwidth, and/or reducing the cost of distribution media, data compression is also applied on the Web, for software publishing, and in mobile telephony to name just a few of the more obvious areas.

But although data compression is such a familiar term, at first sight it appears rather counter-intuitive. Surely reducing the amount of data by some means reduces the amount of information it carries and this would appear to be unacceptable. In fact, both these assumptions are incorrect in some cases. First of all it is often possible to reduce the amount of data without loosing any of the information it carries. And in other cases, by accepting some loss of information an even greater degree of compression can be achieved and, furthermore, that loss of information can sometimes go unnoticed. This article – an introduction to the technology of data compression – will look at many of the methods in use today and explain how a quart can be crammed into a pint pot and why, even if we don't quite manage it, it doesn't always matter too much.

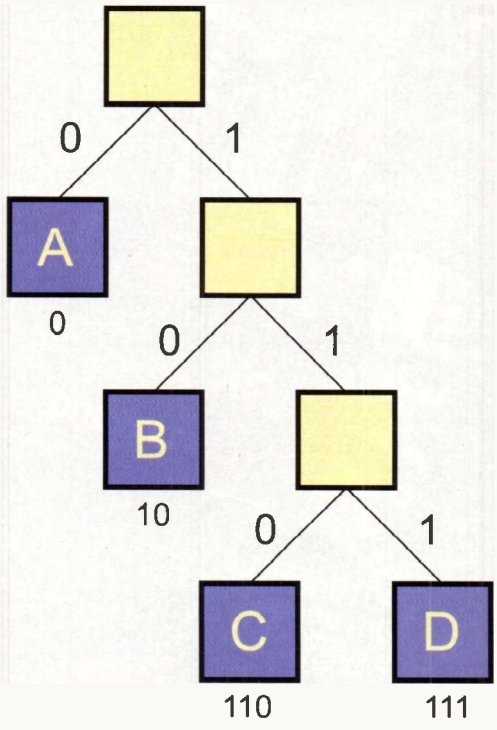


Figure 1.

Lossless Compression

The fact that the volume of data can sometimes be reduced with no loss to the information carried is generally due to the fact that it's represented in an inefficient manner. For example, English text uses the ASCII characters in the range 00 to 7F hexadecimal and it requires seven bits to store any of these characters. For convenience, though, characters are nearly always stored and transmitted as bytes, i.e. eight bits, so one bit in eight is wasted. Clearly, therefore, textual data could be compressed to 87.5% of its original size simply by stripping out these redundant bits. This isn't a practical compression method, of course, because it doesn't achieve an appreciable improvement; I simply give it as an example of how information is often represented inefficiently.

If you're a linguist you'll have noticed that I deliberately referred to English text. And, if we want to be able to write in the common European languages, compressing the data by stripping out the most significant bit won't work since the accented characters which would be required are ASCII characters in the range 80 to FF hexadecimal. Now let's assume that we're writing in French and that, accordingly, an extra handful of characters are required. To use these few extra characters, though, we have to move from seven bits per characters to eight, which seems rather inefficient. But the same argument applies even if we stay with English. The letter J, for example, crops up very infrequently but the ASCII coding scheme assigns it an 8-bit code, just the same as more common letters such as E and T. The problem with ASCII is that it's a fixed length code. When we're dealing with data in which the various symbols have differing frequencies of occurrence, though – and this is common in many types of data, not just text – greater efficiency can be achieved by using a variable length code in which the shorter codes are assigned to the commonest symbols. Compared to a fixed length code, the uncommon symbols will be represented by longer codes but the fact that the very common ones use short codes more than compensates for this and an overall reduction on the amount of data results.

Of course, once we move to a variable length code some method of determining when one code ends and another one starts has to be devised. The most common method is to derive the codes such that no code can start with a bit combination assigned to a shorter code. This is done using a binary tree in which symbols are represented by the leaves of the tree (i.e. the end points) and the code for each leaf is determined by starting at

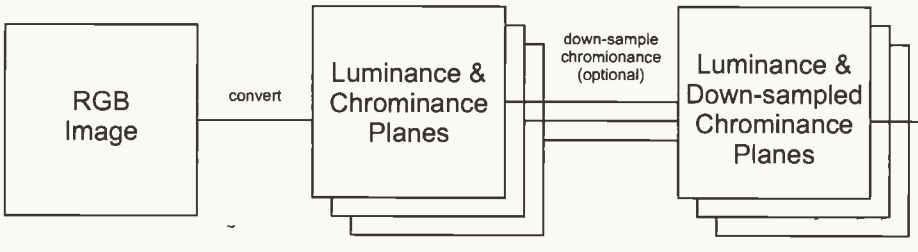


Figure 3.

the top and adding a 1 for each right turn and a 0 for each left turn. Since the symbols are all at the ends of branches, no other symbol can have a route that passes through an already defined symbol that is the property we require. I'm not going to describe how this sort of binary tree is generated but Figure 1 is a portion of a tree for encoding the string "ABBDCAAACBBAABCABAAA". Analysing the string reveals that there are 10 As, 6 Bs, 3 Cs and 1 D so the encoding process must assign the shortest code to A and the longest to D which is exactly what's shown in Figure 1. The string has 20 characters, which if we encoded it in ASCII would occupy 20 bytes. Using this tree, though, the data is reduced to 34 bits or just over 4 bytes. Of course, the definition of the tree must also be placed in the file along with the compressed data and this will reduce the compression ratio somewhat. With long files, though, the overhead imposed by including the tree definition is very small in percentage terms. What I've just described forms the basis of Huffman encoding. This is a common method of lossless compression but it does have a significant disadvantage. Because the data has to be analysed before it can be encoded, it's suitable for encoding a file on disk but not, for example, a stream of data being transmitted via some communication channel.

Another method which achieves much the same sort of compression ratio uses a fixed length code but assigns these codes to differing amounts of data. So for example, one code might represent a single uncommon letter such as J or Z, whereas another code of the same length might represent a whole string of characters that crop up very frequently – " <space> the <space>" for example. This is the method used in the LZW compression algorithm and, unlike Huffman, the coding scheme is built up on the fly so it can be used for compressing data, which can't be analysed in advance. It is used in the common ZIP compression utility and, typically, is able to reduce the size of many types of files by around 50%. Similar compression algorithms have also been built into modems.

Figure 2 shows a small portion of a bitmapped image. You can't make out any features in the image, admittedly, but this is much the same sort of thing you might see if you took a very small portion of any bitmapped image and expanded it like this. Normally, this sort of image would be represented in a file as a string of values, one per pixel, indicating the colour of that pixel. In this case we'll assume that there are 256 possible colours and, accordingly, each pixel has to be represented by a single byte. If we assume that the code for black is 0, the code for red is 63, for blue is 127 and for white it is 255 it should be clear that the data which represents this image is 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 255, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 255, 63, 63, 255, 255, 255, 255, 255, 255, 63, 63, 127, 255, 255, 255, 255, 255, 255, 63, 63, 127, 127, 127, 127, 127, 127. Now clearly, although I've stated that there are 256 possible colours, only four are actually used and this suggests scope for data compression. However, let's forget about the sorts of methods we looked at in the previous section and think, instead, of a method that would work even if most of those 256 colours were represented in an image. A method which is often used for compressing bitmaps is called run-length encoding and takes advantage of the fact that if one pixel is a particular colour then successive pixels will often be in the same colour. The following is the same data represented by run-length encoding: 255, 25, 0, 14, 255, 1, 63, 2, 255, 6, 63, 2, 127, 1, 255, 5, 63, 2, 127, 6. The figures are actually in pairs – the first figure in each pair is the colour and the second figure is the number of times that colour appears in succession. In this case the data has been compressed to 31.25% of its original size. In real world applications much greater compression ratios can often be achieved.

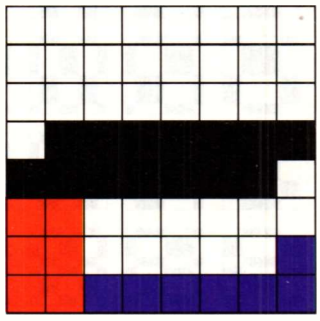
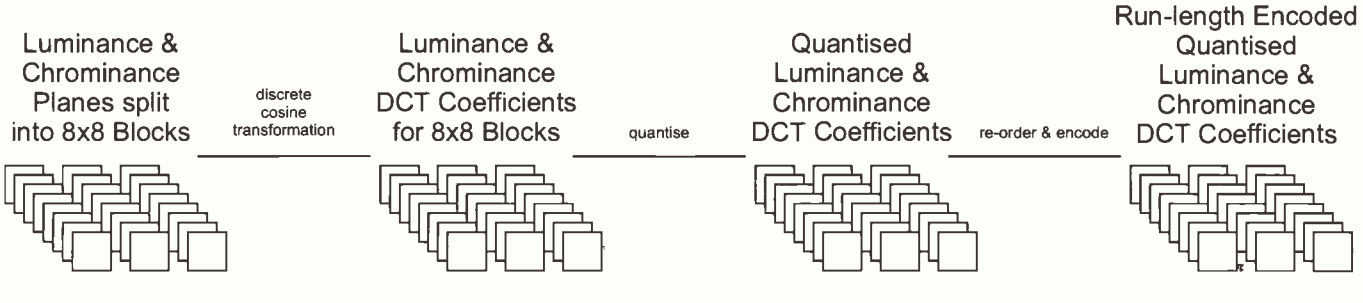


Figure 2.

So far we've looked at three methods of data compression. All three methods have the potential for reducing the amount of data even though none of them will actually loose any of the information that is represented by the data. As such these methods are referred to as lossless. Any method of compression is lossless if the data remains the same when subjected to compression followed by decompression. And for many applications, lossless compression is absolutely essential. Software distribution is such an application. If the compression process causes even a single bit in a program to change then there's potential for that program to crash when it's run. But although the lossless methods are the only ones available in certain areas, the amount of compression achievable tends to me modest. Although there are exceptions – run-length encoding a bitmap consisting of nothing more than a single black dot in the middle of a white background, for example – lossless compression rarely achieves a compression ratio of much more than 50%. To go beyond this sort of performance, lossy compression has to be employed. This is a compression method in which information is lost by compression followed by decompression. At first sight this might seem totally unacceptable. However, if the data represents an image or audio information, for example, the human senses may fail to notice a certain degree of information loss. And even when the loss is noticeable – perhaps as a reduction in the sharpness of a picture – it could be that this is a price worth paying for the reduction in the volume of data.

DCT Compression

The first lossy compression scheme that we'll look at makes use of something called the discrete cosine transformation. It's integral to the JPEG file format which is used for representing images on the Web



and it also forms as part of the MPEG family of compression algorithms which are used for compressing moving images.

The Fourier Theorem states that any waveform can be expressed as the sum of sine waves of differing frequencies and amplitudes. To represent some waveforms accurately an infinite number of sine waves would have to be added together but a waveform could be approximately just by giving the amplitudes of the first few harmonics. A Fourier Transformation is the analysis of a waveform to determine these amplitudes. The Discrete Cosine Transformation (DCT) is a close relative of the Fourier Transformation which is used to split a waveform into frequency components and is at the heart of many methods of compressing photographic images. Figure 3 is a block diagram of the process – this should clarify the following verbal description.

For a colour photograph the first step is to convert the image from the usual RGB form to luminance and chrominance values like those which are used in TV transmission. The luminance contains the basic monochrome image whereas the two chrominance values provides information on the intensity of two of the primary colours (the intensity of the third primary colour is the luminance value minus the two chrominance values). Since the eye is less sensitive to chrominance than luminance information, an optional first step is to re-sample the chrominance data using a coarser grid. Generally a two-fold reduction here goes unnoticed. The other reason for representing the data in this

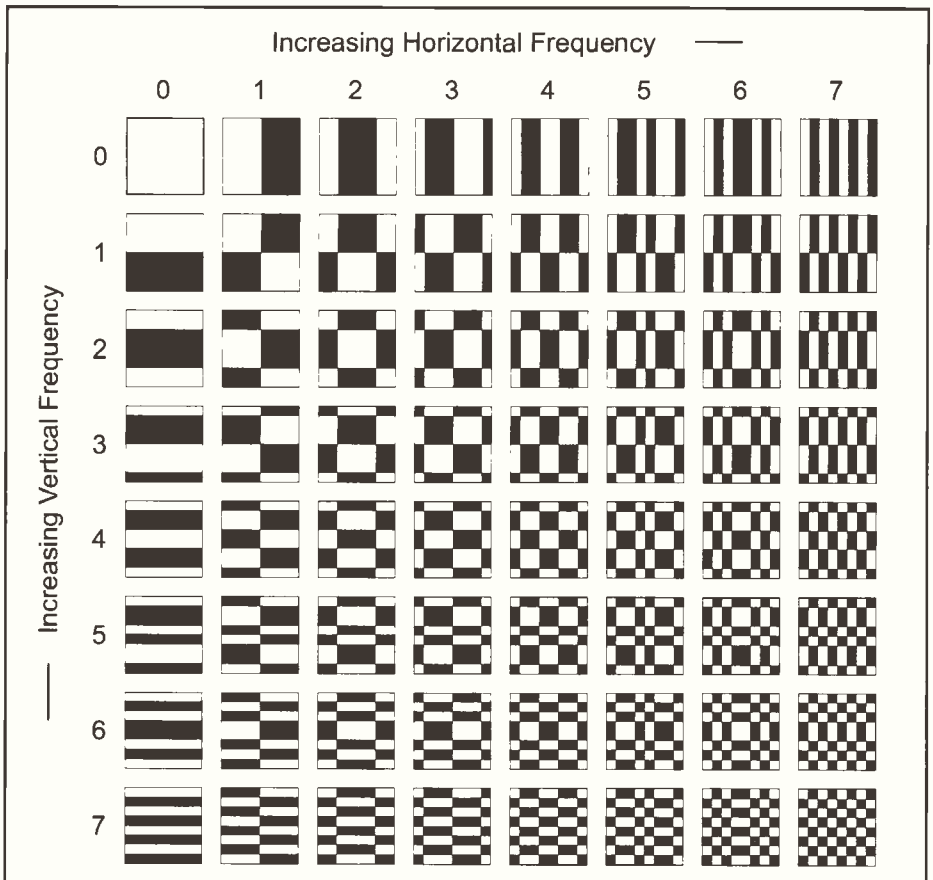


Figure 4.

bitmap is two-dimensional, though, this is somewhat more complicated than performing the transformation on one-dimensional data like an audio signal. The output of this stage is a set of DCT coefficients relating to the amplitude of the various combinations of horizontal and vertical frequencies. A verbal description of this is, perhaps, not the easiest thing to understand but Figure 4 should, hopefully, clarify things. Any pattern that can be represented in an 8x8 pixel block can be expressed as the amplitudes of each of these 64 patterns. Therefore, storing or transmitting each of these 64 coefficients can reconstitute the original image. It's important to note, though, that just converting bitmaps into DCT coefficients doesn't result in data compression. However, it is an important first step.

What does achieve a reduction in the volume of data is the quantisation of each of these samples using different quantisation coefficients for each DCT coefficient. The rationale here is that the eye is more sensitive to low frequency than to high frequency information so the coefficients toward the top left are assigned the most bits and the quantisation becomes more coarse as we move toward the bottom right. The final step is to run-length encode the quantised coefficients but this only

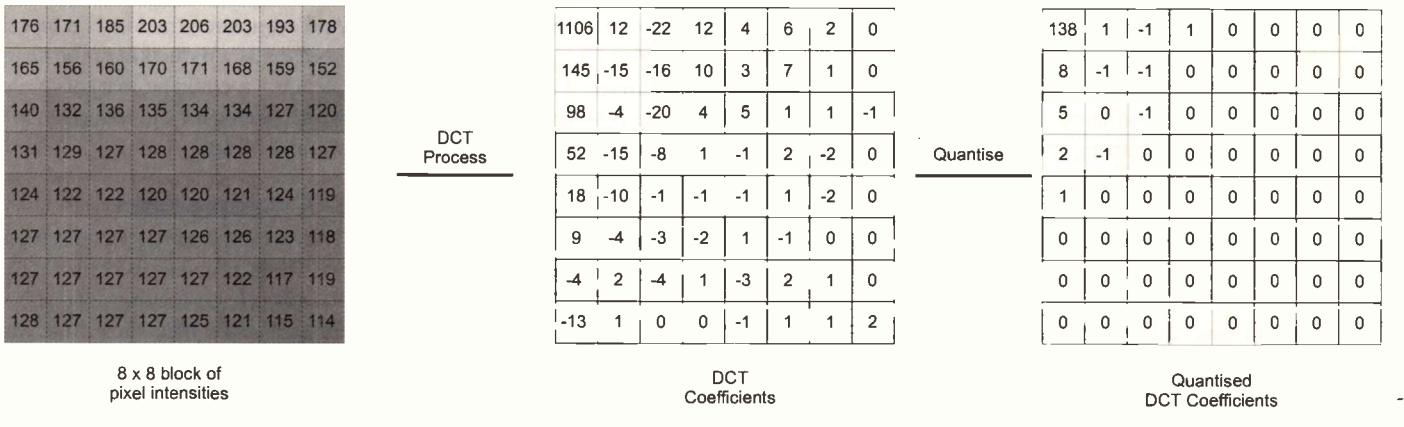


Figure 5.

achieves a further reduction in the amount of data if the coefficients are read out in a zig-zag manner starting at the top left and working toward the bottom right. By re-ordering the coefficients in this way, and since those toward the bottom right tend to be zero, the zero coefficients are generally consecutive so run-length encoding is especially efficient. Figure 5 shows this process on one 8x8 pixel block of luminance information.

This method of data compression takes account of the fact that the eye is more sensitive to some parts of the overall data stream than others. In this instance, having re-coded the image into the frequency domain, the less noticeable high frequency components can be de-emphasised by using a coarser quantisation coefficient. This sort of reasoning is common in lossy data compression algorithms. However, it also raises the question 'at what point can we safely assume that data can be discarded without having an adverse affect on the final quality?'. This question has resulted in much heated debate, for example, in drawing up the specification for DVD-audio, the up-and-coming replacement for the audio CD. However, it also raises the possibility of having variable compression ratios with a corresponding variation in quality. So, for example, you could choose a low compression ratio and, thereby achieve a high quality result, or you could pick a higher compression ratio and, in so doing, accept that the quality will suffer. JPEG offers just such a range of compression ratios and Web designers have to choose between file size (and hence download time) and quality.

MPEG Compression

The next compression scheme we're about to take a look at is MPEG that is used for moving images. The original MPEG was used for transmitting Web-based video but the newer MPEG-2 is key both to digital TV and to DVD so is at the heart of many of today's high profile consumer products. MPEG employs two quite different forms of compression. The first is referred to as intra-frame compression and involves compressing individual frames so this is much the same as compressing still images. As such, the method used is very similar to the DCT compression algorithm that we looked at in the previous section. I'll say little more about it here, therefore, and move on to the aspect which is unique to compressing moving images – inter-frame compression.

The key to inter-frame compression is that, in general, one frame is very similar to the previous frame which represents the state of play a fiftieth of a second earlier. And if very little has changed it's clearly inefficient to duplicate the data. Security recording equipment is an extreme case and one in which MPEG compression is highly efficient. Here a CCTV camera captures an image, which is recorded to tape, conventionally an analogue tape. But unless a burglar walks into the frame, nothing changes at all and every frame is virtually identical to the previous one. Yet an analogue tape will keep on running storing the information for that unchanging over and over again. Clearly if the initial frame can be stored and following this only the changes are recorded, a vast reduction in the overall amount of data can be achieved. But this is an extreme case – movies and TV programs aren't as static as this – so let's look in a bit more detail at how MPEG copes with more typical video footage.

To set the ball rolling a complete frame is encoded. In an ideal world, from this point onwards only changes need be stored but it's not hard to see why this doesn't work in practice. For a start, viewers need to be able to switch on the TV at any time or start watching a movie on DVD part way through. To allow this, complete frames have to be transmitted periodically. But whereas a complete frame every 100 frames may be adequate to allow this – since this would result, at the most, in a two second delay – they actually tend to be transmitted more frequently than this. This is to eliminate cumulative errors in the decoding process. Any dropped bit, for example, will carry forward until the next complete frame is received so these need to be comparatively frequent. In MPEG encoding, these complete frames are referred to as I-frames since they're compressed only by the intra-frame compression techniques.

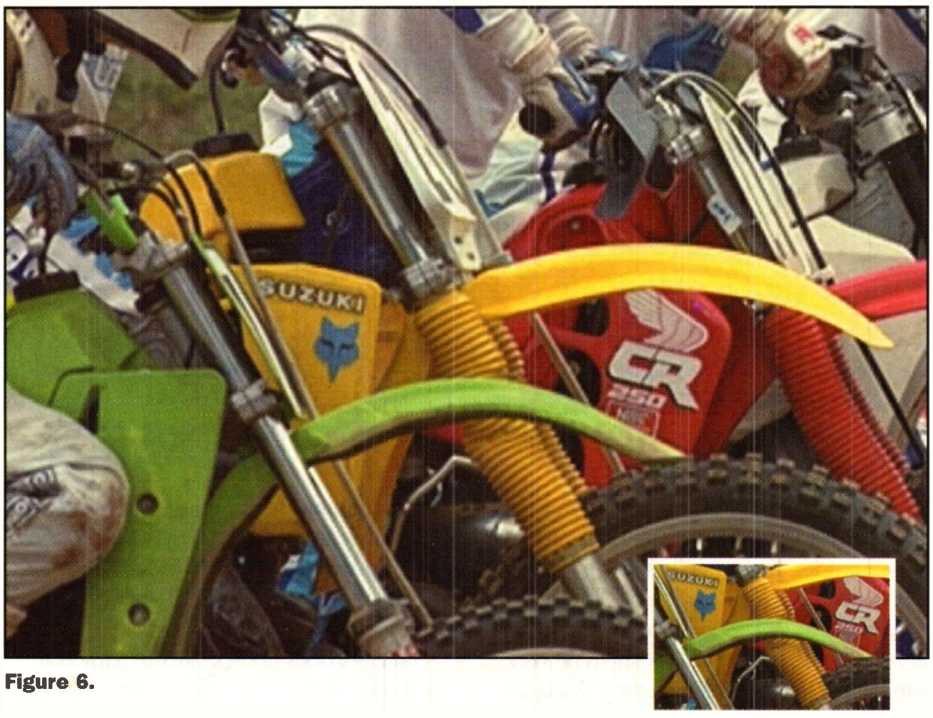
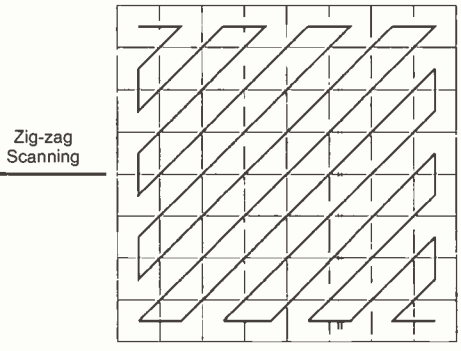


Figure 6.



Data stream to VCL and run-length encoding:

138, 1, 8, 5, -1, -1, 1, -1,
0, 2, 1, -1, -1, 0, 0, 0, 0, 0 etc.

Frequently, for Web use, a high compression ratio is selected even though this will result in a noticeably inferior image. Figures 6, 7 and 8 show an image – in each case with an inset enlargement of part of that image – compressed using JPEG compression ratios of 2, 127 and 255 respectively. The reduction in image quality with increasing compression ratio is clear to see.

Figure 7.

The next type of frame is the P-frame and this stands for predictive frame – here's how it works. The frame is split up into 16x16 pixel blocks. Now the previous frame is scanned to find each of those blocks or, at least, something that appears to be very similar. Having found a matching block, its position in the frame is compared to its position in the previous frame to give something referred to as a motion vector. Typically the motion vectors will be zero or small but, of course, in the case of a fast moving object they can be significant. But transmitting motion vectors alone isn't adequate. You'll remember that I referred to finding a closest match to each 16x16 pixel block in the previous frame. The fact is that blocks don't just move between one frame and the next, they can also change slightly. To take this into account, each 16x16 pixel block in the current frame is subtracted from its counterpart in the previous frame to produce a block of error information. This – which is often strings of zeros and thereby easily compressed – in addition to the motion vectors adequately describes the differences between one frame and the next and is the data contained in a P-frame.

The third type of frame is the B-frame or bi-directional predictive frame. This works in a similar way to the P-frame but it looks, not only at the closest previous I-frame or P-frame, but also at the closest future I-frame or P-frame. Since most blocks will be found in one or the other of these two reference frames, the amount of data in the error signal will be smaller than in a P-frame and, therefore, a higher degree of compression can be achieved. There is a disadvantage in using B-frames, though, specifically that these frames cannot be interpreted until a subsequent frame is received. This can result in a delay that would not be acceptable in some real-time applications such as video-telephony and video-conferencing. These delays are reduced by placing a limit on the number of B-frames that can be interspersed between I and P frames.

MPEG-2 does not specify the particular sequence of I, P and B frames. This can be chosen by the user to give a level of performance, which is appropriate for the application. Specifically a balance has to be struck between the amount of compression, of random access, and of the encoding delay. Using I-frames only (I I I I I I I I I I I I ...), for example, will result in total random access and no delays but the compression won't be very good. If we add P frames only (e.g. I P P P P I P P P P P I ...) the compression ratio is improved, there is still no encoding delay but a lower degree of random access is available. And by adding B-frames (e.g. I B B P B B I B B P B B I ...) the compression ratio improves yet again but an encoding delay is introduced. An interesting feature of MPEG compression, and of many other schemes for that matter, is that the compression ratio depends on the data being compressed. For example, an action movie will compress much less well than a chat show since there will be more motion and hence the motion vectors and error information will be greater. If the data is being transmitted over a fixed bandwidth channel – and this channel has been designed to cope with the average bit rate – this will give problems at times. A means has to be found, therefore, of further reducing the bit rate at times when lots of action would otherwise cause frames to be lost. This is achieved in the intra-frame compression stage that follows the inter-frame compression. The quantisation stage of the DCT compression is controlled so that the output buffer will never overflow. In particularly bad cases, this can result in a very pixelated image for a fraction of a second and this is an artefact that many digital TV viewers will recognise. Figure 9 is an overall block diagram of MPEG compression and Figure 10 sheds a bit more light on the way images are reconstituted from a stream of I-, P- and B-frames.

Wavelet Compression

The up-and-coming compression technique which everyone is now talking about is wavelet compression, as employed in the soon-to-be-released JPEG 2000 standard for the compression of still images. This is quite a big topic and the subject of wavelets and their application to data compression would deserve an article in itself. Nevertheless, no article on data compression could be complete without

Figure 8.

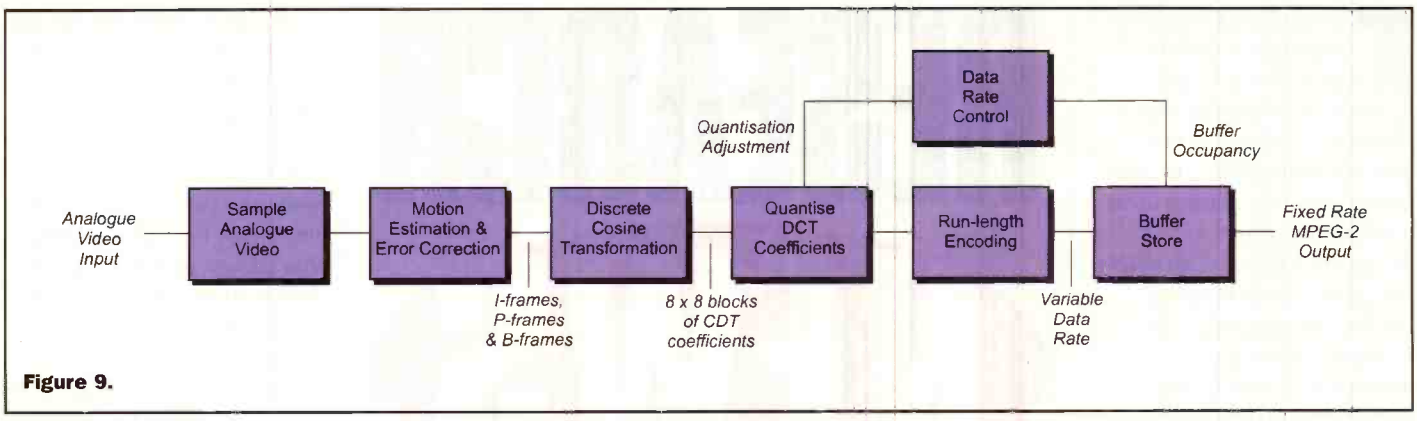


Figure 9.

at least introducing the subject.

We've already looked at the Fourier Transformation and the closely related Discrete Cosine Transformation which is key to many of today's image compression standards. In both cases, a signal is converted from the spatial domain (or in the case of an audio signal the time domain) into the frequency domain. In other words, the input signal ends up being represented as a series of sine waves of different frequencies. Wavelet analysis is like Fourier or DCT analysis in that the end result is the sum of multiple waveforms. However, instead of an infinite pure sine or cosine waves, the waveform which is summed is irregular in shape and is localised. In fact a number of so-called wavelets have been used but one of the most successful ones, at least in the area of data compression, is called the Daubechies wavelet and is shown in Figure 11. You'll notice that it contains a mixture of frequency components and is localised. As such, it is better suited than sine waves for representing many real world waveforms.

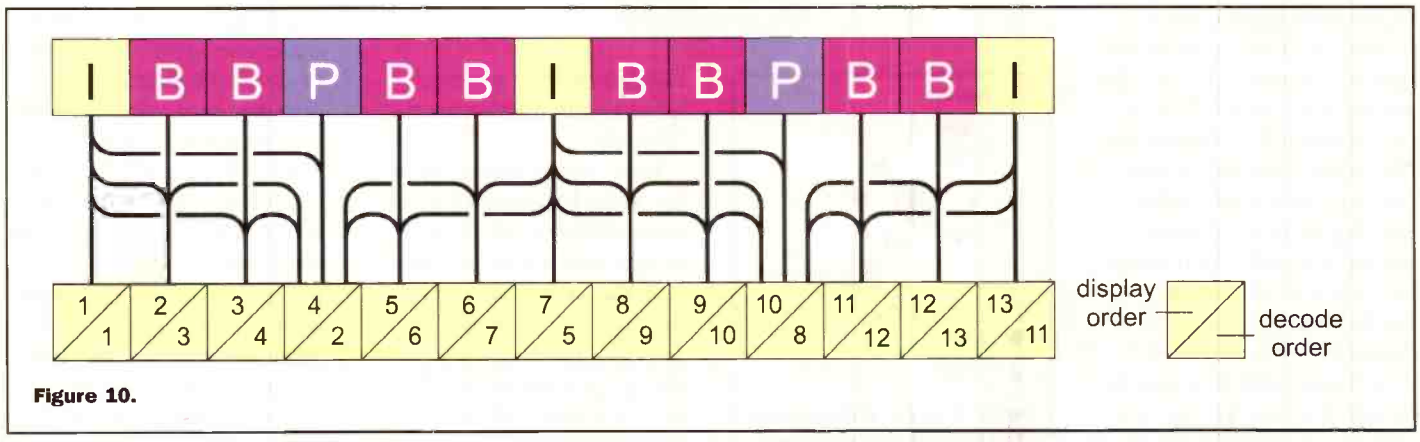


Figure 10.

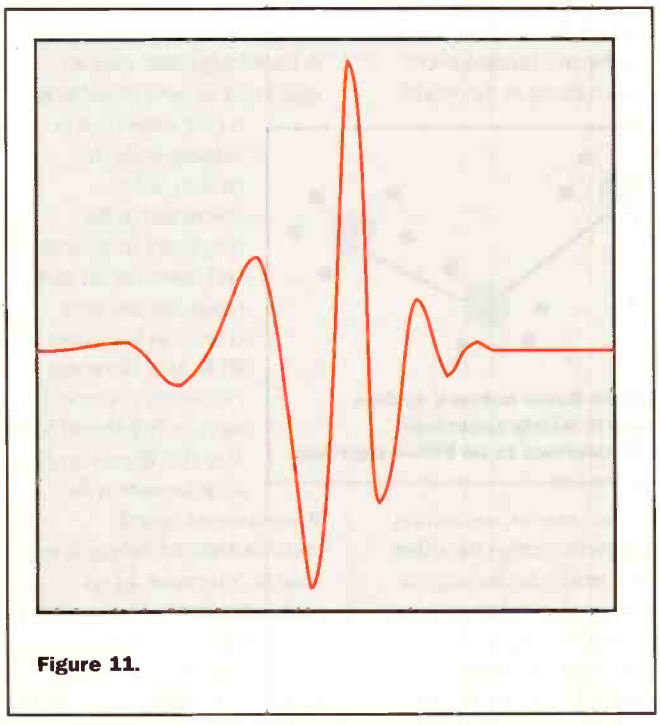


Figure 11.

To cut a long story short, an image expressed as a series of wavelets of differing amplitudes, frequencies and translations can be compressed in much the same way that an image consisting in a series of sine waves can be compressed. Furthermore, it's generally true that a higher degree of compression can be achieved at the expense of less visual degradation. To wind up this brief look at wavelet compression I'll provide one or two facts about JPEG 2000. This will illustrate the advantages of wavelet compression compared to the DCT compression employed by the initial JPEG standard. Its designers claim that JPEG 2000 will "avoid some of the more unpleasant JPEG DCT artefacts – the ringing near sharp edges, the clear tile boundaries, and the harsh colour quantisation" which tend to occur with DCT compression at high compression ratios. Furthermore it is their aim and expectation that the new standard will offer "fair" quality image reproduction at rates down to 0.1 bits per pixel and below. It has also been suggested that a JPEG 2000 file compressed at 200:1 will offer superior quality than a standard JPEG image compressed at 5:1.

The Squeeze is On

But this talk of the advantages of Wavelet compression compared to DCT isn't just of pure academic interest. With BT dragging its feet over the roll-out of ADSL, and with indications that prices will be significantly higher than most people will be prepared to pay, many Web users may be stuck with 56k modems over POTS (the Plain Old Telephone Service) for some time yet. But with new compression standards promising more for less, the lack of wide-band Internet access means that we might not have to continue to endure the World Wide Wait for much longer. And remember, this is just one application of data compression. Digital TV, digital radio, DVD, mobile phones all rely on data compression for their very existence. Like it or not, the squeeze is on and life in the 21st century just won't be the same without it

RESEARCH NEWS

Future Intra-home Communications Networks by Dr Chris Lavers

PART 2

Through fuel blockades or the simple rumour of blockades we have learned a painful lesson that there must be investment in alternative energy sources rather than an exclusive reliance upon a solitary fuel source, i.e. oil. Alternative research is at present limited to a few institutions, notably amongst these is the Centre for Alternative Technology in Wales, (most recently featured in Electronics and Beyond July 2000 p32).

A culture of minimal storage 'just enough just in time' and the implications of 'living social networks' must be considered. The advent of the motor car has eclipsed public transport such as rail, and has permitted people's focus for work and leisure to become much more diverse and 'global'. A hundred years ago the average man would rely upon his local town almost exclusively. Each town would look to local outlying areas to provide the vast majority of raw materials and foods required for ordinary life. Now it is common for a city like Exeter in the South West of England to rely upon London for its newspapers, Worcester for its vegetables, and Dorset for its milk etc. Clearly the distribution network makes links to anywhere and everywhere without clear regard to distance and consequently vastly multiplies the number of interconnections and fuel costs.

Communications networks cannot rely upon this high level of apparently random disorder, and even the lowest level of switched network, the so called Star Network will significantly reduce the number of interconnections to a minimum (Figure 1).

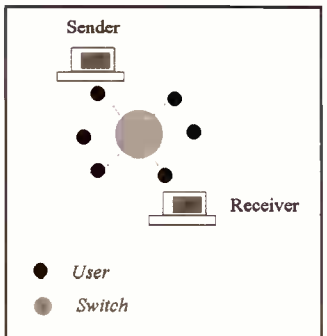


Figure 1. Local arrangement of users without, and then with a single network switch reducing the number of required interconnections for every user to talk or travel to every other user.

At a more subtle level the presence of a switch introduces a degree of structural control over the communications traffic through the system. Clearly, as users at widely separate geographical locations require connection a simple Linear network will permit users in one location to communicate with others in another (Figure 2).

However, any break in either the transmission link (perhaps through cable damage) or switch failure at some point along the signal path will result in so called catastrophic failure. This will leave behind at best two disconnected segments of the system (not unlike the situation with worms when digging in the garden!)

To overcome the problem we take an apparent backwards step by increasing the number of interconnections between switches to form a meshed or Gridded network (Figure 3). The benefits of such a system are clearly that if one path fails, alternative redundant paths exist to carry the message to the desired user, and overloading will become less of a problem with more possible links in the system. Advanced national network systems have a central 'hub' of high speed switches or nodes as well as 'gateway' links to international networks.

The structural arrangement of the network system allows protocols to be established within a network and between networks for the transfer of Voice or Data. When your PC dials a number, a modem at an internet provider will check your name and password with another computer and asks what you want. From here it feeds into a mail server which reads the e-mail's destination and checks it against a phone directory holding many e-mail addresses. There are currently 13 core directories world-wide (10 in the US, 2 in Europe and one in Japan), holding every Internet address in the world.

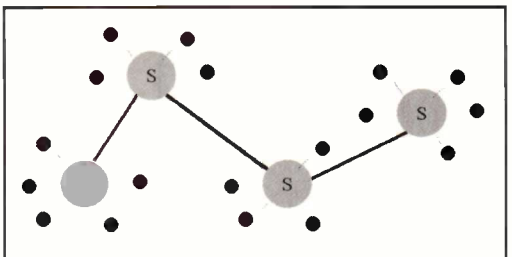


Figure 2. Simple linear network system allowing users in widely separated geographical locations to be linked together.

When the network supporting the recipient notifies the caller that it is ready, the message is broken into a number of equal sized 'packets' (Figure 4) and includes both transmitter/ recipient users addresses and sent independently through the network switch by switch. This requires switches to be connected for only the very shortest duration of time possible, avoiding the problem with voice circuits of tying up the line for the full call duration. The packets are then sent via a router which finds the quickest path to the desired destination. If an e-mail was sent between Britain and the US it would most likely be routed to Porthcurno in Cornwall near Land's End, which houses both a museum of submarine telegraphy and also serves as the base-station for modern digital transatlantic optical cable.

A fibre optic cable consisting of a large number of protected individual glass optical fibres is made from a very low loss core of glass, surrounded by a glass of slightly lower refractive index (or cladding) see Figure 5.

Very short pulses of near infra-red radiation travel down the fibre which is coated in a further plastic absorbing jacket to protect it from damage. Having arrived at the end user's mail server an acknowledgement is sent in reply and when the recipient's mail server and transmitting computer have made a connection then the first set group of data packets will be sent. Upon successful reception an Acknowledgement signal (ACK) is sent, and the next group of packets will follow in due course. On the other hand if any packets are lost then a No Acknowledgement (NACK) signal may be sent requesting a repeat transmission. Subsequently the packets are re-assembled at the recipient's mail server and downloaded later when the end user comes on line. Most Wide Area Networks (WANs) use protocols such as TCP/IP and X.25. The TCP/IP protocol is an abbreviation for Transmission Control Protocol/Internet Protocol, the suite of communications protocols used to connect hosts on the internet. X.25 is a popular standard for packet-switching networks. X.25 packet

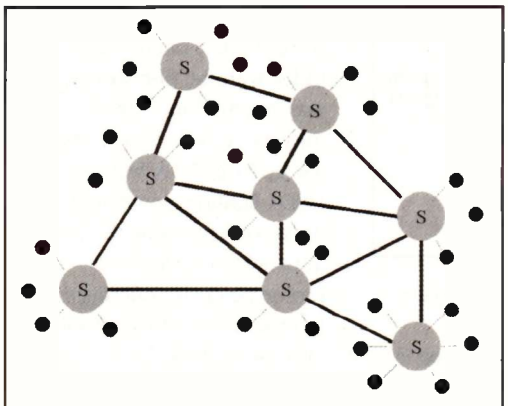


Figure 3. A meshed or 'Gridded' network.

telephone network is a prime example where mobility offers great benefits and is also important in games and navigation based equipment. Ease of installation is useful for static equipment without requiring long cables and cords to trip over. Many existing and new connections can, in principle, be implemented without wires using radio frequency (RF) connections. Within several laboratories research into the standards and devices that will make this possible is now taking place

switched networks allow remote devices to communicate with each other across high speed digital links without the expense of individual leased lines.

Anyhow all of these systems are based upon optical routing of signals down existing fibre optic lines and not upon free space transmission. Although a recent issue of Fiber and Integrated Optics (Vol 19, No 2) highlights the growing use of Hybrid Fibre-Radio (HFR) systems and applications using optical fibre links as back hauls in radio networks to complement existing cellular and wireless access systems.

Currently there is a world-wide push to introduce smart device networking within the home, but obviously without increasing the number of wired connections. Certainly a no-new-wires approach is very attractive. Companies such as NORTEL have already experimented with AC power cabling to demonstrate that data may also be transmitted down power lines. Alternatively a RF connection may be made through the airwaves; using existing telephone lines; or with infra-red connections. It might be practical in a large company with dedicated offices to invest in developing the telephone network, but most houses will have two phone lines at most. Infra-red will only work within a single room. Philips Research have concentrated their efforts on RF connections, which basically means adding a radio to all devices and setting up a protocol for communication between them. The clear benefits of wireless connections are obvious: mobility and ease of installation. The cellular

Setting the Standards

Any device that has to be connected to another piece of equipment can be looked upon crudely to consist of two separate and independent parts; the first deals with the equipment's primary function and the second relates to the network connection. The definition of common interface standards between these two parts has enabled Philips to develop solutions for the network connection without interfering with the crucial device functions.

One big difference between wires and wireless RF connections is that generally it is harder to get a 'fast' connection over a RF link. For video connections, the bit-rate used is about 10Mbit/s, whilst the less demanding application requirements of remote sensing and control links like heating or automatic lighting, only need bit-rates of 10 to 100 kbit/s.

One good reason for working on the narrowest bandwidth range possible is that bandwidth simply speaking is cost. Because the essence of networks is connecting equipment, world-wide standards are essential. Adhering to standards instead of using proprietary systems also has the advantage of a potentially bigger market and lower prices to the customer. To be able to define or influence these standards, companies have to be involved in the early research phase; he who gets in on the ground first generally speaking sets the rules. The grim experience of several rival video systems in the early eighties: VHS, Betamax, and UMATIC, to name but a few is stark evidence of the need to work towards a common standard. Philips is heavily involved in HYPERLAN2 standardisation and in the Eureka project Consumer Multimedia Networks in Digital (COMMEND) which has the primary objective of developing an In-Home Digital Network (IHDN). Other joint partners are Sony, Grundig, and Thomson. Philips is also involved in Home RF, an industry consortium that aims at developing standards for wireless communications within the home.

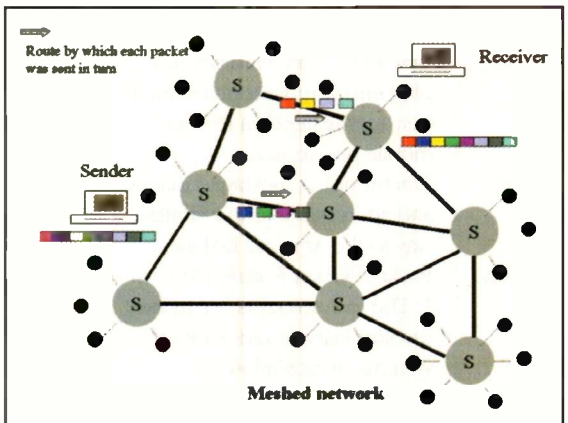


Figure 4. A message broken down into a number of equal sized packets for transmission using packet switching.

Wireless video has already been demonstrated and will generally use compressed video data because this requires the transmission of fewer bits per second. Another problem is that most wireless connections radiate energy uniformly into space and is therefore mostly wasted with respect to the device you want to interrogate. To prevent this wastage Philips are investigating antenna arrays to create directional beams, allowing higher bit-rates at lower transmitted power levels. These may be conventional antennas or miniature Fractal antennas as discussed recently in Research News, and if adaptable (or conformable) like transmitting modules in modern phased array radars, will allow a low powered pencil beam to be formed in precisely the right direction to interrogate the desired device.

I do have some personal reservations of increasing background RF levels as there are currently only guidelines on limits but no legislation, unlike ionising radiation; although that may change in the future via ICNIRP and the NRPB. Clearly legislation must be based on impartial scientific evidence and not determined by companies alone who have a vested interest in passing their devices as 'safe'. Focused conformable arrays will present a greater hazard to the individual than an omni-directional (uniform) source for the same power output and range.

For audio applications Philips is keen to get audio and low bit-rate video signals across wireless links such as Bluetooth™, a standard originally developed by the mobile-phone industry for data connections to and from handsets. Bluetooth™ wireless technology is set to revolutionise in-house device connectivity by providing freedom from bulky cable connections. This low-cost radio solution provides links between not only devices in the home, but includes mobile phone users, mobile lap-top computers, and other portable handheld devices. The technology was originally initiated by Ericsson, and has been unpresidentedly and enthusiastically taken up by a global community of well over 2,000 of the industry-leading companies. Bluetooth devices communicate with each other at high data speeds, over fast, simple and secure wireless connections at distances of

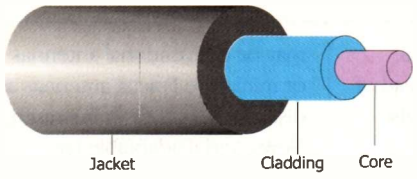


Figure 5a. An optical fibre guiding light by total internal reflection in section (a) and plan (b).

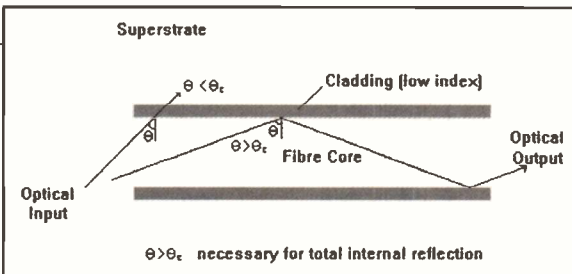


Figure 5b

currently 10 metres, but will be increased up to 100 metres in the near future. The new Bluetooth™ headset from Ericsson is the first hands-free mobile phone accessory on the market to use Bluetooth wireless technology (Figure 6),

It is possible to answer calls, make calls, and receive voice messages or emails, using voice-activated commands. The headset works with the latest Ericsson phones such as the R320 (Figure 7) or the T28. Bluetooth headsets can also be used with other Bluetooth equipment such as PCs or laptops.

Historically Harald Bluetooth was a strong Viking king who made his mark in history by uniting Denmark and Norway by force in the 10th century. Cahners In-Stat., an Arizona-based market research firm, predicts that by 2005 manufacturers will have produced over 1 billion Bluetooth devices. A word of caution is introduced at this point, in that the only way Bluetooth will unite disparate groups of users will be if it permits good horizontal architecture between devices produced from many different manufacturers, and has firm commercial backing from as wide a base as possible in the market place. Too many times good systems have failed to become the set standard due to poor marketing, too high a cost per item, and other issues of greater concern to the customer than the actual 'superior quality' of the product. Another factor to bare in mind is that even if Bluetooth becomes the accepted standard, it could well take a decade for many of our current household items to be replaced by their new radio chip containing counterpart. Very durable items such as the cooker, dishwasher and washing machine may take 10 years to be replaced. In addition the idea that your 'smart' fridge or washing machine may have 'self-diagnosed' a fault and quite independently of you contacted a local Bluetooth™ franchised repairman to come and fix the 'fault' is a little unnerving, and potentially opens the doorway to a new TV series along the lines of 'House of Horrors' for unnecessary work carried out. Still for more information visit www.ericsson.com/bluetooth.

In the near future the Bluetooth™ PC card will just plug into your laptop, making it easy to transfer data to your mobile phone, and synchronising messages, diaries and address books in a similar way to the Amstrad E-Mailer Pocket-Docket featured in part 1. The technology is not in itself revolutionary as various Palm systems already allow the sending and reception of SMS messaging, and web access (e.g. Palm™ m100). But Bluetooth wireless technology has been developed specifically to handle relatively short-range wireless communications between devices. The key component is a tiny electronic module that contains a complete low power wireless transmitter and receiver. Using packet-switched protocols which permits high-quality, high-security voice and data transmission at speeds up to 1Mb/s one Bluetooth™ device can currently work simultaneously with up to seven others, and up to 80 such devices can coexist 'peacefully' in the same room without problems from device interference. Built-in security functions also include automatic authentication, encryption and frequency data hopping, preventing hacking and ensuring privacy. Bluetooth™ wireless technology allows you to connect your phone, laptop, digital camera and now even your fridge together.

A fridge fitted with a screen, unoriginally called the Screenfridge, is being tested in 50 Danish homes. As well as being a food storage facility the fridge offers interactive broadband communication technology via a touch screen and can act as a TV and radio receiver. The 5 months trial is run by TeleDanmark and e2-Home, a joint venture between Electrolux and Ericsson. e2-Home is based in Sweden on the outskirts of Stockholm. The

Figure 6. The new Bluetooth™ headset from Ericsson.
Courtesy Ericsson.

Screenfridge has a colour touch-screen built into its door, and includes a camera with audio output. Connecting the fridge terminal to the Net allows your domestic house appliances to be controlled anywhere via the Web (Figure 8). For more information on Screenfridge see Technology Watch in this issue.

This sounds great, but of course this is also potentially an open backdoor for any uninvited guest who might happen to explore your own personal cyberspace and by extension into your own real house space as well. Under e2's plans homes will be permanently online via a connection that can handle the necessary high data rate. However, widely available permanently connected low cost on-line internet access has currently fallen a little wide of the mark.

Eventually the plan will be to allow the internet via the home server to fully interconnect the fridge with the dishwasher, washing machine, kettle, microwave oven, house and garage locks,TV & VCR (or DVD), lighting, power and music systems using the house intra-net, etc.! Another prototype device offering similar Internet related functions is the Microwave Bank.

Earlier this year in June Philips Research also announced its participation in the more ambitious Oxygen alliance formed by MIT's Laboratory for Computer Science in the United States. In this Alliance Philips aims to develop radically new information processing systems. Philip's strategic 'vision' is towards Ambient Intelligence, where information processing is dedicated towards enhancing the quality of life, combining distributed computing and intelligent interfaces. They intend to create the infrastructure for intelligent environments that will recognise, adapt and anticipate people's needs and respond accordingly.

Fred Boekhorst, Vice President of Philips Research states. 'Our co-operation with MIT and other partners of the Oxygen Alliance will contribute to a much faster research and development cycle to bring these innovations to market.' At this stage it is unclear how the Oxygen Alliance and Bluetooth™ have shared compatibility, hopefully a common standard will be agreed.

Oxygen- The Unseen air we all breathe

One problem with linking a colourful assortment of networks in the past has been joining together a series of separately designed systems for the general public and expecting them to all work seamlessly together. In the next decade half a billion human operated machines and countless computers in the form of household appliances, sensors, controllers will become interconnected. These machines must be able to do particular tasks, but all must freely

Figure 7. The new R320 mobile phone. Courtesy Ericsson.

exchange information. Some 50Billion dollars changes hands over the internet today per year, by 2030 this has been estimated to grow to 4 trillion dollars. According to the chief architect of the Oxygen System, Dr Michael Dertouzos, information exchange will become as universal and yet unseen as the air we breathe.

At the heart of Oxygen is the Handy 21, a device like a cellular phone but importantly also includes a visual display, camera, infra-red detectors and a computer. The Handy 21 is designed like the recently discussed Amstrad E-Mailer to be software-configurable. It will readily be configured to cope with operation in any country and through any network and allow 2-way radio traffic between two Handy 21's via a network node near an office or FM radio.

The second key technology of Oxygen is the Enviro 21. Unlike the mobile Handy 21 the Enviro 21 stays embedded in the home environment. The Enviro 21 is built into the walls of the house or even the boot of the car. The Enviro 21 does everything that the Handy 21 does but with greater speed and with greater capacity. Enviro 21s may also be set up to regulate all kinds of devices and appliances: phones, sensors, fax machines, cameras and microphones.

Oxygen interacts with the physical world through its controllable devices and through the infra-red detectors in the Handy 21s. If a real object is important to you an infra red tag may be placed on it, and the tag can then be read by other Handy 21 users. The network connecting the Handy 21s and the Enviro 21s, is unsurprisingly known as Net 21, and will connect an ever changing configuration of users, links, and appliances. Oxygen will rely heavily on speech recognition and humanity's innate sensory apparatus: eyes, ears, mouth, etc. Oxygen will also potentially allow people to offload menial tasks onto electronic labourers via automation. In brief Oxygen will integrate handheld and wall computers, a novel network, built-in speech understanding, knowledge access, collaboration, automation and individual customisation. It is the synergism of all these features working together that offers perhaps the most exciting possibilities. Dertouzos believes that all future systems will have to be built around the human senses as these are the only things that matter to the human user. Hopefully a network system focused more on human needs, rather than hardware limitations will provide more fruitful avenues of investigation.

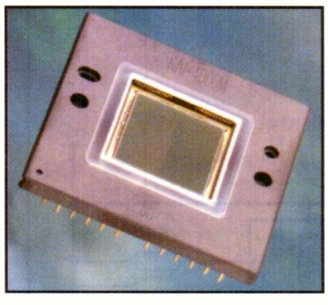


Figure 9. The Kodak KAI-4000M 4 Million Pixel Image Sensor. Courtesy Kodak.

Michael is confident that the adoption of Oxygen, or a system like it, will be the next socio-economic revolution, the first being agrarian, the second industrial, the third computer based information handling, and the fourth, human centred information exchange.

Galaxy is the Oxygen speech-recognition architecture, which started back in 1994 at MIT. It is a distributed architecture so that all computing takes place on remote servers. Galaxy can retrieve data from several sources to answer a user's request, and has 5 main functions: speech recognition, language understanding, information retrieval, language generation and speech synthesis. When you ask Galaxy a question a server called Summit matches your works to a stored library of basic sound units (or phonemes). Having made a best attempt at the sense of your sentence a second server, Tina, applies simple grammatical rules to frame the question in a manner to address a third server Genesis. Genesis then examines a database for the requested information. So far MIT Labs have created 6 Galaxy-based applications accessible by telephone including: Jupiter which offers weather information on 500 cities world-wide, Pegasus providing information on over 400 daily scheduled airlines flights in the US, and Voyager, a car navigation aid based in the Boston area.

Perhaps the future will be based around a combination of these complimentary but parallel technologies: the intra-home network talking with the internet, the use of personal communications centres that can 'seamlessly' join the intranet/internet as well as including wearable electronics and personal items such as intelligent mobile phones. The inescapable drive will be towards 'inclusive' network systems capable of supporting all-comers and intelligently handing over tasks. For example, at lunch someone may ask you to pass the salt, or you could pass it over in advance anticipating their need and taking responsibility for delivery rather than just putting it back into the middle of the table. A 'fuzzy' border blurring the edges of one network with another may help to knit systems better together.

Obviously network security for all of these software-configurable systems is a critical factor and e2 has joined a group that includes the likes of Sun Microsystems, IBM and Nokia to develop secure standards for intelligent homes to be protected from deliberately and inadvertently introduced viruses. After all, no one wants a stranger to start scribbling their own equivalent of a post-it all over your fridge!

4 million pixels on a single chip!

Finally Kodak have gone a step forward again in image sensing by introducing the Kodak Digital Science™ KAI-4000M Image sensor with over 4 million pixels (2048 × 2048). It was designed originally for medical applications such as digital X-ray acquisition to transfer X-ray pictures between medical specialists via computer, but clearly has many potential applications. The pixel size is only 7.4 microns × 7.4 microns. At 20MHz clock rate, the output architecture allows 15 full frames per second, giving almost real time video quality imagery. More information on the KAI-4000M image sensor pictured here (Figure 9) may be found at **<www.kodak.com/go/ccd>** or by e-mail at ccd@kodak.com. One wonders that it cannot be very long before the first single imaging sensors will be on the market with more than 10 Million pixel elements.

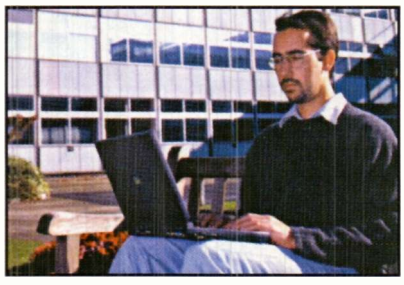


Figure 8. RF connections allowing you to work from anywhere you like! Courtesy Philips.

For further information on Philips work contact:

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<mike.barnard@philips.com>

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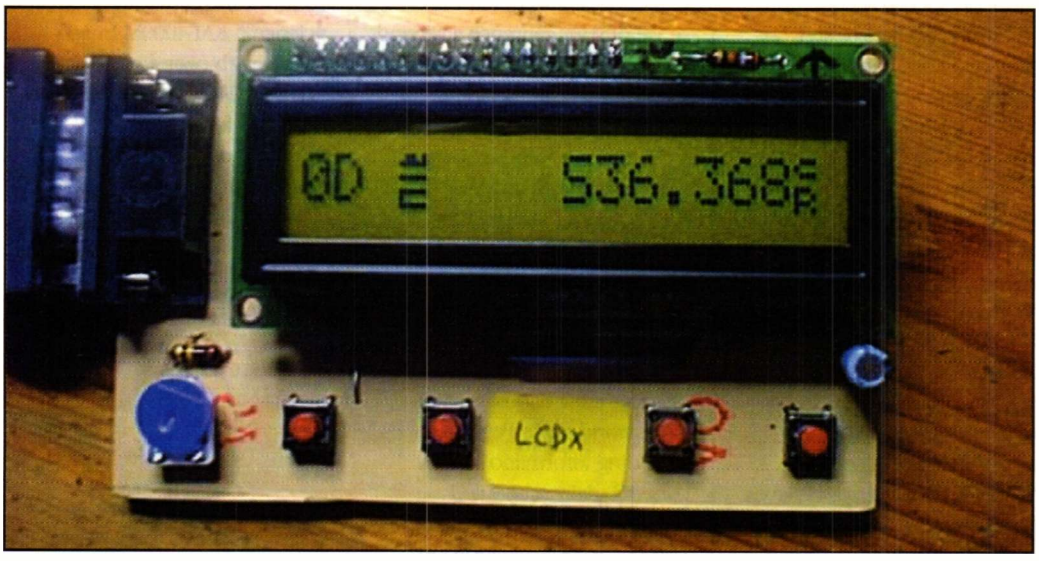
<marty.gordon@philips.com>
Tel +1 408 617 4608
Fax +1 408 839 9036

RS232 ASCII String Generator

PROJECT

by Richard Grodzik



RS232 communications has been with us for over twenty five years and the most common baud rate (speed) is still 9600. Slow by modern day standards, but it is probably the most reliable of all computer communications to such an extent that complex crc error checking is not required and even simple parity checking is disabled. Most PC's/Laptops are equipped with a serial COM1/COM2 port identified by the 9 pin D-type connector. But with the progress of PC technology this RS232 port is gradually being omitted in favour of USB and firewire communication ports, which offer megabit speed. Unfortunately the complexity of the communication protocol which uses packet data similar to networks precludes the hobbyist/amateur/semi-professional, at this point in time, from interfacing home-brewed projects to these ports.

RS232 is still however used universally in a diverse range of equipment including data loggers, electronic weighing scales, meters and of course Terminals that offer 100% reliability. I would not be surprised if the National Lottery computer network does not use RS232 terminal communications in some form. What prompted me to design this project was my experimentation with real-time data (ASCII RS232) streaming to the Excel spreadsheet. As data arrives at the PC's COM port, it is immediately printed into the cells of the spreadsheet. So, I needed an RS232 source, so short of purchasing another PC, I decided to make a small unit which would allow me to generate RS232 data with a couple of buttons.

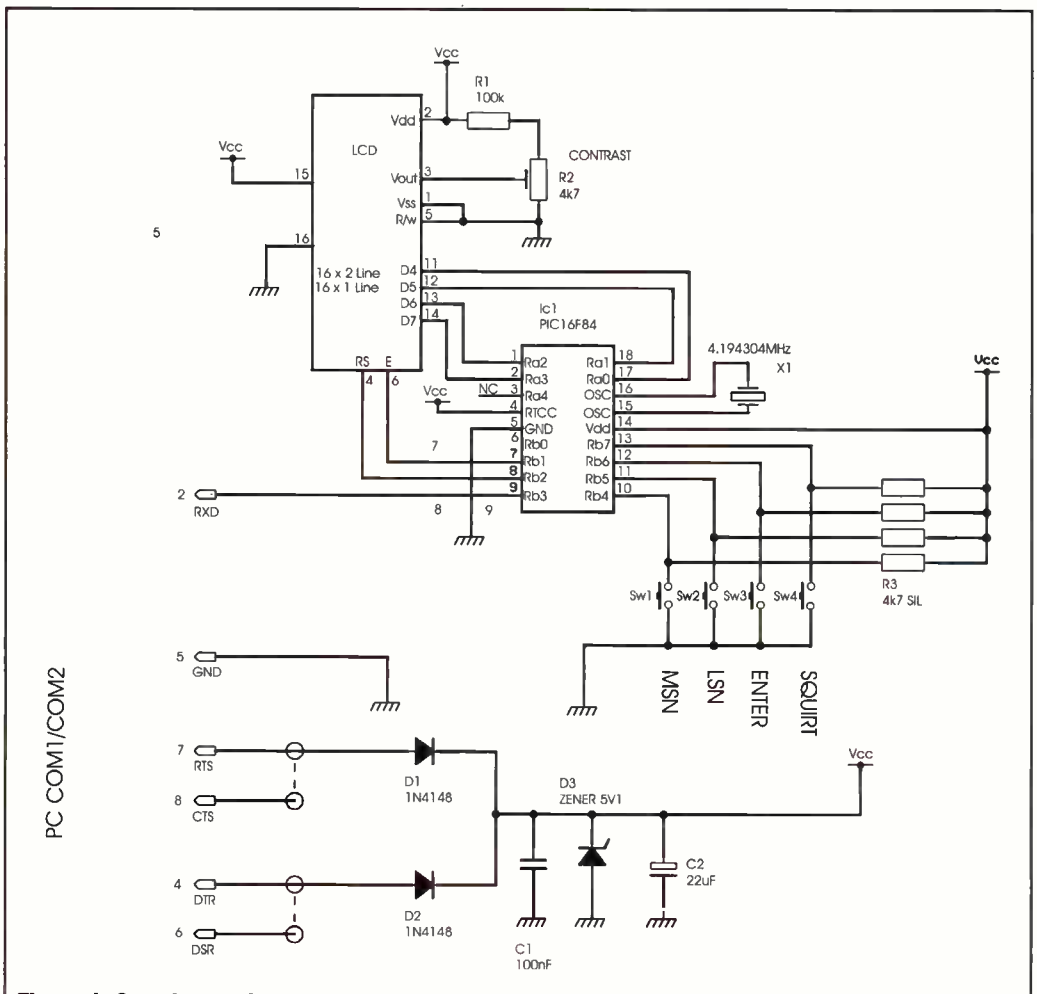


Figure 1. Complete string generator circuit

Description.

The RS232 ASCII string generator is based on a LCD display which can be either a 1 line 16 character or 2 line display, since the same software will work on either - the 2 line display is preferred since it separated the input data from the ASCII String. Two simple press switches SW1 SW2 are used to produce any character found on a full size keyboard. Each switch is used to select the least significant (4 bits) and most significant nibble of the ASCII character. Pressing either switch (They also work together) with increment the data from 0 to F. Keeping the switch pressed with cause automatic incrementation at 0.5Hz. So by selecting 41h will print the ASCII

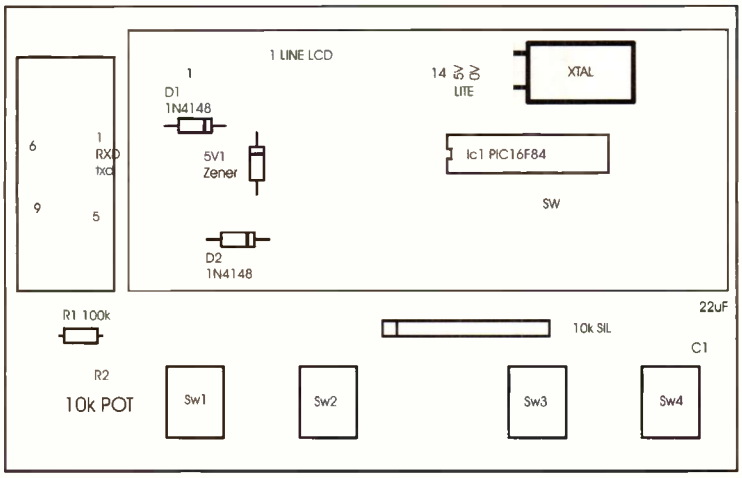


Figure 2. Component overlay

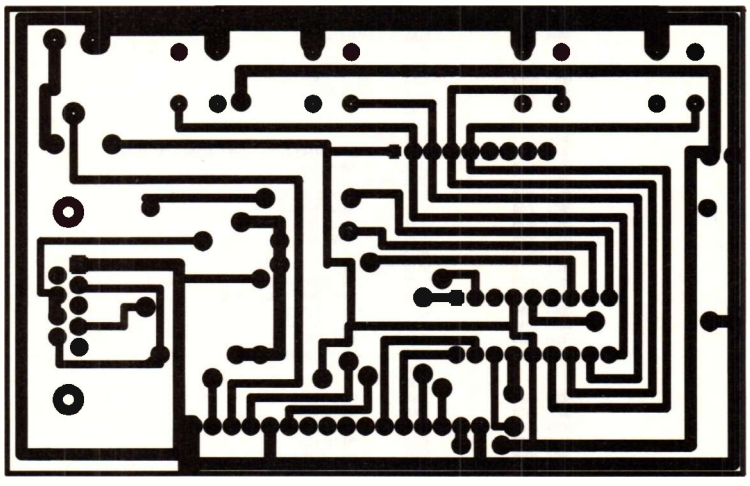


Figure 3. PCB track bottom side

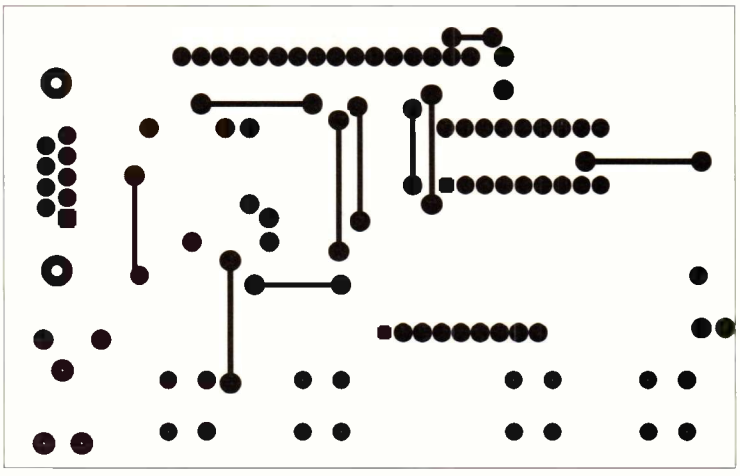


Figure 4. PCB track top side showing interconnections

character 'A' on the display. An ASCII table found in most publications is used to check the Byte required. I still use a table, as I still don't know all the codes! Of course control codes such as linefeed (0Ah) can be selected - a carriage return code (0Dh) will print cr on the display. Each character is selected by pressing the 'ENTER' key (SW3). and gradually the entire ASCII character string is built up (Maximum of 20 characters). Then simply pressing the SQUIRT key (SW4) will output the character string at 9600 baud at precise 1 second intervals.

The power supply for the unit is taken from the PC's serial port. The hardware handshake lines are rarely used and are an ideal source of voltage (9 volts at 20mA). The RTS/CTS and DTR/DSR pins are tied together and they feed the two diodes D1 and D2.These 2 diodes can be incorporated in the 9 pin hood of the connector. A simple 5V1 zener diode then supplies 5 volts to the circuitry. R2 is a contrast control, and provision is made on the PCB artrwork for a backlit LCD (pins 15 and 16 supply the power for the light). When choosing a backlit display select a low current type. A 4.194304 crystal allows for precise timing for the 9600-baud rate and for the 1 second delay.

Note: A Pre-programmed PIC is available from the author for £15.00 pounds sterling, P&P inc. from R.Grodzik (Micros)
53 Chelmsford Road, Bradford BD3 8QN U.K.

Also see the authors web-site at:
http://members.netscapeonline.co.uk/dgrodzik

PARTS LIST

Resistors

R1	100K
R2	4K7 Potentiometer
R3	4K7 SIL network

Capacitors

C1	100nF
C2	22μF

Semiconductors

D1,D2	1N4148
D3	5V1 zener
IC1	PIC16F84 (see note)

Others

SW1-SW4 press to make button switch
9 pin D-Type connectors. LCD display 1 or 2 line 16 character display.
X1 crystal 4.194304MHz

Code Listing for RS232 ASCII String Generator

```
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LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

                      0001
                      0002                                    LIST    p=16C84
                      0003
  0001                0004 E          EQU 1      ;RB1   LCD
  0002                0005 RS         EQU 2      ;RB2   LCD
  0003                0006 TXD        EQU 3      ;RB3
  0004                0007 MSN        EQU 4      ;RB4
  0005                0008 LSN        EQU 5      ;RB5
  0006                0009 ENTER      EQU 6      ;RB6
  0007                0010 SQUIRT     EQU 7      ;RB7
  0005                0011 PORT_A     EQU 5       ;PORT A  LCD DATA BUS
  0006                0012 PORT_B     EQU 6       ;PORT B  CONTROL/MONITOR
  00FF                0013 DEBOUNCE EQU OFFH
                      0014
  0000                0015 INDF       EQU 0
  0001                0016 RTCC       EQU 1      ;RTCC
  0002                0017 PC         EQU 2
  0003                0018 STATUS     EQU 3      ;STATUS REGISTER
  0004                0019 FSR        EQU 4
  0021                0020 BAUD9600   EQU .33
  000C                0021 COUNTER    EQU 0CH    ;ADDRESS  COUNTER
  000D                0022 A_N        EQU 0DH    ;ALPHANUMERIC COUNTER
  000E                0023 ADDRESS    EQU 0EH    ;LCD ADDRESS
  000F                0024 COUNTR     EQU 0FH
  0010                0025 BUFFER     EQU 010H
  0011                0026 DATABYTE   EQU 011H
  0012                0027 STRING     EQU 012H
  0013                0028 ASCII      EQU 013H
  0014                0029 LCDDATA    EQU 014H
  0015                0030 DLYCNT     EQU 015H
  0016                0031 LBYTE      EQU 016H
  0017                0032 HBYTE      EQU 017H
  0018                0033 SLOW       EQU 018H
  0019                0034 NUMBER     EQU 019H
  001A                0035 CHARS      EQU 01AH
                      0036
                      0037
                      0038          ORG 0
0000 3000             0039       MOVLW 0
0001 0065             0040       TRIS PORT_A
0002 3DF0             0041       MOVLW B'11110000'
0003 0066             0042       TRIS PORT_B
0004 1186             0043       BCF PORT_B,TXD
0005 1106             0044       BCF PORT_B,RS
0006 1086             0045       BCF PORT_B,E
0007 300F             0046       MOVLW 0FH
0008 0085             0047       MOVWF PORT_A
                      0048
                      0049
0009                  0050 CYCLEALL
                      0051
0009 2071             0052       CALL INIT_DISPLAY
000A 20FA             0053       CALL GRAPHICS

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LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

000B 2080             0054       CALL SELECTINIT
000C 20EE             0055       CALL SECOND
000D 20EE             0056       CALL SECOND
                      0057
000E 2071             0058       CALL INIT_DISPLAY
                      0059
000F                  0060 NEXTDATA
000F 30C0             0061       MOVLW 0C0H      ;080H
0010 0092             0062       MOVWF STRING
0011 3000             0063       MOVLW 0
0012 0096             0064       MOVWF LBYTE
0013 3000             0065       MOVLW 0
0014 0097             0066       MOVWF HBYTE
                      0067
0015 3020             0068       MOVLW 020H
0016 0084             0069       MOVWF FSR
0017 3000             0070       MOVLW 0
0018 0099             0071       MOVWF NUMBER
                      0072
                      0073
0019                  0074 INC_DATA
                      0075
0019 1E86             0076       BTFSS PORT_B,LSN
001A 2035             0077       CALL GETLOW
001B 1E06             0078       BTFSS PORT_B,MSN
001C 2040             0079       CALL GETHIGH
001D 1F06             0080       BTFSS PORT_B,ENTER
001E 2022             0081       CALL PRINTBYTE
001F 1F86             0082       BTFSS PORT_B,SQUIRT
0020 285C             0083       GOTO SEND
0021 2819             0084       GOTO INC_DATA
                      0085
                      0086
0022                  0087 PRINTBYTE
0022 0812             0088        MOVF STRING,0
0023 208F             0089        CALL COMMAND
0024 20E2             0090        CALL LONGTIME
0025 0810             0091        MOVF BUFFER,0
0026 3A0D             0092        XORLW 0DH
0027 1903             0093        BTFSC STATUS,2
0028 282A             0094        GOTO CARIAGERETURN
0029 282D             0095        GOTO VV
002A                  0096 CARIAGERETURN
002A 3000             0097        MOVLW 0
002B 209D             0098        CALL WRITE
002C 282F             0099        GOTO WW
002D 0810             0100 VV     MOVF BUFFER,0
002E 209D             0101        CALL WRITE
002F                  0102 WW
                      0103
002F 0A92             0104        INCF STRING,1
0030 0810             0105        MOVF BUFFER,0
0031 0080             0106        MOVWF INDF

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LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

0032 0A84             0107        INCF FSR,1
0033 0A99             0108        INCF NUMBER,1
0034 3400             0109        RETLW 0
                      0110
                      0111
                      0112
0035                  0113 GETLOW
0035 0A96             0114        INCF LBYTE,1
0036 0816             0115        MOVF LBYTE,0
0037 3A10             0116        XORLW 010H
0038 1D03             0117        BTFSS STATUS,2
0039 283C             0118        GOTO  AA
003A 3000             0119        MOVLW 0
003B 0096             0120        MOVWF LBYTE
003C                  0121 AA
003C 20C4             0122        CALL LDELAY
003D 204B             0123        CALL GETBYTE
003E 0000             0124        NOP
003F 3400             0125        RETLW 0
                      0126
0040                  0127 GETHIGH
0040 0A97             0128        INCF HBYTE,1
0041 0817             0129        MOVF HBYTE,0
0042 3A10             0130        XORLW 010H
0043 1D03             0131        BTFSS STATUS,2
0044 2847             0132        GOTO BB
0045 3000             0133        MOVLW 0
0046 0097             0134        MOVWF HBYTE
0047                  0135 BB
0047 20C4             0136        CALL LDELAY
0048 204B             0137        CALL GETBYTE
0049 0000             0138        NOP
004A 3400             0139        RETLW 0
                      0140
004B                  0141 GETBYTE
004B 3080             0142        MOVLW 080H     ;0C4H
004C 208F             0143        CALL COMMAND
                      0144
004D 300F             0145        MOVLW 0FH
004E 0517             0146        ANDWF HBYTE,0
004F 20D1             0147        CALL BINARY
0050 209D             0148        CALL WRITE
0051 0816             0149        MOVF LBYTE,0
0052 20D1             0150        CALL BINARY
0053 209D             0151        CALL WRITE
                      0152
                      0153
0054 3020             0154         MOVLW ' '
0055 209D             0155         CALL WRITE
                      0156
0056 0E17             0157        SWAPF HBYTE,0
0057 0716             0158        ADDWF LBYTE,0
0058 0090             0159        MOVWE BUFFER

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LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

0059 209D             0160        CALL WRITE
                      0161
                      0162
005A 20E2             0163        CALL LONGTIME
005B 3400             0164        RETLW 0
                      0165
                      0166
005C                  0167 SEND
005C 0819             0168        MOVF NUMBER,0   ;SAVE NUMBER OF CHARS
005D 009A             0169        MOVWF CHARS
005E                  0170 SEND2
005E 081A             0171        MOVF CHARS,0
005F 0099             0172        MOVWF NUMBER
0060 3020             0173        MOVLW 020H
0061 0084             0174        MOVWF FSR
                      0175
0062                  0176 ALLSTRING
0062 20CB             0177        CALL DELAY_DATA
0063 0800             0178         MOVF INDF,0 ;GET DATA
0064 20B9             0179         CALL CONVERT
0065 20AB             0180         CALL TXD_DATA
0066 0A84             0181         INCF FSR,1
0067 0B99             0182         DECFSZ NUMBER,1
                      0183
                      0184
0068 2862             0185         GOTO ALLSTRING
0069 30C0             0186         MOVLW 0C0H
006A 208F             0187         CALL COMMAND
006B 300D             0188         MOVLW 0DH
006C 208F             0189         CALL COMMAND
006D 20EE             0190         CALL SECOND
                      0191
006E 1A86             0192         BTFSC PORT_B,LSN
006F 285E             0193         GOTO  SEND2
0070 2809             0194         GOTO  CYCLEALL
                      0195
0071                  0196 INIT_DISPLAY
0071 20C4             0197         CALL LDELAY
                      0198
0072 3033             0199         MOVLW 033H
0073 208F             0200         CALL COMMAND
0074 3032             0201         MOVLW 032H
0075 208F             0202         CALL COMMAND
0076 3028             0203         MOVLW 028H
0077 208F             0204         CALL COMMAND
0078 3006             0205         MOVLW 6
0079 208F             0206         CALL COMMAND
007A 300E             0207         MOVLW 0EH
007B 208F             0208         CALL COMMAND
007C 3001             0209         MOVLW 1
007D 208F             0210         CALL COMMAND
007E 20C4             0211         CALL LDELAY
007F 3400             0212         RETLW 0

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LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

                      0213
                      0214
0080                  0215 SELECTINIT
0080 3080             0216        MOVLW 080H   ;1ST LINE    8TH POSITON
0081 208F             0217        CALL COMMAND
                      0218
0082 307E             0219        MOVLW 07EH
0083 209D             0220        CALL WRITE
0084 3052             0221        MOVLW 'R'
0085 209D             0222        CALL WRITE
0086 3065             0223        MOVLW 'e'
0087 209D             0224        CALL WRITE
0088 3061             0225        MOVLW 'a'
0089 209D             0226        CALL WRITE
008A 3064             0227        MOVLW 'd'
008B 2090             0228        CALL WRITE
008C 3079             0229        MOVLW 'y'
008D 209D             0230        CALL WRITE
008E 3400             0231        RETLW 0
                      0232
008F                  0233 COMMAND
008F 0094             0234        MOVWF LCDDATA
0090 0E14             0235        SWAPF LCDDATA,0
0091 0085             0236        MOVWF PORT_A
0092 1106             0237        BCF PORT_B,RS
0093 1486             0238        BSF PORT_B,E
0094 20C4             0239        CALL LDELAY
0095 1086             0240        BCF PORT_B,E
```

```
0096 0814            0241      MOVF LCDOATA,0    ;LSNIBBLE
0097 0085            0242      MOVWF PORT_A
0098 1106            0243      BCF PORT_B,RS
0099 1486            0244      BSF PORT_B,E
009A 20C4            0245      CALL LDELAY
009B 1086            0246      BCF PORT_B,E
009C 3400            0247      RETLW 0
                     0248
009D                 0249 WRITE
009D 008D            0250      MOVWF A_N
009E 0E00            0251      SWAPF A_N,0
009F 0085            0252      MOVWF PORT_A
00A0 1506            0253      BSF PORT_B,RS
00A1 1486            0254      BSF  PORT_B,E
00A2 20CB            0255      CALL DELAY_DATA
00A3 1086            0256      BCF PORT_B,E
00A4 0800            0257      MOVF A_N,0
00A5 0085            0258      MOVWF PORT_A
00A6 1506            0259      BSF PORT_B,RS
00A7 1486            0260      BSF  PORT_B,E
00A8 20CB            0261      CALL DELAY_DATA
00A9 1086            0262      BCF PORT_B,E
00AA 3400            0263      RETLW 0
                     0264
                     0265

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LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

00AB                 0266 TXD_DATA
00AB 1586            0267      BSF PORT_B,TXD
00AC 20BE            0268 NEXT CALL DELAY
00AD 0C90            0269      RRF BUFFER,1
00AE 1803            0270      BTFSC STATUS,0
00AF 1586            0271      BSF PORT_B,TXD
                     0272
00B0 1C03            0273      BTFSS STATUS,0
00B1 1186            0274      BCF PORT_B,TXD
00B2 0B8F            0275      DECFSZ COUNTR,1
00B3 28AC            0276      GOTO NEXT
00B4 20BE            0277      CALL DELAY
00B5 1186            0278      BCF PORT_B,TXD
00B6 20BE            0279      CALL DELAY
00B7 20BE            0280      CALL DELAY
00B8 3400            0281      RETLW 0
                     0282
00B9                 0283 CONVERT
00B9 3AFF            0284      XORLW OFFH
00BA 0090            0285      MOVWF BUFFER
00BB 3008            0286      MOVLW 8
00BC 008F            0287      MOVWF COUNTR
00BD 3400            0288      RETLW 0
                     0289
00BE                 0290 DELAY
00BE 3021            0291      MOVLW BAUD9600
00BF 0095            0292      MOVWF DLYCNT
00C0 0B95            0293 REDX DECFSZ DLYCNT,1
00C1 28C0            0294      GOTO REDX
00C2 0000            0295      NOP
00C3 3400            0296      RETLW 0
                     0297
00C4                 0298 LDELAY
00C4 3003            0299      MOVLW B'00000011'
00C5 0062            0300      OPTION
00C6 0181            0301      CLRF RTCC
00C7                 0302 L_DELAY
00C7 0064            0303      CLRWDT
00C8 1F81            0304      BTFSS RTCC,7
00C9 28C7            0305      GOTO L_DELAY
00CA 3400            0306      RETLW 0
                     0307
00CB                 0308 DELAY_DATA
00CB 30FF            0309      MOVLW DEBOUNCE
00CC 0095            0310      MOVWF DLYCNT
00CD 0B95            0311 REDB DECFSZ DLYCNT,1
00CE 28CD            0312      goto REDB
00CF 0064            0313      CLRWDT
00D0 3400            0314      RETLW 0
                     0315
                     0316
00D1                 0317 BINARY
00D1 0782            0318      ADDWF PC

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LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

00D2 3430            0319      RETLW '0'
00D3 3431            0320      RETLW '1'
00D4 3432            0321      RETLW '2'
00D5 3433            0322      RETLW '3'
00D6 3434            0323      RETLW '4'
00D7 3435            0324      RETLW '5'
00D8 3436            0325      RETLW '6'
00D9 3437            0326      RETLW '7'
00DA 3438            0327      RETLW '8'
00DB 3439            0328      RETLW '9'
00DC 3441            0329      RETLW 'A'
00DD 3442            0330      RETLW 'B'
00DE 3443            0331      RETLW 'C'
00DF 3444            0332      RETLW 'D'
00E0 3445            0333      RETLW 'E'
00E1 3446            0334      RETLW 'F'
                     0335
                     0336
                     0337
00E2                 0338 LONGTIME
                     0339      ;1000.23 MS = 32
00E2 3008            0340      MOVLW 8
00E3 0098            0341      MOVWF SLOW
00E4 3007            0342      MOVLW B'00000111'
00E5 0062            0343      OPTION
00E6 0181            0344 LONGX CLRF RTCC
00E7 0064            0345 LONG CLRWDT
00E8 0000            0346      NOP
00E9 1F81            0347      BTFSS RTCC,7
00EA 28E7            0348      GOTO LONG
00EB 0B98            0349      DECFSZ SLOW,1
00EC 28E6            0350      GOTO LONGX
00ED 3400            0351      RETLW 0
                     0352
                     0353
                     0354
00EE                 0355 SECOND
                     0356      ;1000.23 MS = 32
00EE 3020            0357      MOVLW .32
00EF 0098            0358      MOVWF SLOW
00F0 3007            0359      MOVLW B'00000111'
00F1 0062            0360      OPTION
00F2 0181            0361 LONGA CLRF RTCC
00F3 0064            0362 LON  CLRWDT
00F4 0000            0363      NOP
00F5 1F81            0364      BTFSS RTCC,7
00F6 28F3            0365      GOTO LON
00F7 0B98            0366      DECFSZ SLOW,1
00F8 28F2            0367      GOTO LONGA
00F9 3400            0368      RETLW 0
                     0369
00FA                 0370 GRAPHICS
00FA 3040            0371      MOVLW 040H

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LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

00FB 208F            0372      CALL COMMAND
                     0373
00FC 300E            0374      MOVLW OEH
00FD 209D            0375      CALL WRITE
00FE 3010            0376      MOVLW 010H
00FF 209D            0377      CALL WRITE
0100 300E            0378      MOVLW OEH
0101 2090            0379      CALL WRITE
0102 3000            0380      MOVLW 0
0103 209D            0381      CALL WRITE
0104 301C            0382      MOVLW 01CH
0105 2090            0383      CALL WRITE
0106 3012            0384      MOVLW 012H
0107 209D            0385      CALL WRITE
0108 301C            0386      MOVLW 01CH
0109 2090            0387      CALL WRITE
010A 3012            0388      MOVLW 012H
010B 2090            0389      CALL WRITE
010C 3400            0390      RETLW 0
                     0391
                     0392      END
                     0393
                     0394

MPASM 01.02.05 Intermediate    LCDRG1.ASM   11-28-2000  18:28:22                PAGE  9


SYMBOL TABLE

LABEL                            VALUE

AA                               003C
ADDRESS                          000E
ALLSTRING                        0062
ASCII                            0013
A_N                              000D
BAUD9600                         0021
BB                               0047
BINARY                           00D1
BUFFER                           0010
CARIAGERETURN                    002A
CHARS                            001A
COMMAND                          008F
CONVERT                          00B9
COUNTER                          000C
COUNTR                           000F
CYCLEALL                         0009
DATABYTE                         0011
DEBOUNCE                         00FF
DELAY                            00BE
DELAY_DATA                       00CB
DLYCNT                           0015
E                                0001
ENTER                            0006
FSR                              0004
GETBYTE                          004B
GETHIGH                          0040
GETLOW                           0035
GRAPHICS                         00FA
HBYTE                            0017
INC_DATA                         0019
INDF                             0000
INIT_DISPLAY                     0071
LBYTE                            0016
LCDDATA                          0014
LDELAY                           00C4
LON                              00F3
LONG                             00E7
LONGA                            00F2
LONGTIME                         00E2
LONGX                            00E6
LSN                              0005
L_DELAY                          00C7
MSN                              0004
NEXT                             00AC
NEXTDATA                         000F
NUMBER                           0019
PC                               0002
PORT_A                           0005
PORT_B                           0006
PRINTBYTE                        0022
REDB                             00CD
REDX                             00C0
MPASM 01.02.05 Intermediate    LCDRG1.ASM   11-28-2000  18:28:22                PAGE 10


SYMBOL TABLE - Continued

LABEL                            VALUE

RS                               0002
RTCC                             0001
SECOND                           00EE
SELECTINIT                       0080
SEND                             005C
SEND2                            005E
SLOW                             0018
SQUIRT                           0007
STATUS                           0003
STRING                           0012
TXD                              0003
TXD_DATA                         00AB
VV                               002D
WRITE                            009D
WW                               002F
__16C84                          0001


MEMORY USAGE MAP ('X' = Used,  '-' = Unused)

0000 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
0040 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX

0080 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
00C0 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX

0100 : XXXXXXXXXXXX-- -------- -------- --------
0140 : -------- -------- -------- --------

All other memory blocks unused.


Errors   :     0
Warnings :     0
Messages :     0
```

From Bioelectricity to SPACE TRAVEL

PART 1

In this 2-part feature David Clark looks at the invention and improvement of the first battery - Alessandro Volta's "voltaic pile".

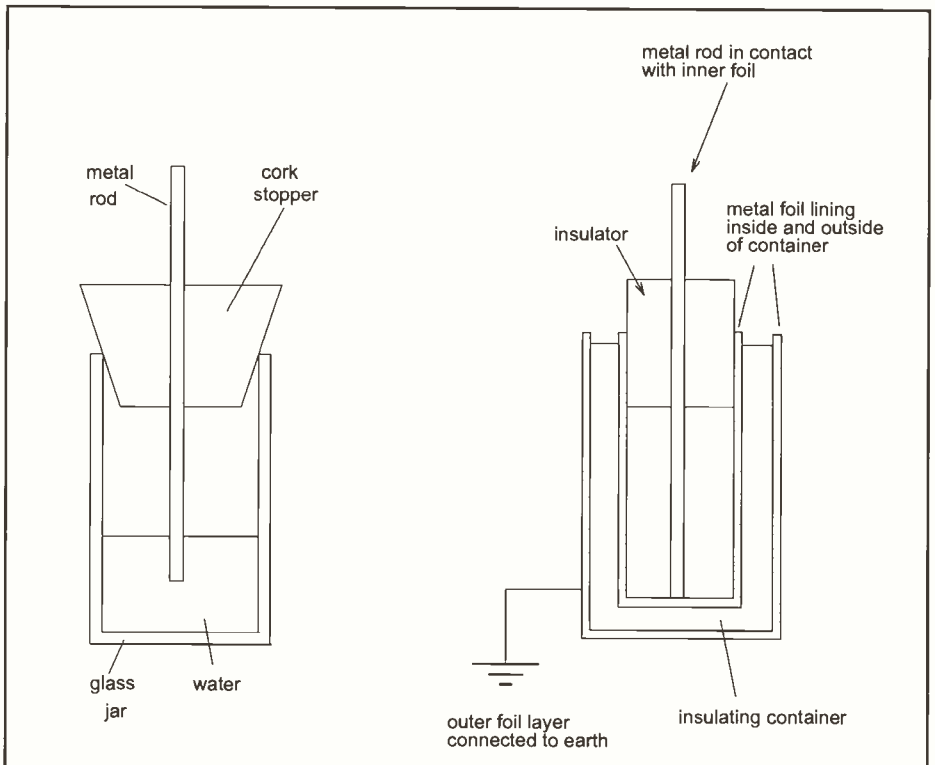


Figure 1.

With the ability to store charge and so do 'proper' experiments, theories about what electricity was began to develop. In France, in 1733, the chemist Charles François de Cisternay DuFay declared that electricity was composed of two fluids, which he called 'vitreous' and 'resinous' (words associated with the insulators used to generate the two types, glass and amber). Normally these two fluids were in balance in a substance and so matter was neutral, but friction could separate them and disturb the balance. The material would then attract or repel other substances. This was the 'two-fluid' theory. A later theory, supported by William Watson and Benjamin Franklin, was the 'single-fluid' theory. Knowledge of the composition of materials had not advanced much in the two millennia since the theories of the ancient Greek philosophers who held that all matter was composed of elements such as earth, air, fire and water. Adherents to the 'single-fluid' theory concluded that lightning electricity was also an element, a single fluid, which was evenly distributed throughout all other matter but particularly present in water and metals (which were therefore conductive). However if an object had too much of this fluid it would become positively charged, and if too little, negatively charged, and this explained the attraction and repulsion effects as the amount of 'electrical fire' tried to equalise between objects.

The 'single-fluid' theory fitted the facts well, although the 'two fluid' theory is perhaps closer to the concept of positive and negative charge. Nevertheless the idea that electricity, and also magnetism, heat and light were fluids, was one that would last until the late nineteenth century when electromagnetic radiation began to be understood. So when Joseph Priestley published his book 'The History And Present State Of Electricity' in 1767, he was stating the knowledge and beliefs of the majority of the scientific community of the time. However there was soon to be some major advances in the knowledge and use of this 'fluid'.

Bioelectricity

The eighteenth century physician Luigi Galvani was possibly the first to witness the phenomenon of a lifeless frog's leg twitching due to electricity. When Priestley's book was published Galvani was well on his way to becoming President of the Bologna Academy of Science, a post which he took in 1772. Like William Watson he too was a physician; Galvani's interests were anatomy and physiology, the sciences of the structure and the functions of living organisms. This became an enthusiasm for electrophysiology when he obtained an electrostatic generator and a Leyden jar, and his enthusiasm soon turned the subject into his primary area of study. A basic tool of anatomy is dissection, and frogs' legs were frequently used as subjects of examination. He is believed to have first observed the kicking of the lifeless frog leg in the late 1780s, the effect being seen both while his electrostatic machine was operating and also during thunderstorms. He went on to prove to his own satisfaction in further experiments that this movement was due to an electrical phenomenon. Galvani decided that a living frog must therefore produce its own electricity in order to move its muscles. He believed he had discovered a 'vital' force, which he named 'animal' electricity. According to Galvani this 'animal' electrical fluid was secreted by the brain and was conducted to the muscles by the nerves. He announced his results in 1791. He thought this was a third form of electricity, 'animal' electricity, to go with 'natural' electricity like lightning and 'artificial' electricity like static electricity. Although his belief in a 'vital force' was incorrect, as was the belief that electricity was some kind of fluidic element, Galvani was correct in his theory that nerve conduction is an electrical effect. In frogs, as in all animals, biological molecules and ions conduct nerve impulses throughout the body.

Metallic Electricity

Alessandro Volta, a physicist of the nearby northern Italian University of Pavia, was not so sure about Galvani's 'animal' electricity. Galvani himself had found that the dead frog's leg would also twitch when its spinal cord was simultaneously touched with a copper wire and an iron wire. Volta believed that the twitching might be a consequence of the electricity produced by the copper and iron metals and that the frog only responded to the electricity; it did not

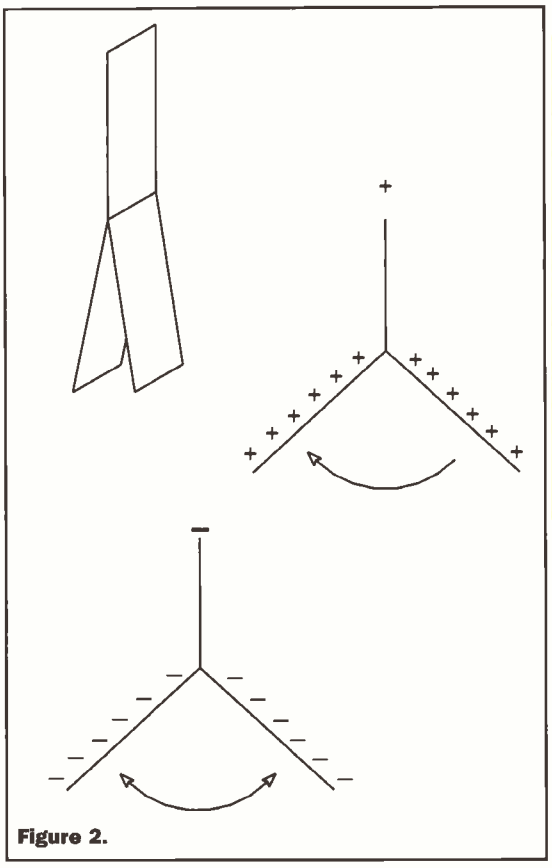


Figure 2.

The Electroscope

Two thin 'leaves' of gold foil are each attached by one end to a fixed conductor. If there is no charge on the conductor the gold leaves fall vertically. If either a positive or a negative charge is connected to the fixed contact both leaves will take the same charge and move apart (since like charges repel). This is a sensitive method of detecting charge but it does not differentiate between positive and negative types.

generate electricity. The frog's legs were merely acting like an electroscope, the device used to show the presence of charge. (See the box text on the electroscope.)

This he called 'metallic' electricity. As part of his investigations Volta had placed two coins of different metals, one on top of and one beneath his tongue. He noticed an unusual sensation or 'taste', not present when the coins were the same. He thought this might be a similar phenomenon to Galvani's 'animal' electricity, until in 1796 he found he could miraculously generate electricity without needing any 'animal' effects by using a piece of cardboard soaked in salty water instead of his tongue. Electricity could be generated simply with metals and salt water! Building on this simple cell (see Figure 3) he made the first battery, or voltaic pile, in 1800. This consisted of multiple layers of silver, moist cardboard and zinc, ie several cells in series.

This revolutionised the study of electricity because, although it produced a smaller voltage than the Leyden jar, it could provide a continuous current. The next year he demonstrated his battery to the Emperor Napoleon, who was so impressed he made him a count and a senator of the kingdom of Lombardy. Volta's battery was a source of power in more ways than one!

The Age of Electricity

The nineteenth century is often called the age of electricity, seeing an explosion of scientific knowledge directly made possible by Volta's invention. Literally within weeks of Volta announcing his source of 'metallic' electricity two English scientists, William Nicholson and Anthony Carlisle had used his battery to break down water into hydrogen and oxygen. Within a few years the battery had been used to isolate many more true elements from their compounds, elements such as sodium and potassium, calcium and magnesium. Two of the best known workers in this field were Humphrey Davy and his assistant at the time Michael Faraday. Davy was instrumental in work on the connection between electricity and chemistry, and in using electricity to establish new theories on the nature of materials and to correct many previously held misconceptions. Faraday's work led to his two laws of electrolysis, laws fundamental to battery operation, which relate quantities of substance, ie number of atoms or ions, to quantities of electricity and the charge on the ions involved. By the mid to late 1800s enough had been learned about elements and their properties for Dmitri Mendeleev to produce an early Periodic Table. The position of an element in the Periodic Table enables its properties to be predicted and so is an important starting point for the 'design' and engineering of materials with specific desired properties.

The Better Battery

Development of materials, then as now, was the key to improvements in the basic battery. Volta himself of course did not see most of the development; he died in 1827, long before he would be honoured by having the unit of electromotive force named after him in 1881. Out of Faraday's work on the relationship between power

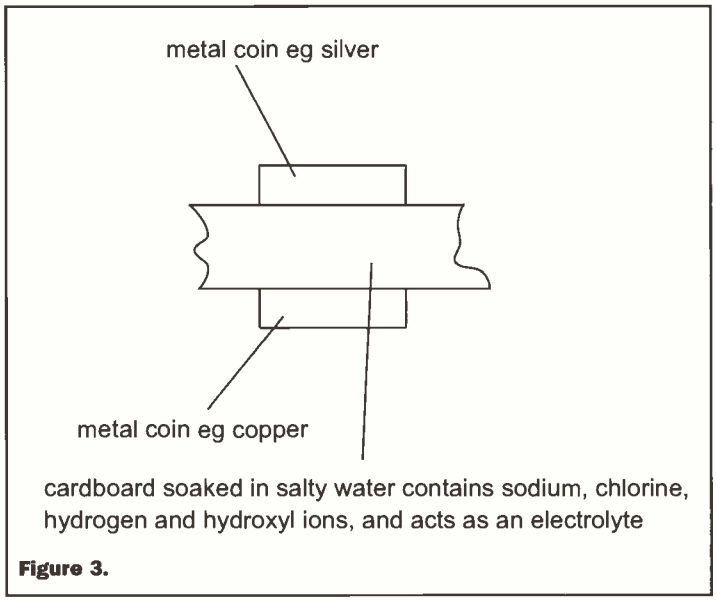


Figure 3.

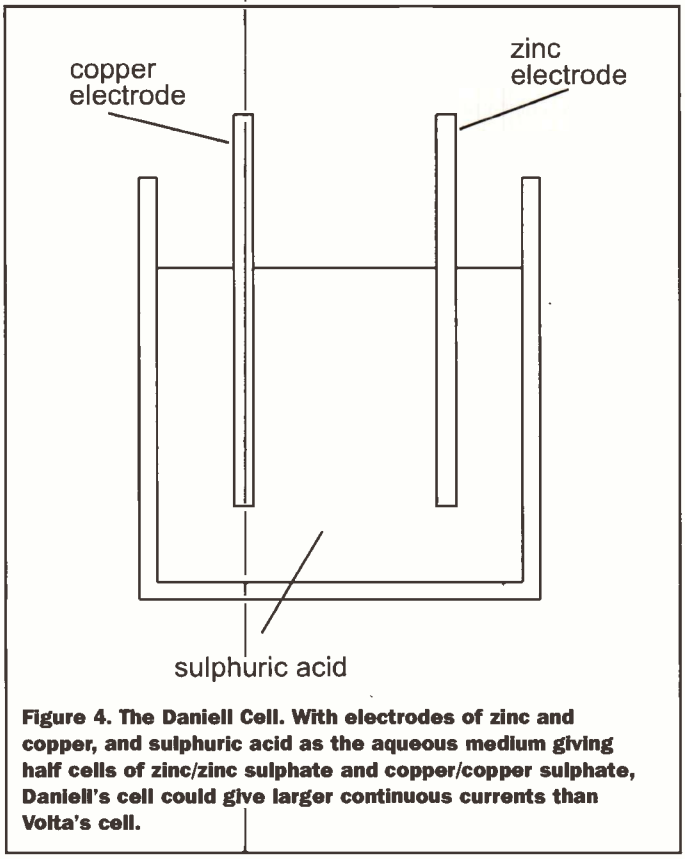


Figure 4. The Daniell Cell. With electrodes of zinc and copper, and sulphuric acid as the aqueous medium giving half cells of zinc/zinc sulphate and copper/copper sulphate, Daniell's cell could give larger continuous currents than Volta's cell.

and electrode material came the cell of the Briton John Frederic Daniell in 1836, followed by a two-fluid cell invented by Welshman William Robert Grove in 1839. Daniell's cell (see Figure 4) used copper and zinc in sulphuric acid, which gave a much improved performance over Volta's cell. Grove's cell (see Figure 5), which used zinc in sulphuric acid and platinum in nitric acid, the two being separated by a porous pot (which allowed electrical continuity), gave even further improvement in performance.

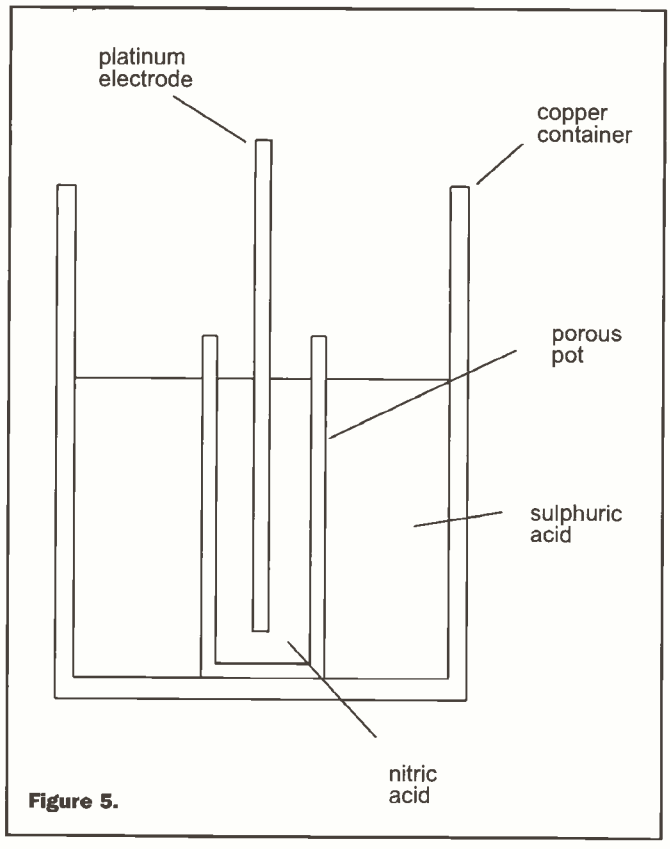


Figure 5.

The German Robert Wilhelm Bunsen made a commercial improvement on Grove's cell when he substituted cheap carbon for expensive platinum. The first lead-acid battery, produced in France in 1859 by Gaston Planté, gave a greatly increased energy capacity and power capability. This same type of battery is still in widespread use today in motor vehicles because of its cost-effectiveness, despite the disadvantage of its weight. Another significant point about this battery is of course that it was the first practical rechargeable battery.

The next major breakthrough was the cell developed by Georges Leclanché in 1866, the forerunner of the first 'dry' cell. This was the first cell to provide a practical solution to the problems of the need for strongly acidic fluids in batteries, which was a great limitation in terms of portability, safety and the size of the unit, and the outgassing of hydrogen, a safety and efficiency problem.

The Hydrogen Problem

The outgassing of hydrogen in the earlier cells was a consequence of the fact that in an aqueous solution the water molecules tend to dissociate into hydrogen and hydroxyl ions.

The hydrogen ion tends to attract electrons strongly, so electrons returning to the positive electrode combine with hydrogen ions. In doing so the hydrogen ions in solution are converted to hydrogen gas which is not soluble to any significant degree. The hydrogen gas accumulates on the electrode and causes loss of voltage. Using a half-cell consisting of a platinum electrode in a nitric acid solution was an attempt to solve this. Nitric acid is a strong oxidising agent, and oxidising agents strongly attract electrons. Electrons returning to the cell electrode are therefore in effect 'absorbed' by the nitric acid, in fact by the nitrogen atom in the nitric acid molecule which in the process changes its 'oxidation state'. This releases oxygen from the nitric acid, which 'oxidises' the hydrogen to water and so hydrogen gas is no longer released from solution.

The Dry Cell

In the Leclanché cell (see Figure 7) the copper negative electrode of early versions of the battery is replaced by a zinc can, and the sulphuric acid electrolyte is replaced by an aqueous paste of ammonium chloride, or an ammonium chloride/zinc chloride mixture. This paste is more easily contained and can be more concentrated than sulphuric acid. The solution to the hydrogen gas problem in this cell is dealt with by the use of manganese dioxide, an oxidising agent in solid form and the substance used in the majority of today's commercially successful batteries. The former platinum rod electrode and nitric acid oxidising agent are replaced by an electrode of powdered carbon (graphite) mixed with manganese dioxide. The electrode surrounds a carbon rod which 'collects' electrons.

The hydrogen released is safely oxidised by the manganese dioxide to water, and the ammonia produced as a by-product of the reactions in the cell dissolves in the paste.

This then is the zinc carbon (also called zinc manganese dioxide) standard battery. The zinc chloride battery is the same as this

The lead acid battery

The lead-acid battery has one lead plate and one plate coated in lead dioxide, both surrounded by sulphuric acid.

At the lead plate the lead reacts with sulphuric acid to give lead sulphate and two electrons, which do work in the battery circuit, and then return to the other plate. At this plate the lead dioxide reacts with the sulphuric acid and takes the two electrons to give lead sulphate and water.

As the battery discharges the sulphuric acid is effectively used up as electricity is generated.

The reactions are reversible however and by charging the battery the sulphuric acid is replenished and so the battery is ready to do more work.

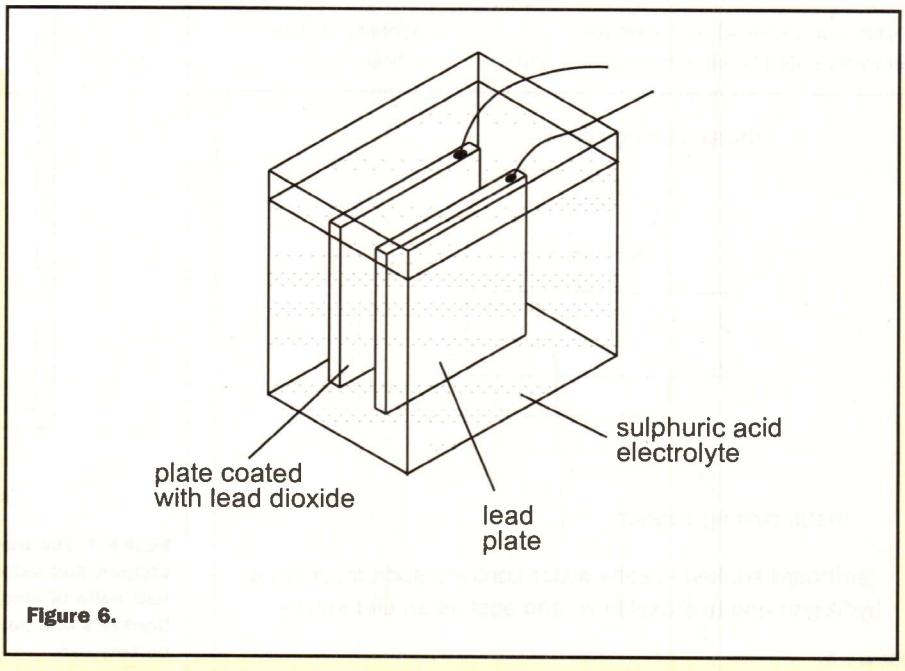


Figure 6.

but uses zinc chloride instead of the ammonium chloride or ammonium chloride/zinc chloride mix as electrolyte.

Alkaline batteries are so called because in this case the electrolyte is the alkaline substance potassium hydroxide. The positive electrode is the same carbon/manganese dioxide combination, but here the negative electrode is powdered zinc contained in a steel case; this gives a much more reactive surface area for yet more power. Hydrogen is oxidised to water as usual, which is readily absorbed by the potassium hydroxide.

Other batteries using alkali electrolyte and a zinc electrode but with different materials for the other electrode are the silver oxide and mercuric oxide types. The common factor in all these electrodes is that they are all metals that can have different 'oxidation states' and so accept electrons. (See the box text on oxidation states).

Further variations use sulphur compounds rather than oxygen compounds – sulphur is similar to oxygen in its chemical reactions as can be predicted from their relative positions in the Periodic Table. Using these different materials however is really 'fine tuning', even though there can be big performance improvements. Despite using varied and modified materials to give specifically engineered improvements the basic battery principle remains the same as in Volta's cell.

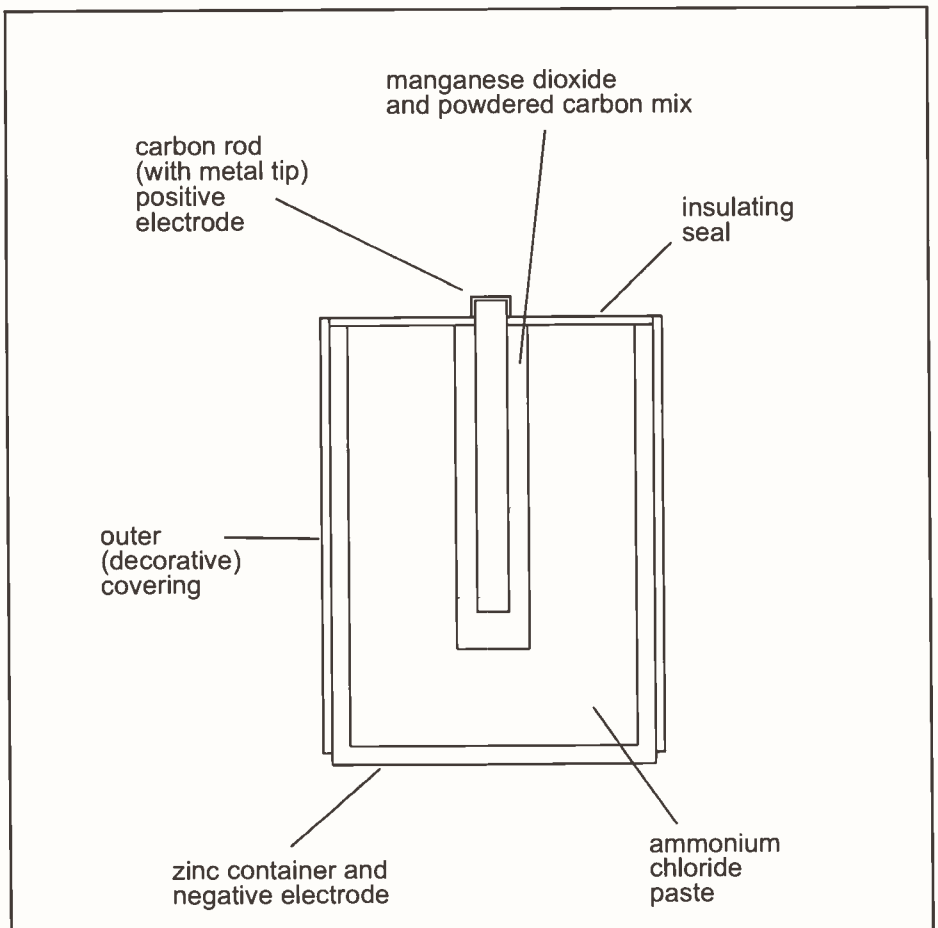


Figure 7.

Conclusion - The Even Better Battery

With contributions from scientists of many nationalities then, the development of the battery seems to have been one of the first dry cell, based on the Leclanché cell and the most successful battery since the 1880s, is the basis of all the general-purpose primary cells that have been used during the twentieth century. It has now been joined by a multitude of options, each with different qualities and so best suited to a different purpose. One major advance in development though is due to the progress being made with polymer (plastic) materials. Before long a completely plastic battery might be available in the local newsagent's shop!

Join us in Part 2 where we take a present day look at batteries.

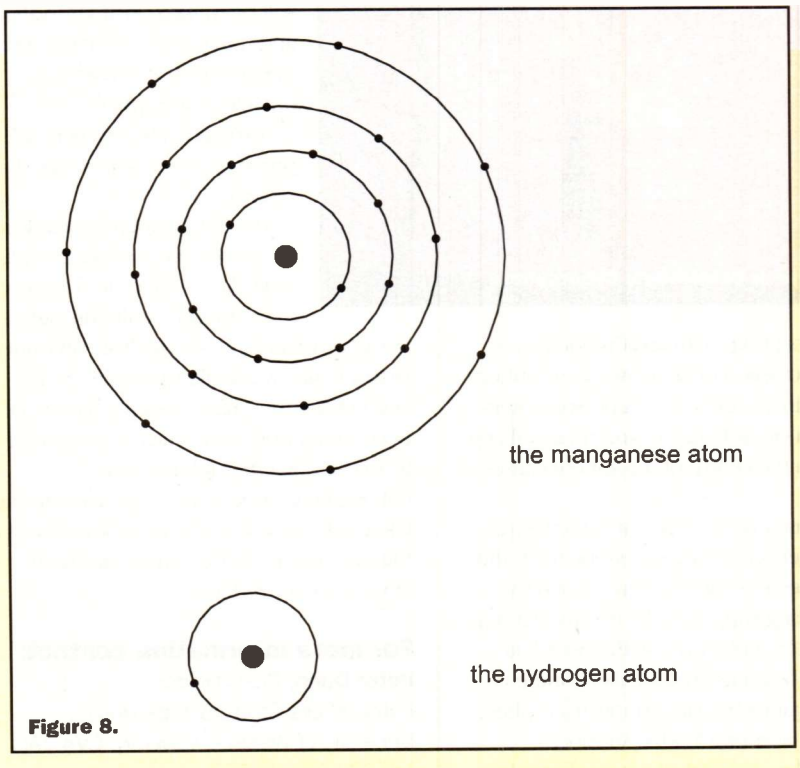


Figure 8.

Hydrogen and manganese atoms

The hydrogen atom has a nucleus with only one positive charge, and so has only one (negatively charged) electron in its normal atomic state. So in solution a hydrogen ion, which is the atom with the electron missing, only needs to gain one electron to become its normal gaseous form. Its oxidation state is said to have gone from one plus to zero.

Manganese however has a nucleus with twenty-five positive charges and so an atom of manganese has twenty-five electrons, seven of these being in the outer shell. In the form of solid manganese dioxide the manganese atom has lost four of the outer electrons and is said to have an oxidation state of four plus. Since the outer shell is not full it can gain another electron and thus be three missing from the full set of seven, and is then said to have an oxidation state of three plus. In this way the manganese, by taking an electron and changing its oxidation state, releases an oxygen atom from the metal oxide that then combines with hydrogen to give water and prevent the release of hydrogen gas.

3D CINEMA

by Reg Miles

A new 3D theatre that is the most advanced of its kind in Europe has been opened at the University of Warwick for use by high tech manufacturing businesses. It forms part of a new complex built by a partnership between the University's Warwick Manufacturing Group, PTC, and Sun Microsystems. It employs the largest 3D capable screen ever installed by virtual reality specialists Trimension.

Until now most engineers have only been able to use three-dimensional techniques to model the manufacturing process of a product at a single workstation. This complex will allow large groups of senior managers and engineers to simultaneously visualise the same engineering process in 3D. The new theatre will also allow those senior managers and engineers to go beyond simple 3D visualisation of products and to actually use it to develop 3D visualisations of production plants, manufacturing processes, management systems and even e-commerce and e-production processes.

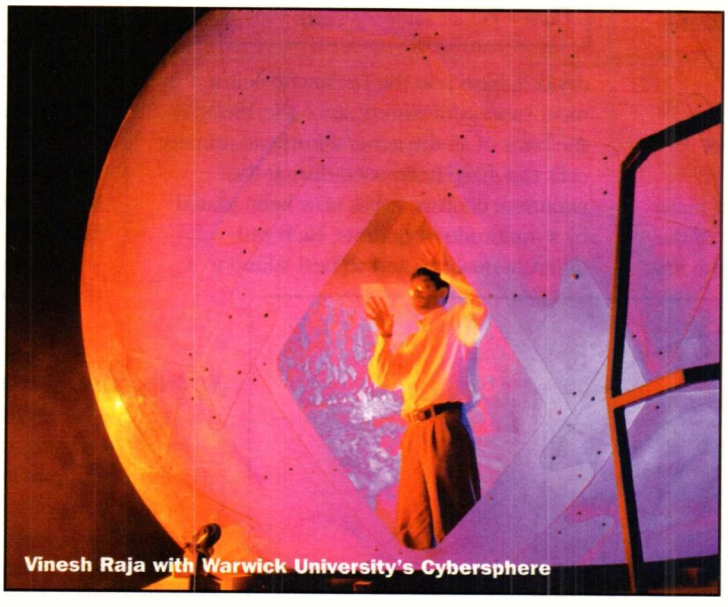
According to Professor Kumar Bhattacharyya, Director of Warwick Manufacturing Group, at the launch, 'These new techniques will allow geographically dispersed teams across large extended enterprises to work simultaneously on the same design project through sophisticated visualisation, information collection, management and delivery technologies. Our new facilities will also allow small and medium sized companies to access this technology that previously could only be supported by large multinationals.'

These sentiments were echoed by C.Richard Harrison, President and CEO, of PTC who said, 'Centres such as this are laying the foundations for the collaborative future of manufacturing industry. PTC's CPC technology is enabling different manufacturing companies to work together more efficiently and effectively on product development and delivery.'

The equipment that has been made available for their use consists of a Sun E450 Server with four 400MHz CPUs, 4GB memory, a 108GB hard disk and three Expert 3D graphics cards. It also comes with a Sun Ultra 10 with two 400MHz CPUs, 512MB memory, an 18GB hard disk and an Elite 3D graphics card; and two NT Workstations employing two Pentium III CPUs, 2GB memory, a 36GB hard disk and a CD writer.

The theatre also includes a Cybersphere: a fully immersive spherical projection system developed jointly by Warwick Manufacturing Group and VR Systems UK. With researcher Vinesh Raja from the former and Principal Design Engineer Julian Eyre from the latter overseeing the project.

The Cybersphere is a hollow, translucent sphere, and 3.5m in diameter, mounted on a ring of bearings with an additional low-pressure cushion of air allowing the sphere to rotate in any direction. A person enters through a closable hatch; and their walking motion in the centre of the sphere causes it to rotate.



Vinesh Raja with Warwick University's Cybersphere

This rotational movement is transferred to a smaller secondary sphere beneath the large projection sphere. This secondary sphere being supported by means of a ring, mounted on a platform, within which are mounted bearings. The smaller sphere is pushed against the large projection sphere by means of spring loaded supports. Rotational movement of the smaller sphere is measured by means of rotation sensors, pushed against the circumference of the sphere by means of spring loaded supports. Signals from these rotation sensors are fed to the computer via cables, and there they are used to update the projected images: thus giving the occupant the illusion of walking through the computer generated environment.

Images are projected onto the external surface of the large sphere by means of high power projectors. Four projectors are mounted on the surrounding walls, and one on the ceiling. Each computer-generated image is projected onto a segment of the outer surface of the large sphere. The plane surfaces formed by the opposite edges of each of these segments subtend a right angle at the centre of the sphere. The surface of this sphere is prepared in a way such that the occupant is able to view the projected images clearly. The combination of the images from each projector provides a fully immersive visual experience.

Construction of the translucent projection sphere proved to be problematic: the manufacture of two complete hemispheres was technically difficult and costly; however, a Patent Applied For technique of sphere manufacture was developed which overcame the difficulty of joining together a number of segments while minimising the visibility of any seams. Construction of a means of entry to the sphere also caused some technical problems. The requirements for any hatch are that it must be able to be latched closed (particularly as it will be walked on at intervals), and that it must be able to be opened from the inside or outside of the sphere. The construction also contains a low-pressure air cushion support system.

The Cybersphere is significant on an international scale, with its facility to allow an occupant to realistically 'walk through' a virtual environment. A significant amount of virtual reality work takes place in the UK and Europe, but many commercial virtual environment products currently originate from the U.S.A. It is felt that the Cybersphere project will help promote the UK and Europe as being actively involved in the development of commercial virtual environment products.

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Email: <puapjd@admin.warwick.ac.uk>

@internet special

8 page pull-out

I think ICANN

It's been known for a few years now that the Internet is running out of top-level domains (top-level domains are the last parts of all the Internet addresses available for email and URLs: .com, .net, .gov, and so on). When the Internet was young, the existing top-level domains were perfectly suited to the governmental, military and academic areas that were then the sole users of the emerging technology. However, when commercial organisations realised that the Internet could be of benefit also, things changed. A few new top-level domains, such as .com, were added to cope; however the Internet is growing rather mushroom-like now, and new Websites blossom every minute of the day.

The organisation given the task of allocating top-level domains is the International Corporation for Assigned Numbers and Names (ICANN). It has recently added seven new top-level domains for general use. These are, in purely alphabetical order:

- **.aero** intended for use by the air transport industry, this top-level domain will be operated by the Societé Internationale de Telecommunications Aeronautiques (SITA), a Belgian airline telecommunications company
- **.biz** a new top-level domain for business use, similar to the .com top-level domain that's currently widely used. The .biz top-level domain is to be jointly administered by the US company JVTeam, and the Australian company Melbourne IT
- **.coop** operated by the US National Cooperative Business Association, which represents the world's cooperative associations around the world. This top-level domain is to be for non-profit cooperatives only
- **.info** for organisations providing information services. The consortium Afilias will administer this top-level domain
- **.museum** the new top-level domain for — you've guessed it — museums around the world. A non-profit organisation called the Museum Domain Management Association has been formed to run this
- **.name** operated by the Global Domain Registry, this new top-level domain is intended to be used for personal Websites and email addresses. As such, this is the top-level domain that could become most familiar to most people
- **.pro** a new top-level domain for professional services personnel, such as doctors and lawyers. An Irish company called RegistryPro will administer this top-level domain.

Although seven new top-level domains appears quite spartan given the wide range of different uses to which the Internet is currently being put to, ICANN will continue to develop new top-level domains with time. The fact that the new top-level domains here contain such specific ones for the air transport industry and museums obviously means that future top-level domains could be equally specific. A top-level domain for the world's health organisations (probably .health) is likely, while others for specific job categories (.journo for people like yours truly, or .pigeonfancier for err, pigeon fanciers) is less likely, though ostensibly feasible. People wishing to administer further new top-level domains must apply to ICANN with a $50,000 non-refundable fee, which doubtless will prevent any but the more serious top-level domains from being accepted.

Negotiations regarding the new domains are scheduled to be completed by December 31 2000, so it's possible that they should be available for use early in 2001.

UK Internet Use Increases

According to a recent survey (conducted by Nielsen/Net Ratings), Internet usage in the UK has risen 10% over the last year, and looks set to rise at a similar rate over the foreseeable future. In comparison to the US, where incidentally rates of usage increased by under 5% over the year, the UK is still not using the Internet to the same extent, however. The average UK surfer spends around 5 hours a week on line, while the average US surfer spends just over 10 hours a week connected.

A greater time on line doesn't necessarily relate to a similar growth in ecommerce, however. Increasingly, Internet users are accessing Websites of sales outlets to make comparisons between products and prices, but not always purchasing the products themselves on line. The reasons for this general underuse of on line shopping are varied, although it's often the suppliers' own faults. Another survey (by Ovum) of 114 UK ecommerce sites found that only a third of sites that allow customers to respond by email bothered to reply to the potential customers.

Weather or not it'll rain

With the rather unusual name of Son of Weather Grok, Mac users have the ability to watch weather data from around the world live on-screen, in a newly released beta version 2. Son of Weather Grok taps into the National Oceanic and Atmospheric Administration (NOAA) data centre via the Internet, and downloads data received from NOAA's weather stations situated at the world's Airports. All you have to do is enter the four letter code for the airport you want to monitor and get the data.

Son of Weather Grok allows a ticker-tape display of received data in a small window, or a full display of data, and users with an always-on connection to the Internet can set the application to check at set time intervals. Son of Weather Grok is available as a standard Mac OS application for Mac OS 9, and as a carbonised application (that is, usable with the new Mac OS X Public Beta — the screenshot shows this). Both versions ran smoothly under test, despite being beta versions. Best of all, they're both freeware, and you'll find them available on most decent Mac shareware sites.

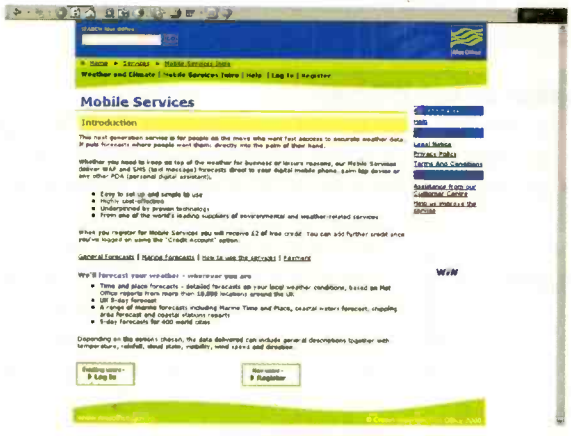
MusicMatch Issues Call for Beta Testers

MusicMatch has unveiled its third jukebox software program for the popular Linux computing platform - MusicMatch Jukebox for Linux 1.0.

With the beta release of MusicMatch Jukebox for Linux, MusicMatch is the first and only company to offer music fans on Windows, Macintosh and Linux a complete personal music system for playing, recording, organising and discovering all of their favourite music in one easy-to-use program.

MusicMatch Jukebox for Linux is now available to beta testers for free download at **<www.musicmatch.com>**.

Mobile Phone Can Forecast Weather



British mobile phone users are to get the world's most personal weather forecasts delivered direct to their handsets.

The new Time&Place service, from weather experts at the Met Office, can forecast with postcode accuracy within a five-kilometre radius and is network independent. It is also the first time SMS messaging has been used to send individual forecasts, and is being hailed as one of the first useful applications of mobile technology.

The service is available from the Met Office Web site at **<www.metoffice.gov.uk>**.

Top Ten UK Brands Inadequately Protected on Web

Some of the UK's largest companies are failing to adequately protect their domain names, according to research from NetNames, the UK's leading domain name registrar.

A survey of the UK's ten most valuable brands revealed that two had failed to register the .co.uk domain name, even though the companies were based in this country. None of the ten companies surveyed had registered common incorrect spellings of their brand names, leaving brands vulnerable to so-called 'typo-squatters', as well as missing out on potential customers.

Only three companies had bothered to register their domain name with the .net suffix, leaving their Internet brand open to cybersquatters, and of the four surveyed companies with two-word company names, only one had registered both hyphenated and non-hyphenated variations.

NetNames is launching its Domain Name Registration System (DNRS) - a total brand management platform, designed to help large corporations and law firms protect trademarks and brand names on the Internet.

The system, which can sit on a client's Web site, intranet, or be accessed directly via the Web at **<www.netnames.co.uk>**, will allow companies and individuals to search in real-time for availability of all 250 top level domains, including generic and country-code suffixes.

Phone Jeeves

Search engine Ask Jeeves at **<www.askjeeves.com>**, which is known for answering questions typed in via a Web site, is enhancing its system to accommodate questions posed over the telephone, using technology from Nuance Communications and General Magic.

The three companies are developing a system that responds to complete spoken sentences, rather than single-word commands or complicated voice mail-type systems. If it works, the Ask Jeeves system could help reduce the need for human operators at customer service centers, a major expense for companies worldwide.

Internet Statistics

- Just under 8 million people in the UK visited an e-commerce site.
- Rail chaos leads to growth in visitors to railtrack.co.uk.
- People gearing up for Christmas as price comparison site visits on the increase.
- The number of home Internet users in October was 10,149,000, up from 9,826,000 in September.
- October was the busiest month this year for visitors to e-commerce sites, with 7.9 million unique users visiting an e-tailing site during the month.
- Over half of these (4.4 million) went on to make a secure connection Tesco.com achieved its highest number of visitors to date, with almost 600,000 unique visitors in October.
- The popularity of price comparison sites continues, with the number of visitors to shopsmart.com growing by 200,000 in the last 6 months.
- Over 500,000 people visited railtrack.co.uk, which was the most visited transport site.

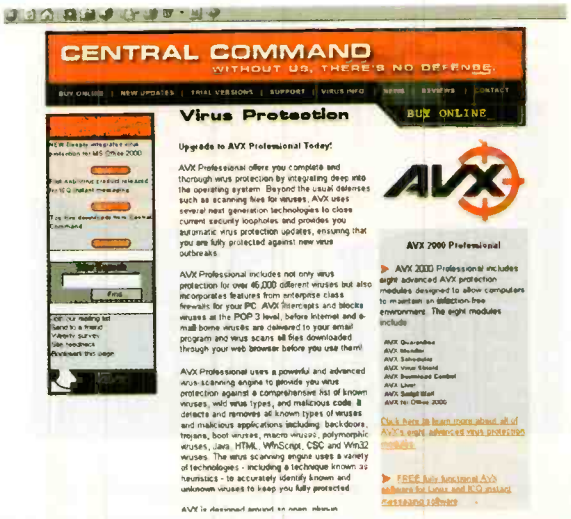
Exodus Announces Enhanced Web Site Testing

Exodus Communications at **<www.exodus.net>** has struck an agreement with United Devices to utilise their MetaProcessor platform for distributed computing technology to create a large real world Web site testing environment.

By tapping into and aggregating the computing resources of individual PCs connected to the Internet, Exodus Performance Labs, in conjunction with United Devices, will help customers determine whether their Web sites will be able to handle unexpected loads.

With this agreement, companies now have access to load testing that's as close to live as you can get because it uses real client machines in homes and small businesses around the world with real variants found in real life with the advantage of repeatability from scripted applications.

Anti-virus Preempts Malicious Virus Strikes



Central Command at **<www.avp.com>** has introduced AntiVirus eXpert (AVX), anti-virus software for Windows 95/98/Me/NT/2000, Linux, and Palm operating systems.

Combined, these versions make up a comprehensive anti-virus utility suite for all computer users. In addition, AVX Enterprise, a network management console also being introduced today, gives network administrators the ability to execute any anti-virus action throughout their networks, through any Web browser or a handheld Internet device.

When a malicious new virus emerges, such as the LoveBug, Melissa, or Chernobyl viruses, other anti-virus solution providers require the user to download a large upgrade file or patch.

But because AVX is designed around an open, plug-in architecture, a technology that easily allows additions of new features, upgrades are automatically downloaded from the Internet, bringing only the minimum of information required to automatically install and configuring the latest virus protection.

This technology reduces the risk associated with new virus outbreaks and eliminates the cumbersome duty of visiting an anti-virus developer's Web site every week to download and install the latest anti-virus patches and fixes.

CompuServe Unveils New Features for CompuServe 2000 Members

The new layout of the CompuServe at **<www.compuserve.com>** provides greater personalisation, allowing for quick access to information and services that members care about most throughout the day, including top news and sports headlines, weather, and local city guides that can be customised so that they appear directly on the Main Menu when members sign-on.

Also new, members will be able to take advantage of the new CompuServe Radio feature, which offers 17 channels of popular music formats, directly from the Main Menu, which is powered by Spinner.com. Additionally, members can easily purchase the music they are listening to directly from the CompuServe Radio feature.

SoftLock Unveils Digital Rights Management Service

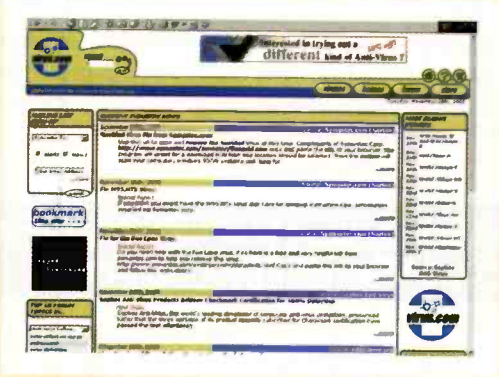
SoftLock.com at <www.softlock.com> has announced Version 3.0 of its patented digital rights management (DRM) service. Version 3.0 offers digital content providers a solution for the distribution of secure digital content.

SoftLock's Dynamic Content Locking a key feature of Version 3.0, enables digital content to be packaged, secured and distributed in real-time.

Dynamic Content Locking is an innovative approach to DRM, which allows consumers to order digital documents that are customised to their interests, packaged on the fly and delivered within seconds.

This technology allows content providers to focus on maintaining their content database rather than on the production and distribution of the final packaged product.

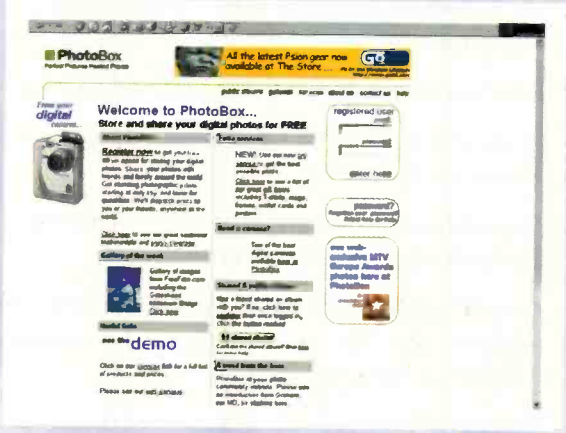
Command Software Unveils Web-Based Instant Virus Scanning



Calling it a new weapon in the fight against computer viruses, Command Software Systems at <www.commandcom.com> has introduced Command On Demand, the Internet's first online instant virus scanning and disinfection service for ISPs, ASPs and Web portals that is fully portable to UNIX, Mac, O/S, Linux, NT, Windows 2000 and Window ME.

The company has also announced that Virus.com at <www.virus.com>, a portal for virus information, will be using Command On Demand on its Web site under the name Virus Striker. The service will be sold to users on quarterly and yearly subscriptions.

UK's First Dedicated Photo Community Site Launched



QBeo has struck an agreement with London-based PhotoBox to make available a customised, co-branded version of QBeo's PhotoGenetics software on the PhotoBox Web site, located at <www.photobox.co.uk>.

The custom version of PhotoGenetics will be distributed as a download from the PhotoBox Web site. In addition, QBeo has also authorised PhotoBox to distribute a trial CD-ROM version of the application through photo retailers and direct mail.

e*ECAD Launches Internet Portal for Design Tools

e*ECAD at <www.eecad.com> has announced the launch of its worldwide Internet portal which delivers EDA tools on a pay-per-use basis.

e*ECAD's unique purchase and delivery system is the first to give customers a comprehensive suite of high-quality EDA software from multiple vendors with a very affordable pricing structure.

e*ECAD transcends traditional licensing methodologies to deliver next-generation solutions, eliminating geographical restrictions and the high costs of licensing and maintenance.

In addition, e*ECAD eliminates the traditional ASP shortfalls by offering tools that are downloadable to the user's machine. e*ECAD-enabled tools are not purchased by the year, month or even day, but rather on an elapsed run-time or pay-per-use basis.

Yahoo! Launches Buzz Index for Brand Marketers

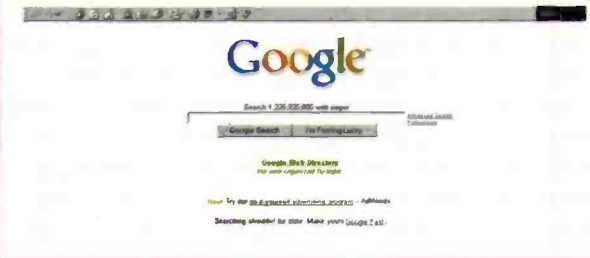
Yahoo! at **<www.yahoo.com>** has announced the launch of the Yahoo! Buzz Index, an interactive market research system developed by Yahoo! to measure public engagement with brands, products, people and technologies on the Internet.

Part of Yahoo!'s Fusion Marketing suite of services, the Yahoo! Buzz Index is calculated each week day and leverages the speed of the Internet by capturing trends nearly immediately, helping marketers to continually measure the effectiveness of their online and offline campaigns.

By aggregating and ranking the search queries of Yahoo!'s 166 million monthly users, the Yahoo! Buzz Index provides insight into the interests of the world's largest connected audience. Buzz is a measure of engagement, which is calculated when users search for terms and products on Yahoo!.

The Yahoo! Buzz Index allows marketers to measure and compare this engagement. Individual users and their searches remain anonymous.

Google Joins MyPalm Portal to Bring Content to Handheld Users



Google and Palm have announced that the Google search engine is featured in the new MyPalm portal at **<www.palm.com>**.

This agreement enables MyPalm users with a wirelessly enabled Palm handheld to search the Web with Google's fast, highly relevant search engine technology.

The MyPalm portal is designed to help make the handheld computing experience more fun and productive. The MyPalm portal enables users to wirelessly access personalised information without relying on traditional desktop-to-handheld synchronisation technology.

Ingenta Launches Enhanced Content Searches

Building on the acquisition of UnCover in March, ingenta has announced that access to the UnCover database is now live and available through ingenta's Web site at **<www.ingenta.com>**.

The addition of UnCover's content puts ingenta at the forefront of the research community by offering one of the largest Web article databases to date - over 11 million article citations and full text articles from journals and publications across the world - all available from one single point, and archived back to 1988.

ingenta's content can now be delivered in multiple formats, with expanded full-text delivery, users now have the option of PDF or HTML delivery direct from the popular UnCover database as well as the traditional fax article delivery.

In addition, ingenta has implemented its access control technology for corporate and library account authentication into the new UnCover service, allowing institutions to track subscription records and access journals they subscribe to free-of-charge.

Way2call Upgrades Hi-Phone Desktop

Way2call at **<www.way2call.com>** has upgraded Hi-Phone DeskTop. The single-line, client-based Hi-Phone DeskTop now supports caller ID, caller ID on call waiting, and enhanced voice energy detection for call centers.

Using the power of virtually any personal computer, the Hi-Phone DeskTop enhances regular analog telephones with advanced voice over IP capabilities. Users can manage sophisticated PSTN and full duplex IP calls over the Web.

WebTrends Awarded Patent for Web Visitor Analysis

WebTrends at <www.webtrends.com> has been granted US Patent Number 6,112,238 for its FastTrends database technology, which significantly reduces reporting time for analysis of large volumes of Web visitor data.

Developed specifically to speed analysis of massive amounts of Web traffic and eCommerce transaction data, FastTrends databases aggregate Web traffic information for faster subsequent analysis across time periods.

Once Web traffic data has initially been analysed by a FastTrends-enabled product, the analysis results are saved in FastTrends database cubes that can be aggregated and reported on across various time lines.

From that point on, whenever the data needs to be accessed, it is read directly from the FastTrends database rather than re-analysed from the raw data.

FastTrends technology significantly reduces reporting times while enabling analysis and reporting of Web traffic data in excess of a billion hits per reporting period.

e-SIM Launches LiveManuals.com Web Site

Helping consumers to master a wide range of consumer electronic, household and telecommunications equipment, e-SIM has launched a one-stop, customer support Web site at <www.livemanuals.com>, offering interactive, functional simulations and online manuals, comprehensive product support information for thousands of products, a product warranty tracker service, product comparison/e-commerce shopping for consumers and more.

The new site enables consumers to learn about and interact with electronics products in a fun and easy online environment. With the site's product support database, consumers can access comprehensive information for more than 10,000 products and experience simulations and access user manuals online from more than 40 manufacturers including Amana, Cobra, General Electric, Kenwood, Maytag and Zenith.

On LiveManuals.com, consumers can, for the first time, try a product online before they buy it. With e-SIM's proprietary simulation technology, they can interact with the product in free-play mode - the buttons, controls and features operate just like the real thing - or they can watch animated feature demonstrations to see how the product works.

Netscape Launches Netscape 6 Browser

Netscape at <www.netscape.com> has launched Netscape 6 browser, offering consumers a new choice, with unmatched convenience, the ability to stay connected to important information and unprecedented flexibility to shape their online experience to fit the ways they live, work, and communicate.

Netscape 6 breaks the mould by letting consumers choose how they use the Internet throughout their daily lives.

Rewritten from the ground up in an open source environment, it is a completely new browser with significant enhancements to Netscape's popular Internet suite of applications, including Netscape Navigator, Netscape Mail, Netscape Instant Messenger powered by AOL Instant Messenger, and Netscape Composer, as well as an array of new features and innovations. The streamlined new look also makes it faster, easier and more convenient to find and use the features and services consumers rely on most.

Netscape 6 lets users continually keep track of important information-like their personal calendar, Buddy Lists, stock quotes and sports scores-by choosing from among hundreds of customised tabs in My Sidebar.

Users can also personalise the look-and-feel of the browser to fit their individual styles by selecting from multiple Themes built by both Netscape and third parties.

In addition, consumers and business professionals can check multiple e-mail accounts, send and receive instant messages between family, friends and business associates, and even update their calendar right from My Sidebar. They can also save time and effort by searching for words, phrases and Web addresses in the Web address field from within the browser.

Record Numbers Visit E-Tailing Sites

The number of visitors to e-commerce sites grew to 7.9 million people in October, exactly one million more visitors than the previous month.

October became the busiest month this year for visitors to e-tailing sites, possibly fuelled by the pre-Christmas rush, and the growing consumer confidence in shopping online. 78.1% of all home Internet users visited an e-commerce Web site, with over half (4.4 million) going on to make a secure connection.

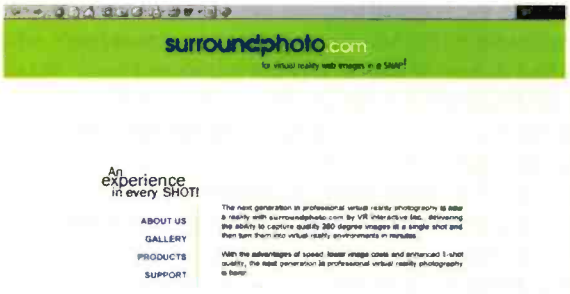
October was a good month for tesco.com, with more than 176,000 additional users visiting the site since September, and total visitors numbering just under 600,000. In terms of visitors to mall sites, tesco.com is still stickiest, with visitors spending an average of 15.9 minutes on the site, and displaying 36.9 unique pages.

Visitors to sites where consumers can compare prices online has risen over the last few months. This will come as good news for EasyGroup who have just announced the launch of their online comparison site, easyValue.com.

Shopsmart.com is the leading price comparison site in the UK, with the number of unique visitors growing by 200,000 over the last six months, to 466,800 in October. Their advertising relationship with bananalotto.co.uk has been an excellent way of driving traffic to the site: bananalotto.co.uk is the second most visited gambling site in the UK, and secured 629,000 unique visitors in October.

Railtrack.co.uk achieved its highest reach of the year so far, with over 500,000 Internet users visiting the site in October (5.2% of all home Internet users in the UK). The site, which was heavily used to access up-to-the minute rail information, beat britishairways.com and easyjet.com to become the most visited transport site.

VR Interactive Introduces Virtual Reality Photography



VR Interactive has introduced Surroundphoto.com at **<www.surroundphoto.com>**, a new product that delivers the next generation in professional virtual reality photography technology.

Surroundphoto.com allows users to create 360 degree vistas in any environment, indoor or outdoor. Using its unique image enhancing reflector that simply attaches to the base of most digital cameras, the Surroundphoto.com system captures a circular image that can be immediately processed on the user's computer.

The user is then able to view the image on any Web browser and navigate around the image by a click of the mouse.

Immersion Unleashes Stuntdog in Kinetic Capers

Immersion at **<www.immersion.com>** has announced a new animated Web showcase named Kinetic Capers featuring Stuntdog to demonstrate the potential of tactile human/PC interactions.

Stuntdog and Rat were created by Animatrix, a San Francisco-based interactive design firm using creative consultation from Chuck Gammage creator of the well-known characters for the movie Space Jam and Roger Rabbit from Who Framed Roger Rabbit?

Stuntdog is a compelling example of truly interactive Web content, allowing computer users to experience tactile sensations for the first time, in addition to graphics and sound.

With an Immersion TouchSense-enabled computer mouse, such as the Logitech iFeel Mouse, a person can interact with dozens of sophisticated tactile interactions while viewing Kinetic Capers. These tactile interactions range from feeling the physics of striking a match to walking a springy tightrope as the animation follows Stuntdog and Rat through a series of impact-driven actions.

Seven New Top-Level Domain Names

The Internet Corporation for Assigned Names and Numbers (ICANN) at **<www.icann.org>** has decided to add seven new top-level domain names for Internet addresses:.info, .biz, name, .museum, .aero, museum, and .coop.

The first two will be for general use, with biz expected to relieve the pressure for businesses to find a unique name within the popular .com domain, which now has 20 million sites; pro is intended for professionals, such as doctors and lawyers; .name will be used to designate personal Web sites; .museum will be restricted to museums; .aero for airline groups; and .coop for business cooperatives. ICANN did not give its approval to other domain names that had been proposed to it, including .web, .kids, .xxx, .union, .health, .travel, and geo.

Web Portal Offers UK's Innovators a Helping Hand

Budding innovators can learn how to make the most of their ideas and protect themselves from counterfeiters thanks to a new Intellectual Property (IP) Web site launched by Minister for Consumer and Corporate Affairs Dr Kim Howells at **<www.intellectual-property.gov.uk>**.

The site provides a comprehensive resource for businesses and inventors, with information on copyrights, trade marks, patents and designs. Users will be able to find answers to frequently asked questions, view the latest news and link to other IP-related sites.

Special sections deal with IP as it relates to business, education and entertainment and there is information on how to profit from IP.

The site will also help people with concerns about using the property of others, for example by sign-posting them to the correct place to obtain a license. There is information for both people with little knowledge of IP and more experienced users.

Sick of Junk E-Mail?

Mailshell.com, the free guide to thousands of free email and Web services along with free protection from junk email and spam, today unveiled the world's first free, single, simple, spam-free email address for life.

Internet users can now simply type nojunk@mailshell.com in lieu of their real email address whenever they want to submit or request information from any Web site, thereby eliminating the fear of unleashing waves of junk email in return.

When users enter this universal email address, Mailshell automatically creates a new, separate, private and disposable proxy email address called a 'mail shell' which is submitted in lieu of the user's real email address.

The 'mail shell' is a fully functioning email address that is created dynamically, in real time. The process is transparent both to the user and the Web site receiving the 'mail shell' address.

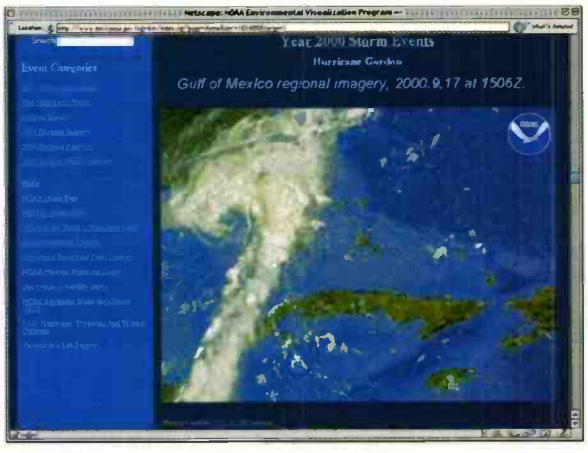
Users can opt to receive the resulting incoming content forwarded to their existing email inbox or stored on their own Mailshell Web-based email accounts. Mailshell's service is completely free and requires no downloads, reconfiguration or changes to users' existing email set-up.

Users can currently access this feature through Mailshell's proxy server, and the company plans to make the feature widely available through open-source code.

Mailshell also creates customised versions of the 'nojunk' feature for ISPs, email providers and companion tools seeking to reduce their users' frustration with junk email.

Site Survey

Destinations of the month



They say that we're a nation that loves to talk about the weather, and given the atrocious varieties of it we've been having lately, there's no wonder it's been central to many of our lives these past few weeks. As such, it's high time we considered here how the Internet can be used to find forecasts and keep us informed as to what's heading our way. Here are several Websites that can provide up-to-the-minute weather reports.

Start with the National Oceanic and Atmospheric Administration's (NOAA) site at: **<http://www.noaa/gov>**, where you'll find dozens of links to services maintained there. NOAA is naturally US biased, but the information is interesting anyway.

The Weather Channel, at: **<http://www.weather.com>** allows you to link to any area worldwide, as does the Weather Underground at: **<http://www.wunderground.com>**, and the Weather Report at: **<http://www.weather-report.com>**. Finally, we mustn't forget our own Met Office, at: **<http://www.meto.govt.uk>**.

DSP HANDS-ON

A Review of Texas Instruments TMS320C5402 DSP Starter Kit by Mike Bedford

Last month we carried an introduction to digital signal processing. The article was aimed at those engineers with no previous experience in the field who had, perhaps, formerly considered it a complicated and very specialised discipline. Hopefully a number of readers have now realised that DSP needn't be for the experts only and have been inspired to learn a bit more about it. One of the best ways to learn about DSP is to get your hands dirty writing some code and trying it out. And one of the easiest ways to do this is to use a starter kit. One such kit is Texas Instruments' TMS320C5402 DSP Starter Kit, a product which I take a look at in this article.

Overview

The kit comprises the main board, a mains power supply and a parallel port cable. You also get the associated software which will run under Windows 95 or later with a minimum of 16KB RAM, 100MB hard disk space, and a Pentium 133MHz processor. A block diagram of the board is reproduced here. You'll see that, in addition to the DSP together with its SRAM and flash memory, the board contains a parallel port for uploading software from a PC, audio input and output connectors with their associated filters, ADC and DAC, a telephone socket for developing telephony applications and a serial port.

Code Composer Studio

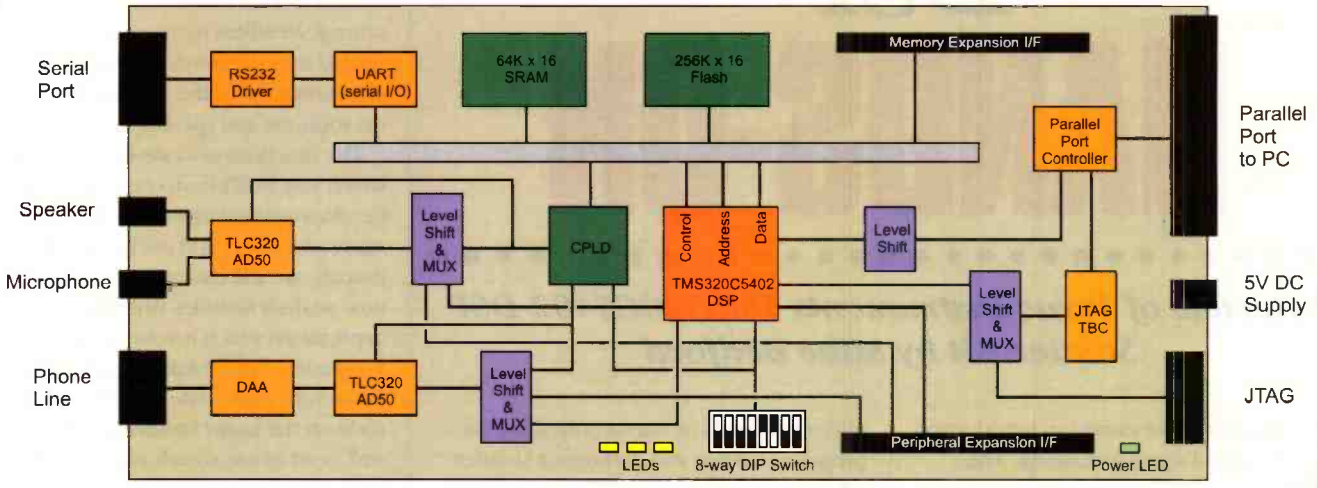
The software provided with the kit is TI's Code Composer Studio which provides facilities for program building, program debugging, real-time data analysis, and data visualisation. If you've used other development environments for microprocessors or microcontrollers, the program building and debugging facilities are much as you'd expect. So there's both an integrated C compiler and an assembler for the TMS320C5402 and the source code appears colour coded to make it easier to read and to interpret. So, for example, one colour is used for language keywords, another for comments and another for assemble directives. Multiple files can be open at the same time and multiple windows can also be used to provide different views of the same source file. TI claim that their C compiler produces highly optimised code, something which is clearly essential for processor intensive real-time applications. Having compiled and/or assembled the source code files, the linker is used to combine these and any libraries to generate executable code. Once the program is ready to be put through its paces, it can be emulated in Code Composer Studio and here the usual range of debugging facilities are provided. So, for example, you can set breakpoints, you can single step, you can interrogate and modify memory locations, or you can just run it as normal. Needless to say you can also upload it to the development board to try it out connected to the real world (e.g. a microphone and speaker).

The functions of Code Composer Studio which you won't have come across in development environments for microprocessors and microcontrollers, though, are the data visualisation and real-time analysis features. And with applications which involve signal processing, just looking at data values is frequently inadequate. Prior to running the code on the target hardware, you could well need to see signals plotted against time. But Code Composer Studio does far more than just this. In addition to simple plots such as ones of amplitude against time, Code Composer Studio can also show constellation plots, eye diagrams and FFT waterfalls. Another sophisticated feature is that, once the application is running on real hardware, as opposed to in the emulator, it is still possible for Code Composer Studio to analyse its behaviour in real time.

Hands-on

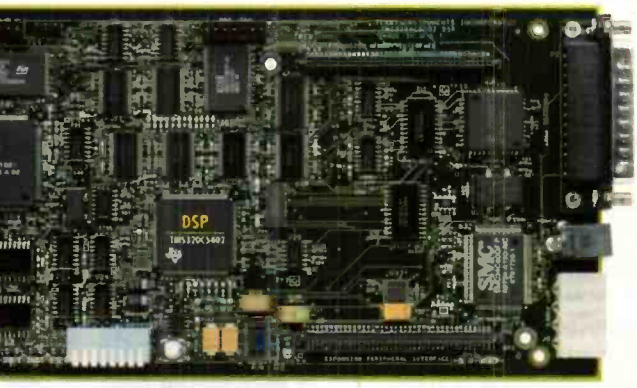
So that's what the development kit is supposed to do but how did I get on with it? Unfortunately, I have to report that I didn't make as much progress in the time available as I had hoped. First of all, when I first installed the software on a PC and connected up the development board, Code Composer Studio refused to run, claiming that it couldn't initialise the board. Suspecting some sort of software conflict I installed the kit on a second PC with exactly the same result. At this point I had to resort to TI's technical support and waited two working days plus the intervening weekend for a response. Having checked that I'd done all the obvious things correctly, TI came to the conclusion that there must be a hardware fault and arranged for me to be sent a new kit. The second kit – this time a working one – arrived about ten days later.

The second disappointment, in view of the limited time available after having had the first kit replaced, is that there's a long learning curve. TI tell me that they expect most people to gain their first experience with this kit on a formal training course. And this is reasonable for an engineer who

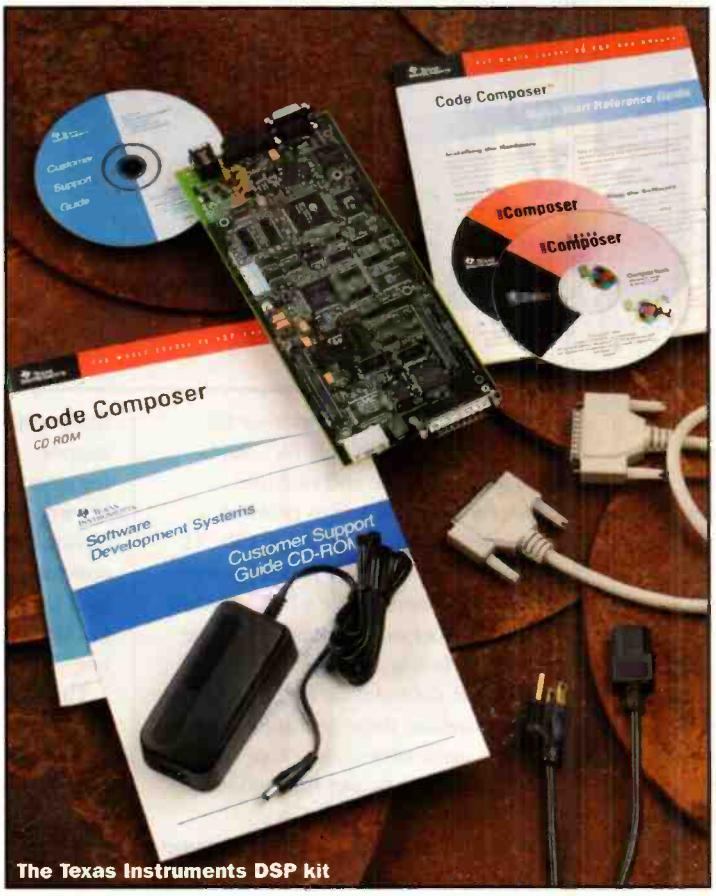


Block diagram of DSP

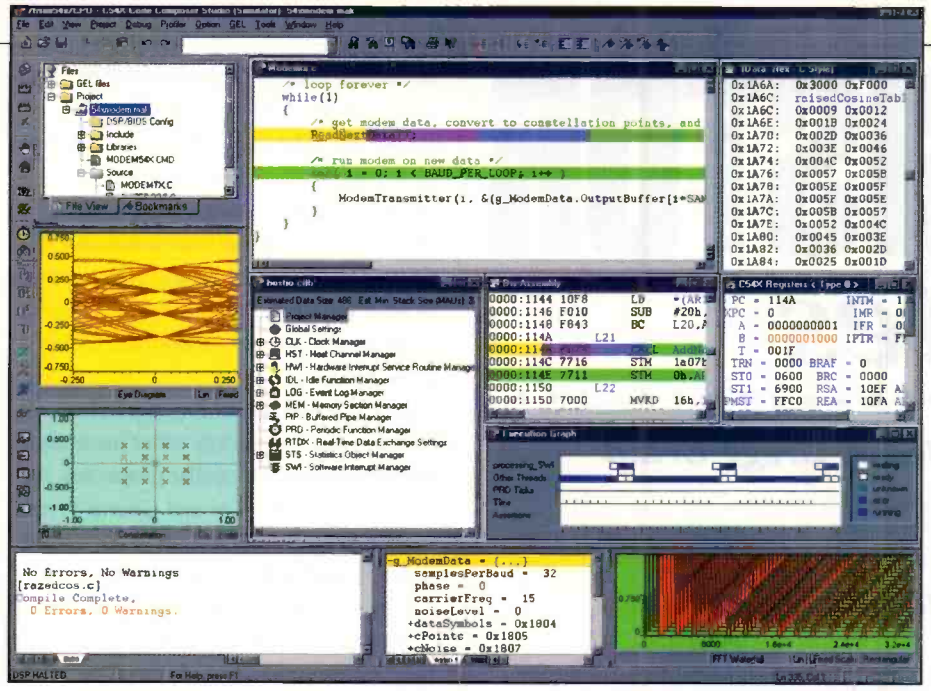
is embarking on a project using TI DSPs. But for an engineer just wanting to improve his general level of education, let alone a hobbyist, the cost of a course, typically quite a few hundred pounds plus travelling and accommodation expenses, just couldn't be justified. And in this case you'd be on your own as I was. I had rather hoped that the kit would come with lots of working examples which you could first run on the board and then modify to do something slightly different. This is undoubtedly an easier approach than writing your first program from scratch and many of the microprocessor development kits I've used previously do, indeed, come with plenty of working examples. Well, there are quite a few examples with Code Composer Studio and there are tutorials which refer to them. However, many of these examples and tutorials, while allowing you to learn to use the development environment, don't actually exercise the development board. Instead, they perform trivial tasks such as writing messages to the host system so that they appear in a Window on the PC and, as such, will run in the emulator. There are, nevertheless, a few examples which do purport to exercise the hardware which forms part of the kit. The first one I tried is called BLINK and it simply cycles the three LEDs on the board. I tried it – it worked – and this gives you the opportunity to try out the various debugging facilities, to investigate the code and so on. Personally, though, I couldn't get too excited about this example since it can't be considered a DSP application at all – it's the sort of thing you could do on a 50p PIC processor and a handful of lines of code. The second example I tried is called CODEC and this program is supposed to sample the microphone input and re-write the signal to the speaker output. Once again not wildly exciting but at least it is a DSP application, at least it does exercise the hardware, and it would have been a good starting point for modification and hence education. You'll notice that I said CODEC "is supposed to" echo the microphone signal to the speaker. The fact is that it doesn't, complaining of invalid addresses. For someone who is already familiar with this kit, I'm sure it would be trivial to get this to work. For someone who's just starting out, though, and who expects example software to work,



View of the complete board



The Texas Instruments DSP kit



Screen shot of Code Composer Studio

this really is the last thing you want. And every other example program I tried seemed to exhibit the same sort of problem as CODEC.

Obviously the kit does work, even though I was only able to prove it on a trivially simple microcontroller-type application. And if you want to gain some experience of DSPs in general or of the TI TMS320C5402 in particular, this would be a good place to start. And for a professional starter kit complete with Code Composer Studio, this really isn't too expensive a solution. Some real, working DSP examples would have been nice, though. And since you don't get these, expect quite a few days of dedicated effort before you start to become comfortable with the kit. So long as you've previously done some programming, and are familiar with debugging concepts such as breakpoints and single stepping, though, I'm confident that you will eventually get your own programs up and running. Having done this, you'd then be in a good position to design your own DSP circuits and write the necessary code to get them to perform useful tasks. And do bear in mind, as you get to grips with DSP, that Electronics & Beyond is keen to publish practical projects involving digital signal processing.

Availability

The development kit is available from the following distributors. Typically, the price is £208.30 + VAT. The product code is TMDX320005402.

Arrow Jermyn, 01234 270027, **<www.arroweurope.com>**
Avnet Macro, 01628 606000, **<www.macro.co.uk>**
Avnet Electronics Marketing, 01438 788500, **<www.em.avnet.com>**
EBV, 01628 783688, **<www.ebv.com>**

It can also be ordered online from the **Dspvillage.ti.com** website (NB no www).

TRANSISTOR Tales

A series of three tales by Gregg Grant

PART 1

The Crystal Maze

Silicon is coming to the end of its usefulness as an Integrated Circuit (IC) manufacturing material. Already there are hints that the new substance Gallium Nitrate could well replace it in this role in the near future. It's time therefore to look back at a material which came to prominence only 50 years ago, yet in that period has completely revolutionised a century-old technology.

Early Days

Semiconductors quite literally run our lives. In fact life as we know it would be quite impossible without them. In cameras, night-vision devices, facsimile machines, TV cameras, medical electronic equipment and home entertainment generally, the semiconductor calls the shots.

There are a trio of properties that distinguish semiconductors from insulators and metals. These are ' . . the negative temperature coefficient of resistivity, the photo-electric effect and the use of semiconductors to achieve rectification.' [1] All of these properties - as table one shows - were discovered in the 19th century, but only thoroughly understood in the late 1940s.

In 1880, the French physicist Pierre Curie discovered that certain substances produce an electric current, as a result of pressure being applied to them. Conversely he found that, if he applied an electric current to the substances, their dimensions changed slightly. Furthermore, if the electrical potential applied varied rapidly, the substance would expand and compress in tune with this change. This effect Curie termed Piezo-electricity, from the Greek word for pressure.

Pierre Curie had used quartz in his experiments, but shortly other materials were found to have similar properties, for example Rochelle Salts and Galena; Pryon or Iron Pyrite and Chalcopyrite, or copper pyrite, a sulphide of copper and iron, in fact the commonest ore of copper.

By 1906, the new technology of radio had been firmly established, although for anything approaching reliable communication, a sensitive receiver was crucial. More importantly, the vital component in the receivers of the day was the detector, the device that untangled the intelligence - speech or music - from its carrier, the radio frequency signal. The radio engineers of the day spent a great deal of both time and money trying to make these detectors as sensitive as possible.

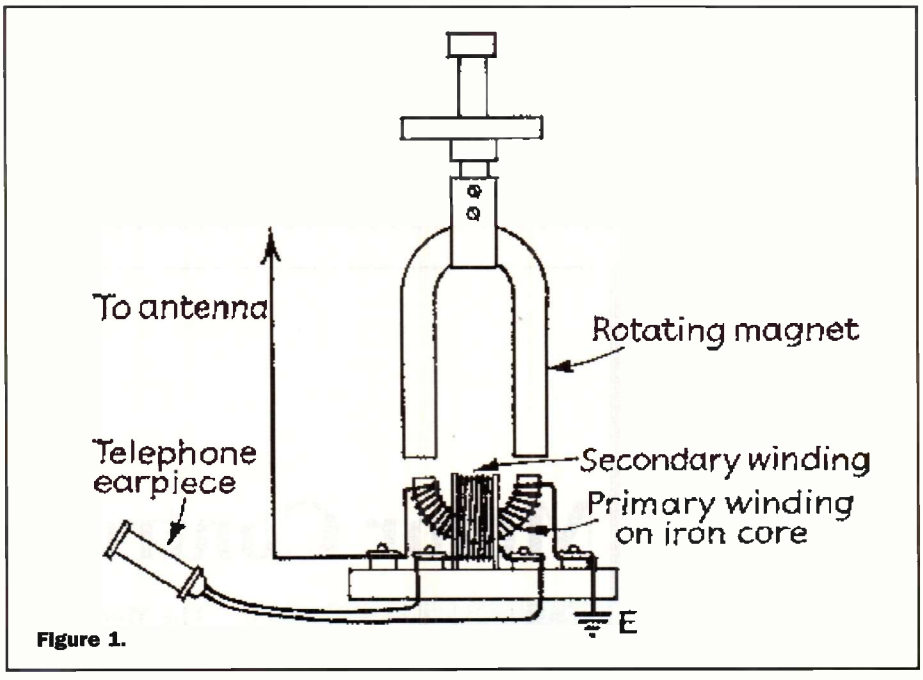


Figure 1.

Year	Discoverer	Discovery
1833	Michael Faraday	The negative temperature coefficient, which he noticed in silver sulphide.
1839	A.E. Becquerel	Observed a photo-electric voltage in an electrolyte.
1873	Willoughby Smith	Observed a photo-electric current in selenium.
1874	Ferdinand Braun	Observed rectification in some crystals, in his case metallic contacts to pyrites and galena.

Table 1: Early Semiconductor Discoveries

The Marconi Detectors

In 1895, the physicist Ernest Rutherford built a device capable of detecting radio signals over a distance of around ¾ of a mile. Five years later he proposed another form of detector, this time employing a moving band of steel tape, which could record the incoming signal.

Rutherford's work came to the attention of Marconi and, in 1902, the radio pioneer

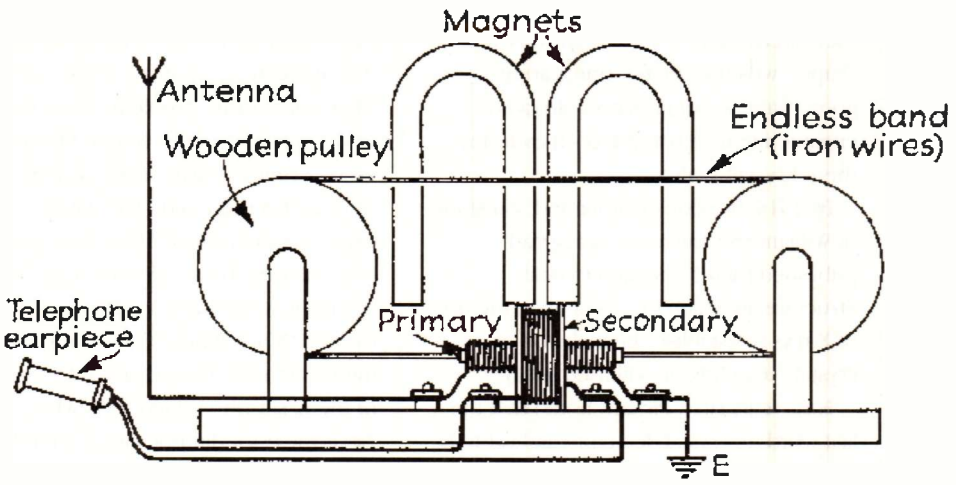


Figure 2.

began experimental work to produce a commercially viable detector, based on Rutherford's research. The result was the detectors shown in Figures 1 and 2. The earlier of the two designs used a rotating magnet and stationary coils, whilst the second attempt was - in its way - a far more practical version of Rutherford's origination.

Known as the Magnetic Detector, this development '. . used an endless band of soft iron wires stranded together but insulated from each other, moving slowly past the poles of a pair of stationary permanent magnets.' [2]

As the internal clockwork drive moved the wire-band at around 7.5 centimetres/second (cm/sec), it was partially magnetised, due to the speed of the movement of the wire-band. On receipt of a signal at the antenna, the hysteresis of the primary coil was cancelled, it becoming fully magnetised with the lines of force appearing at a point opposite the magnet's pole pieces. This induced a current in the secondary winding, which fed the receiving headphones.

Marconi's 'maggie' as it rapidly became known among maritime radio operators, finally did for the earliest of detectors, the less-than-efficient Coherer. As a result it became a company standard, remaining in use for almost two decades.

Pickard and Perikon

In America too, research into the detection of radio signals was being pursued with the same drive and vigour that the Marconi company was giving to the matter.

In 1902, the American Wireless Telegraph and Telephone Company - the first such commercial outfit created in the United States - built two radio stations in New Jersey, one at Cape May and the other at Atlantic City. They also equipped a schooner, the Pleiades, with radio equipment so as to carry out experiments in radio communications.

The company also employed a 25-year old Massachusetts Institute of Technology graduate, one Greenleaf Whittier Pickard, to oversee these experiments. This would be the beginning of a long, determined search for a consistently reliable signal detector.

Pickard began by using a carbon-steel detector - like the one shown in Figure three - before turning to oxidised steel. In July 1902, he found that putting pressure on the steel contact of his detector increased the received signal strength and, at the same time, appeared to reduce the accompanying noise. There was a problem however: the oxide coating was very thin and so easily penetrated.

By October, Pickard had hit on the idea of using magnetite instead of oxidised steel, which further improved reception. This convinced him that the use of oxides - magnetite, or lodestone, is a natural oxide of iron of course - was the way to go where signal detection was concerned.

This was the beginning of a quest that would be thorough. By early 1904, Pickard had already investigated selenium and lead oxide among other substances and recorded how the successful substances shared a common factor: they all had high specific resistance. By autumn, he'd added Chalcopyrite, Iron pyrite and Galena to his list of materials investigated.

Having read of a new product on the market - fused silicon - in December 1905, Pickard attempted to get hold of this material, feeling that a substance formed by the high temperature of an electric furnace

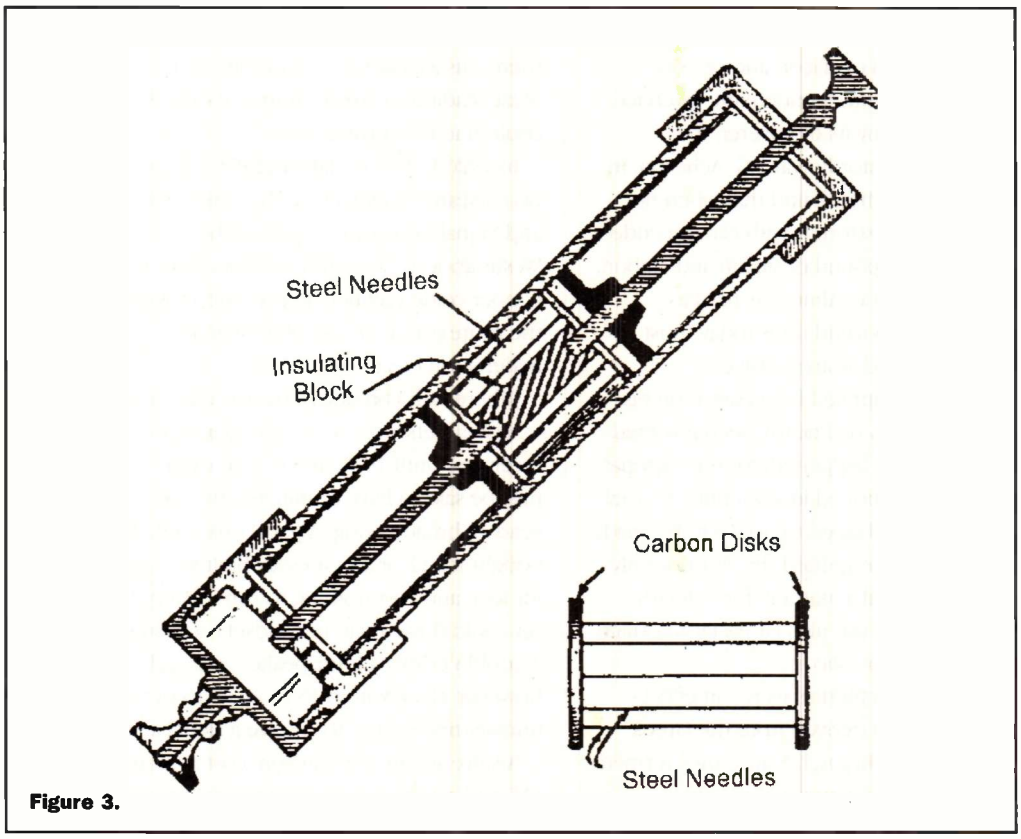


Figure 3.

would be very stable indeed. However, eight months passed before he was successful.

As Pickard had surmised, silicon proved to be the best of all the crystalline materials he'd tried so far. In 1907, he formed his own firm, the Wireless Specialty Apparatus Company, to market his silicon detectors on which he'd taken out patents.

In all, Greenleaf Pickard investigated no less than 31,250 combinations of substances in his search for a reliable detector. He even consulted the American mineralogist Richard Dana's 580-page masterwork A System of Mineralogy, in his search for substances, which could possibly be of use.

Consequently, his company marketed other detectors made from Pryon and Perikon, a detector consisting of zincite in contact with chalcopyrite. The word was an acronym, derived from PERfect pIcKard cONtact.

A General Takes A Hand

On the 26th March 1906, a retired American army general called Henry Dunwoody - who was working for the De Forest Wireless Company - announced his development of the Carborundum detector, an example of which is illustrated in Figure 4. This marked a new departure in electrical materials, flagging up '. . the existence of solid substances which did not obey Ohm's law, and which soon led to the development of a variety of forms of crystal detector which were to challenge the supremacy of the magnetic detector in no uncertain manner.' [3]

A compound of silicon and carbon, Carborundum was a trademark, given to the substance by its discoverer, the American inventor Edward G. Acheson, in 1891. Acheson had found that when he heated carbon strongly with clay, he ended up with a compound of silicon and carbon, or silicon carbide. Almost as hard as diamond, Carborundum is today most commonly used as an abrasive.

Dunwoody applied for a patent on his detector, which had nearly been invented by Pickard as it happened, for the material had been mentioned in a scientific journal but Pickard had failed to notice it. He made it plain that he regretted this, for not only was the material a 'natural' for detector experiments, it was also far easier to obtain at that time than silicon.

All of these materials were - in effect - crystals, a word derived from the Greek word for frost, Kryos, because they termed the symmetrical patterns they saw in snowflakes and hoarfrost Krystallos.

Another aspect of ice noted by the Greeks was its transparency. Consequently, when they discovered rocks with symmetrical shapes, which were also transparent - a good example being that staple radio engineering material quartz - they termed them Krystallos also.

By 1915, the British father and son team of William and Lawrence Bragg had published their X rays and Crystal Structure, in which they described the use of X rays to establish the make-up of crystals, a technique still used today.

Four years later, Pickard noted that the last word on crystal detectors had yet to be written. In fact most of the crystalline substances already looked at were employed in the emerging communication/home entertainments field, and a number of engineers sensed that there was a clear way out of this crystal maze leading to greater things, if only they could find the turning point.

In 1926 L.O. Grondahl and P.H. Geiger, two research engineers at the Union Switch and Signal Company - a part of the Westinghouse Corporation - invented the copper oxide rectifier, an early step towards the more extensive use of crystalline materials in electronics.

Where radio broadcasting was concerned '. . crystal sets were to outnumber (valve receivers) until 1927, and to that extent may be said to have dominated the early years of broadcasting. A good one could be bought for £2 or £3, or easily built at home for less, and cost nothing to run.' [4] A crystal set could drive a pair of headsets, although it couldn't drive a loudspeaker. You had; however, to be within 15 to 20 miles of the transmitting station to receive a signal at all.

A valve set, by comparison, cost at least £15 and required a new High Tension, or HT battery every few months. On top of this, the two - or sometimes three - lead-acid accumulators providing the Low Tension, or LT, current for the valve heaters needed recharging on a weekly basis. There were other problems too; one of which was valve replacement. One of the most common valves of the period - the R valve as it was termed - had a life expectancy of around 100 hours only.

No matter, the development of the electronic valve was a big improvement over the 'Cat's Whisker' and so scientific interest in semiconductors - even the best of them, silicon - waned somewhat. Nevertheless it did not vanish entirely and the increasing use of crystalline substances spurred further scientific - as opposed to engineering - investigation into the mysterious world of these materials.

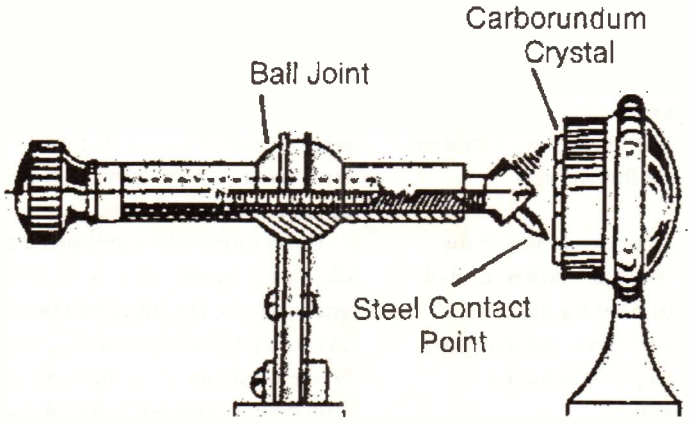


Figure 4.

Given the extensive use of crystal sets at this time as well as the number of amateur radio enthusiasts, it seemed surprising that no-one did successfully navigate the crystalline maze, at least superficially. Yet it would be wrong to imply that there was no attempt at advancement. In the five years between 1926 and 1931, much of the theoretical concepts of semiconductors were developed and it's this facet - among others - we'll look at next month.

References

1: Atherton, W.A. (1984): From Compass to Computer. San Francisco Press Inc., San Francisco. Ch 10, Page 237.

2: Baker, W.J. (1970): A History of the Marconi Company. Methuen & Co., Ltd. London. Ch 7, Page 75.

3: Ibid [2], h 13, Page 120.

4: Geddes, Keith & Bussey, Gordon (1991): The Setmakers: A History of the Radio & Television Industry. BREMA, London. Ch 1, Page 16.

Excursions INTO EXCEL

PART 4

by Mike Bedford

For the last three months, now, I've presented examples of the types of scientific, mathematical, and engineering tasks that can be performed using Excel. And, by now, a few of you are, hopefully, starting to realise that it's far more than a tool for accountancy and business graphics. If so, it's reasonable to assume that some of you are already using it for technical applications. Before we go too far down this path, though, and before you've created too many Excel masterpieces, there's a topic I really ought to cover – that of documenting Excel workbooks. Let me explain what I mean by this.

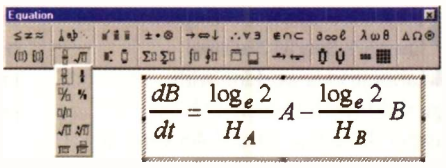


Figure 1.

Good Programming Practice

For the moment let's forget about Excel and turn our attention to a programming language such as BASIC, C++, or PIC assembler code. If you've ever written a computer program you must surely have had the experience of returning to one of your own creations a few weeks, months or years later, and not being able to figure out how it works. What was obvious when you wrote the program is now as clear as mud. And if the reason for returning to the program is to find a bug or to add some new functionality, not knowing how it works is a major disadvantage. What's more, if even the author of software has difficulty in understanding it at a later date, the chances of a third party being able to get to grips with it are even more remote. This is why students on programming courses are always taught to document their programs. This involves putting comments into the programs. These textual messages are ignored by the compiler or assembler but explain the purpose of each line or each section of the code, indicate what each variable represents and so forth. Admittedly, understanding an Excel workbook isn't as difficult as understanding a few thousand lines of assembler code, in fact it's blatantly obvious how most work. Even so, the types of application we're looking at in this series are not run-of-the-mill and it's quite feasible that you'll have difficulty in understanding how your workbooks operate when you return to them after a break. Adequate documentation is, therefore, highly desirable. And if you intend to share your work with others it's a must. In fact, I'd go further than this. A computer program source file is pure ASCII text so the scope for doing anything particularly stylish is limited.

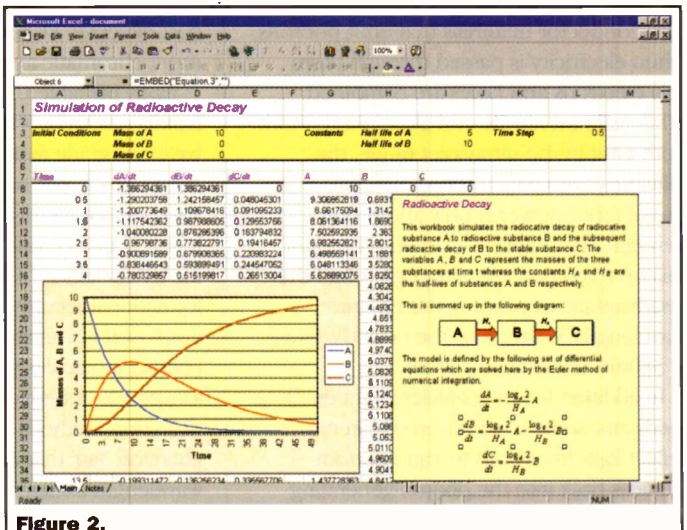


Figure 2.

Excel, on the other hand, provides lots of scope for making a workbook look good. My suggestion is, therefore, that you don't just do the minimum necessary to explain how a workbook works but that you format it in a way that makes it pleasant to read.

Formatting Options

OK, that's enough of the soap box stuff – now to some practical suggestions. First of all the obvious ones. Give your workbook a title that appears at the top of the page. Use the formatting options such as the font, the size and the colour to make that title stand out Give titles to the row and column headings, once again using formatting as appropriate. Include a short textual description which explains what the workbook does. As an alternative to entering the text into a cell, with all the formatting difficulties this brings, you could use a text box that is created from the Drawing toolbar. Text boxes float over the workbook and can be dragged around and resized in the usual way. Alternatively, if you don't want to clutter up the workbook unduly you could use Excel's comment feature, which causes a comment box to open up, when you move the cursor over the cell to which the comment is attached. The commented cell is highlighted with a red triangle in the corner and typically you'd enter something like "see here for further details" in the cell itself. Since we're dealing with scientific and mathematical applications, adding equations will be a common requirement and, fortunately, Microsoft Office comes with an equation editor which can be used from within any of the applications. To add an equation, select Insert > Object... > Create New and then pick "Microsoft Equation" from the "Object type:" list box. If Microsoft Equation doesn't appear then this option hasn't been installed on your PC and you'll have to install it separately. Like text boxes, equations appear in boxes which float over the text. The boxes also have black outlines by default but these can be removed under Format > Object. And although you can't embed an equation within a text box, you

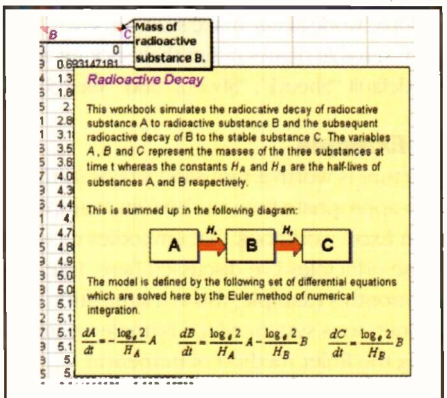


Figure 3.

can float an equation over the top of a text box so that the equation appears to be a part of the text. Finally, you might also want to include line diagrams or even photographs in your workbooks. For simple line drawings you could use the drawing facility which is provided in Excel. However, for more complicated diagrams you might choose to use a separate fully featured drawing package and then import the drawing into Excel.

The documentation we've seen so far is intended to be read by whoever uses the workbook. However, it's also appropriate to add more detailed documentation, perhaps explaining how it's been implemented, to help anyone (including yourself) who might need to modify it in the future. Ideally, though, this isn't the sort of documentation you'd want cluttering up your main worksheet. Fortunately, therefore, Excel workbooks can include multiple worksheets and three are provided by default when you create a new workbook. One option, therefore, is to include all the behind the scenes implementation information in a separate worksheet. If you make use of multiple worksheets, make sure you give them sensible names rather than sticking with the default "Sheet1", "Sheet2" and "Sheet3".

An Example

A picture is worth a thousand words so this is an appropriate time to show an example of an Excel workbook that embodies most of the principles I've discussed here. Like last month's example, this is a simulation of a continuous system which is implemented using the Euler method of numerical integration to solve the differential equations. This should all be familiar to you so you can concentrate on this month's theme, namely the way in which the workbook has been documented. All you need to know about the example, therefore, is that it's the simulation of radioactive decay in which radioactive substance A decays to produce radioactive substance B which, in turn, decays to give the stable substance C. The following equations define the model:

$$\frac{dA}{dt} = \frac{\log_e 2}{H_A} A$$

$$\frac{dB}{dt} = \frac{\log_e 2}{H_A} A - \frac{\log_e 2}{H_B} B$$

$$\frac{dC}{dt} = \frac{\log_e 2}{H_B} B$$

where A is the mass of substance A, B is the mass of substance B, C is the mass of substance C, H_A is the half life of substance A and H_B is the half life of substance B.

Ultra Violet LASER

By Reg Miles

Researchers at the US Department of Energy's Sandia National Laboratories working with colleagues at Brown University have demonstrated the first ultra violet vertical cavity surface-emitting laser (VCSEL - pronounced 'vic-sel'). The team leader, Jung Han, said: "Many groups are racing to create such lasers in the UV range. It was a dream, yet distant. Now we have achieved it."

At present the UV VCSELs are powered by bigger, conventional lasers, using optical pumping. The next step is electrical pumping, a more commercially useful way to power such devices. This will require developing connectors that will transmit electricity to the microscopic lasers. Han expects his group to demonstrate this capability in one to two years.

So far the project has been running for three years. And it was only in 1999 that it advanced significantly - when indium was added to the VCSEL materials. VCSELs are made of nanoscopically thin layers of semiconductor materials that emit photons when electricity is passed through them and electrons and holes are combined. While gallium nitride and aluminium nitride both emit in the ultraviolet range, the efficiency with which those materials make use of input power is only about one percent. The addition of indium brought this up to 20 percent; although it had the disadvantage of pushing the emitted wavelength further into the near UV range at 380nm rather than 400nm.

In addition to being efficient light emitting mediums, some of the layered materials reflect light from both top and bottom surfaces back into the photon-generating area to facilitate the release of still more light, just as do conventional lasers. The successful synthesis of highly reflective bottom mirrors (or distributed Bragg reflectors - DBR) from aluminium-gallium-nitride was another important factor. Sandia normally uses titanium oxide as a top DBR; but because that absorbs light below 450nm Hafnium oxide is used instead. Sandia is apparently one of the leaders in developing and improving VCSELs - which now exceed 50 percent efficiency in infrared and red.

One of the major applications for UV VCSELs will be for lighting, using a phosphor coating like a fluorescent tube. Such solid-state emitters are predicted to last five to ten times longer than fluorescent tubes and be far hardier. And as each chip containing several hundred VCSELs will only be the size of a postage stamp, they can be arranged in any configuration, and be placed anywhere that electricity can reach (presumably from a battery, as well as from AC mains?).

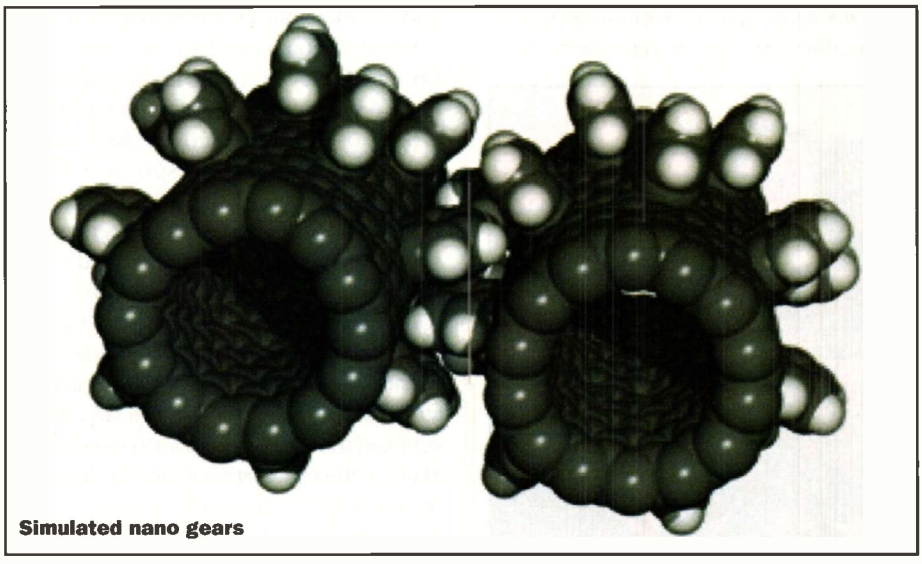
While many possibilities exist to produce white light from semiconductors, VCSELs are thought to be a leading contender for several reasons. Blue LEDs that are already commercially available produce white light through phosphors, but it is a cold white; combinations of red, green and blue LEDs can produce white light, but may not be cost effective. VCSELs create a more monochromatic and directional beam.

Easily portable UV laser light also interests Sandia researchers because it causes weapons grade fissionable materials and dangerous E. coli bacteria to visibly fluoresce. "No one before this has achieved the technology to create a compact laser source for UV excitation,' Han said. 'It is important for national security because many agents employed in chemical and biological warfare contain molecules which do not respond to longer wavelengths of light." Current detection methods require adding a chemical 'tag' that responds to longer wavelength excitation, which is apparently time consuming and expensive (a case of paying the price for much of what has been developed by other US researchers working in the chemical and biological warfare field!).

For additional information contact:
Neal Singer, <nsinger@sandia.gov>
Tel:(505) 845-7078

Electronic Circuits OF THE FUTURE

By Douglas Clarkson

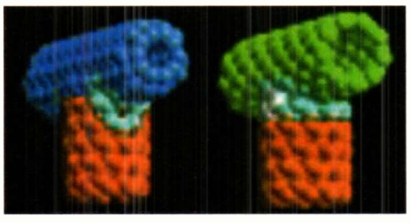


Simulated nano gears

Performance levels in microprocessor circuitry are forever on the up. And to fulfil some of these needs, the current generations of researchers are thinking about creating smaller and smaller scale electronic circuits in order to achieve these levels of performance. Since the physical world presents such amazing diversity at smaller and smaller scales of physical organisation, a broad range of technologies are being investigated to maintain the momentum of technology - with some already being demonstrated while others reside firmly in the domain of cutting edge research. It does look, however, as if through one mechanism or another, there will be at least another generation of rapid technological innovation and indeed one that may use a more diverse range of technologies than the largely silicon based era we have all experienced.

Silicon as used in semiconductors has dominated the 20th century and delivered ultra dense levels of fabrication and ultra fast circuits. As sub micron levels of track separation and circuit elements come into play at around 200nm, then increasing problems will occur due to cross talk across smaller and smaller circuit interface dimensions. Unless researchers find some intrinsic way of making silicon behave better across these interfaces, then the steady progression of circuit density known as Moore's law where circuit densities double around every 18 months, will come to an end.

For some time, however, researchers have been aware of alternative options for fabrication of circuits. So-called organic circuits have emerged as a future technology that has the potential to achieve extremely high-density packing of circuits. Aspects of nanotechnology are also poised to introduce significant increases in the packing density of circuits with in one regard the prime goal being the development of circuits which can store and sense single electrons. Also miniature devices with physically moving micro elements have already been developed in optical switching applications which will have great significance for telecommunications systems.



Forming nanotube junctions

Organic Circuits

In considering the science of organic circuits, a completely different concept of logic function and design is encountered. In silicon and other semiconductors, material is doped with n type or p type elements to create excess of charge carriers. This in turn creates energy structures that are modified by applied voltages. The structure of gates, also, in semiconductors relates to large groupings of atoms of physical dimensions of order of micron or sub micron to around 0.5 micron (500nm).

In the case of organic molecules, the current path is within the clouds of valence elections distributed across the surface and cross section of the molecule. In a single dimension of a layer of molecules of thickness 0.5nm, this can be considered to give rise to current flowing in a very thin layer. If the molecular film is limited in some way to define conduction channels and gate areas, then the greatest dimension of these will typically be several nm.

While the implementation of organic circuits is at the earliest of days, there is this clear perception of the much higher potential gate density that can be achieved - of the order of a million times greater.

It is therefore very much the case that the understanding of organic chemistry is being applied in a wholly new field. The building block for much of this research has been based around so called polyphenylene based chains. The phynyl group is expressed chemically as C_6H_5. The familiar benzene ring has formula C_6H_6. In addition, other chemical components can be added to the phenyl group to modify the behaviour of the structure.

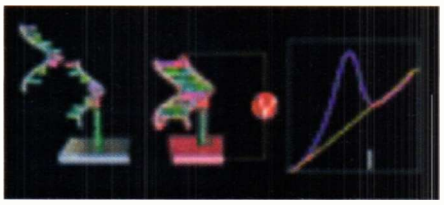
It has been demonstrated that such chains of molecules can readily conduct current. In one experiment using molecules based on three linked benzene ring polyphenylene-based chains, 1000 molecules were able to conduct 30mA - providing around 30nA per molecule. This current density however is some half a million times greater than a copper wire of typical interconnect dimensions.

Molecular electronic circuits have come to the stage where the implementation of gates such as AND, OR, XOR and NOT is quite straightforward. It is estimated, for example, that an XOR gate fabricated from polyphenylene based rectifying diodes would be of size 5nm x 5nm. Also, a half adder incorporating molecular AND and XOR gates would be only 10nm x 10nm in size. To create a full adder device, two half adders would be combined with the addition of an OR gate - creating a device some 25nm by 25nm. In the design of such structures, however, it is likely that elements to restore signal gain will be required in order to achieve signal isolation and maintain fan out. These gate sizes, however, are of the order of a million times smaller in area than conventional and corresponding silicon based circuits.

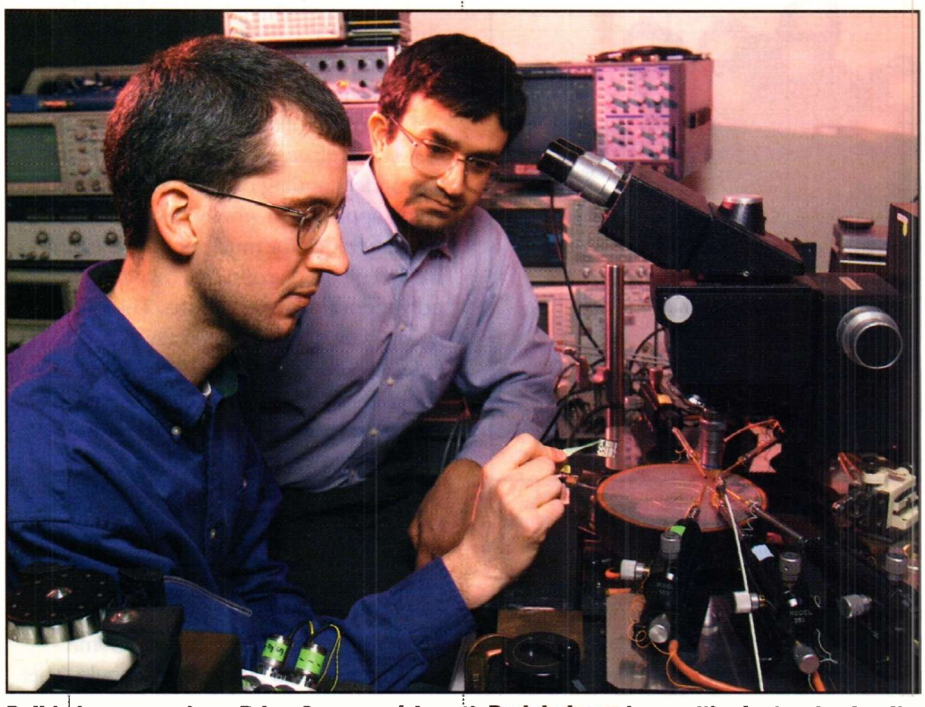
The field of organic circuits is only now

beginning to move from the domain of theory to the domain of demonstrated circuits. As an example of this, Aviram and Ratner first expounded the theory of rectifying diodes in 1974 though it was only in 1997 that groups at the University of Alabama and Yale University demonstrated practical molecular rectifiers.

Bell Labs/Lucent Technologies have recently announced the demonstration of a range of organic electronic circuits. These include a 5 stage CMOS ring oscillator with a frequency of 10kHz, a 864 transistor 48 stage shift register and at the time of their announcement during March 2000, broke records for speed and transistor complexity - the previous record for gate density being 326 devices. If organic electronic circuits follow a law like Moore's law and double approximately every 18 months, then it will be around 30 years before the present density of 300 million transistors on a chip achieved today with silicon will be attained.



Forming a carbon nanotube dna sensor



Bell Labs researchers Brian Crone and Ananth Dodabalapur busy with electronic circuits incorporating organic transistors.

Researchers are exploiting their broad understanding of chemistry to identify useful building blocks to fabricate organic circuits. The use of the so called Thiol group (-SH), for example, bonds extremely well to Gold and is described as an 'molecular-alligator-clip' in terms of providing a robust and highly conductive connection point for external connection.

In studies at Oak Ridge National Laboratory in the USA, photodetector cells based on photosynthetic molecules, which occupy a region 2nm by 2nm, are being used to detect light with unprecedented spatial resolution and with the capability of detection of individual photons.

At North Western University in the USA, a specialist marking system has succeeded in storing the equivalent of 80 million words on a single square inch chip. The technique employed utilises the latest in atomic force microscope and a specialist writing tip to create ink lines some 15-30nm wide and separated by only 5nm. Water collects at the microscope tip and forms a capillary that allows the ink to flow to the surface. The technology has potential applications in the archiving data or in the creation of ultra small electronic circuits.

Carbon Nanotubes

As with most things in science, a picture is worth a thousand words when it comes to describing carbon nanotubes. A specific structure is shown in photo 1, which shows the nanotube very much like an elongated balloon with the linked carbon atoms forming around the exterior. The interest in carbon nanotubes comes across many development areas, and indicates the potential for the future in applications in nanotechnology. Indeed nanotube research is very much an 'in' topic in the academic world.

Carbon nanotubes were first identified by Sumo Iijima of the NEC laboratory in Tsukuba, Japan in 1991 though it is very likely that they could have been fabricated prior to this but without recognition of their unique structures.

In terms of interconnect technology, at the level of nanostructures, the use of so-called carbon nanotubes is another approach being investigated. While are more highly conducting compared to the polyphenylene backbone, they cannot yet be produced using bulk chemical methods.

While the carbon nanotubes are more highly conducting than polyphenylene devices, organic circuit elements probably do represent the ultimate degree of miniaturisation of 'molecular' logic circuits, though no doubt the optimists in terms of silicon nano fabrication may agree to differ.

When carbon nanotubes were first fabricated, they were typically as multi-wall units. A significant breakthrough for the process of development of the field was the ability to create single-wall structures. The Rice University group in the USA achieved this in 1996 and allowed the properties of such single layer devices to be tested against quantum models of electron conduction. Since then researchers have spent thousands of hours probing the surface of such nanotubes with specialist atom probes and in the process largely verifying the properties of such structures. Many of the observational findings relate to the conductivity properties around discontinuities in the nanotube surface. Excellent localised behaviour as rectifying diodes has been observed in numerous devices.

The method of creating single-wall nanotubes developed at Rice University involves laser vaporisation of a carbon target in a furnace at 1200 degrees C. The presence of a cobalt-nickel catalyst assists in the formation of the nanotubes. Flowing argon gas sweeps up the nanotubes from the furnace onto a water-cooled copper collector. Other centres have developed techniques employing high temperature carbon arcs. Clearly the techniques of manufacture relate at present to produce amounts suitable only for research purposes.

Unlike organic circuits, where researchers have already begun to demonstrate logic functions with assembled devices, carbon nanotubes are still very much being explored for their potential. It is very early days, however for emergence of reliable electronic devices though carbon nanotubes are likely to find application in many areas in science.

The carbon nanotube, however, presents a new environment for the electron. The very shape of the nanotube confines them to move only along the nanotube axis and also establishes a series of standing waves around the circumference of the nanotube. This is therefore an example of a specific and unique type of geometry of arrangement of atoms creating a special set of rules for conduction. The different

modes of symmetry confer on the nanotubes the properties of either metallic or semiconducting behaviour. It is very much at present a case of investigating the properties of such devices rather than building specific test circuits on well-established principles.

In terms of developing nanotubes as circuit elements, one of the more realistic scenarios is to incorporate specific defects into selected nanotubes to produce specific electrical characteristics. It is certain, however, that the transition to demonstrable circuit elements incorporating carbon nanotubes will be a key development.

Simulated image of collection of single-wall carbon nanotubes. Courtesy Rice University

The study of single-wall carbon nanotubes is a theoretical challenge, which has in turn initiated a large amount of studies to verify such models. Subsequently, however, studies have progressed to investigate the properties of carbon nanotubes conjugated with other materials. Groups in the USA and Ireland are investigating carbon nanotube behaviour when conjugated with a polymer called PmPV.

Carbon nanotubes are in fact being studied across a broad range of scientific disciplines. One novel application, for example, relates to the ability of carbon nanotubes to absorb large amounts of hydrogen. Scientists at the Chinese Academy of Sciences in Shenyang, China and Massachusetts Institute of Technology in the USA have demonstrated how carbon nanotubes can be made to retain large amounts of hydrogen - as much as one hydrogen atom for every two atoms of carbon. In a special process to remove impurities, the carbon nanotubes are soaked in hydrochloric acid and heated to 500 C for two hours. While this is a significant development, there is a considerable way to go before such techniques become practical technology. A today's prices, it costs over $1 million to produce a single kilogram of carbon nanotubes. The take up of fabrication of carbon nanotubes, however in other industrial sectors will, however, speed the development of their incorporation into electronic circuits.

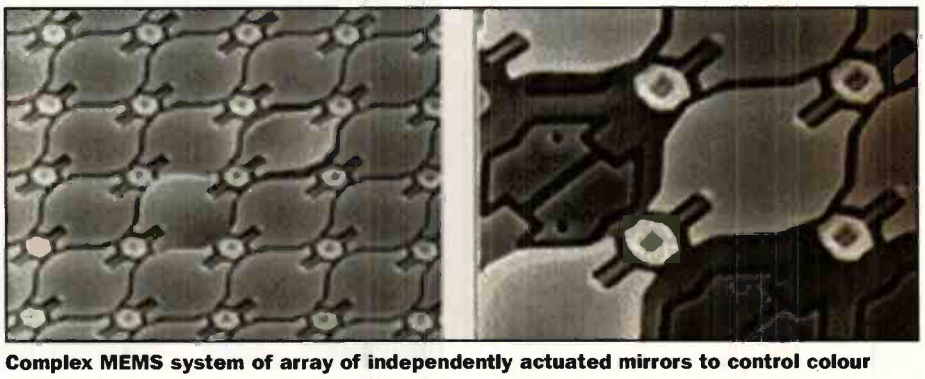
Carbon nanotubes are also very strong physically and have the potential to provide the ability to produce ultra strong structures in both compression and tension. Single wall nanotubes are, however, remarkably flexible. They can be manipulated in all kinds of ways without causing them to break. One role anticipated for carbon nanotubes is as applicator devices for assembling of nanotechnology structures.

Simulated image of collection of single-wall carbon nanotubes. Courtesy Rice University

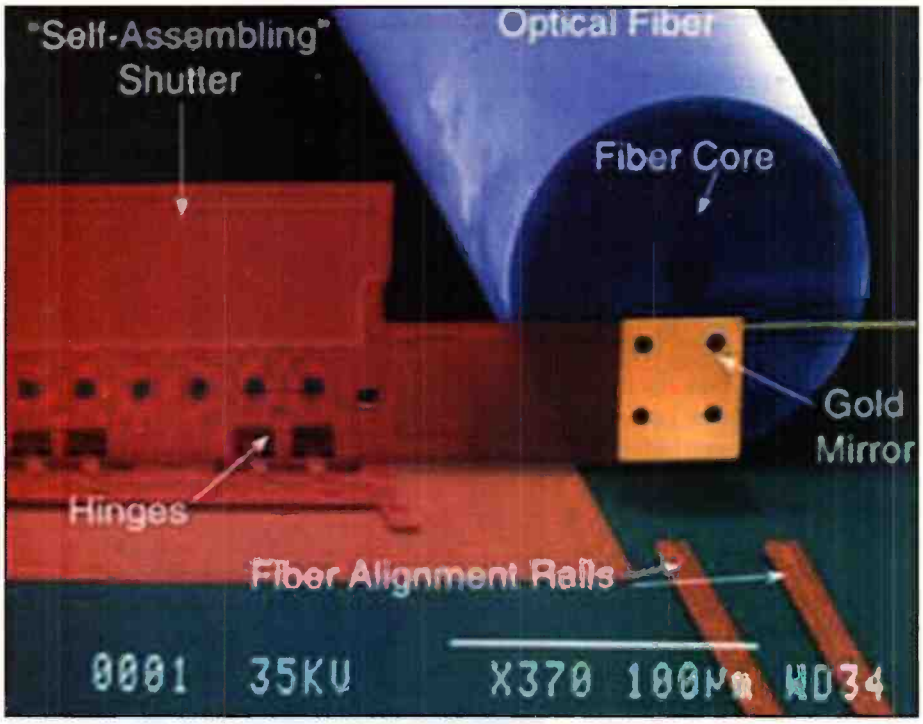
NASA is also very interested in carbon nanotubes in applications directly linked to space vehicle design. The exceptional strength/weight ratio of carbon nanotubes is focusing attention in developing systems for manufacture of ultra light but ultra strong material for space vehicle construction, fabrics for space suits and material to provide a degree of protection from space debris.

Optical Computing

The concept of optical computing may not be new, though some new angles on its implementation are being proposed by NASA scientists. Practical systems to implement optical technology tend to utilise so called hybrid circuits. A key stage in the fabrication of such systems is the fabrication of polymer films.



Complex MEMS system of array of independently actuated mirrors to control colour on a display module. Courtesy Texas Instruments



Example of first practical micro electro mechanical optical switch. When the bar is lowered (as shown) the signal on the left is deflected to the rear fibre. When raised the signal path continues to the fibre on the right without interaction.

Researchers at NASA are investigating the advantage of depositing these polymer films in conditions of micro gravity aboard the Space Shuttle in order to minimise problems caused by convection which tends to result in non uniformity's of patterns of deposition. It can be anticipated that extensive series of microgravity experiments involving such films are planned to utilise the resources of the International Space Station.

Micro ElectroMechanical Systems (MEMS)

In the miniaturisation of circuit elements, a key requirement has been to route light signals between fibres. While there have been conventional ways to undertake this using electro-optic multiplex/demultiplex circuits, the emergent technology of micro electromechanical systems allows this to be undertaken using miniature moving elements. The so called 'seesaw' switch essentially allows direct coupling left to right when the movable element is raised and reflection from left to rear fibre when lowered. The movable element responds to electrostatic forces applied via a voltage switch. In the fabrication of the switch, various films of polysilicon, silicon nitride, silicon dioxide and gold are deposited and processed to produce complex multilayered three-dimensional structures. The final stage in fabrication is a novel 'release step' which involves an etching process that leaves the device with its movable elements.

Using similar techniques mechanical elements of rotary electric motors, toothed gears, linear stepper drives, hinges, inclined planes, screws, pulleys and bending beams can be implemented to fabricate in situ devices. It is clear, however, that the integration of such mechanical elements into electronic circuit design will immediately make existing equipment much more compact that should in turn make such equipment cheaper to manufacture. There are certainly many routes of application in medical laboratory analysers and associated equipment where smaller scaled devices would be advantageous.

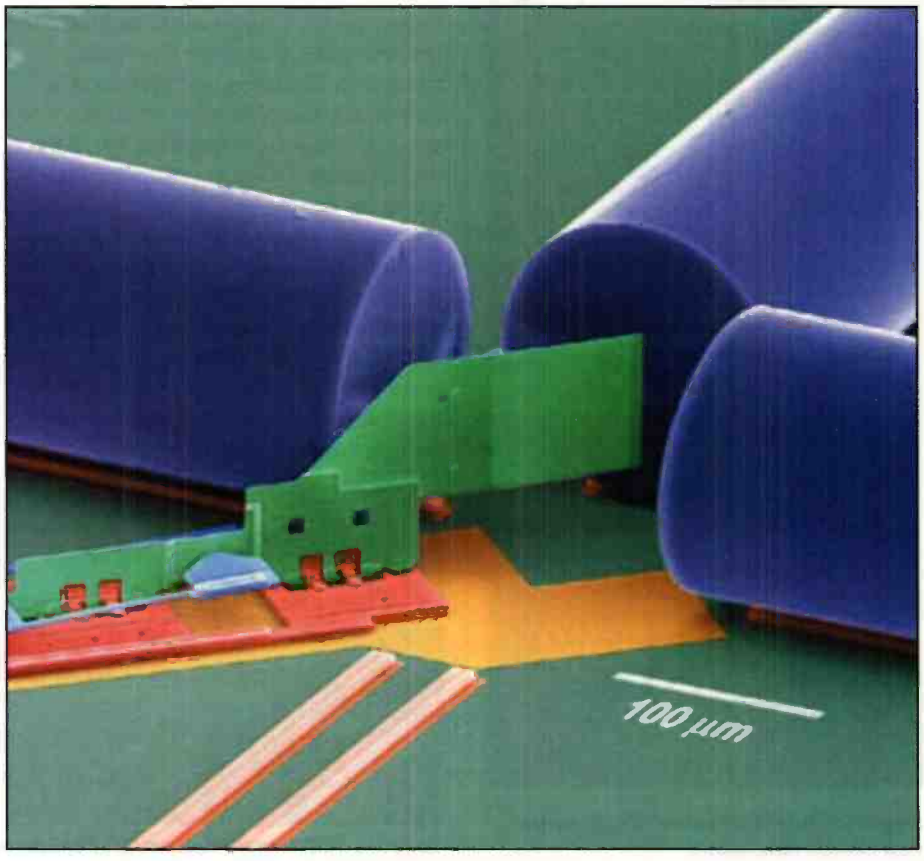
One option for example could be to implant a small device in the anterior chamber of the eye that could sense intraocular pressure and action a miniature pump to pump excess fluid through to the exterior of the eye.

Nano Silicon Fabrication

While organic circuits present themselves as an interesting shift in design modalities, there are colossal pressures to continue to exploit silicon technology. Various groups are currently studying the practicalities of sub 50nm fabrication methods to create one terabit of storage capacity within an area of a few cm2. The QUEST group in Lille, France is seeking to fabricate silicon devices below the 20nm limit by use of SPM (scanning probe techniques). The technique planned to be used by QUEST relates to creation of a floating gate between a MOSFET channel and a command gate. Peter Nuytkens at MIT has successfully developed an A/D device based on atomic scale transistors.

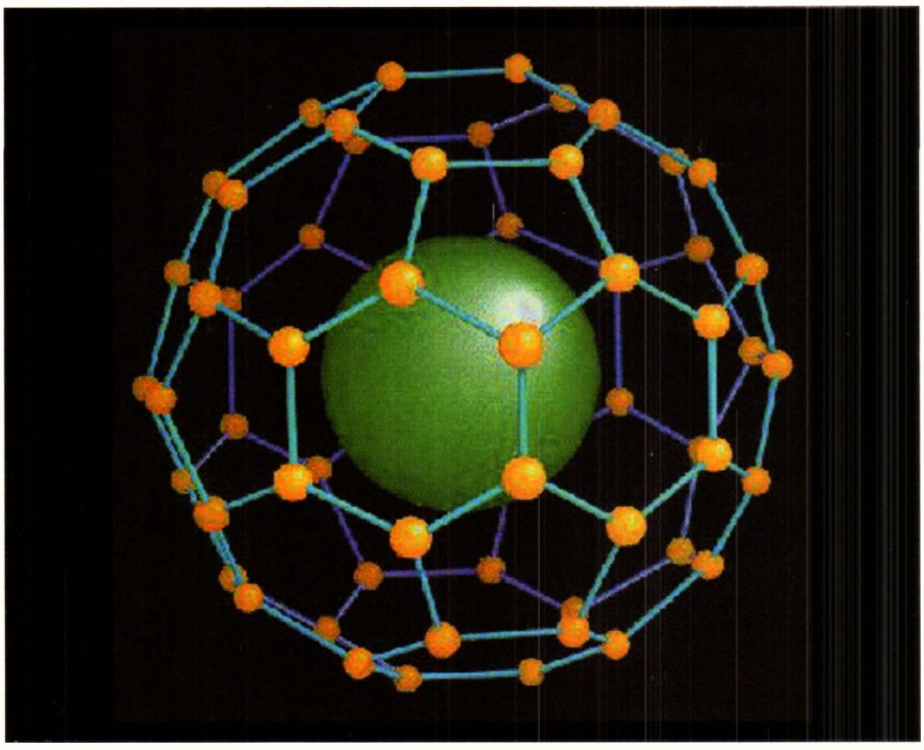
Langmuir-Blodgett (LB) Films

These films are produced on the surface of water when one end of a long chained organic molecule is water loving (hydrophilic) and the opposite end is water hating (hydrophobic). Where these films



Further example of microelectro mechanical optical switch

can be assembled and further compressed they produce materials with properties that include optical non-linearity, piezoelectriciy and semiconductor behaviour. This is a good example of an area which has been extensively studied in relation to conventional aspects of characterisation of material properties but which now has the potential to provide a mechanism to manufacture materials for use in nano electronic circuits. When such molecules are dispersed in water, they can surround and isolate small spherical volumes and provide a means to produce so called nanopowders.



'Bucky ball' with doping

Embracing Nanotechnology

In terms of real applications, there is the trend for small physical structures to become integrated into conventional logic circuits. This in turn is dependent on the availability of useful devices to perform useful tasks. We are perhaps only seeing now the very first set of such devices and in the future design engineers will have at their disposal a very much enhanced set of components and functioning sub unit to incorporate into real circuits.

Toshiba America, for example, has engineered a micro motor that can achieve a speed of 50,000 RPM from a 2V signal and with the device able to fit on the head of a pin. Gel fibres have been developed which can shrink 4% of their volume in 1ms based on a switched electric field of 5V/mm. This has enabled the development of micro pumps in medical drug infusion technology. Also, the development of such gels has coined the term 'wet ware' - structures that can be incorporated into medical applications - for example as artificial muscles. Nanofabrication systems are now available which can work to a resolution of 0.1 micron within an area of 115 by 50 by 50mm area.

As the limitation of mask processing and photolithography become ever more real, one role seen for extra strong nanotubes is as an engraving tool tip for semiconductor devices. While work may be slow in the extreme when working with one tip, there is the opportunity to assemble large arrays comprising thousands of such elements to simultaneously engrave semiconductor surfaces.

The prime focus of electronic circuit technology is therefore moving to integrate mechanical actuation and sensor function to smaller scales so that chip technology will become considerably more integrated to incorporate a range of diverse functions.

The study of many of the physically moving elements of structures is identified as nanotechnology. As an emergent field, it still retains an aura of lack of credibility in the claims of its proponents, but as time marches on, there is a gradual validation of an increasing number of concepts. There is also a very large global corporate investment in systems to develop and exploit its technology.

Nano Wars

As ever, however, the military sector is very much aware of the potential advantages of nanotechnology in defensive and offensive systems. Courtesy of the freedom of information act in the USA, however, areas of current interest can be readily determined on the Internet. There is, for example, a focus of development to develop smart sensors to rapidly detect chemical and biological agents. They make interesting through to some extent worrying reading. The fields that will be researched in the military sector in the USA in terms of nanotechnology developments of electronic circuits overlap pretty much with the work on going in the academic and industrial sectors. Though the Military Sector will probably fund key areas to significant levels which will in turn maintain momentum in terms of base line development of the technology.

Summary

There is much exciting work in progress in relation to crossing new frontiers in the fabrication of electronic circuits. This gives a measure of assurance that the technological revolution we have all been experiencing will be an on going process. It is probably, however, going to be a different sort of revolution.

It is likely that there are going to be some unpredictable and surprising outcomes - especially in relation to nanotechnology that could lead to instability in financial markets. It could, for example, just happen that human ingenuity will develop a process scaled at the nanotechnology level that will add the ingredients of solar energy, water and carbon dioxide from the atmosphere to produce hydrocarbons that can be used directly as fuel. Perhaps this has even already happened but word has not got out...

However, while our perception of our environmental world order at this early stage in the 21st century is one of increasing awareness of the requirement of responsibility in how the world's resources are managed, this does not seem to carry forward to the areas of endeavour and application being targeted in new circuit technologies. Why, for example, is there not more in the way of basic research into developing ultra efficient solar cells and generally addressing many of the pressing issues of stabilisation of global carbon dioxide emissions?

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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.

January 2001

10 to 11 Jan. Communications for Business 2001, NEC, Birmingham, Tel: (0208) 541 5040.

29 Jan to 1 Feb. Digital Solutions - Imaging & Output Olympia, London. Tel: (0207) 357 6161.

February 2001

7 to 8 Feb. Softworld HR & Payroll ExCel, London. Tel: (0208) 541 5040.

7 to 8 Feb. Legal IT Business Design Centre, London. Tel: (01491) 575 522.

13 to 14 Feb. Technology for Marketing Olympia, London. Tel: (020) 8987 7905.

20 to 22 Feb. Smartcard ExCel, London. Tel: (01895) 454 545.

21 to 22 Feb. Computer Trade Show, NEC, Birmingham. Tel: (0208) 541 5040.

23 to 24 Feb. Digital Mapping Show, Barbican Centre, London. Tel: (01883) 652 661.

March 2001

7 to 8 March. Softworld Accounting & Finance Olympia, London. Tel: (0208) 541 5040.

13 to 15 March. Telecommercexpo ExCel, London. Tel: (020) 8910 7910.

22 to 23 March. Linux Expo 2001 Olympia, London. Tel: (01256) 384 000.

28 to 29 March. Softworld Supply Chain NEC Birmingham. Tel: (0208) 541 5040.

April 2001

3 to 5 April. Electronic Design Solutions, NEC, Birmingham. Tel: (020) 8910 7910.

3 to 5 April. NEPCON - Electronics Exhibition, NEC, Birmingham. Tel: (020) 8910 7910.

9 to 11 April. Convergence, Olympia, London. Tel: (01244) 881 777.

24 to 26 April. Webcom ExCel, London. Tel: (01732) 377 646.

May 2001

16 to 17 May. The Embedded Systems Show, ExCel, London. Tel: (0207) 681 1000.

16 to 17 May. European Cable Communications, ExCel, London. Tel: (020) 8910 7910.

21 to 23 May. Mediacast Communications & IT, ExCel, London. Tel: (020) 8910 7910.

21 to 23 May. Cable & Satellite Mediacast, ExCel, London. Tel: (020) 8910 7910.

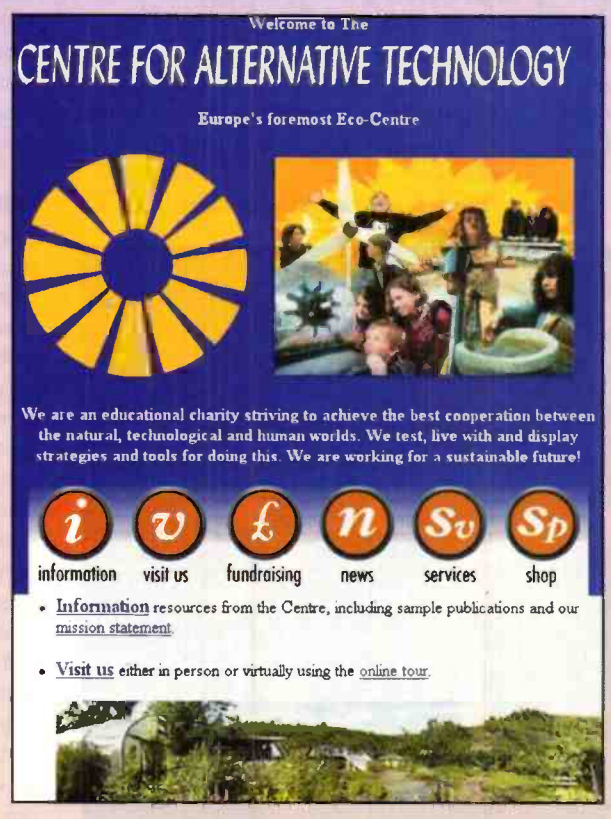
22 to 24 May. Mobilexpo, NEC, Birmingham. Tel: (020) 8910 7910.

June 2001

26 to 28 June. Networks Telecom, NEC, Birmingham. Tel: (020) 8987 7905.

Please send details of events for inclusion in 'Diary Dates' by e-mail to: swaddington@cix.compulink.co.uk.

What's On?



CAT celebrates its 25th anniversary with the opening of a new environmental information centre - AtEIC, which aims to respond to the ever increasing demand for environmental solutions with a vastly improved facility, which will provide practical information, contacts and advice, seven days a week.

Paul Allen, CAT Development Director said, "It is no longer a question of 'must we change?' but 'how must we change?' Twenty-five years down the road, many of CAT's 'alternative technologies', such as composting or wind and solar power, have been identified as key ecological solutions. AtEIC hopes to support the assimilation of these sustainable technologies into the mainstream by becoming a large-scale clearing house for vast amounts of practical information and advice".

For further details, check: <www.cat.org>.

Alternative Technology No Longer Alternative

Back in the seventies, a group of young idealists colonised a derelict slate quarry in mid-Wales and started to develop an experimental community to test the emerging alternative technologies. Twenty-five years later, Europe's leading Eco-Centre, the Centre for Alternative Technology (CAT), demonstrates a vision of a sustainable future.

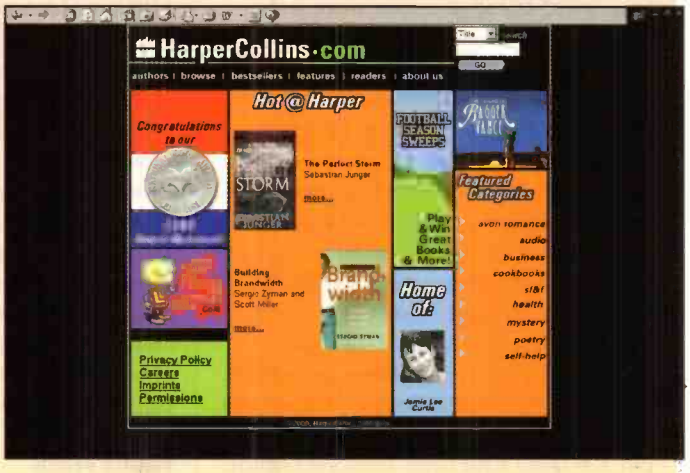
CAT Founder, Gerard Morgan-Grenville said, "The creation of CAT was like a stone cast into still water; the ripples move ever outward to touch distant shores unknown to us. Yet we may observe their effects in the changing attitudes that reflect the validity of our beliefs. As the founder of CAT, I feel greatly fulfilled by the immense success of the project but realise very well that it has flourished solely through the dedication of its staff".

CAT acts as a bridge between those seeking to explore more ecological ways of living and the practical, hands-on experience the centre has gained by working with environmental technologies over the last quarter of a century.

HarperCollins to Publish Account of the Microsoft Trial

HarperCollins will publish Pride Before the Fall - The Trials of Bill Gates and the End of the Microsoft Era, John Heilemann's definitive investigation of the 20th Century's most important business story in January 2001.

The book builds on Heilemann's explosive and widely acclaimed cover story on the Microsoft trial which appeared in the November issue of Wired - which at nearly 50,000 words occupied almost the entire magazine.



Pride Before the Fall is based on extensive and exclusive interviews with Bill Gates and his

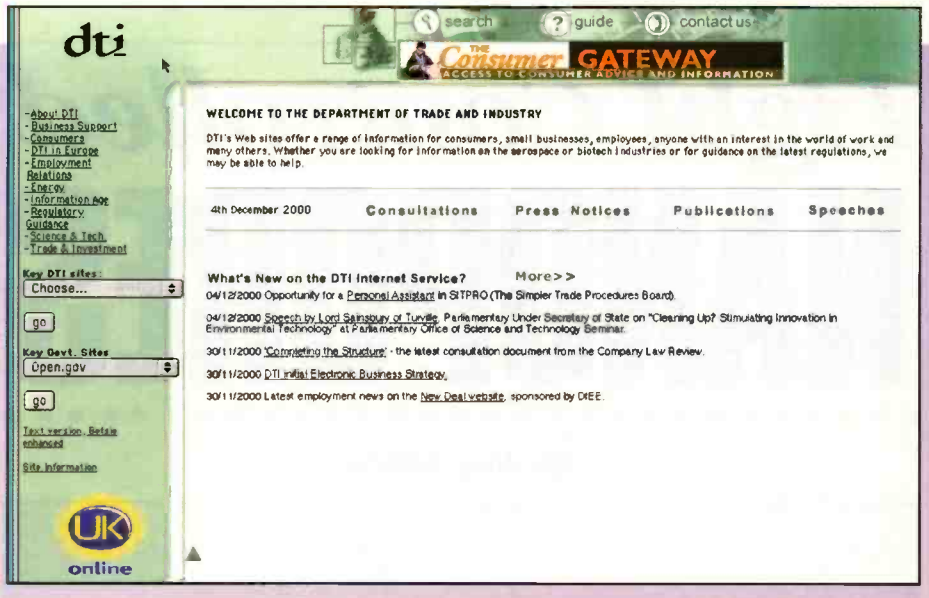
second-in-command at Microsoft, Steve Ballmer; the Justice Department's then-assistant attorney general Joel Klein; chief government counsel David Boies; Intel chairman Andy Grove and other leading high-tech executives; and scores of lesser-known but pivotal players.

In riveting style, it uncovers the untold story behind the headlines - including the hidden roles of some of Silicon Valley's most powerful men in shattering Microsoft's aura of invincibility and the climate of fear that held an industry in its thrall.

Pride Before the Fall also describes the humbling of the richest man on the planet. Venturing deep into Gates's private world, Heilemann reveals Microsoft's leader telling friends at a dinner in 1993 that "I have as much power as the President" - and then shows him five years later despairing that "The whole thing is crashing in on me; it's all crashing in," and bursting into tears at a Microsoft board meeting.

Heilemann details exactly how the high-tech kingpins whose companies Gates had tried to destroy or strong-arm worked behind the scenes to help the government bring Microsoft down. Finally, he explores the lasting damage that the trial has inflicted on the first great empire of the new economy.

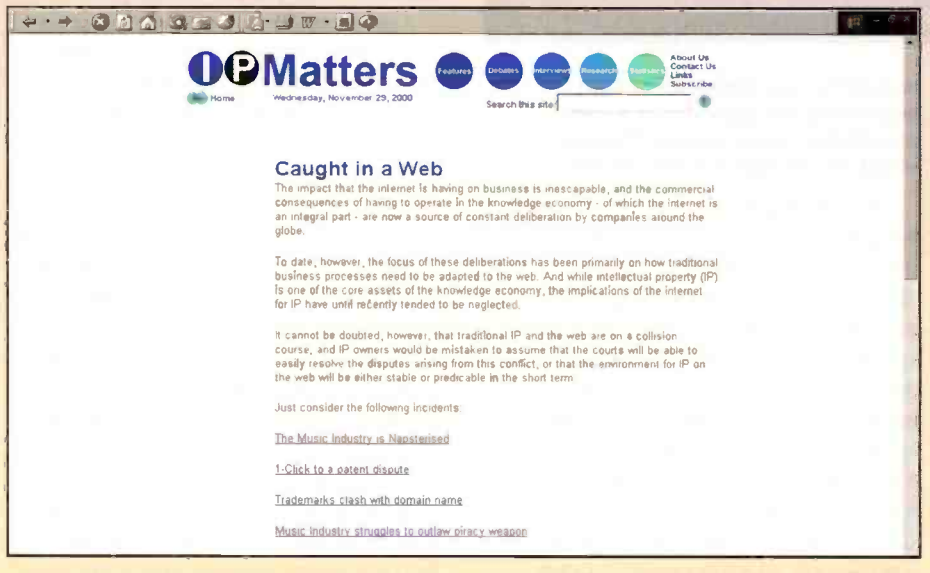
For further details, check:
<www.harpercollins.com>.



rights abroad as they have at home. He said, "Simply having a customer complete an electronic form over the web, a European company could infringe a US Patent even though it never sets foot outside its own country."

The UK-Government is currently seeking the views of the public on whether it should follow the US example and allow patents for software and business methods.

The professor's comments are amongst several views that appear in a forthcoming book called Caught in a Web, Intellectual Property in Cyberspace by Derwent Information that looks at the intellectual property minefield on the web. A chapter of the book on patenting is previewed on



US Patents Could Stifle European Web Business

Software patenting in the US is set to limit the practices of European businesses on theWeb whether Europe adopts American-style e-commerce patenting or not, claims a leading legal academic.

Professor Richard Stern of George Washington University Law School explains that US companies are keen to ensure that they have the same intellectual property

the Internet at
<www.ipmatters.net/webcaught/intro.html>
and Internet users are invited to post their views on the topic in an online forum.

The chapter also examines the fears felt by many people, that smaller companies will soon be unable to compete in the harsh atmosphere of prohibitive licensing demands, whilst larger organisations will waste billions of dollars fighting pointless legal actions. The Internet could slowly grind to a halt as a result.

Caught in a Web explores whether there is a need to provide an effective intellectual property system for the Internet. In the 208-page guide, the roles of patents, trademarks and copyright with respect to theWeb come under the scrutiny of experts from the Internet and IP professions alike.

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

Byers Announces Major Technology Investment

Medical research, the building of the next generation of computing power and the development of fundamental new technologies are to be in the vanguard of investment in the UK's science community over the next three years according to Trade and Industry Secretary Stephen Byers.

Announcing the allocations to the Research Councils from the Science Budget for the next three years, he said research into the role of genes, especially in diseases such as cancer, would be a key component of the research to be supported.

£252m is to be invested by the country's Research Councils in three key areas:

Genomics (£110m);
e-science (£98m); and
basic technology (£44m).

This represents the largest package of joint research programmes that the Research Councils have been asked to collaborate on.

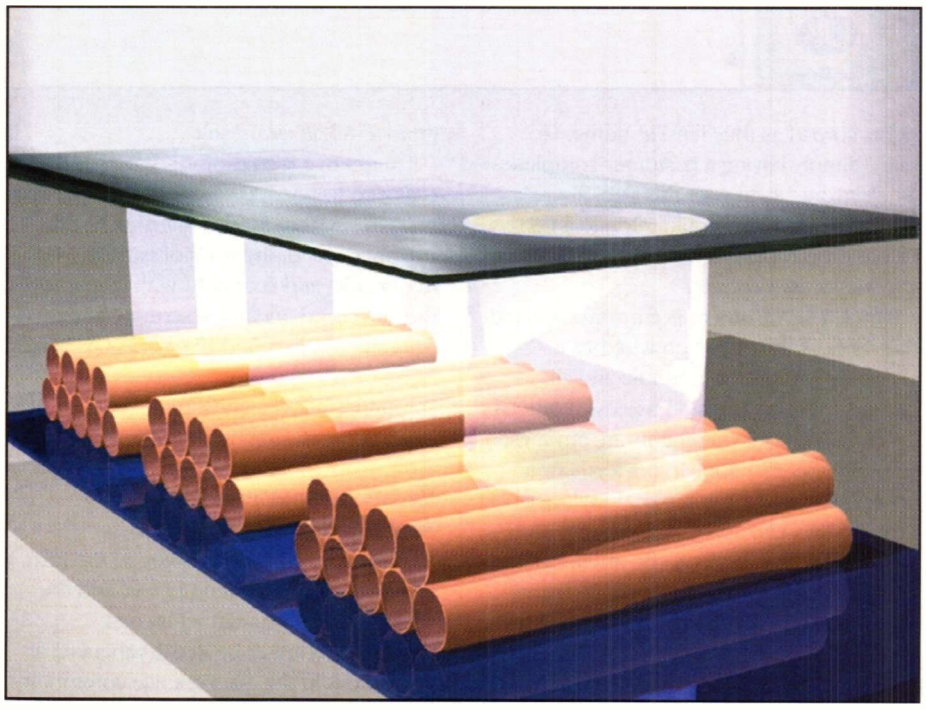
In addition the Research Councils are to be given a further £100m for work in their own specific areas.

The funding is part of a major package of Government investment in science which includes increases to the Science Budget amounting to £725 million over the next three years.

For further details, check:
<www.dti.gov.uk>.

Light Controlled NANOPORES

By Reg Miles



'A graphic representation of light influencing the pore size of a self assembled nanostructure. The area struck by UV light is being shrunk.'

A research group has reported the precise adjustment of the size of nanopores through use of a beam of ultraviolet light. Apparently, the precision is so great that it could achieve the goal of membrane-based separation of oxygen from nitrogen, a difference in size of just 0.02nm. It is also applicable to sensor arrays, nanoreactors, photonic and fluidic devices, and low dielectric constant films. The work is a joint effort between the US Department of Energy's Sandia National Laboratories, the University of New Mexico, and the Vienna University of Technology and Applied Materials Corp. in California.

According to Jeff Brinker, senior scientist at Sandia National Laboratories and professor at the University of New Mexico, and lead researcher on the multi-institution project, 'The Holy Grail of membrane science is air separation. People would love a filter that could separate oxygen from nitrogen. Industrialists have invested hundreds of millions of dollars to do that. Now, in a systematic way, we might go from pores of, say, 3.4 to 3.6 angstroms (0.34-0.36nm) in diameter, tuning the membrane to optimise oxygen-nitrogen separation.'

The honeycomb-like structure, looking like a bundle of straws (see Figure) has pores that shrink in unison when illuminated by a beam of UV light. The membrane is composed of photosensitive, self-assembled, thin film silica. Changes to the pore size are due to photoacid molecules that self assemble and uniformly incorporate into a periodic nanostructure. A light shone on these molecules breaks them apart to form an acid that causes silica to solidify locally. The amount of solidification, which necessarily shrinks pore sizes to create the denser material, is proportional to the amount of light shone on the membrane. A further feature involves shining light through a lithographic mask that varies its intensity, producing so-called 'grey scale' patterning, which theoretically allows for a broad continuous spatial variation of the materials' structure and properties. The same process can also be used to produce optical diffraction gratings that, being made of silicon, are resistant to damage from lasers.

Dhaval Doshi (a UNM graduate student) with Kelly Simmons-Potter and B.G. Potter (both at Sandia), used an evaporation-induced, self-assembly process to prepare and characterise photosensitive films. The work incorporated molecular photoacid generators compartmentalised within a silica surfactant mesophase.

"Using light to change pore size is a kind of nanostructural engineering,' Brinker said. 'In addition to creating an overall pattern as achieved by conventional lithography, this kind of lithography also can help us define the internal structure of the films on the nanoscale. Even though the overall shapes we create are at the high end of the nanostructure regime, the light influences pore size and connectivity in the heart of nanoland, varying pore sizes continuously over a range within that illuminated pattern.'

'Tuning a ten angstrom hole to 8 or 9 angstroms should make a huge difference in membrane performance. While modifying pore sizes by small amounts so far seems to be completely controllable, we haven't yet demonstrated control in going from huge to teeny pores. We're not sure what the dynamic range of the process is."

A joint patent application has been filed on the process by Sandia and UNM.

This is the latest example of the group's work on nanostructures that self assemble to produce repeating patterns of pores of exactly the same size.

A gel coating with a porosity increases the sensitivity of sensors to air and water borne molecules by about 500 times, with virtually no increase in the size of the sensor. Pore sizes can be precisely controlled (up to 10nm) to accommodate a variety of molecules.

Silica nanospheres, ranging in size from 2-50nm, with a variety of pore shapes that can trap or allow free flow, could be used for the controlled release of drugs into the body. It could also be used as fillers with superior characteristics to those used in encapsulants, and as coatings on silicon chips.

An ink that dries into nanoscopic pores contain ligands that interrogate any gas or fluid, laser light, or electric or magnetic field that passes through. Prototypes have already monitored the pH of fluids transported by capillary action, and formed structures that could act as waveguides to direct laser light. According to Brinker, 'With positive ligands in the mix to act upon incoming chemicals, we would have the equivalent of an analytical machine that built itself instead of needing construction.'

For additional information contact:
Neal Singer, 505 845 7078,
<nsinger@sandia.gov>

COMMENT

by KEITH BRINDLEY

I'm sitting here, at my computer, penning this month's column, but in fact spending more time looking at my latest acquisition in the form of a cable modem. Such a device, in case you aren't aware, is a high-speed interface between a computer and the Internet. It works in a vaguely similar sort of way to a conventional modem, in that it interfaces the computer's internal workings with the Internet. The exception is that where a conventional modem merely interfaces the computer with a low speed telephone connection (at maximum, a 56Kbps connection) to the Internet, a cable modem interfaces directly to a supplier's cable network. Now as the supplier's cable network allows a 512Kbps download and a 128Kbps upload connection via this cable modem. This is known as a broadband access method and surfing the Internet occurs much more rapidly than when doing so using a conventional modem. So fast, in fact, that things which are currently unrealistic when using a conventional modem — video streaming, rapid download of files, and so on, are easily achieved with the cable modem. File downloads such as software updates, electronic purchases, mp3 music files and so on, occur at a wonderfully fast rate.

Part of this increase in speed comes from the fact that all connections between a computer and the Internet are in a purely digital form. Conventional modems send analogue signals — the squeaks and squawks you usually here for a while as the modem dials up your Internet service provider down the telephone line, in comparison. Part of the increase comes from the fact that analogue modems can rarely sustain their initial connection speed for more than a few seconds. However it is feasible that you might get logged onto the Internet at a speed of 50Kbps, say (it's virtually impossible to get higher than this, despite the fact the modem may be a 56K one), this usually drops to 40Kbps or less after a short time. To make matters worse, use of conventional modems implies that phone calls have to be made to log on to the Internet. Now phone calls cost money, although there's a few methods of gaining Internet access free of call charges (usually for a monthly standing charge of some greater or lesser extent, depending on the hours you expect to be on line).

Of course, there are other means of getting computers logged on to the Internet. Traditionally, the integrated services digital network (ISDN) is capable of giving a higher connection speed (up to 128Kbps, mind you; still only a quarter that of cable modem) and a digital one, at that — to the Internet. But, like a conventional modem, ISDN features a dial-up method of connection. In other words, you pay for the time you are logged on. So, at around £25 a month (after call discounts), and other call charges on top, ISDN is no great advantage.

A cable modem, on the other hand, is what's known as an always-on service. For its flat-fee monthly charge, you can be on line for 24 hours a day, 7 days a week. Indeed, as long as the cable modem is powered on the Internet connection is maintained, ready for you to surf at your whim. This means no further call charges, together with instant access (there's no lengthy dial-up handshake, as with conventional modems).

A cable modem has a competitor in the form of digital subscriber line (DSL). DSL is a digital variation that uses ordinary telephone cabling as its transmission medium into the home or office. As such, this is a useful means of getting broadband Internet access without the physical requirements of re-cabling into the premises. As you might expect, DSL is the medium touted by our main telephone provider, British Telecom. British Telecom's version of DSL features asynchronous connections, so is actually known as asynchronous digital subscriber line (ADSL). It is very similar to cable modem in use, in that it operates at exactly the same broadband speed as cable modem i.e. 512Kbps download, and 128Kbps upload and is, like cable modem, an always-on service.

However, two things give cable modem the edge over ADSL. First is availability. As long as you live in an area serviced by a cable provider (ntl, say) then cable modems are available now. ADSL, in contrast is only being rolled out gradually around the country. Second, and the greatest cable advantage is price. BT's ADSL is at least £40 a month, depending on supplier. ntl's cable modem service on the other hand is priced at only £20 a month, so at half the cost of BT's ADSL, it is significantly cheaper.

The cable modem service from ntl is actually so cheap, that it's perfectly viable that many home users will want to have it. It doesn't take an Einstein to work out that anyone who spends just a few hours each month surfing the Internet using a conventional modem will be running up call charges approaching that amount anyway. Sure, you can take 'advantage' of BT's SurfTime deals to cut the cost of call charges, but then SurfTime itself costs you a significant monthly standing charge anyway — and only allows you to access the Internet at conventional modem speed. If you take up BT's SurfTime AnyTime deal, which allows you to log on to the Internet at any time of day or night — at £20 a month — then you are paying the same cost as cable modem, without the inherent cable modem advantage of high speed. Without any of these standing charge methods of cutting the costs of Internet access, it's perfectly feasible that home users could be facing telephone bills very much higher than anticipated, all due to high Internet usage. I'm sure that large numbers of families around the country have faced excessive telephone bills at one time or another due to over zealous Internet use by one or more family members.

Effectively, always-on broadband Internet access services like cable modem and DSL mean that the cost of Internet access is standardised. You know what the bill for Internet access for the month is going to be, and it doesn't matter how long you are on line. Given the constraints of availability and price, the Internet world is suddenly a whole lot faster.

Tram TRACTION

Dave Gibson, Technical Director of Stored Energy Technology Ltd reports on a radical new design of tram that uses an electric motor within the wheel.

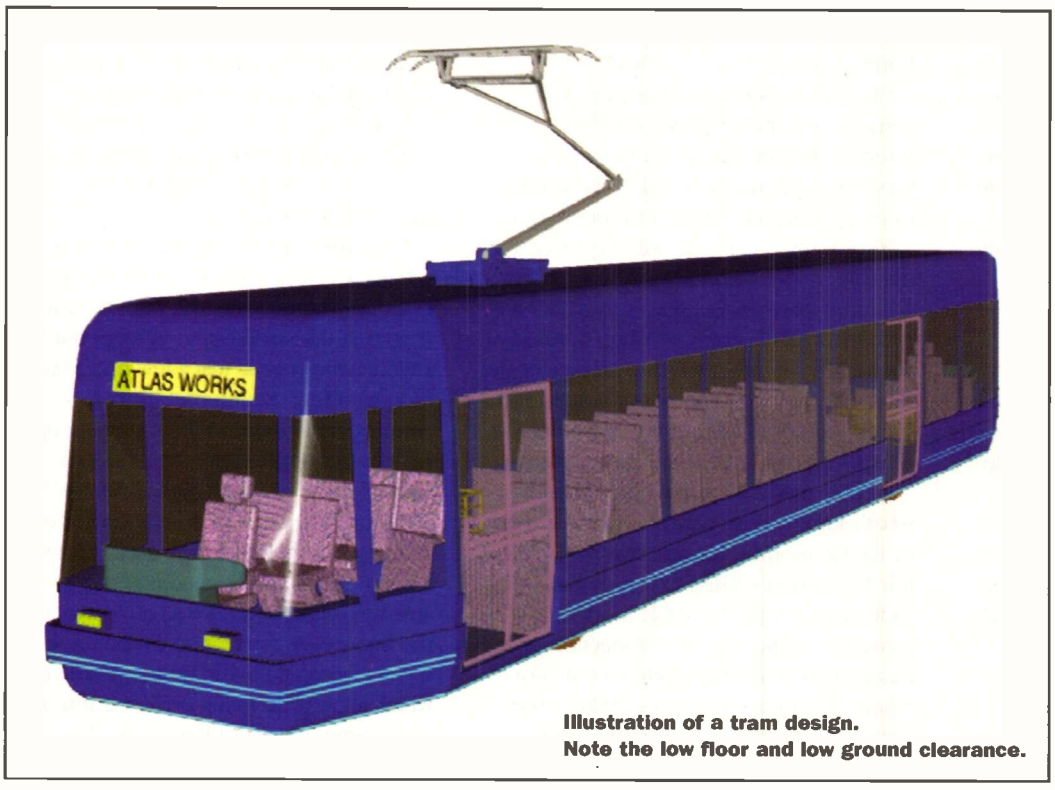


Illustration of a tram design. Note the low floor and low ground clearance.

Trams have been rediscovered in Britain, though of course they never went away in many countries, whilst development effectively ceased here in the 1930s. Although we generally follow the USA, we never got their development of the PCC (Presidents Conference Committee) car that was developed in the 1930s. This at the time was a revolutionary change, and heralded rubber cushioned wheels, lightweight high-speed motors with quiet hypoid gears, and a control system that gave a smooth and rapid acceleration. This technology spread to mainland Europe, both east and west, and was refined in Germany to produce articulated trams that often double up as underground trains. Eventually it came here as the Tyne and Wear Metro, which rejuvenated the suburban rail system on Tyneside. The Docklands Light Railway followed in London, but the real breakthrough was Manchester Metrolink that reintroduced street running to Britain (apart from Blackpool, that has kept running with modernised, but basically old equipment). Since then, trams have reappeared in Sheffield, Birmingham-Wolverhampton, Croydon, and are under construction in Nottingham, and Manchester has and is extending its system.

Many other cities want to follow, but are hampered by high costs. Meanwhile, the busmen are extolling the virtues of guided buses. These generally use very crude guide rails to activate conventional steering gear. The supposed advantage is that cheap buses can be used, instead of trams with a £1M + price tag.

The basis of our development is to reduce the cost of a light rail vehicle to nearer that of a bus on a per passenger basis, and considerably reduce the weight.

A normal rail vehicle has wheels rigidly fixed to an axle, forming a wheelset, and has two wheelsets in a bogie. A single vehicle will have two bogies, one at each end, and articulated vehicles share one or more bogies. Bogies are used to enable the wheels to operate roughly tangential to the rails. The use of bogies adds a lot of weight, the running gear of a rail vehicle is the major source of weight and cost. A road vehicle on the other hand has normally only four wheels, all of which can operate at different speeds, and the front wheels are mechanically steered to negotiate curves. Our technology is to combine both systems.

It was thought that it should be possible to actually build a motor into a wheel as an integral part, eliminating gears and couplings, and making a compact, lightweight assembly. The motor technology that would give the best power to weight ratio is a permanent magnet synchronous machine, using the latest high-energy rare earth magnets. To get the most benefit, the windings should be as near as possible to the wheel tread. The simplest way of achieving this is to make the motor inside out. The rotor consists of the wheel rim, from which the steel tyre is mounted via a rubber cushion assembly. The permanent magnets are attached to the inside of the wheel rim, and form a multi-pole field assembly. Using this approach saves materials, as the wheel rim supports the tyre, and acts as the rotor magnetic circuit, and transfers the torque directly from the magnets to the tyre. The stator that carries the windings is inside the rotor, and is mounted on a fixed stub axle that carries two bearings that supports the wheel rim via end plates. The unit is fully sealed, and is water-cooled. The efficiency is about 97%, from electrical input to power at the rail, and a continuous output of 60Kw is available for a tread diameter of 715mm. The short term rating for acceleration is 125Kw at full speed that is 50mph. The overall weight is about 380Kg, which is about a half of that of conventional systems with separate motors, gearboxes and transmissions. The latter are difficult to accommodate in a low floor vehicle, and the overall efficiency is much less. The wheel-motors also act as brakes when required, down to standstill, and convert kinetic energy back to electrical energy which is returned to the power supply. Because of the high efficiency of the wheel-

motors, and the low rolling resistance of a rail vehicle, over 60% of the input energy can be recovered in a normal urban duty cycle with frequent stops.

Having now got independent wheels with their own drive, it is possible to steer them by varying their relative speeds. The wheels can pivot in the vertical plane from a suspension system outside the wheels. This allows a totally low floor to be possible, apart from the wheels that are located under seats. Steering allows the conventional bogie to be eliminated, the vehicle form being more like a road one, with four wheels on a long wheelbase. This gives another large weight and cost saving. The relative speeds of each motor are calculated from data obtained from a track detector at the front of the vehicle. This is in effect an array of metal detectors that determine the divergence of the track ahead from a straight line. This data is converted into a frequency differential signal, which is multiplied by the desired frequency. The resulting frequency, as a digital signal, is applied to the individual inverters for each wheel. As the motors are synchronous, they run at a speed directly proportional to the applied frequency, independent of load, at least within the working load range. The general "housekeeping" of a synchronous motor is more critical than that of an induction motor, but is well within modern data processing, and the motor can operate at a much better power factor than an induction machine. As the excitation comes free in a permanent magnet machine, the efficiency is high. The inverters are based on IGBTs.

Wheel Motor Assembly

At the present time, one experimental full size wheel-motor has been built, and tested with complete satisfaction at Nottingham University. A ninth scale model vehicle has also been built with four wheel-motors, track detectors, computer and four inverters. This work was originally carried out by a sister company, GGS Engineering, with the help of a DTI Smart award for innovative development. This proved the concept, and from this funding was obtained to set up a new company, Stored Energy Technology Ltd, to take this forward to production. The first thing to do is to build a full size test and demonstration tram to prove the concept in real working conditions. We have a budget to do this over a three year programme, which now has two years to run. The tram will be single deck, 15 metres long, with a wheelbase of 7.5 metres, capable of carrying 100 passengers, half seated, at up to 50mph, with an acceleration rate of 1.3 m/s/s. It will be built to a high standard, and will probably use bus components to reduce costs. The body may be built by a bus manufacturer. It is intended that initial testing will be undertaken on a test track to be built at our premises that will have plenty of sharp curves to test the steering capability. When this testing is complete to everyone's satisfaction, we wish to get some higher speed experience on a tram or light rail system, with the aim of real passenger service. The use of radically different technology means that safety under fault conditions is important, and the aim is for the suspension to keep the wheels stable under flange guidance in the event of a system fault. The control system will be built on a redundancy basis, in that a lower order of control can be implemented in the event of a higher order fault.

Since the development started, supercapacitors have become available that can store the amounts of energy recovered in regenerative braking, about 3M Joules in periods of about 10 seconds. These would be very useful in maximising the use of regenerated energy. Normal traction substations are incapable of returning it to the grid system, and it can only be used by another vehicle motoring on the same substation supplied section. Substations can be made to invert to the ac supply, which happened in the days of rotary converters, but supply companies do not pay for regenerated current as much as they charge for supplying it! Also, they part charge on the basis of peak current, the maximum demand, irrespective of the direction. Storing regenerative energy on the vehicle for reuse when accelerating would smooth out the energy demand, and result in lower power charges. It would also reduce the amount of copper required in the overhead line, and the rating of substations, with consequent cost savings, and giving aesthetic improvements in the overhead equipment.

We are looking at incorporating this technology, as well as the possible use of high technology batteries to further smooth power demand on a longer basis, and allowing some operation without overhead lines.

On this basis, our energy consumption for traction should be about 0.5 KWH per Km per 100 passengers in a typical urban duty, whilst giving a high performance. In view of the low traction demand, the other loads such as heating and lighting need to be kept low. The small amount of heat produced in the motors and inverters, both water cooled, will be used for car heating when required, supplemented by line fed heating as necessary. Interior lighting will be by low energy fluorescent tubes, driven by our own inverter ballasts. Rear, brake and direction lights will use L.E.D.s, and marker lights will be either compact fluorescents or white L.E.D.s. Headlamps will possibly be metal halide.

The result of all this is to produce a tram at a price per passenger similar to a bus, but with greatly reduced energy consumption, and of course no pollution at all at the point of use. The lightweight vehicle, with steerable wheel-motors will also reduce infrastructure costs, both initial and maintenance.

Whilst our demonstrator vehicle is a single unit single deck vehicle, other formats are possible if required, such as articulated or double deck, but these will still give all the advantages of lower operating costs, and allow the advantages of light rail systems to be implemented in many more places.

Hopping ROBOTS

Reg Miles looks at two contrasting approaches to the same concept-hopping robots.

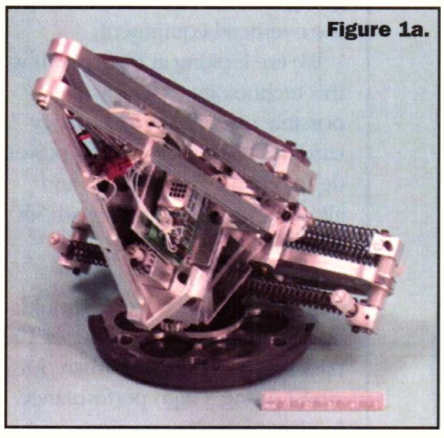


Figure 1a.

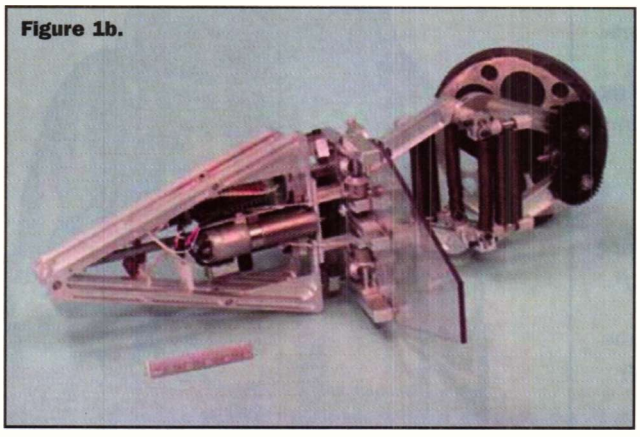


Figure 1b.

These hopping robots are from NASA's Jet Propulsion Laboratory and the US Department of Energy's Sandia National Laboratories. Both developed with the same goal in mind - to go where no hopping robot has gone before and explore Mars.

The JPL 'Frogbot' incorporates an electric motor and uses the force of a spring between its legs to achieve its hops (see Figure 1). And it was the 'robot of the month' in the Robot Watch news section of Discover magazine's December issue. Sandia's hoppers employ a combustion driven piston to hop about (see Figure 2).

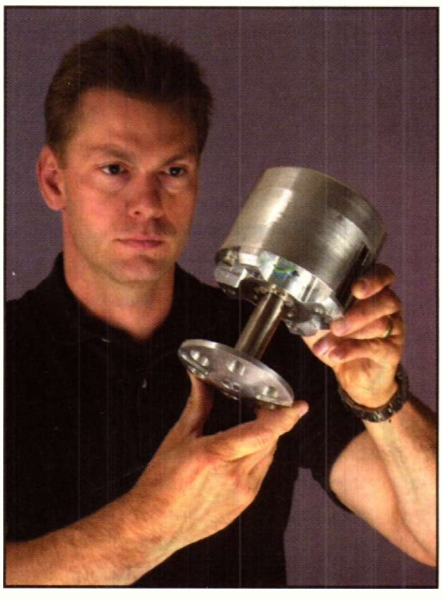


Figure 2.

While frogs seem to have been the inspiration for JPL's Frogbot, it was grasshoppers that inspired the Sandia version. Apparently, Rush Robinett, of Sandia's Intelligent Systems and Robotics Center (ISRC), conceived the idea whilst catching grasshoppers to use as bait for trout fishing. He said, 'I noticed they jump around in a random fashion, hit the ground in an arbitrary orientation, right themselves, and jump again. I said to myself: 'I can make a robot do that'.

But it turned out that the doing was not so easy as the saying. The researchers at ISRC reviewed the attempts of others to produce hoppers using electrically actuated springs and other methods, but they felt that the energy required for a leap that could at least clear the robot's own height was too great. They also felt that the batteries wouldn't last long enough for long range missions. Then senior scientist Barry Spletzer suggested that because hydrocarbon fuels provide much greater energy densities than batteries, a small combustion powered hopper could, theoretically, travel greater distances and clear larger obstacles. 'Most mobile robots are designed to steer directly to a spot very efficiently. But over long distances you don't need that kind of precision. With a hopper you have time to make corrections after each jump, so it doesn't need to steer while it's in the air. Once we determined that semi-random mobility was okay, we knew a hopper was possible.'

'We spent a long time getting here,' said the ISRC's Gary Fischer, who developed the robot's internal combustion engine. 'It wasn't easy. Our first jumps were weak because we were looking for the correct fuel mixtures and spark energies to achieve ignition. When we finally made it fall over, we were happy.'

Now, one ('low') hopper jumps about 1m in the air and about 2m from its starting point on each jump (see Figure 3); going for about 4,000 hops - roughly 8km - on 20 grams of fuel. Which can be any of several compressed gases, including propane, butane, and methylacetylene. Each hopping cycle takes about 5 seconds - giving an average speed of approximately 1.5kph. Another ('high') hopper can jump from 3-6m in the air (see Figure 4); and can manage about 100 hops. This is being developed as a mobile landmine platform for a 'self-healing' minefield, with hopping mines that sense an adversary's mine clearing operations and co-operates with each other to fill any gaps. The work is funded by the Defense Advanced Research Projects Agency, one of a number of guises of the US Military, so it was inevitable that some lunacy would result).

The mechanism is contained within a grapefruit-sized plastic shell, shaped so that it rights itself after each jump - piston toward the ground but slightly askew. A pre-programmed microprocessor inside the hopper reads an internal compass, and a gimbal mechanism rotates the offset-weighted internal workings so that the hopper rolls around until it is pointed in the desired direction. The combustion

Figure 3.

chamber fires, the piston punches the ground, and the hopper leaps.

They have been tested in a variety of conditions, and are said to have performed reliably against obstacles, mud, sand, and rough terrain, and are unaffected by wind.

Now the research team is working on a hopper that can be controlled remotely using a joystick, as well as hoppers with shock absorbing rubber shells that can land on concrete. Several patents are pending on the invention. Because the hopper is lightweight (the first prototype weighs about 0.5kg) and could be inexpensive to produce, Spletzer foresees a variety of worldly uses for hoppers: gathering war fighting intelligence, and assisting police during stand-offs or surveillance operations (apparently, the first prototype hoppers are surprisingly quiet, with the noise from landing being greater than the contained combustion). 'You'd like a robot that Marines or SWAT teams could toss into a second story window, then hop it around for a look inside. That could save lives. But where we want to go is Mars and the moon. With a hopper, you could go much farther from the lander. You could throw out a dozen of these to search in all directions.'

Figure 4.

The joint developers of the Frogbot, JPL and the California Institute of Technology are in full agreement with that sentiment. 'Hopping is a more efficient form of transportation in low gravity environments,' said Dr. Paolo Fiorini, an engineer in the robotics group at JPL. 'Our hopping robot performs much like a frog. It has a spring between its knees that makes it bend its legs and hop. When the spring releases, the Frogbot takes a 1.8m hop on Earth, which could become a 6m leap under low gravity conditions on planets like Mars, depending on terrain.'

Engineers believe that in low gravity environments, such as small planets, and in micro-gravity environments, such as asteroids, wheels successfully used on rovers may not be the most efficient forms of locomotion. In laboratory experiments slithering, rolling and hopping have been shown to be alternative methods of propulsion.

In the future, NASA envisions missions involving dozens of small robotic vehicles. 'To be effective, a small exploratory robot vehicle must frequently go over obstacles that are many times its body size,' said Joel Burdick, the Caltech co-inventor of the robot. 'Hopping or leaping motions are some of the few effective ways for small vehicles to overcome such relatively large obstacles.' And according to Dr. Neville Marzwell, head of the Advanced Projects Office at JPL, 'Our goal was to come up with a locomotion method and design that would use a minimal number of instruments and that would be small, compact, lightweight and still be able to perform useful scientific study.'

(According to the JPL press release, 'Researchers at Sandia National Laboratories in Albuquerque, N.M., have also developed a hopping device, with more limited manoeuvrability.')

The Frogbot weighs 1.3kg; and is powered by a single motor. It is equipped with a camera, solar panels, sensors and onboard computer that executes commands autonomously.

The Frogbot technology will be ready in about three to five years and could help scientists capture images and collect ground samples. One of the major challenges facing engineers is precision navigation necessary to control the hopping robot. Engineers are also developing a hopper that adheres and climbs vertical walls; and are testing prototypes on different ground terrains (Figure 5 shows one in a 'Mars-like' terrain).

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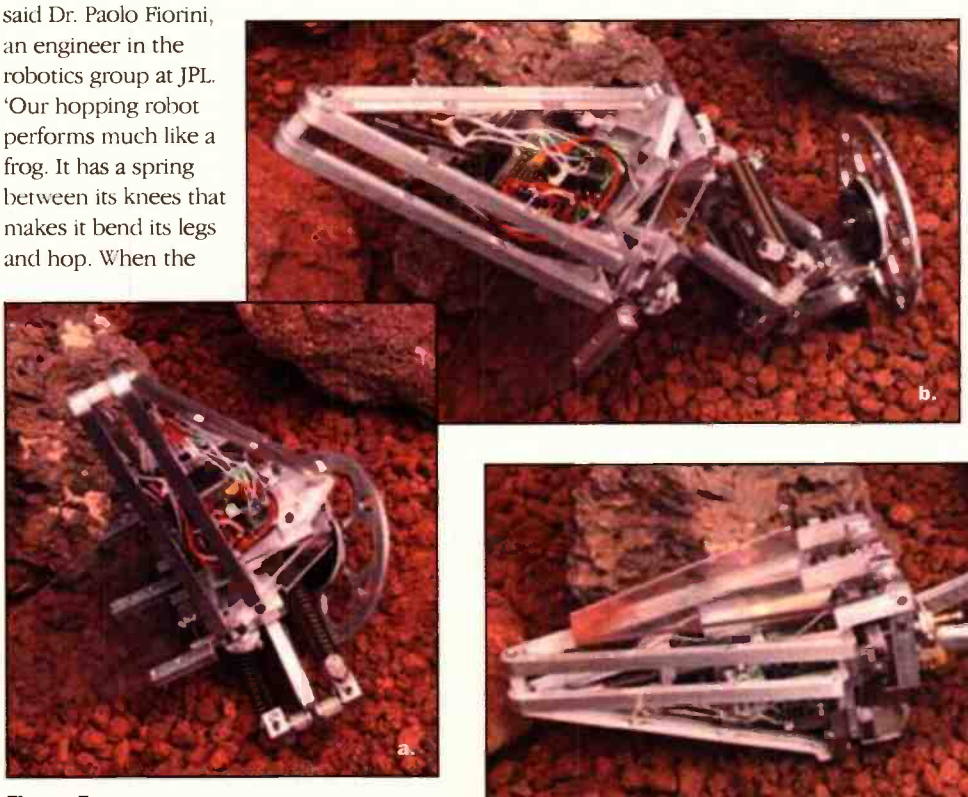
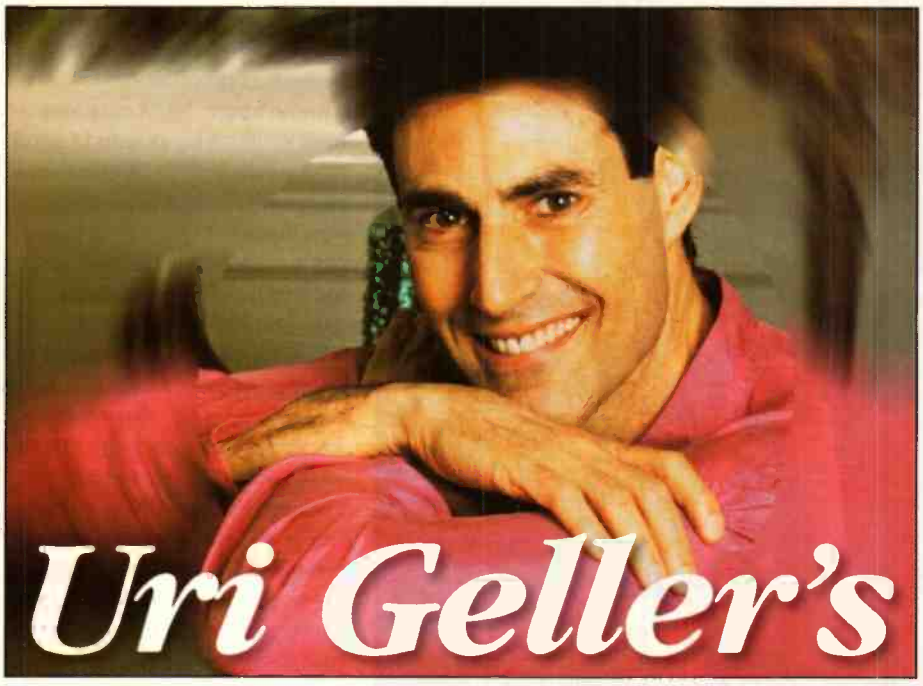


Figure 5.



Uri Geller's EXTENDED REALITY

THE CRYSTAL EFFECT

There is something about crystals that has fascinated people ever since history was recorded. The Chaldeans, the Egyptians and the ancient Greeks all used them for all kinds of purposes, both decorative and practical, In fact, crystal technology is one of the oldest there is and it is used today more than ever, from the first wireless sets to the NASA spacecraft, whose astronauts carried special aluminium cards containing crystals charged at 7.85 Hz, the so-called Schumann resonance - the fundamental mechanical vibration rate of the earth -ionosphere cavity - to help them cope with weightlessness and absence of the natural magnetic field of earth.

It's well known that crystals are good conductors of energy because of the piezoelectric effect, whereby a crystal under pressure converts one form of energy to another, and its memory storage capacity has made this ancient mineral vital to the modern computer. They have also been used for centuries as 'crystal balls' in which people claim to be able to see things and foretell the future by what the Greeks called crystallomancy.

I became seriously interested in crystals in the mid-eighties. Up to then I had been a bit dubious about claims that they could actually affect people, and I wondered what people who called themselves 'crystal healers' thought they were doing apart from conning people. When I read on the first page of a book about crystals that Atlantis was destroyed by misuse of crystal power (Plato clearly says it was destroyed in a flood), I didn't bother to read any further.

Then, soon after I had moved into my present house, I saw a picture of a huge quartz crystal, a foot wide and more than two feet high, in an auctioneer's catalogue, and I decided to buy it for my entrance hall just as an ornament. I had no idea it could be anything else. Then, one day my six-year-old son had a very nasty accident, failing over the banister on to the marble floor beside the crystal on its podium. He was rushed to hospital and well treated, and I spent a sleepless night.

Getting up very early. I made some coffee and was walking past the crystal when I suddenly saw a beam of light emanating from one of its facets. It shot across the hall almost like a laser beam, breaking into thousands of little prisms on the wall. This effect lasted for about twenty seconds, long enough for me to be sure I was not hallucinating. It was a grey morning with no sun, and I even checked to see if anyone was shining a torch through the window. I still have no idea what produced this extraordinary effect which has never been repeated. All I know is that it made a powerful and lasting impression on me. If any reader has a normal explanation for it, I would be glad to hear it.

It seems to me that there is a good deal of research to be done into crystals, and the ways in which their energies interact with ours, which they certainly can do. I have found (quite by chance) that I can make natural crystals get very hot just by holding them in my hand, and I like to give small 'hot' crystals to sick children, telling them they will act as a good-luck charm. I never claim the crystal will heal them, although I believe- it can act as a placebo that helps put people in a positive frame of mind, and so enhance their immune systems. Whether it also transmits energy remains to be seen.

I am not the only person who has had an unexpected experience with a crystal. For the past twenty years the Dragon Project Trust headed by author Paul Devereux has been studying ancient sites all over the world and measuring their energies. He and his colleagues have seen (and photographed) light emanating from crystal-bearing stones, they have recorded ultrasonic pulses and have even been given electric shocks by them. Their quartz watches have frequently gone haywire on site, but they have also reported getting a kind of energy-charge after a day among the stones. An English Heritage Inspector has even reported seeing a rainbow above the ancient site of Carn Ingli in Wales - after sunset! Curiously enough Britain's best known site, Stonehenge, seems to be the only one where no magnetic or ultrasonic anomalies have been recorded.

When you think of the enormous effort involved in building those stone circles, it is obvious that they were not just decorations in the landscape, but were built for practical purposes, perhaps for healing or for altering consciousness. A House of Lords select committee recently declared that crystal therapy was one of the 'unacceptable' alternative therapies but while we cannot yet say exactly what crystals do to people, there seems no doubt that they can do something that was of great importance to the ancient circle builders. Perhaps they knew something about natural energies and ways of converting them that we have forgotten?

Information on the Dragon Project Trust: **<www.acemake.com/PaulDevereux>**

Read Uri Geller's stunning online novel, Nobody's Child, at **<www.uristory.com>** Visit him at **<www.urigeller.com>** and e-mail him at **<urigeller@compuserve.com>**

From Bioelectricity to SPACE TRAVEL

PART 2

David Clark looks at the underlying principles behind electrochemical energy sources, from the 'voltaic pile' to the solid polymer fuel cell.

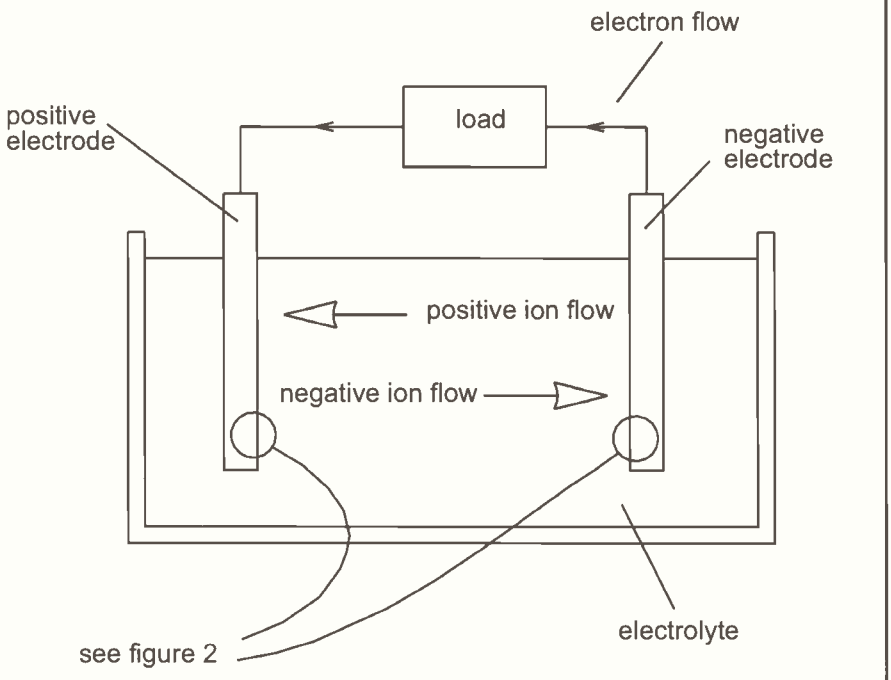


Figure 1. The basic battery

Although there are many different types of battery available, the variety is primarily based on trade-offs between cost and the primary requirement for a particular market. This might be voltage output, maximum current capability, total energy capacity, weight, volume, shape, range of temperature of operation, voltage stability, flatness of discharge curve, safety and environmental concerns, commercial demand, or shelf life. For secondary (rechargeable) cells additional factors might include charge method, charge time, memory effects, or the number of charge cycles the battery can survive and still be useable. The materials used in the manufacture of the battery are then chosen (or developed) accordingly. So what's going on inside a battery, determining these factors?

The Four Elements

The purpose of a battery is to provide energy to do some useful work, which it does by producing free electrons that carry charge. The only materials where free electrons are available in large quantities (at normal temperatures) are metals. Furthermore the charge-carrying electrons must flow in a closed circuit to be able to do any significant work. Since a battery is a device that generates free electrons through chemical means, the electrons are 'produced' at a metal/chemical interface, and 'travel' through the chemical part of the battery by being 'carried' by atoms in the form of ions. (If an atom has more or less than the normal number of electrons associated with it then it becomes an ion that can carry charge, negative in the case of extra electrons and positive in the case of missing electrons). A substance that forms ions when dissolved in a solvent and takes part in chemical reactions associated with the transport of electrons is known as an electrolyte. Electrons are therefore effectively 'carried' by the electrolyte and so a closed system can exist that enables the battery to do useful work. This circuit is summarised in Figure 1.

So there are four main elements to a battery. Firstly a metal/chemical interface that donates electrons (the negative electrode). Secondly a metal/chemical interface that receives electrons (the positive electrode). Thirdly an electrolyte that carries charge between the electrodes inside the battery. And additionally in a practical battery there is usually a means of reducing the electrochemical side effects that occur that decrease its ability to work effectively. But how does a metal/chemical interface release electrons?

The Electrode/Electrolyte Interface

When a piece of metal is dipped into a solution containing ions of the metal some of the metal dissolves to form metal ions, releasing electrons. At the same time some of the ions 'grab' an electron and become a metal atom again, thus becoming deposited on the electrode surface. See Figure 2.

Both processes occur at the same time and an equilibrium is set up. The free electrons can only occur in the metal and so a negative charge builds up on the metal. This negative charge attracts the positive end of water molecules (undissociated water molecules have a dipole moment, that is they have a slightly negative end and a slightly positive end - see box text, p64).

The water molecules therefore line up against the metal electrode, and for the same reason the negative end of the water molecules surround any positively charged ions. This arrangement effectively creates an 'atomic' capacitor with the metal surface acting as one plate, the 'layer' of ions acting as the other, and water molecules acting as the dielectric, as shown in Figure 4.

The voltage between the two 'plates' depends on the temperature and the concentration of the solution (since it is a chemical process), and also on how readily the metal releases electrons. For a given concentration of solution and temperature the voltage between the 'plates' is fixed and different for each metal. When the metal/metal ion voltage values are arranged in a decreasingly negative order they are called an electrochemical series (see Table 1).

Metal/Metal Ion	Voltage Generated
Lithium	-3.03
Aluminium	-2.87
Zinc	-0.76
Lead	-0.13
Platinum/Hydrogen	0.0
Copper	+0.34
Silver	+0.80

Table 1. Electrochemical Series (standard conditions of 25°C and ion concentration 6.023 x 1023 ions [= 1 'mole'] per litre)

The reason for the differing voltages is that different metals 'hold onto' their outer electrons to different degrees depending on their atomic structure. This is due to differences in the charges on the nucleus of the atom, the size of the atom, and the number of electrons in the inner electron shells (which influence the electrical properties, but don't take part directly since only the outer electrons are free to leave the atom). See the box text on The Electrochemical Series.

An arrangement of one metal electrode in a solution of its ions is called a 'half cell'. If two different metals are placed in an ion solution the ions provide a conductive connection between the two 'atomic' plates of the 'atomic' capacitors since the ions can carry charge through the solution (how fast they can carry the charge depends upon other factors such as the rates of chemical reactions). There is therefore a voltage across the two metal electrodes equal to the difference between the voltages of the two half-cells. This is an electrochemical cell, or battery, and under fixed conditions these voltages are accurately known and can be used as laboratory references. For example the Clark cell uses a zinc-mercurous sulphate-mercury device to give 1.434 volts and the Weston cell uses a cadmium-mercurous sulphate-mercury arrangement to give 1.019 volts. The electrochemical cell is the device that Volta accidentally discovered 200 years ago.

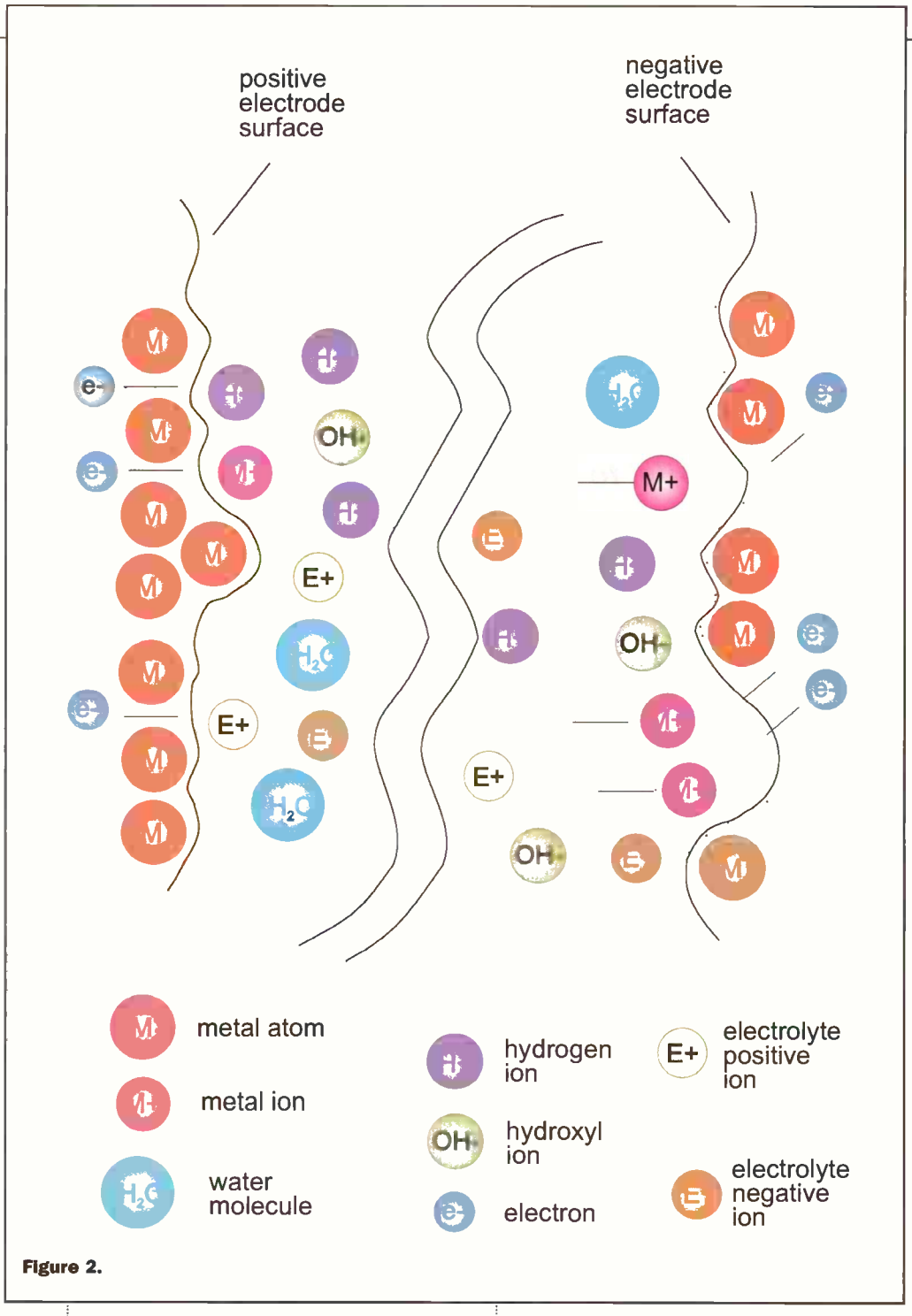


Figure 2.

Oxidisers and Transition Metals

The need for an aqueous solution means that hydrogen is released at the positive electrode and this reduces the effectiveness of the interface. It is also a problem for a practical battery since hydrogen gas is explosive, or if contained builds up pressure. One solution as has been seen is to use nitric acid as an oxidising agent to oxidise the hydrogen to water. This is not a very practical method for general use and the use of the manganese dioxide/carbon electrode has been adopted. This works because of the properties of a group of metals called the d-block or transition metals, of which manganese is one. Other important ones are nickel, silver and mercury. Metals conduct electricity because their atoms easily give up the electrons in their outermost electron shell. Zinc for example has two such electrons. But manganese can donate up to seven electrons, and in the form of manganese dioxide the manganese atom has given up four electrons, ie it is an ion with an overall positive charge of four. Its strength as an oxidising agent is that it can accept electrons singly and become a manganese ion with an overall positive charge of three. In 'grabbing' an electron at the electrode interface manganese dioxide

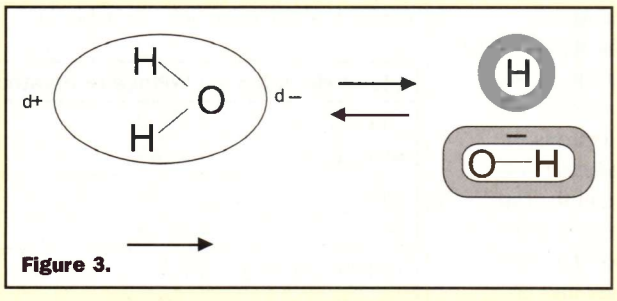


Figure 3.

Water Dipole Moment

The water molecule tends to dissociate slightly into hydrogen and hydroxyl ions, which are strongly positively and negatively charged. Because of the strongly negative oxygen ion however the water molecule also tends to have a slightly positive and a slightly negative end, and will therefore 'surround' other charged ions, including the hydrogen and hydroxyl ions themselves. A molecule with opposite small charges at either end is said to have a dipole moment and this can be represented by a small arrow (as in Figure 4).

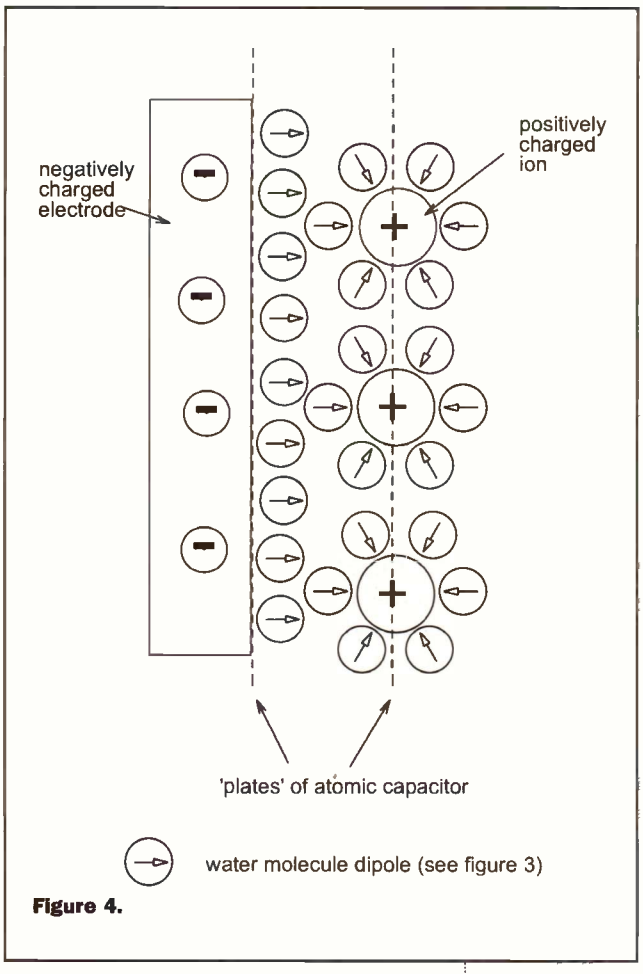


Figure 4.

effectively prevents the hydrogen being released as a gas. Manganese has the largest number of possible different stable states of electrons free to take part in interactions with other atoms, but all the transition metals can do this to varying degrees.

Battery Capacity

Michael Faraday established in 1834 the other main principle behind battery operation, relating the amount of material in the battery to the amount of electricity it can produce. For example for every two electrons flowing in the circuit one atom of zinc is dissolved in the electrolyte in the form of its ion. At the same time two atoms of manganese four plus are converted to manganese three plus. The electrolyte must be able to carry the equivalent charge through the electrolyte by means of ions carrying one negative charge (or positive charge for ions moving the opposite direction) for each electron. So the amount of charge a battery can produce is governed by the amount of material present and its purity. Within the electrolyte itself the concentration can be increased to give more ions per volume, but the less solvent there is the less of the electrolyte is in the form of ions, which is essential for battery operation. So there is a fundamental limit to the total amount of charge a battery can produce. The rate at which this charge can be produced ie charge per unit time, or current, is ruled by the rate of the chemical reactions occurring which again depends on factors such as chemical concentrations, surface area available for reactions and temperature. The total amount of energy that the battery can provide depends on the voltage generated across the electrode/electrolyte interfaces and is the familiar volts times ampere-hours formula. So it can be seen how all batteries are ruled by these basic principles and that the choice of materials and configuration is the best compromise that can be achieved for the required performance specification. So what are the different options?

Battery Variations

The most basic general-purpose battery available is the one that has been around for over a century, the one based on the Leclanché cell and consisting of graphite/manganese dioxide and zinc electrodes with an ammonium chloride/zinc chloride electrolyte. The main development of this was the replacement of the electrolyte mixture with zinc chloride alone, the ammonium chloride tending to 'leak' though the zinc electrode/container when the battery was 'used up'.

The next development was the familiar alkali battery, which replaced the zinc chloride electrolyte with the alkali substance potassium hydroxide. This gives the highest power to size ratio of the manganese dioxide and zinc type batteries.

A more specialised variation of this type is the manganese dioxide and magnesium battery, which is used where light weight is important. Other specialised alkali cells are the mercuric oxide-zinc and silver oxide-zinc cells, commonly used as watch batteries.

Lithium is a relative new material for commercially available batteries. Its use was initially prevented because it reacts aggressively with aqueous solutions and so non-aqueous electrolytes needed to be developed; electrolytes such as lithium tetrafluoroborate in a carbon based solvent. The advantage of a lithium half-cell is its high voltage (refer to Table 1). One cell using lithium is of the lithium-manganese dioxide type. Another is the lithium-iron sulphide cell. A commercially successful type is the lithium-carbon monofluoride battery. Yet another lithium type that demonstrates a further technological advance is the lithium-thionyl fluoride cell. This uses the liquid thionyl chloride not only as the electrolyte solvent but also as the material of one of the electrodes. A film of lithium chloride automatically forms to provide the barrier between the two half-cells. This type of cell provides the greatest commercially available energy and power density, and furthermore will operate at down to –54 C. It is used for providing backup power in aerospace systems.

Electrochemical Series

The degree to which the outer electrons of materials are held depends on the charge on the atom. Metals with large nuclei contain more protons and have more positive charge, which tends to attract electrons. But atoms with more protons also have more electrons in the inner shells (a neutral atom has the same total number of electrons as protons). These inner shells therefore shield the outer electrons from the positive nucleus and the outer electrons are less firmly held. Additionally the atoms with more protons and electrons are larger and so many of the electrons are much further away from the nucleus and so feel the attraction of the positive charge even less strongly. The interaction of these effects determines the metal's electrode voltage.

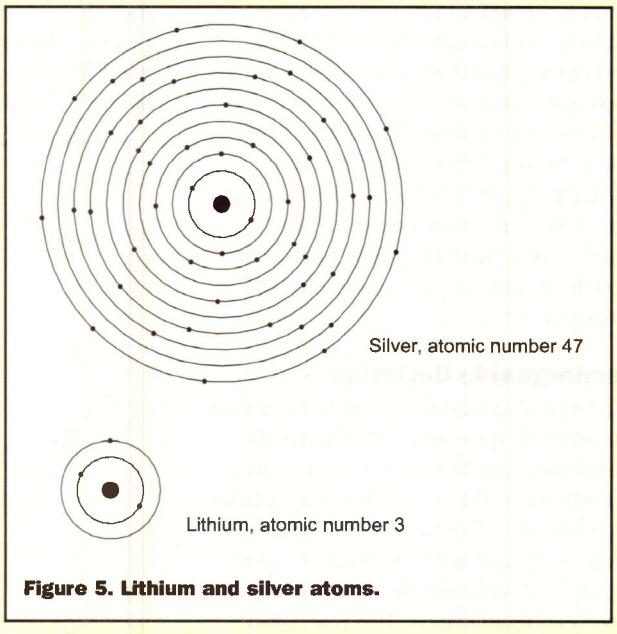


Figure 5. Lithium and silver atoms.

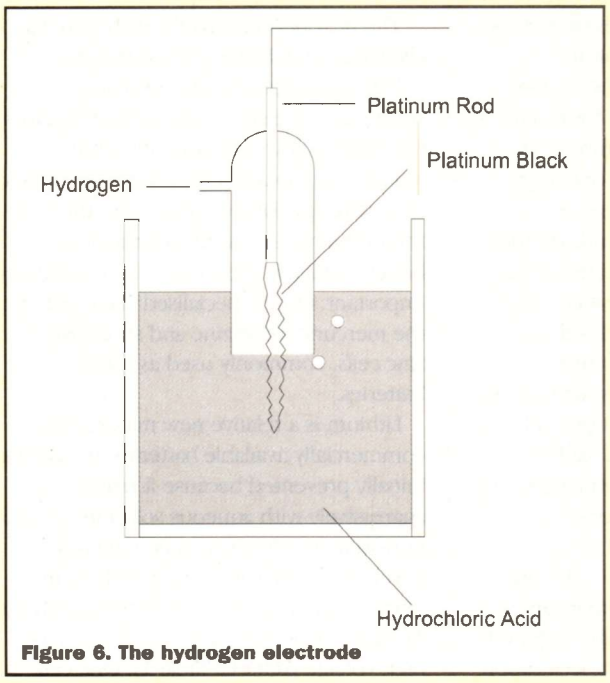


Figure 6. The hydrogen electrode

Hydrogen electrode

Instead of an electrode rod of hydrogen (obviously impossible) a rod of inert platinum coated with platinum black (a finely divided platinum layer that provides a large surface area on which reactions can occur) is dipped into a solution containing hydrogen ions (such as hydrochloric acid). Hydrogen is passed over the electrode, the reactive area of the platinum rod being partly in the ionic solution and partly in the hydrogen gas.

Gas and Air Electrode Cells

A similar cell to the lithium-thionyl fluoride type is the lithium-sulphur dioxide cell, which uses sulphur dioxide gas under pressure as one electrode. One practical problem is the need for the gas to be under pressure but there is another class of cells that use the oxygen in air as an electrode. It may seem strange to consider a gas as an electrode but in fact the hydrogen electrode is used as the reference against which all other half-cell voltages are measured (see the box text for the hydrogen electrode).

Zinc-air systems are commercially available but are difficult to make. If oxygen reaches the other electrode it will attack it. Aluminium-air cells are also available, and research is underway to develop a cell of this type in which the used reaction products are removed and replaced. This is where battery and fuel cell technology start to overlap. The particular appeal of these devices is their light weight and high energy density, which makes them of special interest for electric powered transport vehicles and aerospace use.

Rechargeable Batteries

The technological differences between non-rechargeable (primary) and rechargeable (secondary) batteries is no longer as great as it was when the comparison was between zinc chloride cells and lead-acid batteries. Apart from in vehicles, probably the most widely used rechargeable battery is the nickel cadmium battery. This is an alkali electrolyte battery and the electrons flow between nickel and cadmium compounds as they change oxidation state according to whether they are charging or discharging.

Cadmium is unfortunately a highly toxic pollutant and hopefully the nickel metal hydride battery will eventually replace it. The part of cadmium is taken by a metal hydride, a molecule that consists of atoms of a metal and hydrogen, the hydrogen being of the form where it gains an additional electron rather than the usual situation where it loses the electron from its outer, reacting, shell.

New Cells

Perhaps the most exciting technological advances in battery manufacture are in the use of plastics, or polymers. Normally of course plastics are insulators and this is due to the fact that they are composed of chains of carbon and hydrogen atoms, the bonds between the atoms of the molecules being such that there are no free electrons to conduct electricity. However it is now possible to 'dope' the polymers with atoms of other materials such as sulphur and lithium, and this frees some electrons giving the polymers useful electrical properties. Most important of these properties for battery manufacturers is the ability of the material to act as an electrolyte and hence allow for a completely solid, light, very thin battery. Some polymers may soon replace metal electrodes, allowing for a completely plastic battery!

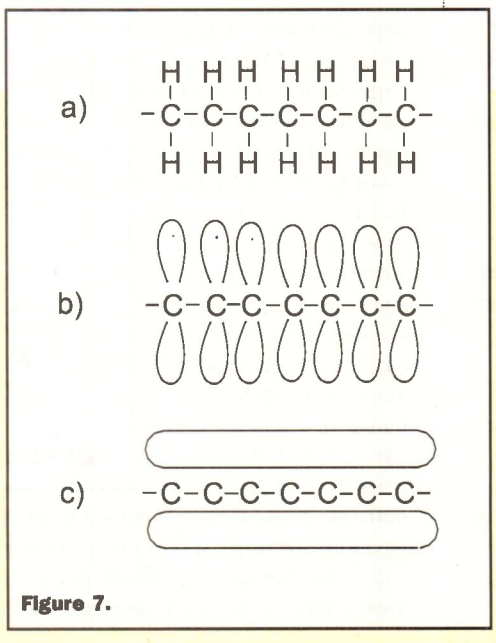


Figure 7.

Ion polymers

a) Polymers are made by linking small carbon and hydrogen based molecules to form long chains.

b) The electrons associated with the bonds between the atoms are normally fixed in orbitals.

c) By adding other atoms such as lithium into the structure the electron 'clouds' can be made to overlap. This gives polymers with properties that enable them to be used as conductors and electrolytes since the electrons can then move through the material.

Fuel Cells

Fuel cells have existed for nearly as long as batteries. When the first batteries were found to break down water into hydrogen and oxygen it wasn't long before the reverse effect, generating electricity from hydrogen and oxygen was discovered. William Grove established this in 1839. It was the need for small highly efficient and stable power supplies for satellites and spacecraft in the 1950s and 60s however that prompted the development of these devices. A fuel cell is essentially two different gas 'half' cells connected together as a single cell (see Figure 8). A practical cell uses porous electrodes and an incorporated catalyst to maximise gas/electrolyte/electrode contact and hence improve efficiency. Pumps and control systems are needed to regulate pressures and temperatures, but once these have been designed to operate reliably the cell will produce electricity for as long as there are gases supplied.

A major advantage of fuel cells is their efficiency in converting fuel to electricity. This is because the fuel is converted to energy directly, rather than by for example burning fuel in a first stage and then using a second process to create the electricity. This might involve the use of steam to turn a turbine, or an internal combustion engine to drive a generator. This is obviously of major environmental importance for reducing fossil fuel consumption and in generating fewer waste products, whether greenhouse gases or toxic materials. The ideal system could use combined fuel cell and battery technology. Fuel

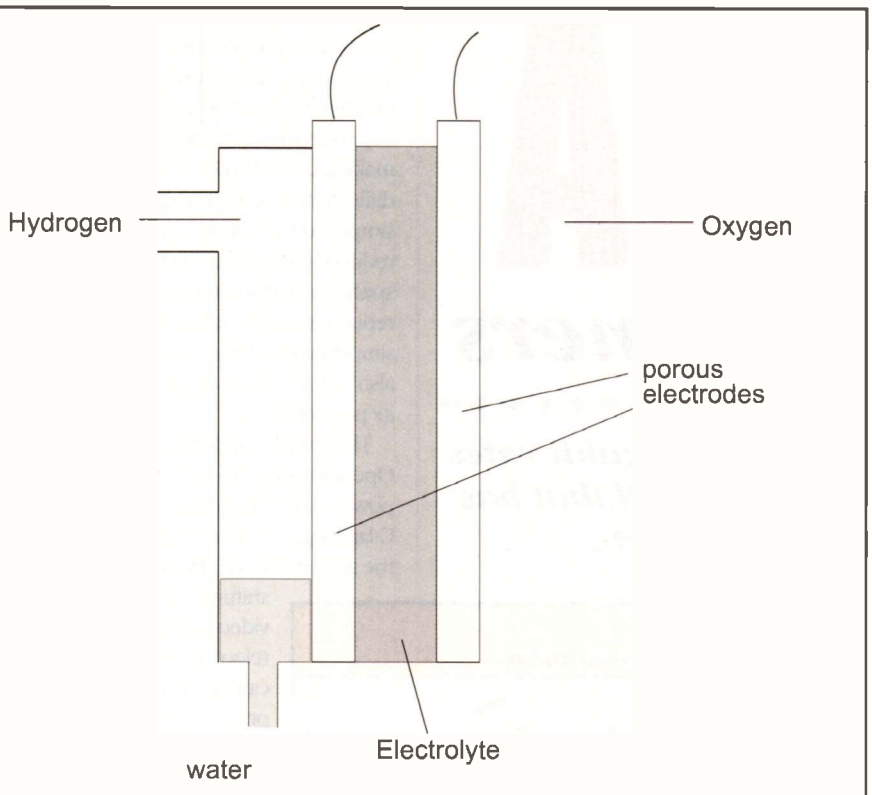


Figure 8.

cells would generate the electricity for charging lightweight high energy density batteries to be used in electric powered vehicles, removing the need for the most widespread generator of pollution and environmental damage. Some fuel cells can convert energy at efficiencies of around 80%; the internal combustion engine is less than 40% efficient.

Another major advantage is that the processes occurring in these kinds of system are reversible. A fuel cell using hydrogen and oxygen as fuel produces electricity and water. Using electricity the water can be broken back down into hydrogen and oxygen for re-use. If the electricity used to regain the hydrogen and oxygen fuel were to be obtained from solar energy a highly efficient system would be in place. The problem at the moment is the level of technology needed for the materials making up a fuel cell. As will be seen in the next section, fuel cell materials need some special properties.

Types Of Fuel Cells

There are several different types of fuel cell in existence, but a problem common to most of them is the complexity of the requirements for the electrode structure. Electricity is only produced at the surface of the electrode so careful design is needed to maximise the interaction between metal, fuel and electrolyte. This also has safety implications. If too much or too little electrolyte reaches the reacting surface the reaction will be slowed. If fuel reaches the electrolyte compartment there is danger of explosion through pressure and/or ignition. A catalyst is needed to speed up the rate of reaction especially for those fuel cells operating at lower temperatures. To fulfil all these requirements an electrode assembly must typically consist of a conducting supporting structure capable of carrying the current generated, a thin gas-permeable waterproof membrane such as polytetrafluoroethylene to separate the fuel and the electrolyte and a catalytic layer of platinum or an organometallic compound (consisting of molecules of a metal linked to a carbon based material). Not an easy or cheap device to design and manufacture to perform with high levels of efficiency and safety, particularly at the temperatures employed in some types of fuel cell!

Alkaline fuel cells, like alkaline batteries, have an aqueous solution of potassium hydroxide as the electrolyte. Electrodes are typically of carbon and nickel, and the device usually operates at less than 100 °C, although even at this relatively low temperature special care must be taken over construction, as the hot electrolyte tends to attack joints and seams. The water by-product is removed by evaporation, and can be recovered by condensation. The cell can be up to 80% efficient. This is the type used in space vehicles, in particular the United States Space Shuttle.

High Temperature Fuel Cells

Another type of fuel cell named after the material used as the electrolyte is the phosphoric acid fuel cell. This cell operates at up to 200 °C and can use hydrogen that is contaminated with some carbon dioxide, so the fuel need not be purified to such a high degree thus reducing costs. Two other types of fuel cell are expected eventually to be used as electricity generators in power stations. These are the molten carbonate and the solid oxide fuel cells, and these use a mixture of hydrogen and carbon monoxide for fuel, usually obtained from fossil fuels. (The advantage over conventional power stations is efficiency.) The electrolytes are respectively molten potassium lithium carbonate and a conductive oxide such as yttria treated zirconium. They operate at around 650 °C and 1000 °C respectively, and are expected to provide around 45% and 55% efficiency. Important issues for the use of these types include design and safety factors because of the nature of the materials and the temperatures involved. However the costs of the materials needed are less than with other types because the electrodes are metal based and simpler in construction - the fuel is deliberately mixed with the electrolyte as part of the reaction process, so separation of fuel and electrolyte is not necessary.

Solid Polymer Fuel Cells

In the same way that polymers are making inroads into commercially available batteries following a period of being restricted to use in specialised applications, solid polymer electrolytes are beginning to be used in fuel cells though currently at high cost. The electrolyte is based on an ion-conducting membrane such as perfluorosulphonic acid. An early version of this fuel cell was used on the Gemini spacecraft that flew in the 1960s as part of the programme to develop the docking techniques that would be needed for the Moon landings at the end of that decade.

Conclusion

The use of hydrogen and oxygen to generate electricity and water for use in spacecraft is a reversal of exactly the same process that nearly two hundred years earlier had been used to break down water into hydrogen and oxygen. This was the process that began the understanding of the elemental composition of substances, and enabled the prediction of their properties, knowledge that has enabled the development of yet more powerful and efficient batteries. From the simple bioelectricity experiments of Galvani and Volta to the power sources of the Space Shuttle the battery has undergone many changes but in some ways has hardly altered. However with the new polymers coming into general use a dramatic new phase of battery evolution could be underway.

Acknowledgements: Encyclopaedia Brittanica CD ROM.

MAP-CA

The Video Streamers

Streaming high quality video at sub Megabit rates was thought impossible not long ago. All that has changed as Reg Miles now reports.

The jointly developed Equator and Hitachi Media Accelerated Processor for Consumer Appliances (MAP-CA) is claimed to set 'a new world standard for cost-effective image computing.' It is also anticipated that it will change digital television product design and development from a hardware-centred to a software-centred approach.

According to Shigemichi Matsuka, Executive Vice President and Director of Hitachi, 'Joint development with Equator has given birth to a very powerful product with a new concept software solution. Hitachi strongly believes that together with other Hitachi microprocessor products, MAP-CA gives birth to a family of de facto standard microprocessors for information appliances in the Internet era.' To which John Setel O'Donnell, co-founder and president of Equator, adds, 'At five times the performance of existing VLIW' (Very Long Instruction Word) 'DSPs, and at one hundred times the price performance of multimedia desktop general purpose processors, and with support for all HDTV format decoding in software, the MAP-CA system will make hardwired video chips obsolete. Our platform's software based approach is ideal for designers that have to keep pace with rapidly emerging and constantly evolving standards for Internet connected appliances and products. This approach allows manufacturers to provide product upgrades and enhancements to units in the field, eliminating both service calls and consumer concerns about early obsolescence. Broadband system operator's can greatly cut time-to-revenue for new interactive services, updating in the field units via software downloads to add new services as business models are established.'

This integrated single chip solution is designed for multimedia products such as interactive set-top boxes, digital TVs, video conferencing systems, medical imaging products, digital video editing equipment, and office automation imaging products. There are also those rapidly multiplying communications products such as modem concentrators and cellular base stations. Products can be multi-functional because the basic functions are delivered by application software rather than dedicated hardware. A MAP-CA based set-top box can support MPEG-4, H.263 teleconferencing, analogue time shifting, modems and other services without incremental cost or complexity; while the imaging engine in a colour printer/copier can be fully soft, and support a wide range of image formats and algorithms at high performance and low cost.

The MAP-CA is a combination of General Purpose RISC and high performance DSP architectures integrated into a VLIW framework. This is an alternative to super-scalar architecture for achieving instruction-level parallelism to realise the potential for executing more instructions per cycle. VLIW combines multiple operations into a single instruction word, which is executed as a broad instruction unit. In VLIW the grouping and scheduling of instructions for execution is done at compile time, rather than execution time as with super-scalar architecture. The consequence is that less on-chip hardware is required to resolve data dependencies to issue parallel operations. By making the compiler responsible for the difficult task of finding parallelism a simplified CPU design can be achieved with a reduced gate count, providing either more space for performance enhancements or a reduction in fabrication costs. This simplification of the processor architecture also reduces cycle times, further increasing its performance.

The single chip MAP-CA delivers 30 Giga Operations Per Second (GOPS) of processing power, while programming in a high level C-language. Programming only in C enables the all-software HDTV decoding, video time shifting, full screen streaming video and video teleconferencing functions that can be provided at the same price as single function digital television products, with shorter design times.

Unlike traditional DSPs, the MAP-CA architecture includes features such as byte addressing, caches, and virtual memory for rapid application porting and wide operating system hardware support. It can unify the host processor with the image processing capabilities, SDRAM and PCI interfaces, and a flexible multimedia I/O system to allow a single external bank of DRAM to support the entire range of OEM product functions. System level power consumption is reduced both by the MAP-CA's design for low voltage operation and the unified memory system. In addition to using advanced CMOS technologies, the MAP-CA system includes architectural improvements that give better performance during image compression and improved I/O capabilities - such as direct connection to multiple video channels. A glueless SDRAM controller supports access up to 128MB of SDRAM at up to 150MHz. A 32-bit 33/66MHz PCI bus interface is also supported.

According to Professor Yongmin Kim, of Image Computing Systems Lab of University of Washington, 'The MAP-CA is currently the most powerful media processor (imaging and video DSP) that exists today. MAP-CA's key advantage is that it can deliver very high performance, even while programmed in C! I believe that MAP-CA will play an increasingly important role, and become a core platform technology in many digital imaging and video applications.'

A number of companies are already on the verge of introducing products based on the MAP-CA - notably Celvibe and Snell & Wilcox.

Celvibe was founded to develop video streaming technologies for future GPRS and 3G cellular networks. Because it believes that a quite different approach is required for that purpose, by comparison with Internet streaming, it has developed a proprietary solution to those particular problems in the form of the CelFeed Digital Versatile Converter (DVC), which provides real-time streaming video in scaleable MPEG-4 format to mobile subscribers.

The CelFeed DVC can transcode compressed digital formats, such as MPEG-1, 2 and 4, in real-time and without the need for decompression, into streaming MPEG-4, and encode analogue formats into the same. It also conducts 'on-the-fly' verification of what the network is capable of handling for each and every live video broadcast, dynamically adapting the bit-rate to the prevailing conditions to provide the mobile subscribers with the best possible video quality. According to Oded Peretz, CEO of Celvibe, 'Being able to dynamically adjust the delivery of content over fluctuating media, such as the air interface of the cellular network, while maintaining high quality video is very difficult. This is one of many features that make the CelFeed such an exciting product.' There is additionally a server in the CelFeed box that acts as a video bypass to avoid Internet traffic that would slow down or disrupt the streaming video (see Figure showing connections).

Future uses could include non-wireless applications such as video conferencing, distance learning and Video-on-Demand.

For additional information contact:

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Snell & Wilcox has developed the world's first streaming video that is superior in quality to VHS at sub-megabit bandwidth. This first end-to-end, optimised digital video platform will enable consumer products to inexpensively deliver the quality that people have become used to over more than twenty years of VHS. According to Professor David Youlton, Snell & Wilcox Chairman, 'We've brought our experience in broadcast quality video processing to broadband media delivery. Our technology coupled with Equator's MAP-CA processor in the set-top box allows us to deliver for the first time a video experience superior to VHS at sub-megabit bandwidths. Alternative solutions using fixed function MPEG-2 codecs require twice the bandwidth.'

Demonstrations at just 800kb/s have shown the technology will do all that is claimed for it. Called VHS-plus/Megabit-minus, it will mean that operators can either cut their costs by reducing the bandwidth they use or charge more for extra variety without increasing their bandwidth -nor reducing the quality.

For additional information contact:

Snell & Wilcox David Cunningham, Press Relations Manager Phone: +44 (0)1730 818904, FAX +44 (0)1730 818248 Email: david.cunningham@snellwilcox.com

Another company that is making use of the MAP-CA is Optibase, a company that specialises in digital streaming solutions over broadband networks. It has been incorporated into the second rollout of its Streaming Media Gateway product line, dubbed MGW 4000. Building on Optibase's powerful server platform capability, this gateway will enable video streaming for broadband services by supporting MPEG-4 and Microsoft's Windows Media Technologies formats.

According to Yaniv Garty, vice-president of marketing and business development at Optibase, 'The deployment of broadband connections is underway, creating an answer to the rising demand for rich media applications.'

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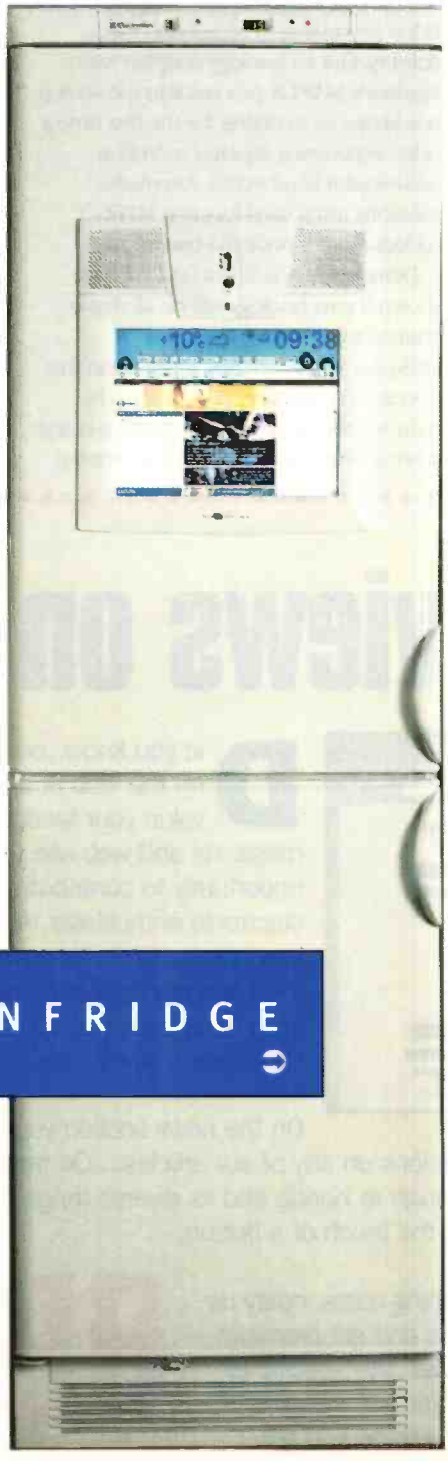
TECHNOLOGY WATCH

With Martin Pipe

Fridges are, like most domestic appliances, somewhat boring. They have one job in life - to keep your food cool! The long-established Swedish white-goods manufacturer Electrolux, in conjunction with Ericsson, is working to bring fridges into the 21st century. It has already attempted to do the same thing with other household electrical goods, including a robotic vacuum cleaner (due for launch soon) and a £1000 lawnmower that do their jobs automatically! Screenfridge, which made its public debut at the German trade show Domotechnica in February 1999, is essentially a cross between a fridge and a touch-screen (hence the name) Internetworked PC. But why build a computer into a fridge in the first place? Because it's in the kitchen! Electrolux research reveals that the kitchen is where 70% of family decisions are made. In terms of the number of visits, 40% of the average householder's time is spent there. It's the focal point of domestic life - and so why not put the PC there? Electrolux reckons that the PC is normally installed in the least-used room in the house (typically a spare bedroom).

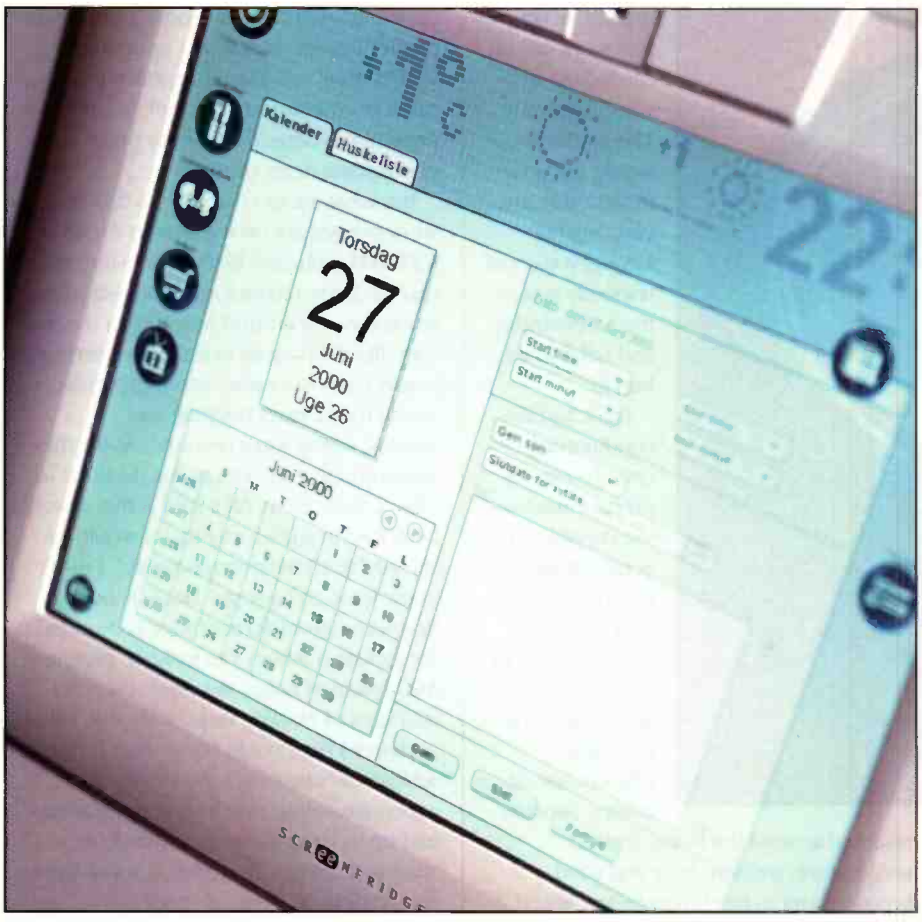
The same research programme has identified other barriers that prevent us from exploiting the PC and the Internet to their full extent. PC location apart, these include slow start-up, slow log-on, unresponsive and complicated user-interfaces, and 'information overload'. Such factors drove Electrolux to develop Screenfridge's simple user interface, which consists of self-explanatory elements working in a flat menu structure. The Screenfridge is intended for use with a fast internet connection that is 'always-on' - such as cable or DSL. It's networkable in other respects too. You can interface security and home-automation systems to the Screenfridge, which acts as a central 'hub'. In terms of the hardware, the Screenfridge is based around standard PC components, but with a TFT colour touch-screen as the user interface (how long would the average keyboard, mouse and monitor last in a kitchen environment?). Hardly surprisingly, the software that runs the show has been custom-developed.



Screenfridge prototype

The decision to base Screenfridge around upgradable components is a logical one. The average fridge has a service life of between eight and twelve years. In that time, the computer hardware will have become obsolete and unable to run the latest applications and Web services. After all, how many ten year-old PCs are still in active service today? But then again, one has to consider that PC components have also changed in design. Motherboards have become smaller, while power supplies have moved from the old 'AT' design to the 'greener' ATX design. Who knows what the future will bring? Let's hope that exact-fit internal upgrades will still be available for that Screenfridge, five years after you buy it!

So what kinds of things can the Screenfridge do? Some of the applications of the prototype are, naturally, tailored around the needs of the family and kitchen. A 'food management' section deals with how to store, handle and prepare food. A 'digital cookbook' with hundreds of recipes is also provided. How practical is that, though? Most budding chefs would rather rely on a physical book, which can be transferred to the food preparation surface! Who wants to constantly pay visits to the fridge to check on the instructions? It could have some practical benefits, though. If the cooker and microwave were to be linked to the Screenfridge, then optimum cooking times precisely tailored to the quantities of food involved could be transferred across. There's no way of monitoring foodstuff levels yet, although Electrolux is considering including a bar-code reader for inventory management purposes. If the fridge was to include built-in drinks coolers, it could monitor the levels of fruit juice and milk remaining (and tell you when to clean out the storage tanks and nozzles) but there's no such provision in the current prototype. Electrolux has discussed an inexpensive 'printable microchip' with built-in RF transponder that could be available in the future. These would presumably be supplied, like sticky-tape, on a roll - and applied to foodstuffs. The fridge would be able to interrogate such stickers, and keep track of sell-by dates and remaining quantities. Shopping lists can be maintained, and transmitted to a WAP cellphone so that you can buy exactly what



you need - now isn't that better than a scrawl on the back of an old envelope!

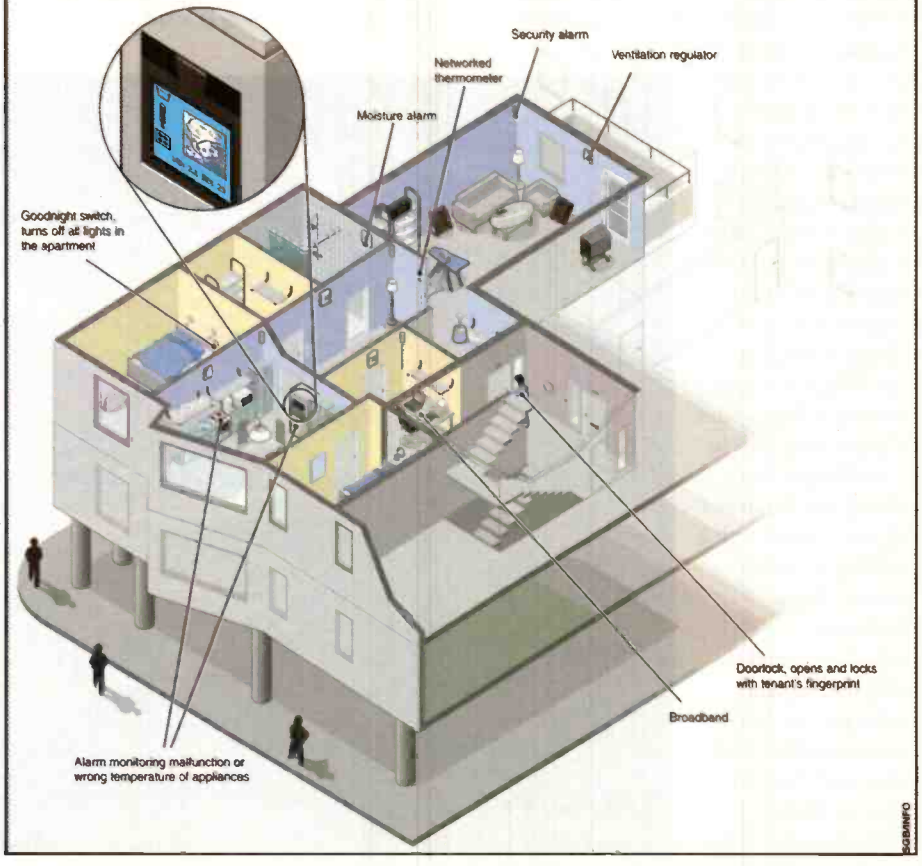
Screenfridge is also capable of acting as a communications centre. It supports not only traditional 'Post-It' notes and fridge-magnet secured paperwork (for which there is still room) but also the electronic equivalent! In addition to sending video messages to family members (there's an in-built camera, which presumably has security applications too) you can also use the Screenfridge to send and receive e-mail. Family members have their own mailbox, where both e-mail and video messages are stored. A touch of a button is all it takes to record a video message, and post it to another family member. Web surfing (and thus home shopping) is possible too, although no information as to the nature and compatibility of the browser has been provided (Is it modelled around the latest Microsoft Internet Explorer? What plug-in support is there?). Presumably, the software will 'auto-update' where necessary, so that new technologies - such as the latest incarnation of Macromedia Flash - can be added without pain. For entering URLs and messages, users can call up a 'virtual keyboard' on the touch-screen.

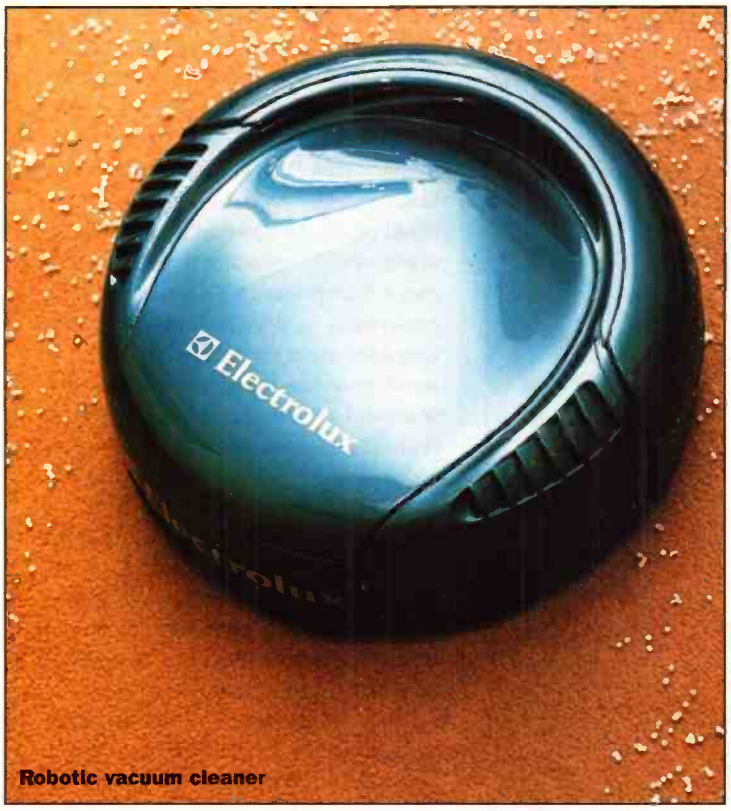
Screenfridge is also equipped with a TV and radio receiver. As a result, there's no need to clutter up your kitchen with the more traditional varieties of broadcast receiver. Instead, you'll be able to watch the morning news directly on the fridge instead. And unlike the average kitchen TV set, the Screenfridge will be able to tune into 'web-casts' and access weather/traffic information. Local 'Neighbourhood Watch' cameras, funded by groups of 'Screenfridged' citizens, could also be set up. The high speed of that cable/DSL connection should translate to a fair picture/sound quality. You can also connect up surveillance cameras, so that you can monitor your back garden or the nursery. Electrolux also reckons that the device could be used to control your VCR (the device could itself act as a recorder, seeing that it incorporates a TV tuner and - presumably - a large hard disk). If you've forgotten to set the VCR, you could remotely-access the Screenfridge from work and tell it to start recording a given channel at a given time. Other remote-access features could include security monitoring, and the switching on of cooking appliances and heating systems.

As I've mentioned before, the Screenfridge is currently in a trial phase. Some of the features may be removed due to lack of interest, while new ones could be added. 50 families in the Danish district of Ballerup are currently involved in these trials, which have been organised by a Ericsson/Electrolux joint venture known as e2-Home AB. Also contributing to the Home Communication Concept (HCC) trial is Tele Danmark, which is functioning as a service provider and network operator. The families will present their opinion when the six-month experiment finishes at the end of January 2001. Each of the 50 families, carefully chosen for demographics and lifestyle, has been equipped with a

The networked home

The Screenfridge is connected to the Internet and serves as the information center in the networked home as well as message board for the tenants.





Robotic vacuum cleaner

Screenfridge, a Tele Denmark 2Mbit/sec ADSL high speed data connection and an Ericsson WAP mobile phone.

An early version of the Screenfridge has also been selected for six 'smart-houses' being built on an island outside Stockholm. 180 apartments are also being equipped with the technology. Here, the Screenfridge is linked to security, home-delivery and environment management systems. The security system is disarmed using a fingerprint sensor - this is an early example of biometric validation within a domestic installation. e2-Home AB is also considering voice recognition - after all, customers would like a system that switches off the security system, turns on the lights and even opens the front door for them if they're carrying shopping! They've got a struggle ahead of them - what's to stop a thief, hiding in the bushes, from making a recording of the 'voice print' with a high-quality audio recorder and a directional microphone, and using that to gain access to your home? Service engineers and other workmen can be given access to selected rooms within the house, so that work can be carried out in your absence. The workman would call your mobile and, after verifying his identity, you could remotely access the Screenfridge and tell it to let him in.

Light and air-conditioning systems can be programmed via the centralised Screenfridge touch-screen user interface. But that's not all - the system is also capable of ensuring efficient use of energy. Sensors mounted around the home feed temperature, ambient light and wind direction data to the Screenfridge. Based on these conditions, the unit will open or close blinds and air vents to take advantage of natural cooling, heating and light. Another interesting idea is the 'universal delivery unit' (UDU), which is provided for home deliveries. Built into a wall, this is a fridge-freezer with additional non-refrigerated space. If you're not around to take in your Internet purchases, the delivery man will plug in a special code (issued to him on a 'one-time' basis by the retailer's ordering system) to open the UDU's door, and leave the goods in the relevant compartment. A built-in camera is provided to deter theft of any other uncollected items present.

But what about cost? The six Stockholm show-houses are on the market for around £300,000 each, and Electrolux estimates that all of the technology plus installation worked out at around 5 to 10% of the total cost. Retro-fitting an existing property would work out rather more expensive, owing to the extra building and ducting/wiring work required. As for the Screenfridge itself, Electrolux declined to offer a likely price. All it said is that it would be priced in such a way that it would be 'affordable to the average family'. I don't know what an 'average' family is but the first commercial Screenfridge is destined for inclusion within Electrolux's 'premium' AEG-branded range. 'Average', then, for residents of Mayfair, Paris or Beverly Hills perhaps? Prices could fall in time, but the additional computer functionality and expensive colour touch-screen will always add up to a significant premium over a 'standard' fridge. Electrolux is considering non-traditional business models, such as lowering the price to consumers in return for displaying banners on their fridge doors. Deals with telecoms companies could also be in the offing.

Martin Pipe welcomes comments and ideas. E-mail him at:
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Or look out for him online! His ICQ ID is: 15482544

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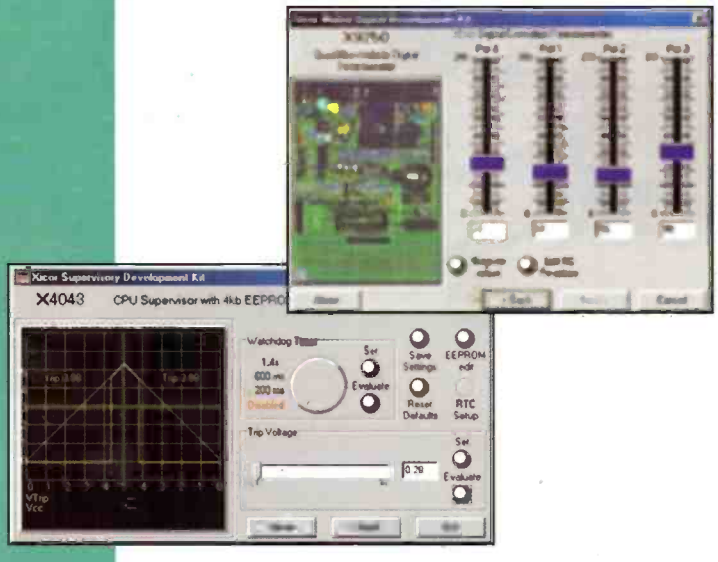

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