ELECTRONICS and Beyond

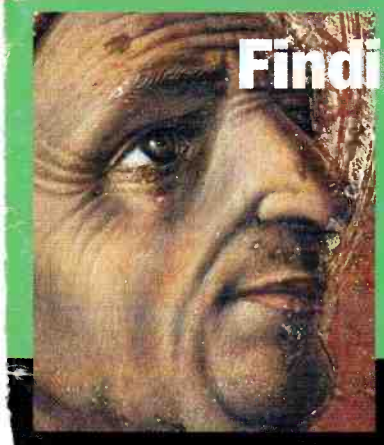
RUGGED

Taking Electronics to the extreme

Luxury

All the comforts of the automated home

APRIL 2001 No. 160 £2.65



Finding the Fakers

Revealing the secrets of art

Grating Light Valves *a new display*

Silicon Mouse Brain

Op Amp Cookbook *part 2*

www.electronicsandbeyond.com

Projects

Car Immobiliser

MIDIMatrix 2

Data Logger for Palmtops

RS232 IO Control Board *part 2*

Britain's most widely circulated magazine for electronics!

BACK ISSUES

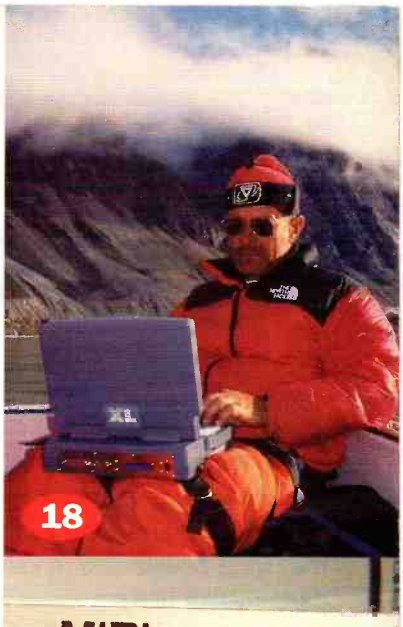
are available from both Maplin Electronics and Kanda Systems.
Only £2.65 each.
Call the Electronics and Beyond Hotline on
01970 621039
and order today.

Issue 155	Issue 156	Issue 157	Issue 158	Issue 159
PROJECTS ★ PWM Controller ★ Remote Printer Controller	**PROJECTS** ★ PC Based Radio Links	**PROJECTS** ★ PC Based Analogue Wireless Link ★ Disco Light Controller	**PROJECTS** ★ Solar Powered 5V Supply ★ RS232 ASCII String Generator	**PROJECTS** ★ 20 Second Sound Recorder Modules ★ RS232 IO Control Board
FEATURES ★ Automated Environments ★ Beyond Silicon Disks ★ Optical Circuits - The Way Forward ★ GPRS in Technology Watch	**FEATURES** ★ Neural Networks ★ Mobile Services ★ Digital Potentiometers ★ Atomic Holography ★ Single Laser Crystal	**FEATURES** ★ Rail Transport of the Future ★ Silicon Nanowires ★ Fuel Cell Developments ★ MP3 Players Reviewed	**FEATURES** ★ Hopping Robots ★ Carbon Nanotubes ★ From Bioelectricity to Space Travel ★ DSP Hands On	**FEATURES** ★ Superconduction ★ Understanding Colour ★ Magnetic Trains ★ Op Amp Cookbook ★ Web Crime

ELECTRONICS and Beyond

April 2001 Vol. 20 No. 160

Regulars



Editorial
Editor Paul Freeman-Sear BSc (Hons)
News Editor Stephen Waddington BEng (Hons)

Production
Layout
Iain Houston
Published by Kanda Systems Ltd.
Unit 17/18 Glanyrafon Industrial. Estate, Aberystwyth, Ceredigion SY23 3JQ.
Tel: (01970) 621030.
Printed by,
Cradley Print. Chester Road, Cradley Heath, West Midlands B64 6AB.

Management
Manager
Paul Freeman-Sear BSc (Hons)

Subscriptions
Paula Matthews. Kanda Systems Ltd.
Subs Hotline: (01970) 621039.

Marketing and Advertising
Natasha Nagaoka.
Kanda Systems Ltd.

UK Newstrade Distribution
Kanda Systems Ltd.

Export Distribution
Comag Magazine Marketing
Tavistock Road, West Drayton, Middx, UB7 7QE

ELECTRONICS and Beyond

Are we going to find ourselves playing with many more remote controlled devices in the automated home of the future? This notion has certainly been reinforced recently by the likes of Orange, the mobile telephone people. They have bought and renovated a house in Hertfordshire and equipped it with many experimental electronic devices. It has become a research centre for them to investigate the ways in which we might be using wireless applications including a 'WAP' phone to control just about everything in the house. The merits of whether you want to key-in or indeed voice-in commands to control the simplest of our household white-goods has to be questioned. We, after all, are already questioning the fact that we as a nation have become unfit for a variety of reasons. Arguably one reason for that, is the TV couch potato syndrome. The future prospect of operating many more devices by handheld controllers may just put us further into the immobile seat. It has to be said however that this research house is demonstrating some highly beneficial technology. The solar panel installations are a good example. In Technology Watch this month, Martin Pipe has taken a look around the house and he gives us an insight into the way that Orange might want to take our household lifestyle in the future.

Just when you thought we had reviewed the latest in display technologies last month; along comes another brilliant solution to large or small screen high definition displays. This time it uses the way we can manipulate light at the micro and nanoscopic level. Using mechanical motion at this level on a chip could be the way forward. Reg Miles reports on Grating Light Valves.

On the projects front, especially for the electronic music enthusiasts, we have an 8-channel MIDI patchbay that can store 64 of your favourite preset patches, a project to catch data to feed to your palmtop computer and a car immobiliser. Enjoy your read.

Paul Freeman-Bear

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

Intel Introduces Portable Digital Audio Player

Intel has unveiled a portable digital audio player that provides up to four hours of music programming and more than 20 hours of spoken-word audio.

The new product is equipped with 128 MB of memory for storing digital audio in MP3 and Windows Media Audio (WMA) formats.

The Intel Pocket Concert Audio Player can be used with the optional Intel Audio Accessory Kit that includes a home stereo dock and car audio adapter so that consumers have more ways to access, use and enjoy their music.

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

IBM and NCSA Create World's Fastest Linux Supercomputers

IBM and The National Centre for Supercomputing Applications (NCSA) at University of Illinois at Urbana-Champaign has announced that NCSA will install two IBM Linux clusters, creating the world's fastest Linux supercomputer in academia.

NCSA's clusters will have two teraflops of computing power and will be used by researchers to study some of the most fundamental questions of science, such as the nature of gravitational waves first predicted by Albert Einstein in his Theory of Relativity.

For further details, check: **<www.ncsa.uiuc.edu>** and **<www.ibm.com/eserver>.**

Multifunction Card Converts PC to TV, VCR and DVD

Hauppauge has created a TV viewing and recording system, called WinTV-PVR, that plugs into any multimedia PC, allowing owners to watch TV on their PC monitor, pause, record live programmes, and use a CD recorder to create disks.

In addition, the WinTV-Scheduler allows users to program the system like a conventional VCR. The easy-to-use interface allows for daily, weekly or diverse recordings, with a full titled index and instant access to recordings.

On-board processors leave the PC free for other tasks. The WinTV-PVR's built-in processor communicates directly with compatible graphics cards, taking up none of the PC's resources. This allows users the freedom of true multitasking- edit documents or surf the Internet, whilst the TV plays in a Window.

WinTV-PVR is priced at £239 and is available through PC retail outlets including Maplin Electronics.

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

Omega Launches GPS Vehicle Tracking System

Omega Research and Development has launched its new GPS 2000 advanced vehicle tracking and theft notification system which will immediately notify customers by phone, e-mail or pager when their car alarm is triggered.

Omega GPS 2000 combines a small hardware unit and a Web/wireless notification, control and tracking services platform.

Omega provides its customers with a GPS 2000 system that includes a Global Positioning Satellite (GPS) receiver and a cellular radio modem. The module is installed in the vehicle where it is not accessible by a car thief, and the customer determines how he wants to be notified if his car is stolen.

At the time of purchase, users are provided a user ID and select a passcode allowing them to track the vehicle anytime on the phone or Web, change notification parameters, and perform control functions such as unlocking car doors.

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

NEWS BYTES

3i and Cazenove Invest £5m investment in Speech Recognition

3i and Cazenove Private Equity are set to invest up to £5 million in the Speech Recognition Company (SRC), a provider of high-performance speech recognition solutions.

SRC will invest in expanding its range of enterprise speech recognition technology solutions and developing a suite of new telephony speech recognition services. Since 1995 SRC has been delivering speech recognition solutions to many of the UK's leading businesses.

Developments in the capabilities of the core engine technologies and faster processing power have led to growing demand for speech solutions and services to the corporate market.

SRC claims it will be unique in offering a complete portfolio of speech telephony solutions in addition to its current portfolio of speech dictation, digital dictation, and data-entry and capture solutions.

For further details, check: **<www.src.co.uk>.**

Infrared Data Association Demonstrates Future Payment

The Infrared Data Association (IrDA) along with Visa, Palm Computing, VeriFone, CrossCheck and Personal Solutions has demonstrated a new financial messaging standard called the Infrared Financial Messaging (IrFM) which features IrDA's infrared communication technology.

The demonstration shows financial information such as credit, debit or checking data to be sent via an IrDA interface from devices like Palm handhelds or mobile phones to a Point-of-Sales (POS) terminal

The Infrared Financial Messaging (IrFM) specifications form the basis of an open, universal standard for payment processing equipment and financial services. The standard is designed to accommodate more than million mobile phones, PDAs, POS terminals and other IrDA-enabled devices already in the marketplace.

For further details, check: **<www.irfm.org>.**

NEWS BYTES

Microsoft Backs Fonix TimeTalk for PocketPC

Fonix TimeTalk, a software utility for PDAs that utilises Fonix Customised Text-To-Speech (TTS) engine to speak the time of day, has received Microsoft's stamp of approval.

In a review of Microsoft Mobile Devices on the Club PocketPC page at **<www.microsoft.com/mobile/pocketpc/reviews/timetalk.asp>**, Microsoft calls Fonix TimeTalk for PocketPC an impressive text-to-speech technology that Fonix developed in-house.

Fonix TimeTalk for PocketPC enables PocketPC owners to have their handheld devices read the time of day aloud in a completely natural and pleasing female voice.

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

AMD Wins Microprocessor Report Award

The AMD Athlon processor has won the Microprocessor Report Analyst's Choice for Best PC Processor at the Cahner's MicroDesign Resources Analyst Choice Awards 2001. The win marks the second consecutive year in which AMD has been recognised for having the best PC processor.

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

Intel Has Designs on Budget PCs

Intel has unveiled a new processor and chipset for budget PCs, advancing the fundamental hardware building blocks of Intel-based budget PC designs.

The new 800MHz Celeron processor is the first Intel desktop budget PC processor to include a 100MHz system bus, a technology that offers a wider communications path between the processor and the rest of the system, resulting in faster overall system performance.

The Intel 810E2 Chipset supports the bus and a variety of other system innovations.

Meanwhile the Intel 810E2 Chipset brings new Intel technology innovations to budget PCs, including an advanced I/O controller, support for ATA-100 Ultra DMA hard drives, and new USB controllers to support four plug-and-play ports for system attachments and other consumer items.

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

GeoDiscovery Announces GPS Module for Handspring

GeoDiscovery has announced availability of the Geode GPS Module for Handspring Visor handheld computers and GeoView Mobile Software for Palm OS.

Together, these products bring new integrated, geo-aware capabilities to some of the most basic of travel tools - the map, compass, guidebook and travelogue.

These are the first of a new breed of GeoDiscovery Active applications enabled by the same platform. Customers can now order the Geode at **<www.amazon.com>** or at **<www.palmgear.com>**.

Prime Minister Launches Tesco Computers for Schools

The Prime Minister has launched the 10th Tesco Computers for Schools scheme in Sedgefield, County Durham. Cutting a special 10th birthday cake with children from Hardwick Primary School in their local Parish Hall, he praised the scheme - the UK's longest running and most successful schools' promotion ever - which has delivered over £62.5 million worth of computer equipment to schools.

The Prime Minister, Tony Blair says, "Tesco Computers for Schools is a fantastic scheme and is very successful. Education is the key to success and we're investing in schools to provide this."

Terry Leahy, Tesco chief executive said, "We've given £62.5 million worth of computer equipment to UK schools in the last nine years, which includes 42,200 computers and 328,000 additional items of computer equipment. ICT is vital for everyone's future - and schools need as many PCs as possible to give pupils the best chance.

Tesco Computers for Schools is the UK's longest running and most successful schools' promotion ever. There are over 38,000 schools in the UK - 22,000 of which took part in the scheme last year. In nine years the scheme has delivered more than 42,200 computers, which is the equivalent of more than one computer for each school in the UK.

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

Pine Takes the Skip Out of MP3 CD Listening

Consumers can now listen to MP3 files on the move skip-free as Pine launches its second generation MP3 CD player at CES.

The SM-200C+ offers an improved 50-second anti-shock mechanism, compared to the original version, to give listeners endless hours of skip-free MP3 listening. In addition, the player comes with new features such as resume play and an album search function.

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

BT Puts Disabled People In London In Touch With Technology

National charity AbilityNet is to open a regional centre in London. The new centre will be based at one of BT's key operational buildings - the Angel Centre in Islington, and will be funded over the next three years by BT.

The facility will be the eighth AbilityNet centre in a growing network run with the help of partners in public, private and voluntary sectors.

Other AbilityNet centres are already in operation in Liverpool at the Glaxo Neurological Centre, in Reading on the Microsoft Campus, in York at the College of Ripon and York, on the Agilent Technologies site in Edinburgh, at IBM in Warwick, and at West Byfleet and Malvern.

The new AbilityNet London @ BT centre, will expand the availability in the capital of the range of services that AbilityNet offers nationally.

These are: assessing the needs of individual disabled people to identify the best solution for their computing requirements, free information and advice, the supply of computer equipment fully adapted for use by people with disabilities, training, technical support, awareness education for professionals and employers and consultancy for employers.

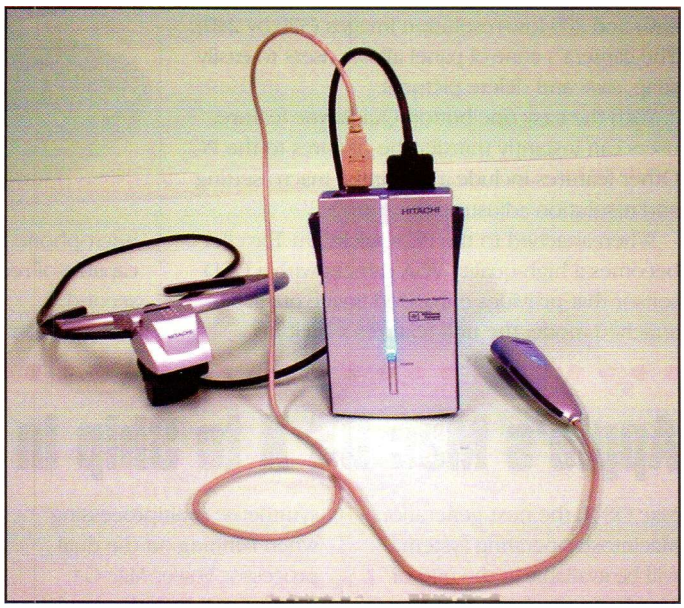
For further details, check: **<www.abilitynet.co.uk>.**

Wearable Internet Appliance Collaboration

Hitachi, Shimadzu, Colorado MicroDisplay and Xybernaut are exploring business opportunities in the field of Wearable Internet Appliances (WIA) and have developed an initial prototype device.

WIA allows hands-free, mobile access to the Internet. The prototype appliance includes a wearable display that allows hands-free viewing of a PC-class high-resolution large screen image, and a control unit that supplies images, including streaming video, to the display, and provides wireless access to the Internet.

A Hitachi SH-4 32-bit RISC processor and Microsoft Windows CE 3.0 power the prototype control unit.



WIA could be an ideal solution for a range of business applications, from call centre and maintenance services to environments requiring worker mobility such as in postal services and logistics, health care and hospitality industries.

For further details, check: **<www.hitachi.co.jp/wia>.**

C&W and Alcatel to Build World's Most Advanced Cable

Cable & Wireless is building the world's most advanced Internet Protocol (IP) transatlantic cable, known as Apollo, together with Alcatel, world leader in intelligent optical networking, to meet growing IP and data demand.

The new cable system is scheduled to begin service in the summer of 2002 and will make available to Cable & Wireless customers significant bandwidth at lower cost, well in advance of competing systems using similar technologies.

It anticipates the huge demand for bandwidth that analyst's forecast to grow on average at around 100% per annum, as a result of the rapid adoption of business internet communications worldwide.

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

NEWS BYTES

Semiconductor Sales Reach Growth of £120 Billion

Worldwide sales of semiconductors were up £11 billion in November 2000, an increase of 28.4% over £9 billion a year ago, according to the Semiconductor Industry Association (SIA).

The Japanese market grew 38.9% and the Asia/Pacific market 20.9%. The US market rose 30% and the European market 24.1%.

Semiconductor product sectors that experienced strong growth in 2000 included flash memory, standard mobile and communication-specific integrated circuits.

These products can be found in mobile phones, Internet infrastructure and personal digital assistants, as well as in other communications and consumer products.

From its beginning in the 1950s, the semiconductor industry has been characterised by a four-year cycle, sporadically modified by unexpected economic factors.

The semiconductor industry has grown at a compound annual growth rate of 17% over the past 40 years.

For further details, check: **<www.semichips.org>.**

Switch-Hits 500 million

In what must be something of a world record Duraswitch announced this month that one of its PushGate pushbutton switches has completed over 500 million actuations.

The test began in January 1998 and has been running almost continuously at about 400 cycles per minute ever since.

Switch design engineers worldwide have been able to follow the test by viewing a counter on the Duraswitch Web site.

The Duraswitch technology is a result of physicist Tony Van Zeeland's efforts to find a better switch. Van Zeeland knew that the traditional membrane dome and electro-mechanical switches have been typically the weakest component of any electronic product.

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

NEWS BYTES

CyberGuard Keeps Networks Safer

CyberGuard has announced that its line of firewall appliances, which includes CyberGuard STARLord, KnightSTAR and FireSTAR, are the first firewall appliances in the world to receive Common Criteria Evaluation Assurance Level 4 (EAL4) certification, the most prestigious and rigorous IT security evaluation process available.

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

3Com Home Wireless Gateway Sets Users Free

Computer users who have longed for the freedom to surf the Web from the garden, download recipes in the kitchen or respond to e-mail from the comfort of their front room now have the solution, thanks to 3Com.

The company's latest Digital Home innovation allows consumers to peacefully share high-speed Internet access, personal files and resources wherever they are in the house (within 300 feet) - without drilling any holes or installing any new cables.

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

Fingerprint Reader Secures Toshiba PCs

Toshiba has announced the availability of an enhanced security solution for mobile computer users. Toshiba's PC Card Fingerprint Reader uses Biometrics technology to offer security that is quick, convenient and reliable.

Attached to a standard Type II PC Card, the retractable fingerprint reader captures an image of the user's fingerprint and uses the information as identification for entry into the system.

Called Biometrics, this technology uses complex algorithms to convert the image into a map of points. Eliminating the hassle of remembering cryptic passwords, this technology will provide a simple, worry-free method of mobile PC security.

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

Better Deal for Greener Generators

Helen Liddell, Minister for Energy, has welcomed proposals to help greener generators secure a better deal. The initial report from a working group set up to boost electricity production by small electricity generators was published in January.

The Embedded Generation Working Group, which has experts from across the industry, was set up by Government to look at ways to improve access to regional electricity distribution networks for smaller generators.

This is particularly important for renewable energy plants and combined heat and power (CHP) installations that need easy low cost access for their projects to be viable.

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

Logitech Snap Photos Away From PC

Logitech has announced a dual-purpose camera, QuickCam Traveller. This new product joins the popular QuickCam family, which has helped more than five million users create closer personal connections over the Internet.

QuickCam Traveller combines easy Web communication with the freedom of a digital still camera. When detached from the PC, the camera can store up to 60 high-resolution images (640 by 480) and 200 low-resolution images (320 by 240). The camera's control panel allows users to easily snap, save and delete pictures.

With the easy one button QuickSync feature, users can instantly transfer the pictures to the PC. Other features include a self-timer, macro setting and resolution adjustment.

When attached to the PC, QuickCam Traveller becomes a high-quality VGA camera with a CCD sensor that provides enhanced image quality. In attached mode, the unit features a built-in microphone for natural communication and is capable of recording video at up to 30 frames per second.

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

Apple's Mac OS X to Ship in March

Mac OS X, the next generation Macintosh operating system, will be available at the end of March. Apple claims that Mac OS X is the world's most advanced operating system, combining the power and openness of UNIX with the ease of use and broad applications base of Macintosh.

Apple has shipped more than 100,000 copies of Mac OS X Public Beta since its release in September and has received more than 75,000 individual user feedback entries from Mac users and developers.

Mac OS X is built upon an incredibly stable, open source, UNIX based foundation called Darwin and features true memory protection, pre-emptive multi-tasking and symmetric multiprocessing when running on the dual processor Power Mac G4.

Mac OS X includes Apple's new Quartz 2D graphics engine (based on the Internet-standard Portable Document Format) for stunning graphics and broad font support; OpenGL for spectacular 3D graphics and gaming; and QuickTime for streaming audio and video.

The operating system also features an entirely new user interface called Aqua. Aqua combines superior ease of use with new functionality such as the Dock, a breakthrough for organising applications, documents and document windows.

Mac OS X is the first operating system designed from the ground up for the Internet and includes a number of key Internet applications including Microsoft Internet Explorer:mac 5.1 Preview Release; Apple's new mail client compatible with the most popular Internet e-mail accounts; QuickTime player; and Sherlock Internet search tool.

Apple's innovative suite of Internet Services will be fully integrated into Mac OS X, providing all users with an automatic iTools account and access to new features such as quick access to their iDisk Internet storage folder.

For further details, check: **<www.apple.com/uk>.**

Digital WATERMARKING

Protecting audio and video copyright still remains a problem as Reg Miles reports

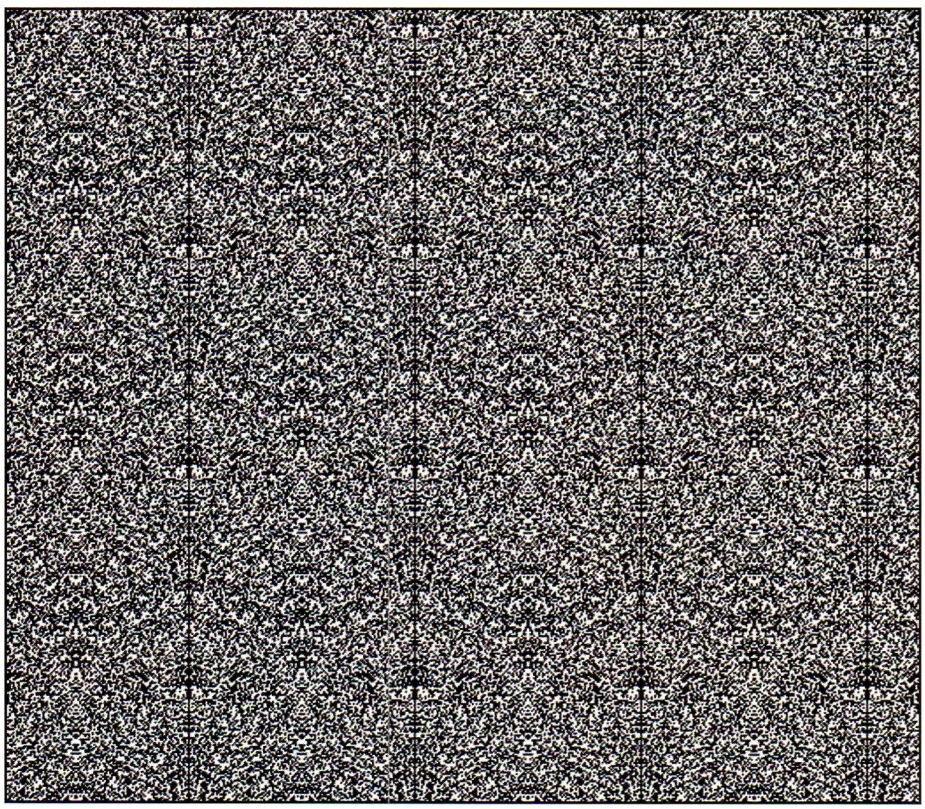


Figure 1. A watermark pattern from a still image.

With the growing availability of consumer digital recording devices, audio and video, the copyright holders are demanding increased protection for their material - against consumers as well as pirates. In particular the big broadcasters, film studios and record companies, have generally opposed any developments that would allow anyone to record from original or transmitted sources (the numerous court cases down the years attest to that fact).

They felt threatened while everything was in the analogue domain, with the scope for copying and distributing copies restricted in scope due to the degradation at each stage. Each copy of a copy was noticeably degraded and the limit of acceptability was soon reached. Now with Digital they are positively paranoid at the thought of unlimited copying without degradation! An exaggeration, of course: most of the material that is and will increasingly be made available to the public is initially degraded by compression and, despite error correction, each copy will further degrade the quality - it will just happen more slowly than with analogue. Which is cold comfort, I suppose.

The major film studios and record companies have consistently opposed any improvements in reproduction quality since the introduction of consumer recording equipment - the late Fifties for audio and the late Seventies for video. They have also opposed any additional means of disseminating their material. Initially they objected to radio and television on the grounds that if people could hear/see the things then they would not wish to buy them. But the record companies were pleasantly surprised: when people heard a tune they liked on the radio they were quite likely to buy the record (that was in the days before we were inundated with radio stations and music programmes). The film studios, however, had their worst nightmare realised: people who had been visiting cinemas once or twice a week before television went once or twice a year, if they could be bothered to go at all, when they got television. Now they all have to face up to the Internet, and changes that that will bring to production, promotion and distribution.

The film studios and record companies cannot, or will not, comprehend the fact that many people object to contributing further to their rich coffers (and to the well-lined pockets of the film and pop stars). The TV licence has also proved to be a bone of contention; and TV subscription charges are likely to be viewed with increasing dislike. So that any further restrictions are likely to be unwelcome.

However, that possibility is not deterring the copyright holders in their search for ultimate control over the uses to which the material is put, under the guise of 'keeping honest people honest'. Various means of approaching this goal are available to them (it will never be reached, of course), and these can be used individually or in various combinations depending on the application and the intention. Their thinking at present is to use as many means as possible in combination to provide in-depth defence.

One such means is digital watermarking; which has been getting an increasing amount of publicity in recent times, due precisely to its potential for controlling the consumer's use of copyright material, as well as inhibiting the work of pirates. Watermarking can be used for both audio and video. When done properly the results are claimed to be imperceptible to even those having 'golden ears' or 'golden eyes'.

Watermarking operates by adding a low energy, noise-like, signal to the programme content that alters the audio, video or still image to produce a pattern that is determined by an algorithm (Figure 1 shows one type of video watermark). The pattern can contain a variety of information, including the name of the copyright holder, whether it is permissible to copy the original, the name of the purchaser, and such like. In the case of audio and video the watermark will be repeated at a frequency that will depend on the particular application for the duration of the programme content. These watermarks are made possible by exploiting 'perceptual headroom' - the imperfect human perception that enables the changes to be made without, generally, being perceptible to viewers or listeners. However, the presence of a watermark can be detected by a decoder using the same algorithm that created the pattern. Encoders and decoders with their embedding and detection algorithms can be implemented in digital signal processors, on dedicated chips, or in software according to the application needs. Some watermarking applications keep the algorithms secret to achieve security. However, this method violates Kerkhoff's principle in cryptography which states that

'security by obscurity' is flawed. Others use a secret key mechanism to create and detect the pattern. It is only the key that needs to be kept secret it does not matter if the algorithms are where they can be 'got at', so any company can produce equipment for what is essentially an open system.

Most watermark embedding makes use of spread spectrum techniques - the same techniques that are used for mobile communications and radio networks. And for the same reasons: to make the signal more robust, to disguise it as noise, and to make it more difficult to decipher. This is based on a 1942 patent for wireless broadcast technology granted to Hollywood actress Hedy Lammarr and composer George Antheil. As with radio the two commonly used variations are direct sequence spread spectrum (DSSS) and frequency hopping spread spectrum (FHSS). Both change the narrowband signal into a wideband one, spreading the signals in a psuedo-random manner. The former by phase-modulating the carrier (the data elements selected for modification from the signal to be watermarked) with a pseudo-random number (PN) sequence that spreads each watermark bit into a longer chip code. The latter by dividing the available bandwidth into a range of channels (subsets of the signal to be watermarked) and rapidly hopping through them in a sequence that is again determined by a PN sequence, so that the embedded watermark changes pseudo-randomly over time.

A number of alternative techniques are used or have been proposed. One straightforward method is to alter the brightness of pixels, increasing the luminance of some by one quantisation step and reducing the luminance of others by the same amount. Another is to add faint geometric patterns; but as these can be at least partially seen the technique violates perceptual headroom - although it would be acceptable when it is used to view replicas of original images that would be acquired for a fee. The same applies to the aforementioned technique of altering the brightness of pixels, only by a greater amount - IBM used the technique for replicas of Vatican Library originals, having digitised everything. In the case of text the character or line spacing can be altered or serifs added or removed; or alterations made to the text itself, such as inserting spelling errors, or by using alternative words or phrases. However, none of these are resistant to attacks from anyone wishing to remove the watermarking. Nor is the technique of encoding the least significant bits of randomly selected words.

More resistant are those methods that are based on modifying the discrete cosine transforms (DCT) that are produced as part of the compression process: such as inserting a sequence of bits into the mid-band frequencies of the 8x8 DCT coefficients (compression normally removes the high frequencies). Another way is to linearly add a PN sequence, first shaped to approximate characteristics of vision, to the 8x8 DCT coefficients; or again modifying the perceptually most significant DCT coefficients in a non-linear fashion to shape the watermark spectrum to that of the underlying original image.

Some other possibilities include creating a PN pattern, the same size as the original image, which is encoded with an n-bit word; modifying some statistical property of the original image; and modifying pixels in the proximity of commonly occurring patterns in the original image.

On the purely audio side, echo coding works by giving the watermark bits an imperceptible delay period like an 'echo'; phase coding replaces the short term phase of the audio signal with a signature; while spectral shaping uses the watermark signal to shape the audio signal. Audio also makes use of techniques such as spread spectrum and least significant bits.

To be effective the watermark and the information that it carries must be resistant to both legitimate manipulations and tampering. In most cases it is also desirable that it be transparent to the viewer or listener. Unfortunately, these criteria tend to conflict. While the former requires the maximum energy, the latter requires the minimum. One way around this dilemma that is commonly employed is to use variable depth watermarking in which the strength varies according to whether there is a lot or little detail in the signal to be watermarked. Parts with a lot of strong detail

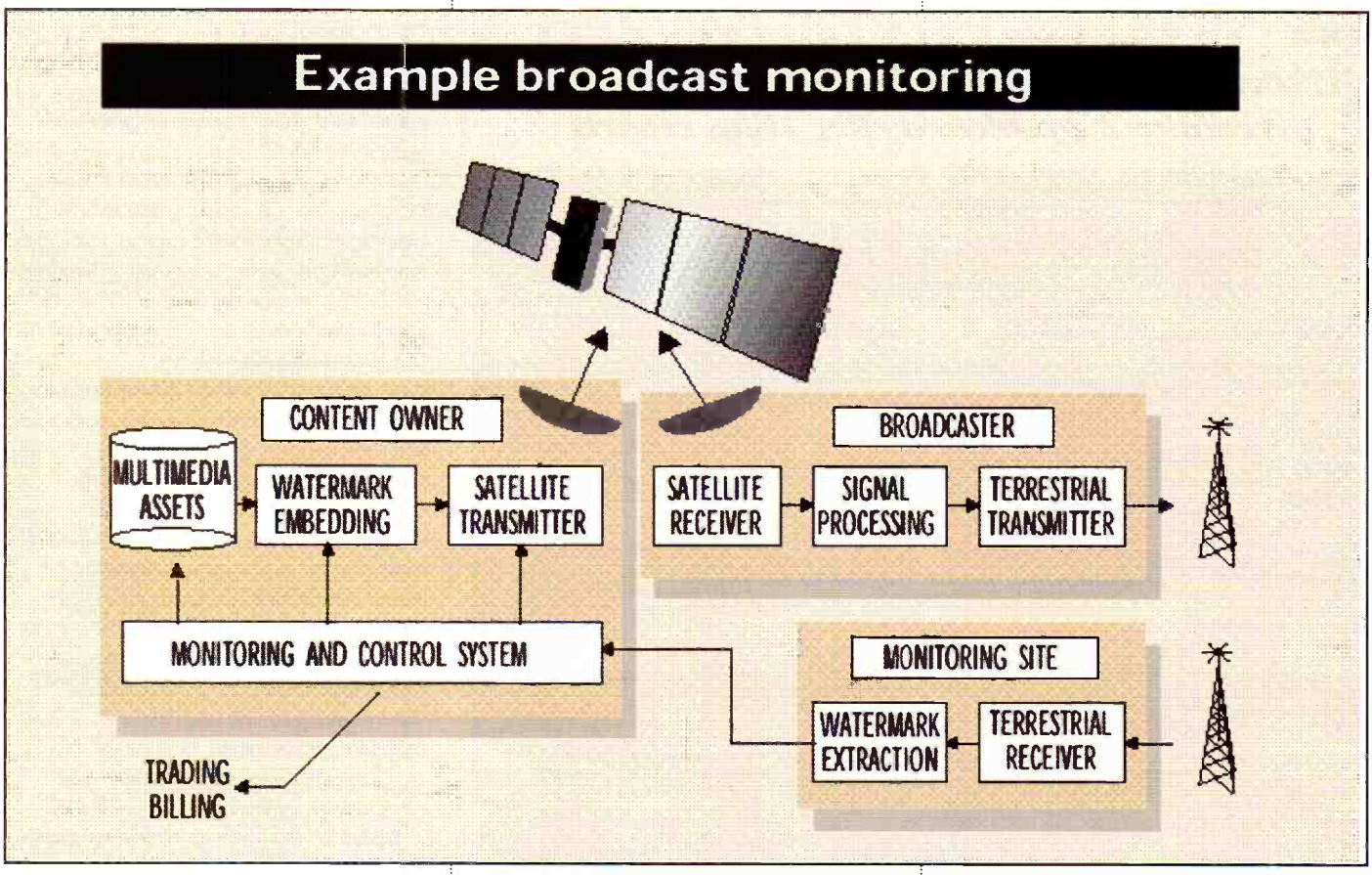


Figure 2. Tracking wartermarked video for copyright holders. Picture: Philips Broadcast

will effectively mask the watermark allowing it to be embedded to a greater depth.

Legitimate manipulations include lossy compression - JPEG, MPEG and the various audio varieties, conversions from one format to another, and conversion from analogue to digital and vice versa. In the case of still and video images the contrast may be enhanced, and geometric distortions introduced in the forms of cropping, rotating and scaling; in the case of audio the frequencies may be modified, and the duration altered. Most of these alterations will be done during post-production; although some will be done subsequently, including legitimate modifications by the consumer of the product to personalise the picture and/or sound quality.

These changes may or may not obliterate the watermark (and the latest systems are quite resilient to such treatment); but assuming it remains largely intact it may be rendered undetectable - at least until the distortion is corrected by the detector, if it can be.

As to deliberate attempts to remove a watermark, there are no shortages of methods that have been tried. However, they do not guarantee success, the criterion of which is that the original work remains intact - it is obviously far easier to 'throw baby out with the bathwater' and end up with nothing but noise. The point is that they generally require time and expertise to do the job properly; so, as with other methods of protecting copyright, watermarking is largely effective against the actions of consumers if not entirely against those of pirates.

The Millennium Group has been formed to attempt to rectify that. It is a consortium of Digimarc (one of the leading watermarking companies - and there are a growing number of them), Macrovision (who produce the analogue copy protection system for VHS, and for DVD to prevent its being copied to VHS), and Philips (who will produce the hardware). Philips Broadcast has already launched the WaterCast embedder to enable the European broadcasters to keep track of their programming. Figure 2 illustrates how this will be done to monitor the use of news and sports releases, checking the usage of commercials or identifying recipients (known as fingerprinting). It can also be used to trace the source of any illegal copies, proving original ownership, and improving contents identification and archiving by adding meta-data (data about the data) such as title, scene, director, camera operator or camera position to the video material. This was developed by Philips Research for the European project Visual Identity Verification Auditor (VIVA). This project ended in 1999. The Millennium copy protection embedder for consumer use is being made available as I write. Of course, to be worth anything that requires watermark detectors to be embedded in all consumer electronic and PC based digital recording and playback devices. Philips has announced that it will implement the Millennium solution in its second-generation DVD+RW format recorders. This 'solution' has been proposed to the Copy Protection Technical Working Group: a grouping of hardware and software companies aimed at developing standards for copy and playback control of DVD. There is a rival, Galaxy Group, consisting of Hitachi, IBM, NEC, Pioneer and Sony with the same ideas. This is to label all DVD discs with 'never copy' or 'copy once', with 'no more copies' being added as a secondary watermark by the DVD player or recorder (only the absence of a watermark would allow free copying).

Figure 3 illustrates the Philips WaterCast system. The basic watermark pattern is cyclically shifted (positive and negative respectively to aid detection), tiled to resist spatial shifts and added to the luminance part of the video content. On the detection side, the video frames are accumulated (generally over twelve frames); these are then folded, summed and stored until sufficient data is available. Symmetrical Phase Only Matched Filtering (SPOMF) correlation is applied with the basic patterns and the watermark is detected.

Philips is not the only company that is planning to provide broadcast monitoring, eventually globally: MediaTag is developing its MonIPR system to mark multimedia material and to track it with its Media Monitoring Stations, initially in the UK then globally. In this case it is the audio that will be watermarked, using the company's AudioTag - both digital and analogue. MediaTag also offers an Internet tracking service using the latest, automated search technology to identify watermarked audio day and night.

Digimarc's MarcSpider scans the Internet looking for watermarked images. However,

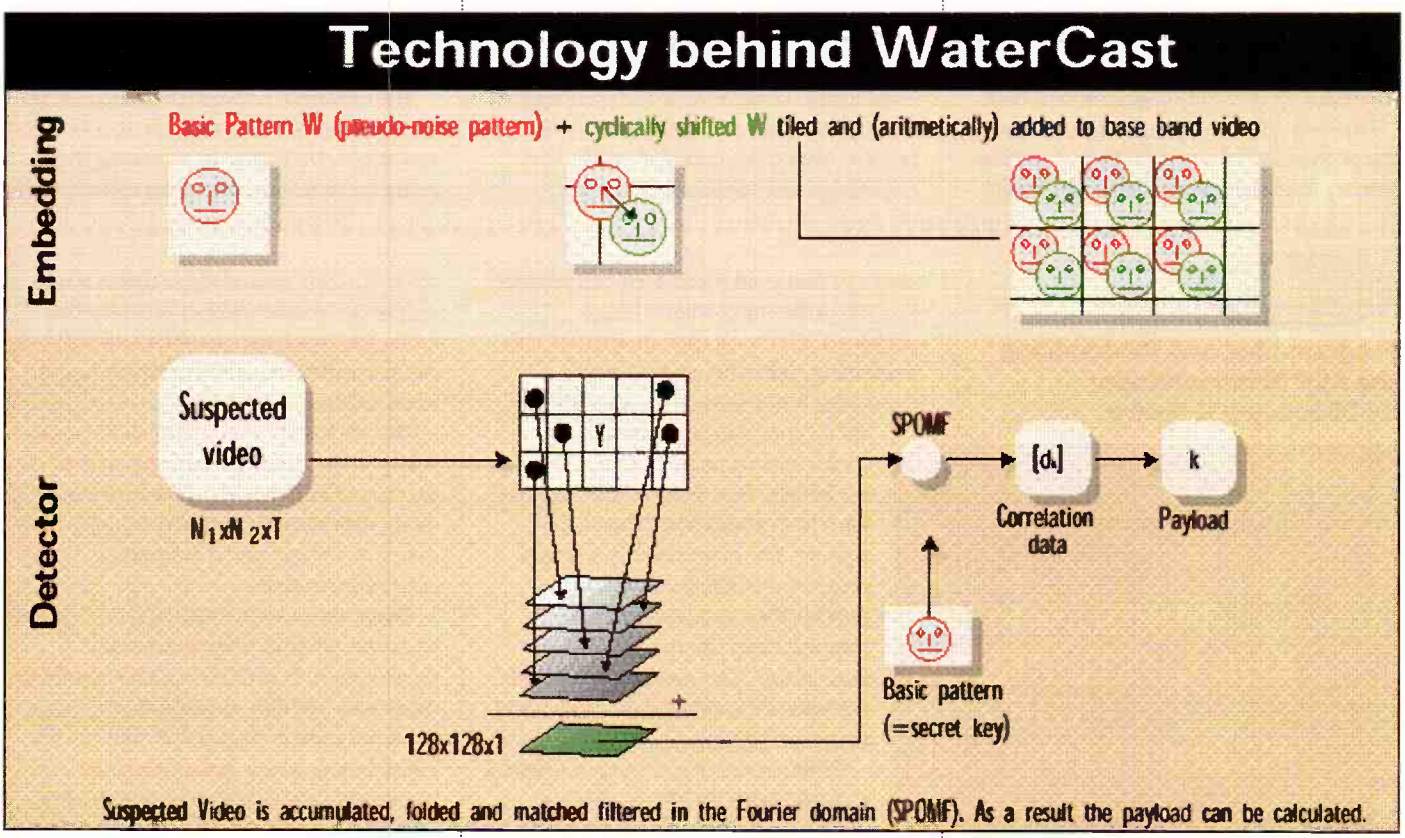


Figure 3. Philips Watercast embedding and detecting. Picture Philips Broadcast

watermarking can have other uses besides or in addition to copyright protection. In combination with a web camera or scanner Digimarc's MediaBridge software will read watermarks embedded in printed and digital images that will take the user to an appropriate web site to get information or to order something. These can be embedded in a variety of things such as magazine editorials and advertisements, book and CD covers, catalogues, credit cards, circulars, event tickets, greetings cards, even packaging. The watermark employs spread spectrum techniques - DSSS in the spatial domain for the watermark and FHSS in the frequency domain for synchronisation. This is embedded in blocks of pixels in a digital image, which is then printed normally. Kodak is also working along similar lines, their scientists have developed a way to store all the digital files for an image onto a hard copy, in a way that is not detectable to the eye. When this is put into a scanner the digital original can be retrieved apparently without loss. Some of Kodak's digital still cameras have the facility for recording a watermark. This can be simple like the date and time, or text, or a graphic or logo. The digital development of the photographic data back.

However, all is not going as smoothly as the proponents of watermarking would like. Notably so in the case of the Secure Digital Music Initiative, created by the music industry to control the distribution of music. The chosen watermark, from Verance, has had its transparency thrown into question. Some musicians detected changes in the music due to the watermarking - although others did not. Naturally, those who are in favour of using it play down the significance of its being perceptible to some because it is not perceptible to all - and is even less likely to be perceptible to untrained ears. Also, quite naturally, those who are opposed to its use, for whatever reason, play up the significance on the grounds that the goal of modern reproduction methods should be to eliminate distortion as far as is possible, not to deliberately add it. It has also been chosen for DVD-Audio by the 4C Entity, composed of IBM, Intel, Matsushita and Toshiba. But this setback did bring joy to one company, Blue Spike, whose Giovanni watermark technology was the only one to be rated as inaudible by SDMI tests.

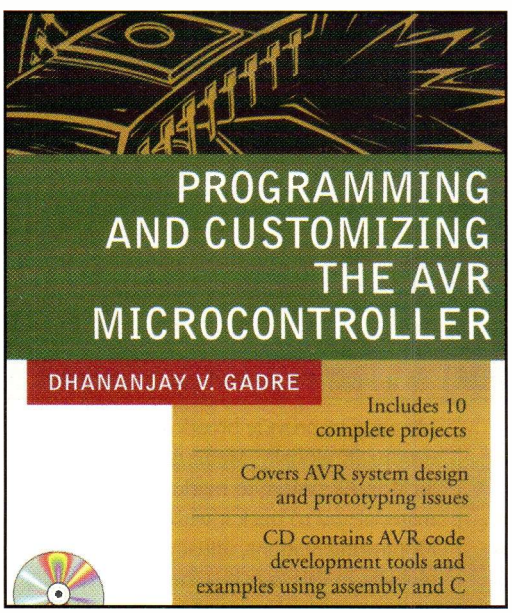
Another problem that awaits watermarking is that of its use with mobile communications. As the services increase, and streaming digital audio and video become commonplace, with their considerable compression, the compromise between strength and transparency will become even more critical. Possibly requiring a new approach? And more investment in R&D if it is to keep up with the pace of development of the material it is called upon to protect?

But as Long John Silver hops off into the sunset it is worth remembering that it was largely the acquisitive efforts of the pirates that kick-started the video software industry. The major studios and at least some of the broadcasters were hostile to video; and the only software that was available came from companies with catalogues filled with B films, old films and cartoons, a few specialist companies with instructional and learning videos, and some pornography. Most of it expensive and for sale only (there was a general objection to rental). The only ones who were giving people what they wanted - new films at reasonable prices, sale or rental - were the pirates (the quality varied, with some of it appalling but much of it up to the commercial standard of the time). It was only when the studios realised that there were profits to be made from distributing their films on video - and the pirates were making them - that they entered the market. At first half-heartedly, with older films for sale at high prices; then forced by the pirates to release newer films at reasonable prices - and for rental.

The difference between then and now is that with digital media the copyright holders can respond to threats by increasing their restrictive practices rather than relaxing them.

BOOK REVIEW

Programming and Customising the AVR Microcontroller by Dhananjay V. Gadre



Review by Toby Maxwell-Lyte - Kanda Engineer

I really enjoyed this book. It is well laid out with lots of pictures and diagrams to clarify what is being explained.

It starts you off explaining some of the basics so that even if you aren't an engineer you can understand what is being explained. The book then progresses into interfacing code with an AVR, and interfacing AVR's with other common (or not so common) peripherals. The book contains projects so that you can implement what you are learning and learn in a project-based hands-on manner. The first project is a simple program that lights an LED; the projects then progress to more complex ideas like the 'follow me musical toy'. The projects cover both the software and hardware angles and are very complete.

Within hours of receiving this book I was able to get an AVR to give me visible results, I got an LED to flash! Simple I know, but it impressed me.

The section on communication appealed since the idea of getting chips to "talk" to each other is really interesting to me. I didn't realise that there were so many different ways that chips could "talk" to each other. Amongst many, there's CAN that's used in cars or USB to talk to PC's. These different communication interfaces mean that micro controllers could be used in robots or home control, for example you could get a micro controller to turn down the TV volume when the phone rings. It seems really amazing that all these things are so readily achievable without breaking the bank, and this book has shed new light on these possibilities, some of which I never knew existed.

The enclosed CD contains all the code that is in the book; this speeds up the process of implementing the projects, along with relevant data-sheets, application notes, and some useful software development tools.

There are recommendations from where to obtain other development tools, development boards etc which is useful for those who are new to the AVR.

All the code in the book is well commented, which makes it easy to understand and simple to follow what is going on in the code.

All in all this is a very good book. I would recommend this book to anyone who wishes to enter the world of micro controllers or someone that already has and needs something comprehensive and informative to refer to. As far as comparing to other Micro controller books, this one was very intuitive and easy to get into. I really hate those in-depth, over-the-top books - this wasn't heavy, but still gets all the info across, and me up and running with AVRs!

Price $39.95.

Available from **<www.kanda.com>**

Grating LIGHT VALVES

Reg Miles reports on another revolutionary display technology

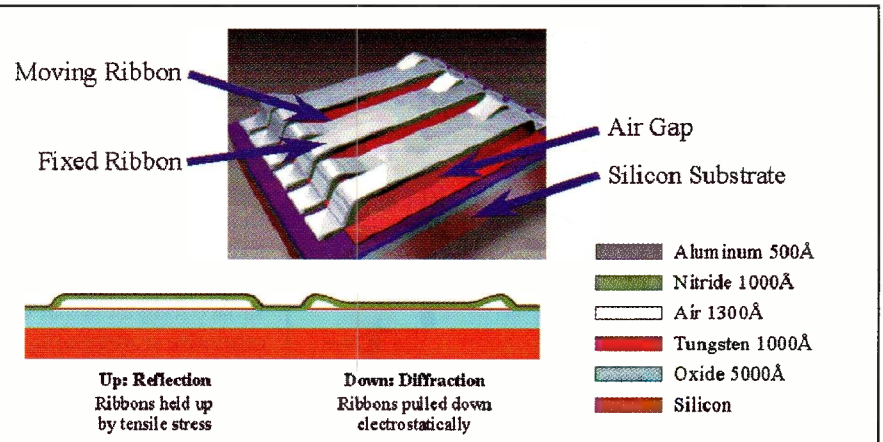


Figure 1.

An interesting display technology is being developed by Silicon Light Machines in Sunnyvale, California, that has the potential to cater for a broad range of applications, from HDTV and high speed digital photofinishing to immersive simulators and electronic cinema. Also, it is claimed to be both simple and scalable; enabling low cost, high performance systems suited for high volume consumer applications.

Originally developed and patented by Professor David Bloom and his students at Stanford University, the Grating Light Valve (GLV) is one of those increasing number of micro-electromechanical systems (MEMS) that are providing mechanical functions at a microscopic scale - in this case that of a phase grating. The MEMS techniques are used to form pixels on the surface of a silicon chip. Each pixel is composed of parallel ribbons (see Figure 1); these are alternately fixed and movable - the latter being achieved by use of electrostatic forces. When in the same plane the ribbons reflect all the light, when alternate ribbons are pulled down a square well diffraction grating is created, diffracting the light. Thus, when the matrix is addressed by control signals an appropriate image pattern is formed on the surface of the chip. And this image is made visible via a lens system, either projected onto a front or rear screen or viewed directly.

'Perversely' it is the reflected incident light that produces a dark pixel and the diffracted light that produces a light one. A Schlieren optical system is used to discriminate between reflected and diffracted light. Reflected light is blocked on its return path; but when the (alternate) movable ribbons are pulled down diffraction produces light at a different angle to that of the incident light and it passes out (see side view Figure 2).

In one implementation, the ribbon lengths are 20mm and the ribbon pitch is 5mm. The pull-down distance is one-quarter the wavelength of the incident light. With these dimensions, a set of four ribbons (two fixed and two movable) produces a 20micron square pixel (see Figure 3). The 'up' position of the ribbons is maintained by the tensile stress of the silicon nitride material from which they are made. By integrating electrodes below the ribbons, and applying different voltages to the ribbons and the bottom electrodes, an electrostatic attraction force will pull the movable ribbons downward (the precise distance being determined during manufacture).

Controlling the GLV device is 'simply' a matter of directing the up and down ribbon movement of this two-state technology. To pull them down, a voltage difference (the switch-down voltage, V2) is applied between the movable ribbons and bottom electrodes. The ribbons maintain their down state even as the voltage differential is reduced. Thus, the pull-down state can be maintained with bias voltage alone - saving power; until the voltage differential falls below V1 and the ribbons return to their up state (V2/V1 is approximately 2). Switching speed is approximately 20 nanoseconds: which is about one thousand times faster than Texas Instruments' Digital Micromirror Device light valve, and about one million times faster than conventional LCD devices.

The reasons for the high speed are the small size and mass, and small excursion, of the GLV ribbons. Several advantages are gained from this high speed switching. It is easier to streamline drive electronics and to simplify the memory requirements. There is no need to provide buffers or delay functions to complement the mismatch in speeds between electronic devices and the MEMS device. Another speed advantage is the ability to modulate, over a wide range, the time ratio of up-to-down states, which produces the effect of shades of grey or colour variations. GLV switching speeds make it easy to implement an 8-bit or greater grey scale, and are fast enough to support colours and greys over a 1000:1 dynamic range.

A simple row and column addressing

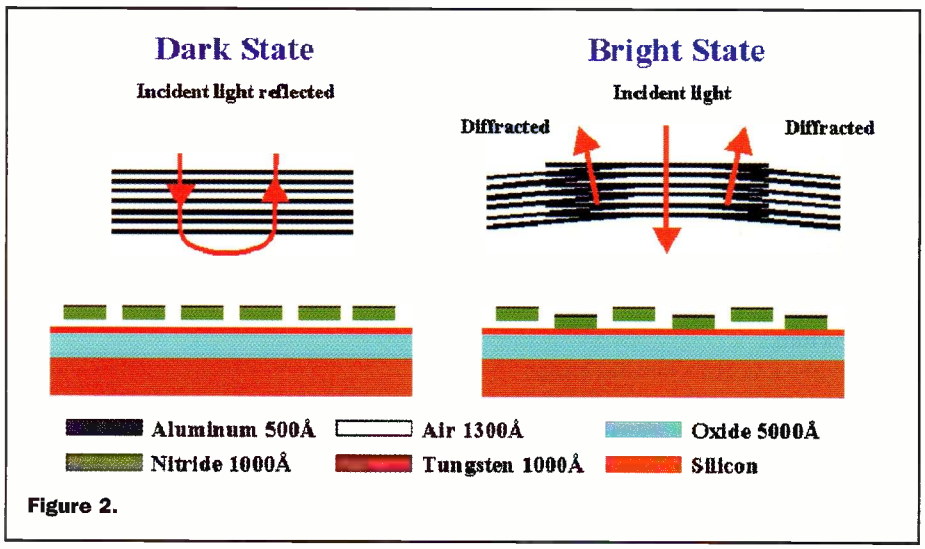


Figure 2.

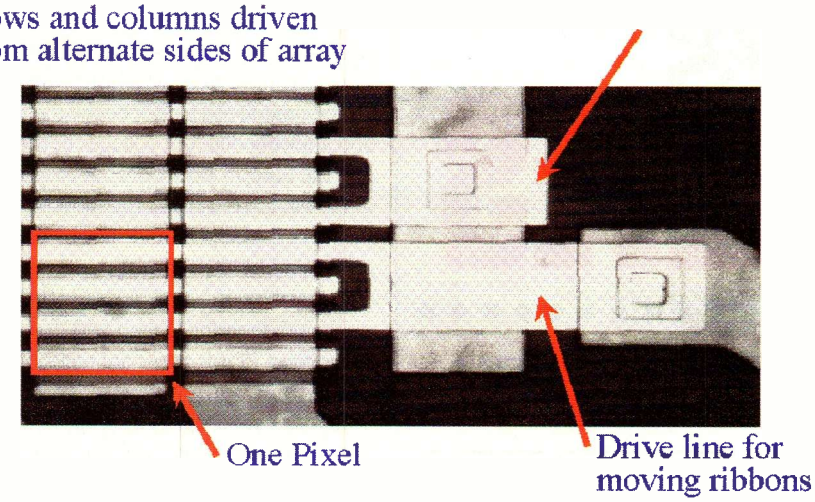


Figure 3.

scheme can be used, and passive matrix (rather than the more complex active matrix) pixel control is all that is required. This eliminates the need for any transistors in the GLV array itself, simplifying the manufacturing process. The GLV technology can be addressed in either digital or analogue modes. In digital mode the pixels are switched rapidly between 'on' and 'off' states using pulse width modulation to give the appearance of changing shades of grey. In analogue mode the depth to which ribbons are deflected is precisely controlled by varying the drive voltage. Moving the ribbons to positions between the two-up/down limits produces the necessary shades of grey. In this analogue mode the GLV has a response that is claimed to be close to the logarithmic response of the human eye. And the GLV's inherent lack of pixel structure is said to give a smooth, film-like image. Variations of these analogue or digital techniques are used to achieve colour reproduction.

One way of reproducing colour is by having three sub-pixels, each with a different ribbon pitch, creating an RGB pixel 'triad' (see Figure 4). White light is introduced slightly off-axis; each sub-pixel refracts its own wavelength normal to the GLV plane, while other wavelengths are refracted at different angles. Colour is produced by reducing the slit width to allow only a limited bandwidth about each of the primary colours to be selected. In a frame-sequential projection system (see Figure 5) a white light source is filtered sequentially by an RGB filter wheel spinning in synchronisation with the RGB signal. In the system shown, a turning mirror is used both to direct light onto the GLV device and as an optical stop blocking reflected light. An even simpler, handheld, colour display device uses three LED sources (see Figure 6). At the opposite extreme, Figure 7 shows a projection system using three GLV devices, with the white light being split into RGB by dichroic filters.

The entire GLV device is designed to be built using mainstream IC fabrication technology. The basic GLV pixel is produced using a simple, 2-mask IC process. Silicon Light Machines has built devices using only 7 masks. Fifty GLV devices can now be produced on a single 6in wafer at very high yields. The ribbons are then coated with a very thin layer of aluminium; making it very thin avoids some of the surface roughness that would otherwise scatter the light and reduce the contrast. When the GLV device is finished and tested, a clear glass lid is fixed above the ribbons area sealing in a dry nitrogen environment for pressure equalisation and to prevent oxidation (see Figure 8). The packaged GLV

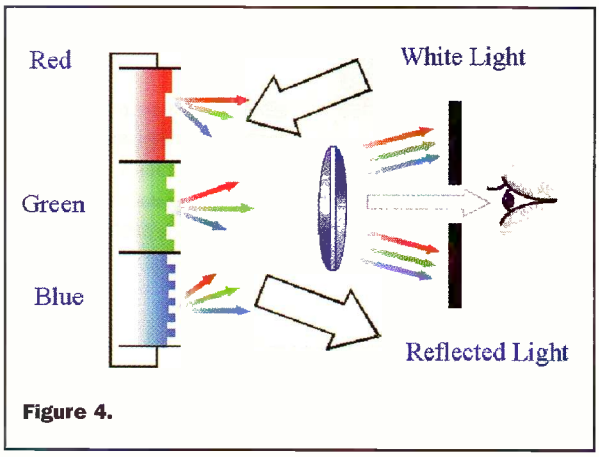


Figure 4.

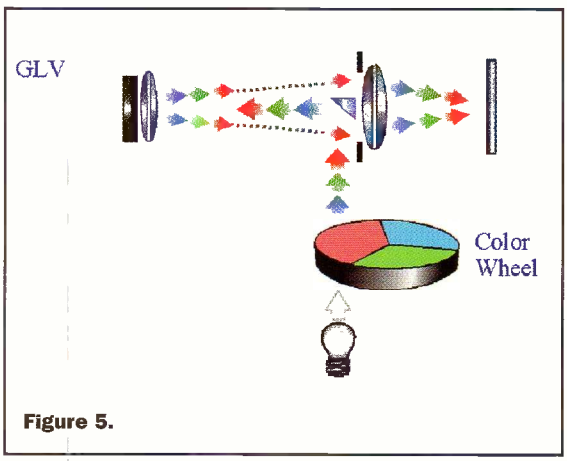


Figure 5.

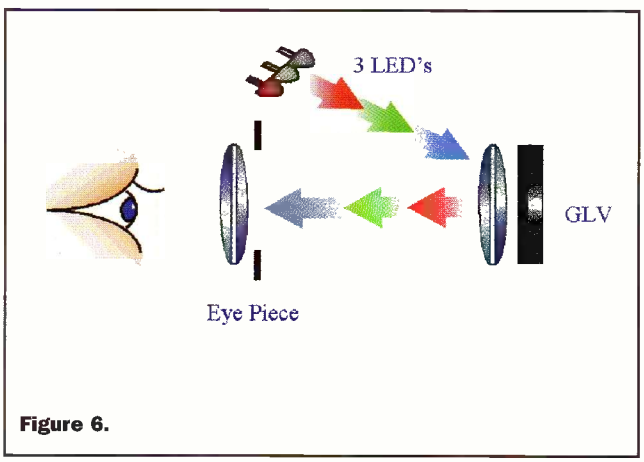


Figure 6.

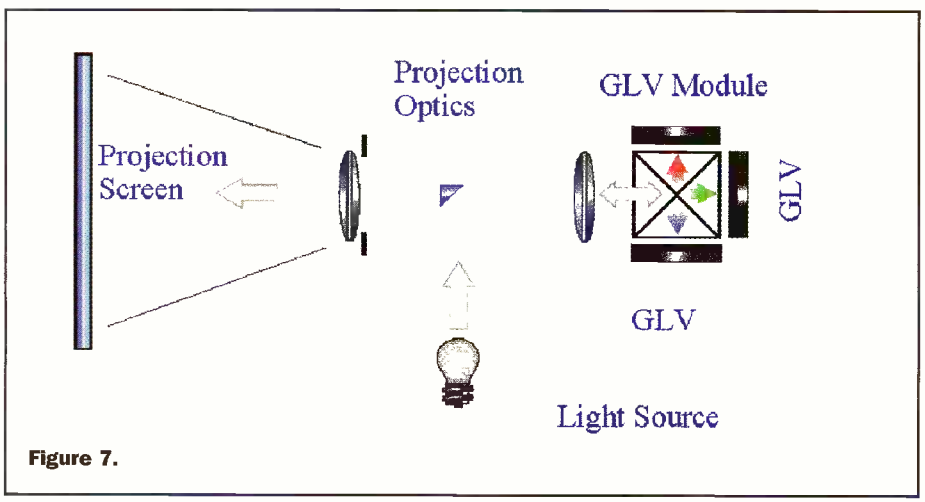


Figure 7.

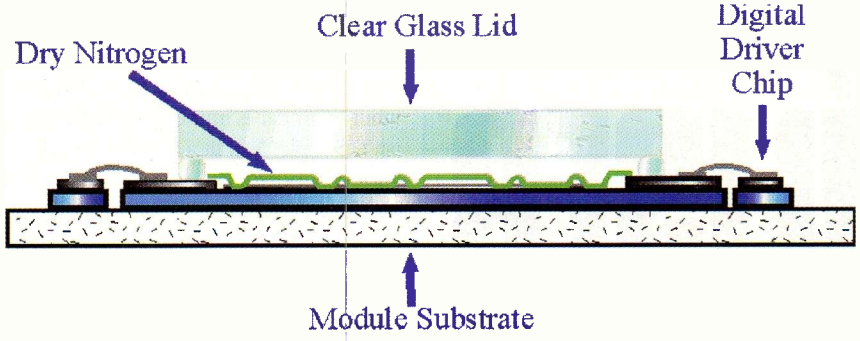


Figure 8.

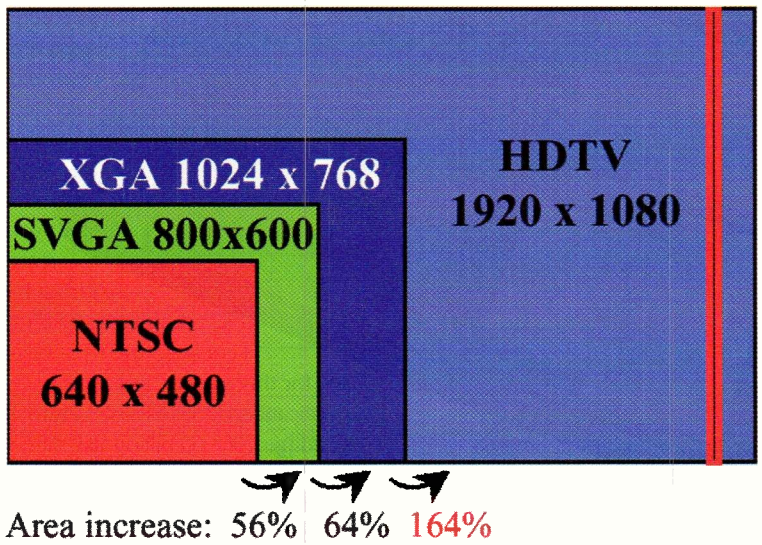


Figure 9.

sub-system can include additional electronic interface circuits for higher integration and lower cost.

Apparently, the GLV is also exhibiting very encouraging reliability: experiments have shown no ribbon fatigue after 210 billion ribbon switching cycles. This is equivalent to a television display system running non-stop for 15 years. With their higher optical efficiencies, GLV systems can deliver higher levels of brightness per watt of power consumed; and their small size makes it practical to build over a million pixels in a 1.3in diagonal. Coupled with their mass producibility, this should make the GLV ideal for high-resolution, low-cost displays. And the near zero-power pixel-state retention should make it ideal for use in small, battery-powered devices.

There is also an alternative to the matrix arrangement, in the Scanned Linear GLV Architecture. Here, a single vertical column of GLV pixels is optically scanned at a high rate to produce a projected image (see Figure 9). As the scan moves horizontally, GLV pixels change states to represent successive columns of video data, forming the complete image column by column - a feat enabled by the rapid switching. The advantages of this approach are that an HDTV image of 1920x1080 pixels only requires a 1080-pixel column instead of over two million pixels of an area array - much reducing the bandwidth; the aspect ratio can easily be changed; and the optical elements can be smaller and, hence, less expensive. Development is being concentrated on full integration of three, RGB, stripes per chip, although a single column can be illuminated sequentially.

An alternative proposal to HDTV projection is as a head up display (HUD) for vehicles (see Figure 10). The technology is also suitable for a large number of print applications. Because it can handle very high optical power densities at wavelengths ranging from infrared to ultraviolet, it is suitable for high energy printing and marking applications or maskless photolithography. Its very high switching speed offers the potential for high throughput photofinishing or desktop hardcopy output. In high performance display and print applications, the GLV technology uses diffraction gratings to modulate, attenuate and filter specific wavelengths of laser light. This fundamental functionality can also be directly applied to a number of optical networking component applications.

Silicon Light Machines was recently taken over by Cypress, and is now a wholly owned subsidiary of that company. Even more recently, it has granted an exclusive licence to Sony to manufacture and sell display devices. This will not affect its licence to Evans & Sutherland, who retain the exclusive right to use it for simulators and planetaria.

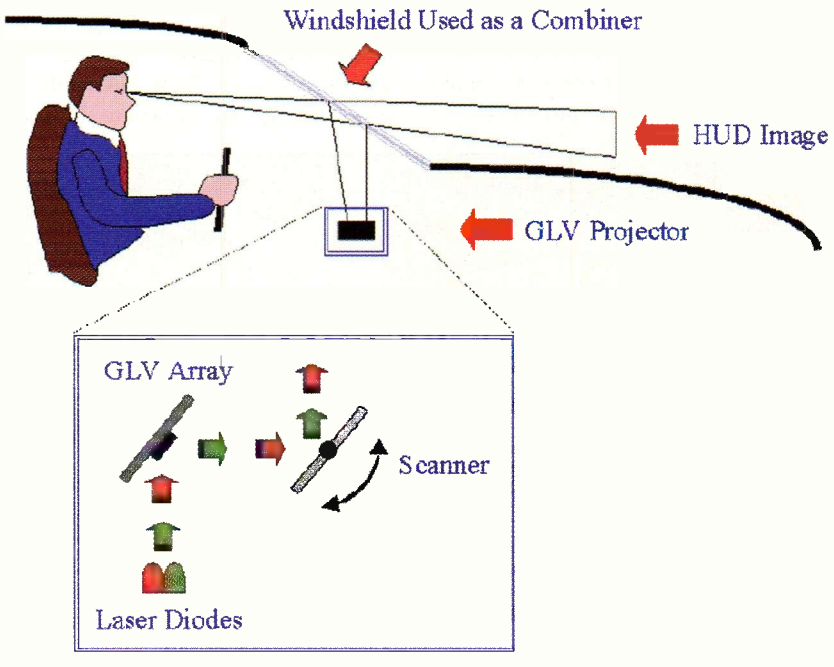


Figure 10.

For more information, contact:

Rob Corrigan Silicon Light Machines
408-541-4902 rob@siliconlight.com
Dan McCranie Cypress (408) 943-6887
jmy@cypress.com

Car IMMOBILISER

PROJECT

by Colin Kent

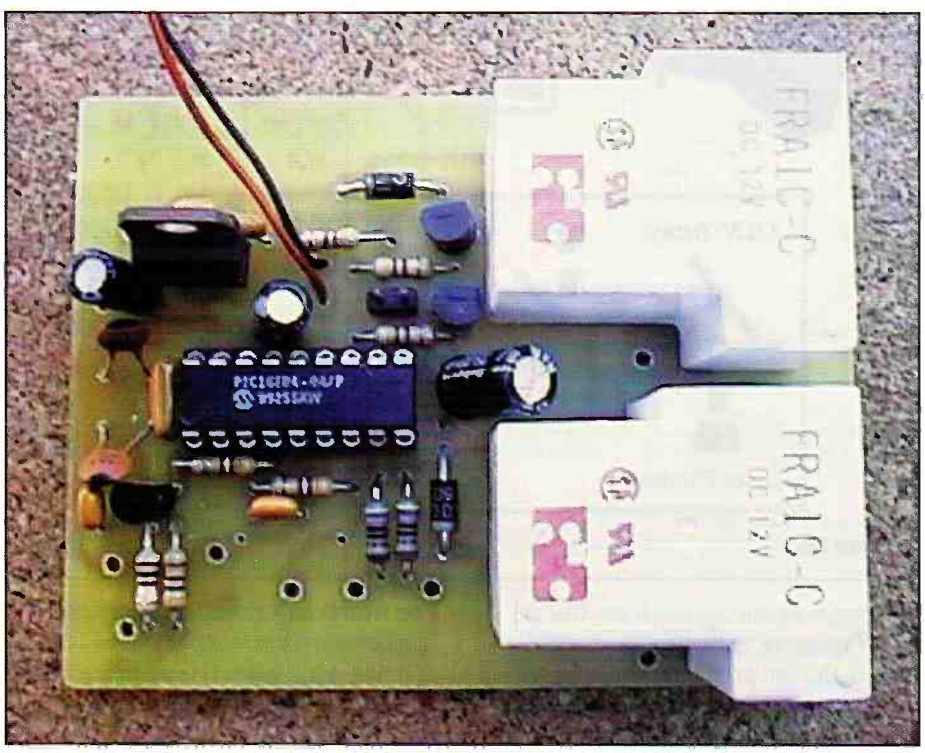
Unless you're lucky enough to be able to afford to buy a new car, or a reasonably new car with an immobiliser already fitted as standard, chances are your car is at this minute sat fully mobilised and ready to go on your front drive. This makes it easy for any would-be-joyrider to come along and take it for a spin. I decided to construct a car immobiliser for my own car after a near-miss when some would-be joyriders were stopped from stealing my car by my brother arriving home at a very opportune moment and blocking their exit from the driveway. Car thieves and joyriders can often manage to bypass ignition switches easily and quickly, so the aim of this project is to make it a bit more difficult for the little toe-rags to run off with your wheels! The advantages of fitting an immobiliser to your car are two-fold – firstly there is the security aspect, making it less likely that your car will be stolen (if they can't get it started they're not likely to run off with it). Secondly, there is the possibility that your car insurance premiums will come down slightly with this extra anti-theft protection.

So, how does it work? Put simply, it immobilises any two circuits in the electrics of your car, for example the starter motor and the ignition system. Disarming the immobiliser is achieved through use of a Dallas touch key, which when pressed to the touch key receptacle (sited either on your steering column, next to the ignition, or on the dashboard) reactivates the immobilised circuits in your car, enabling you to start the car. How do you know when your car is immobilised and when it isn't? Simple! You fit a bi-coloured LED to your dashboard, and when it flashes red, you know you are immobilised, and when it flashes red and green alternately you know you are ready to go.

Arming the system couldn't be easier – it arms itself automatically, when it detects that the ignition has been switched off. The relays drop out immediately, but the system remains unarmed for 30 seconds, so if you stall your car, for example, you can restart it without having to disarm the system again.

I chose to use the Dallas touch key for this project because its specification brings distinct advantages, including: 200,000 billion key differs, meaning that no other Dallas touch key has the same serial number. It is passive, so no battery is required in the key fob. As it uses contact to transmit the serial number, the unit can be used anywhere in the world without any radio approval; the key information cannot be remotely copied, and the touch keys are cheap to buy, with a range of different coloured fobs available.

Completing this project is not expensive – the Dallas touch key costs in the region of £2.50 from Maplin Electronics. The complete project costs in the region of £40.00, and the programmed PIC is available from myself for £10.00, including postage and packaging.

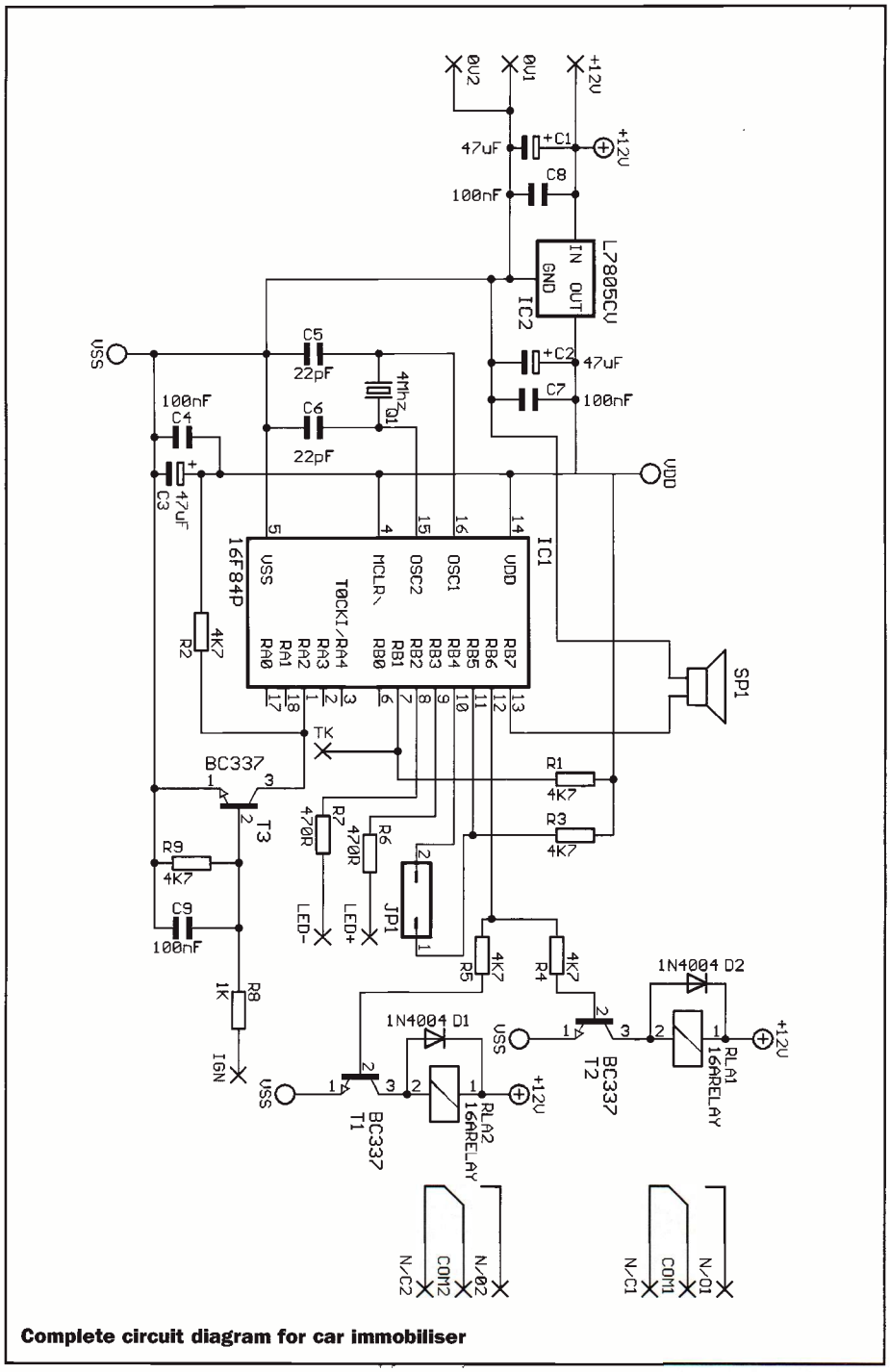


Completed car immobiliser board.

Circuit Description

A full circuit diagram is shown in Figure 1. A continuous 12 volt supply is applied to the 0v and +12v. This is then regulated via the 7805 voltage regulator, and decoupled via C1, C2, C7 and C8. This then supplies the 5 volts that are needed by the PIC controller.

The PIC 16F84-04/P controller forms the heart of the immobiliser system. This controller is very well suited to this application as it has onboard EEprom, which can be used to hold the security key information, even when power is removed for long periods of time, meaning an external EEprom chip to hold the key information is not required. The IGN input is connected to a 12v switch supply from the ignition switch. This then switches T3, which supplies a 5v signal to the PIC to tell



Complete circuit diagram for car immobiliser

it that the ignition is switched on or off. The two output relays are heavy duty relays, primarily intended for automotive applications. The contacts are rated at 16 amps, 24v DC, and each relay has a N/O and N/C contact. The relays are activated via T1 and T2. The TK input is connected to the touch key receptacle, and is used to communicate with the touch key.

FS1 and FS2 are primarily for protection if a fault occurs within the immobiliser circuitry, and prevent any damage to the vehicle's electrical system.

Assembly

The assembly of the PCB is fairly straightforward. As a general rule, start with the smallest components first, i.e. the resistors and diodes, working your way up to the voltage regulator and relays. The location of the components can be found in Figure 2. Care must be taken to fit the diodes the right way round. The cathode is indicated by a white band on the body of the diode, and should match the ident in Figure 2. When mounting the electrolytic capacitors, take care to insert the devices correctly. The negative leads are positioned as per the ident in Figure 2. When mounting TR1 to TR3, take care to ensure the flat side matches that on Figure 2. Finally, mount the relays and build up the tracks with solder, since these have to withstand the current you are switching. Thoroughly check the board for errors and misplaced components, any dry joints or solder bridges. Decide which colours and sizes of wiring you wish to use, and then wire the board. Your PCB is now complete and ready for testing.

Box Preparation

The box drilling information is shown in Figure 4. Mark out the holes and cut and file them as required. Fit the rubber grommet into the side of the box. Using a small amount of silicone sealant, seal the peizo sounder over the second hole when the board is in place. When completed, use some silicone to seal the lid onto the enclosure, to provide a good seal.

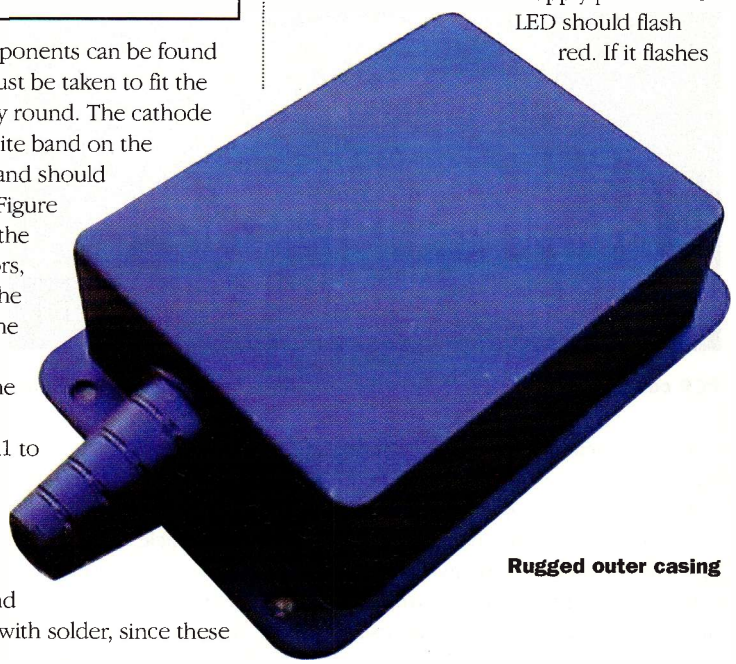
Wiring

On the prototype I used all 1.5mm wire, which is ample for most applications. I chose to use all black wire so a would-be thief would have a problem knowing which wires to join to get the car to start. After building, I used heat shrink of different colours to mark the cabling, but there is no reason why you shouldn't use colour coded cabling if you prefer.

You must be 100% sure of the rating of the cable you are going to use. If you use the wrong rating, the wire could overheat and melt, causing a short circuit.

Testing and Programming the Immobiliser

Before installing the PIC, apply power to the unit and check the voltage between pins 5 (0v) and 14 (+5v) on IC1. 5v should be seen on a multi-meter. If not seen, check for dry joints and solder bridges around the 7805 regulator. Once 5v is seen correctly, remove the power and insert the PIC 16F84 into the IC1 socket. Temporarily connect the LED and the touch receptacle and reapply power. The LED should flash red. If it flashes

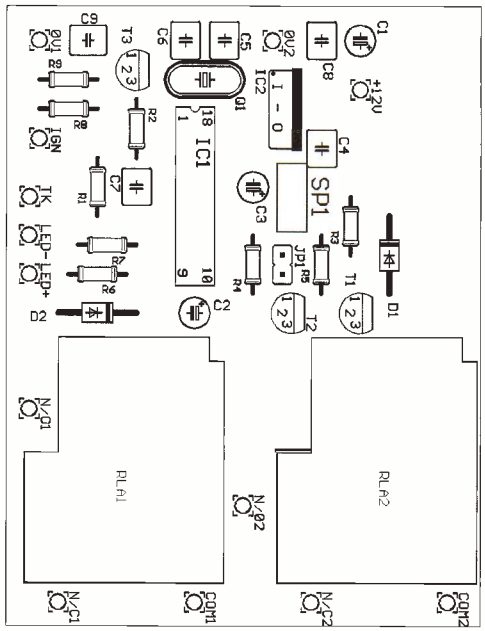


Rugged outer casing

green, reverse the wires connecting the LED to the PCB. If the LED doesn't light, go back and check solder joints and wiring.

Programming the Touch Key

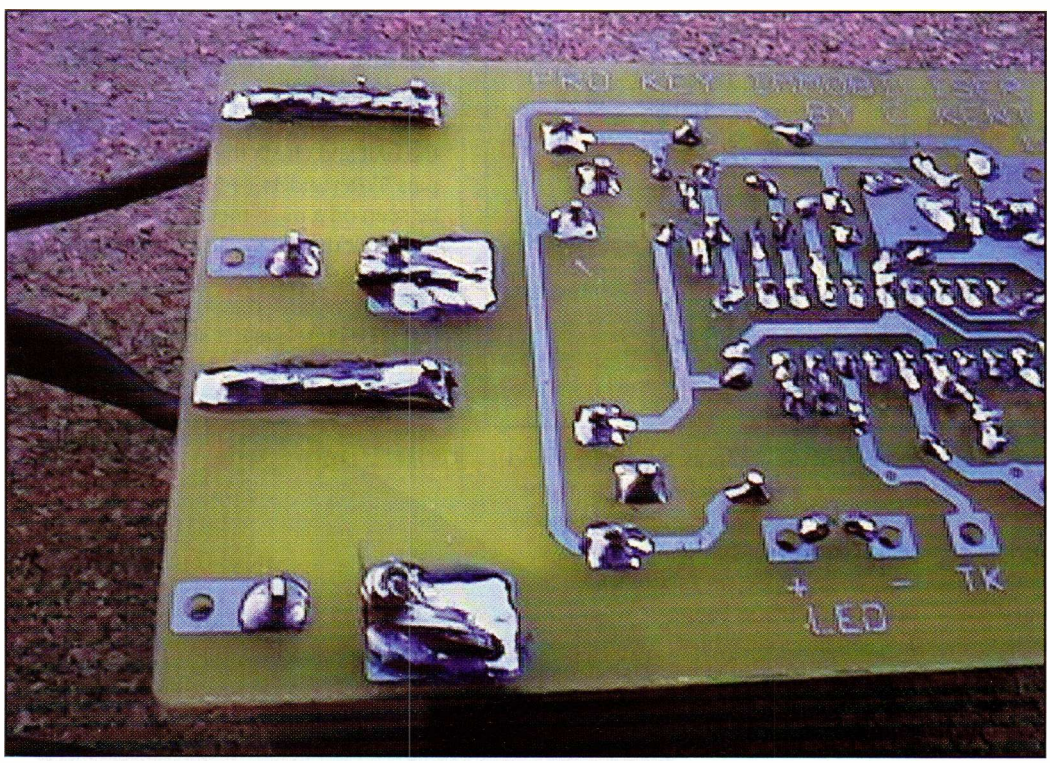
Remove power from the unit and link JP1. Reapply the power – the LED should light red constantly and should not flash. Choose one of your touch keys to be your master key. Touch the key on the receptacle. A two second tone should be heard, and the LED will change colour to green, to indicate that the key serial number has been written into the EEProm of the PIC. If the LED does not change colour, try touching the key again. If it still does not read the key, make sure you have not made a mistake when wiring the receptacle. Once you have programmed the key, remove the power and remove the link JP1. You can now programme the user keys (the unit can learn up to two user keys in addition to the master key). Apply power – the LED should start flashing red. Touch the master key to the receptacle. The LED should stop flashing and show continuous red, and the two-second tone should be heard – after the tone the LED extinguishes (if the unit does not respond to the key, try going back and reprogramming the master key). The unit is now ready to learn the first user key serial number.



Component overlay

Take the first user key and touch it to the receptacle. When it has read the key, the LED will turn red and the two-second tone is heard. The LED will again extinguish. The unit is now ready for the second user touch key. If only one user key is to be programmed, touch the first key to the receptacle again at this point. To programme the second user key, touch the key to the receptacle. The LED will flash three times, and you will hear three beeps. This confirms that the serial numbers of the keys have been programmed successfully into the memory of the PIC device.

The unit will now revert back to secure mode, i.e. the LED will flash red. Now take one of the user keys and touch it to the receptacle. The LED should now flash red and green alternately. This indicates the system is unlocked, but only for 30 seconds, unless the wire to the IGN (ignition sense) is connected to +12v, simulating the ignition being turned on. After 30 seconds, the LED turns red and a two-second tone is heard, indicating that the unit has reverted back to secure mode. Touch the user key to the receptacle again to unlock the unit, and connect the ignition sense wire to a positive supply. The LED extinguishes, and the relays are heard energising. Remove the ignition sense wire and the relays will de-energise. After 30 seconds the unit will again revert into secure mode.



PCB connections

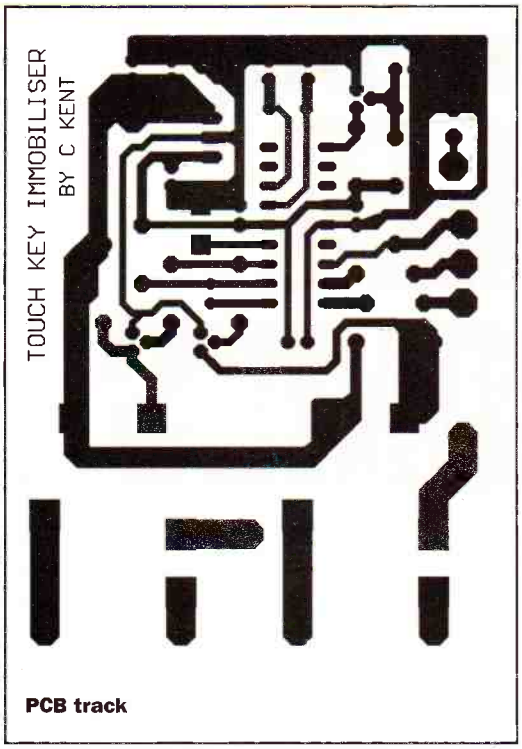
Fitting the Unit

WARNING: All connections should be soldered and insulated to ensure a permanent connection. The use of snap-lock or scotch-lock type connectors should not under circumstances be considered. If any of the connections should become loose or disconnected, your car will stop INSTANTLY! Great care must be taken when connecting the immobiliser if you do not want to cause at best a serious accident and at worst the death of yourself and/or other people. If you are in any doubt about your abilities to install the immobiliser correctly and safely, please contact an automotive electrician for help and advice.

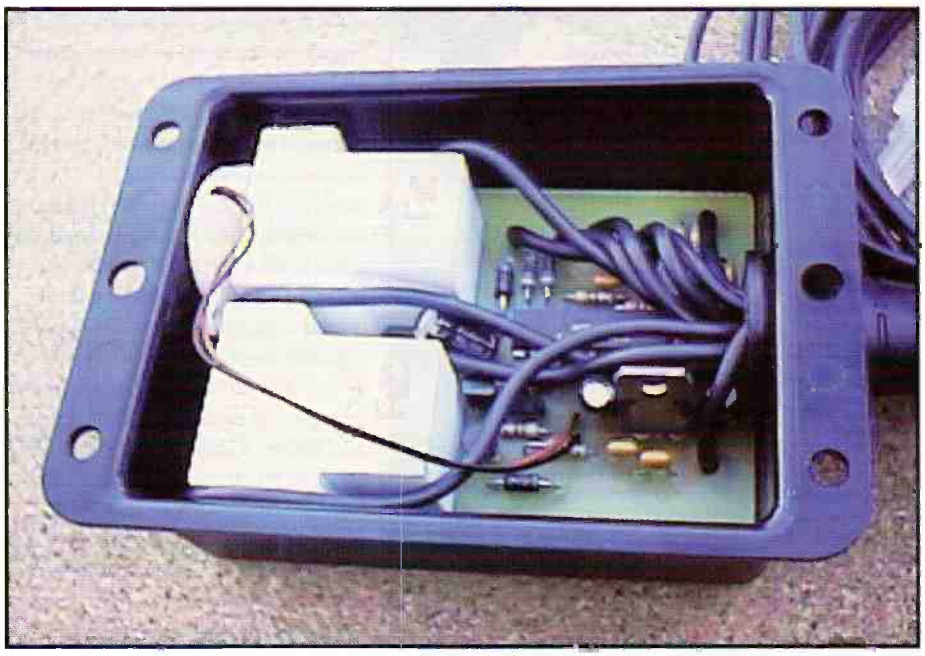
Firstly, using a multimeter, locate a continuous 12v supply from the car battery. This supply MUST be live constantly, irrespective of any of the car's other electrical items being operated, and note the wire's location. Secondly, locate a switched live feed. This must be live only when the ignition switch is in the run and the start position. This will be used for the ignition sense. Before continuing, check with your car manufacturer's handbook that removing the battery will not cause any problems to your car's ignition control unit. After checking, remove the positive lead from the car battery and then locate a suitable position for mounting the control unit, preferably underneath the dashboard, where the unit will be kept dry. Now decide where you wish to position the LED and the touch receptacle. A good place for the LED is on the dashboard to the right of your steering wheel, where it is easily visible to you (and a visible deterrent to thieves). After positioning the LED and the touch receptacle, wire both to the control unit. Connect the ignition sense wire to the ignition switch supply, and then connect the 12v supply wire to a continuous 12v supply. Finally, connect the 0v wire to a good Earth point on the car. Replace the car

battery and the LED should start to flash red. Touch one of the user keys to the receptacle, and the LED should start flashing red and green alternately. Switch the ignition on. The LED should extinguish and the relays should energise. Start the car, making sure that the relays do not de-energise when you switch the ignition to the start position. If this happens, your connection to the ignition sense is incorrect, and another feed should be found. If everything is okay, locate the two circuits you wish to immobilise, taking into account the warning at the beginning of this section.

Cut the wire of the first circuit you wish to immobilise, and try the circuit to make sure the results are what you expected, i.e. if cutting the starter motor circuit, try switching the ignition on and try starting the car. If the starter doesn't turn, you know you have cut the right wire. Now connect the two wire ends to the relay outputs of the control unit and try the circuit again. Don't forget that this will only work when the immobiliser is disarmed. Now do the same with the second circuit that you wish to immobilise, and test. This should complete the installation.



PCB track



Usage Instructions

Once you have successfully installed the immobiliser you can use either user key to disarm the system, by touching it to the receptacle – you must ensure that you touch the complete surface of the user key to the receptacle in order for it to work. The vehicle should now be able to be started. After the ignition has been switched off, the unit will rearm automatically after 30 seconds. If one of your user touch keys is mislaid or lost, you can reprogram up to two new keys by using the master key, so that the lost key will no longer disarm the system. You can do this by following the instructions on how to program the master key above. Finally, there is a service mode where the unit can be stopped from arming, i.e. for when the vehicle is to be serviced, so that you don't have to keep disarming the system. To access the service mode, touch the user key to disarm the system, and hold the key in place until a tone is heard and the LED turns green. Remove the key. The unit is now in service mode, and the LED will flash green and the tone will sound every 30 seconds. Each time the ignition switch is operated in service mode, the unit will automatically disarm. To rearm the unit, touch one of the user keys to the receptacle. The LED will flash red and green alternately for 30 seconds and then rearm automatically.

PARTS LIST

Resistors

All 5% 0.6W metal film resistors

R1-R5, R9	4K7	6
R8	1K	1
R6-R7	470R	2

Capacitors

C5, C6	22pF disc ceramic	2
C1-C3	47µF 25v elec	3
C4, C7-C9	ceramic 100nF	4

Semiconductors

T1-T3	BC337	3
D1, D2	1N4004	2
IC2	L7805CV	1
Q1	4MHz Resonator	1
IC1	PIC16f84-04/P*	1

*See note at end

Miscellaneous

SP1	Piezo sounder	1
JP1	2.5mm straight header	1
FS1, FS2	In line fuse holder	2
RL1, RI2	12V 16A Relay	2
IC Socket		
Enclosure		1
Fuse 1A		2
Pin jumper		1
LED mounting bezel		1
Touch probe		1
Cable grommet		1
DS1990 Key		3
Touch key fobs		3
Cable – see wiring instructions		

Buying the Programmed PIC

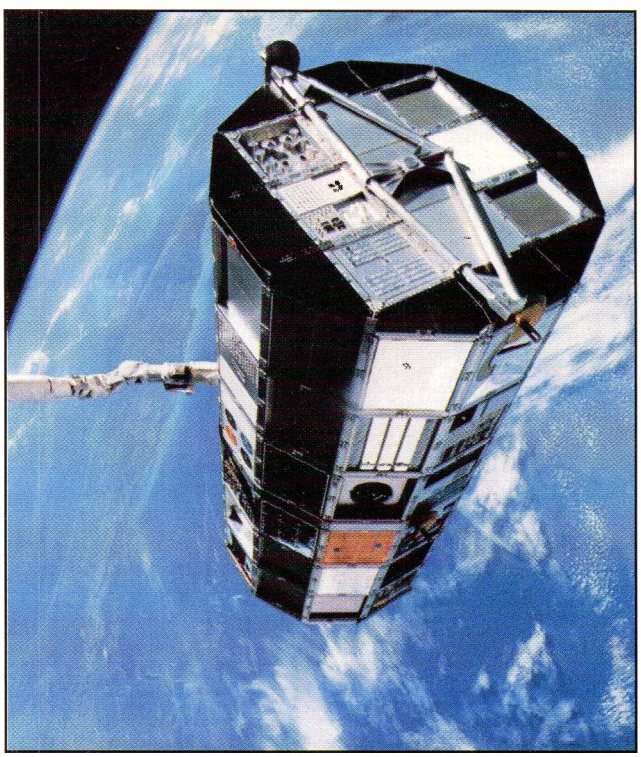
The programmed PIC is available from Kent Electronics at a cost of £10.00 each, including postage and packaging costs. Please send a cheque or postal order, made payable to Colin Kent, and send to 243 Carr Lane, Tarleton, Preston PR4 6BY. Please mark your envelope 'immobiliser'. Alternatively, call 07787 515619 (mobile) after 6.00 pm; or e-mail colin@kentelectronics.fsnet.co.uk; or visit the Kent Electronics website at **<www.kentelectronics.fsnet.co.uk>**

Introducing RUGGED ELECTRONICS

by Mike Bedford

The phrase "military specification" has long been associated with components or equipment designed to withstand the rigours of the battlefield or of the fighter aircraft. Such equipment, intended for use in seriously hostile environments and/or in applications where failure cannot be tolerated, has tended to be horrendously expensive. But it's not just military applications in which equipment has to be able to withstand rough handling. Surveyors, civil engineers, police officers, process engineers, and many others need to use electronic equipment and computers outdoors, perhaps in the rain, and for that equipment to survive the occasional knock or drop. Equipment designed for this market, while not as expensive as that designed exclusively for military use, has tended to carry a high price premium. Specialist, seriously tough laptops, for example, have typically cost two to three times as much as an ordinary laptop, have been much larger and heavier, and yet have offered less processing power. Needless to say, these products didn't attract the more casual user. This is a shame since the increasing use of electronic equipment on the move means that it's more prone to damage than when it was used, almost exclusively, in the home or the office. But things are changing and many companies, even those addressing the mass market, have realised that accidents do happen as soon as equipment is removed from the safety of a building and taken into the world outside. As such, a whole range or rugged and/or waterproof equipment is now on the market and whereas you still have to pay for that added protection, the cost of ruggedisation is much less than it once was.

Perhaps this mass market rugged equipment doesn't offer the sort of protection required of the military, or even a civil engineer, but let's face it, most people won't be taking their mobile phone or laptop onto a battlefield.



NASA photograph of the Long Duration Exposure Facility. Space exploration must be one of the most demanding applications for electronic circuitry. The LDEF shown here has been used, among other applications, for investigating the effect of long exposure to space on electronic equipment. Photo courtesy NASA

Here we take a look at rugged electronics. First of all we'll consider what's needed and how ruggedisation is measured and specified. This will be of relevance to those buying equipment for use in the great outdoors as well as those involved in designing tough equipment. We'll then move on to take a quick look at some of the less specialised rugged equipment which is now available – much of it for the consumer market. And then, we'll investigate some of the special measures which have to be taken in order to produce this class of equipment. For those interested in buying a rugged laptop or a waterproof digital camera this will just be background information. However, we also anticipate that this will provide some useful pointers for those who need to design or build equipment which will survive the elements or rough handling.

What's Needed?

To set the ball rolling, let's investigate, in general terms, what's needed of this type of equipment. Admittedly this depends on the application and the environment; some elements of environmental protection will be very specialised, applying to certain applications only. Nevertheless, certain requirements are common, if not universal, so we'll start with these before briefly mentioning some of the less common requirements.

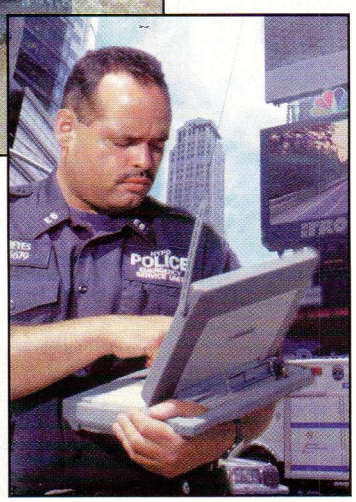
If the equipment is ever to be used outdoors, then waterproofing becomes paramount. However, as we'll see later, there are degrees of waterproofing so the exact requirements need to be recognised and specified. Another common requirement is immunity from vibration and physical shock caused, for example, by knocking or dropping the equipment. Operating temperature and humidity ranges will often need to be much wider for portable equipment than for desk-bound equipment although what is, arguably, even more important, is immunity from thermal shock caused by repeated cooling – heating cycles. And issues of ergonomics often become much more important for this type of equipment too. So, for example, if equipment is intended to be used outdoors in any weather, large, widely-spaced controls which can easily be used while wearing gloves, might be deemed highly desirable. Closely related are issues associated with use in all possible ambient light levels. Back lights for keyboard switches, for example, are necessary for operation in the dark, whereas special daylight-readable LCD panels are required for use in bright sunlight. All we've seen so far is pretty much necessary, or at least highly desirable, for all rugged equipment. In certain very specific applications or environments, though, protection against corrosive chemicals, sea water, radiation, high vacuum, and other less common hazards may be required.

Specifying Ruggedness

In general terms, we now know the hazards which rugged equipment has to be able to survive. And in some areas, the temperature range, for example, it's blatantly obvious how this is specified. So, for example, if the specification sheet gives an operating temperature range of 0 – 40∞C and a storage temperature range of –10 – 50∞C then it's quite clear that no permanent damage will be done to the equipment so long as it remains within the temperature range –10 – 50∞C, and that the equipment can be used anywhere in the temperature range 0 – 40∞C. But what about waterproofing and immunity from vibration and physical shock? These are very important characteristics of most rugged equipment yet the means of specifying these elements of environmental protection aren't universally understood. Let's take each in turn.

Waterproofing is defined in the DIN EN 40050 standard and is specified by a so-called IP number. In fact, this measure relates both to waterproofing and protection from the ingress of solid objects as detailed in Table 1. The IP number has two figures, the first relates to solid objects and can take a value from 0 to 6 whereas the second relates to water and can take a value from 0 to 8. However, rugged equipment nearly always offers the highest possible degree of protection from solid objects since this is the easiest to achieve and it's hard to envisage equipment which offers any degree of waterproofing yet isn't totally protected against the ingress of solid objects. In the main, therefore, it is the second of the two figures which we'll be interested in and (excluding zero which implies no protection) this varies from drip-proof to dunk-proof. For example, equipment specified to IP66 is totally protected against the ingress of solid objects, sand and dust, and will withstand jets of water from any direction. Exactly how waterproof equipment should be depends not only on where you expect to use the equipment but also how much protection you want to provide against accidents. For example, it would be quite a rare application which requires equipment that will operate underwater, but it might not be too uncommon for hand-held equipment to be dropped in a pool of water. Related to this, something else to bear in mind is whether the equipment floats.

For professional rugged equipment, immunity from vibration and physical shock are often specified by referring to the American military specification, Mil-Std 810E. It's common to see a manufacturer just quote "Mil-Std 810E", but although this might look good on a specification sheet, it means nothing at all unless the part of the specification against which the unit has been tested is also specified. Within the standard, method 516.4 relates to shock, and this is divided into a number of procedures. The most commonly quoted one is procedure IV which is a drop-test. It requires that a unit must be capable of surviving drops from a height of 1.2m onto a steel plate over concrete. Specifically, it requires that the equipment must withstand that drop whichever of its 26 faces, edges or corners it lands on. Other portions of the standard, especially the ones which refer to vibration, become very technical and we don't have space to look at them in any detail here. However, the standard is freely available and if you have a serious application for rugged equipment and, correspondingly, expect to be handling a large budget, this is something you'll need to get to grips with. For consumer equipment, this standard isn't usually quoted but you'll often see a drop test figure in the specification sheet, nevertheless. The sort of phrase you might see is "one metre onto a carpeted floor" or "two metres onto concrete". Needless to say, though, this is not as rigorous a definition as that in the US military standard and such a vague specification allows a less scrupulous company to quote an overly optimistic figure. So, whereas equipment adhering to Mil-Std 810E will withstand the 1.2m drop however it falls, you might want to check that a manufacturer specifying a simple drop test figure hasn't quoted a best case scenario.



Above: The rugged and waterproof laptop from Itronix. Right: The same laptop being used by a New York Police Officer

Equipment Available

Before moving on we'll take a quick look at the sorts of portable rugged and waterproof equipment which is currently available. After all, much of this is quite new to the market and many people are quite unaware of what's out there. My emphasis here will be portable equipment. Rugged equipment intended for use on the factory floor is also available but this, of course, is much more specialised.

One of the first categories of electronic equipment to be given the ruggedisation treatment was the portable PC. Seriously rugged and waterproof laptops are available from a number of specialist manufacturers including Itronix (formerly Husky in the UK), Telxon, Fieldworks, CTEC and Rocky. These PCs often tend to be large, heavy, under-powered, and expensive compared to business laptops. They are, therefore, the sole domain of those needing rugged equipment for very specific applications. At the other end of the continuum, Panasonic has decided to provide all its laptops with a degree of ruggedisation. The rationale for this family of PCs – the Toughbook range – is that all laptops are prone to damage as soon as they leave the office. So, although these laptops are targeted at ordinary businessmen, in addition to those involved in higher risk activities, all provide a degree of waterproofing and ruggedisation. Although not nearly as rugged as the specialist rugged PCs, the Toughbooks tend to have more processing power and attract, perhaps, just a 50% price premium, compared to the price doubling or more which is more typical of the specialist PCs. A third category of rugged PC which is starting to become established, is the hand-held PC or PDA. Itronix, Symbol and Psion all have products here.

GPS receivers tend to be designed for

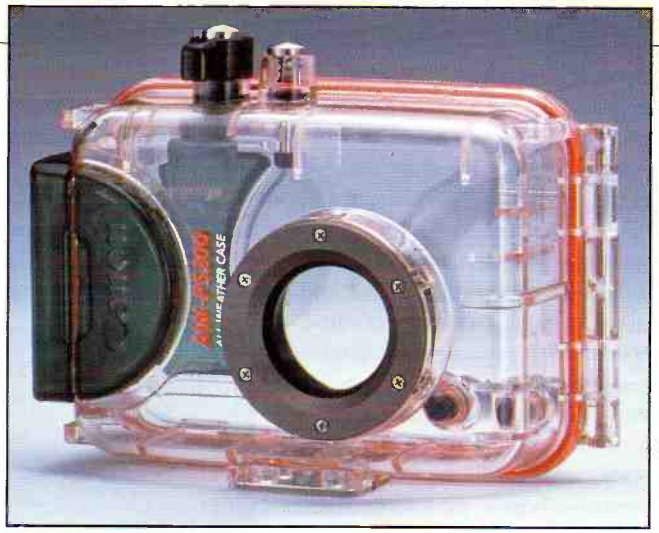
marine, mobile or pedestrian use. And whereas the latter are intended for use outdoors – and are particularly popular with hikers and hot air balloonists – the majority are not designed to withstand the elements. An exception is the Garmin eTrex, a small hand-held device costing around £130. This is waterproof to IP67 and it will float. The case has a rubbery feel to it which suggests some degree of immunity from physical shock although the company declines to provide a drop test figure.

The Garmin eTrex GPS receiver. This is waterproof to IP67 and it floats.

As the most common type of electronic equipment to be used outdoors, it's rather surprising that so few manufacturers of mobile phones have addressed the issues of waterproofing and ruggedisation. The only rugged phone I'm familiar with is the Ericsson R250s PRO (£99 with contract, £325 otherwise). A quote from Ericsson's promotional literature is probably the best way of summing up what it will cope with. "Robust, sturdy and will survive a fall from a ladder, a drop in the mud, or a splash with paint and water. Simply brush off or wipe down and the phone is ready to make the call".

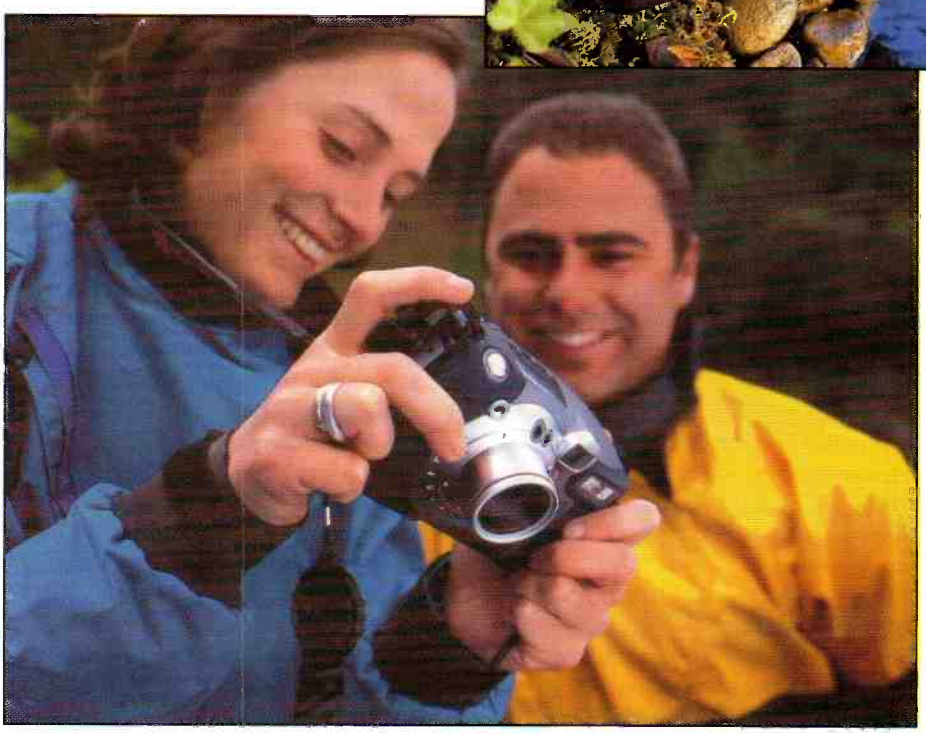
PMR 446 is the comparatively new European standard for licence-free 2-way radio communication. The units operate on very low power so the range is limited to 3km in open countryside or less in towns but, they have proved popular with outdoor enthusiasts, nevertheless. PMR 446 radios start at around £70 per pair but these entry-level units are not very rugged or waterproof. Motorola's Handie Pro (£199 each), though is waterproof to IP54 and offers some protection against environmental shock. Although the company won't be drawn on exactly how tough it is, I was told, unofficially, of a unit which had survived a 60 foot drop. For additional waterproofing, Motorola provide the £25 AquaBag which provides protection to a depth of ten feet. All controls can be accessed through the bag.

One of the latest types of electronic equipment to enter the waterproof and rugged arena is the digital camera. Traditionally, the existence of memory card slots has meant that digital cameras are much less suitable for outdoor use than a film camera. Kodak's £530 DC5000 breaks this mould in offering protection against heavy rain and splashes from a swimming pool but not from immersion or being held under a tap. As such, it sounds about as waterproof as a good film camera. The camera is also described as rugged although this isn't quantified, and the controls are designed to be used while wearing gloves. This level of protection is not adequate, for example, for use by a canoeist or a diver but even here solutions are now becoming available. Although no submersible digital cameras are currently available, a few manufacturers, including



Waterproof housing for the Canon Digital Ixus digital camera. This allows the camera to be used down to 10 feet underwater.

Canon, Olympus and Sony have now produced waterproof housings for some of the cameras in their respective ranges. These housings, which allow the camera to be used, typically, to a depth of around ten feet, are designed for one specific camera. The reason for the dedicated nature of the housings is that they include waterproof switch actuators which have to line up precisely with pushbuttons on the camera.



Kodak DC5000 waterproof digital camera

Electrolube Conformal coating spray protects PCB tracks from corrosion.

Waterproofing Equipment

We'll now move on to look at some of the techniques that are involved in designing equipment which will survive the great outdoors. And whereas some of this will relate to large scale manufacturing, my main aim is to give some guidance to those building rugged equipment in small quantities. After all, manufacturing rugged equipment is a specialised area and, as such, we can expect that companies involved in this market sector will employ engineers with specific design expertise.

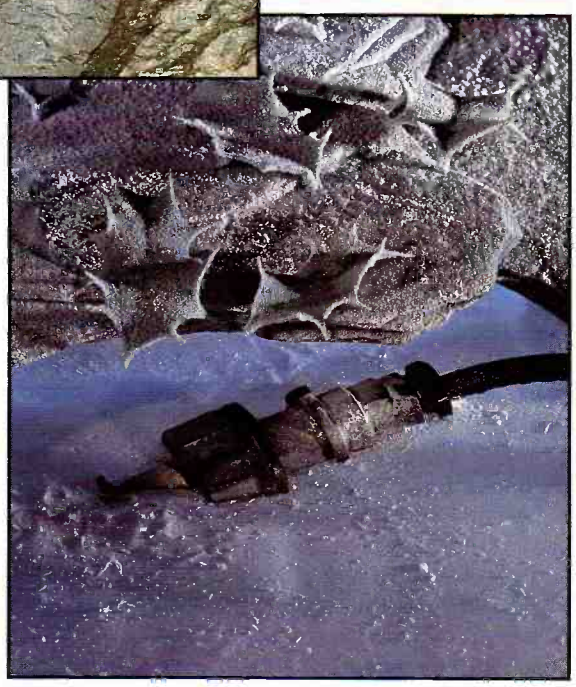
For prototyping and small-scale production, building a custom case is out of the question so we must turn our attention to off-the-shelf boxes. Waterproof boxes are produced by a number of manufacturers and are widely available through the various catalogues (e.g. Maplin, Farnell etc.). These cases are mostly two part ABS plastic or die cast boxes with a rubber gasket to form the seal between the two halves. Typically, these boxes range from IP54 to IP68. Needless to say, though, as soon as a hole is made in one of these boxes – for an indicator, switch or connector, for example – the wateroofing is compromised. In addition to the box, therefore, all panel mounting components should be waterproof. And in this context, waterproof means that the component itself must be able to withstand water and also that, when properly fitted into the panel, it will not allow water to pass through into the case. Although you may struggle to find some types of waterproof panel-mounting components, waterproof indicators, switches, many types of connectors including BNC, D-type and specialised multi-poles, and even loudspeakers are available. You should be aware, though, that some connectors are only waterproof when mated but these connectors are often available with sealing caps (tethered via a chain) to provide the necessary protection when not mated.

Although the use of a waterproof enclosure and waterproof panel-mounting components should ensure that the completed equipment is waterproof, there are some additional measures which you might choose to take, as additional precautions. One such measure is to apply a layer of lacquer or conformal coating to the assembled PCB to provide extra protection from humidity. Various conformal coating aerosols are produced by Electrolube. Another possibility is to include a sachet of silica gel in the enclosure. This will absorb any humidity in the enclosure and, in the case of self-indicating silica gel, there is an associated colour change – from blue to pink – to indicate if there has been any ingress of moisture. Furthermore, following exposure to moisture, the sachet can be restored to its initial state by baking it in an oven at a modest temperature for a few hours.

Shock-proofing Equipment

Although most electronic equipment will survive a degree of rough handling, designing kit which is seriously rugged is, perhaps, a greater challenge than making it waterproof. Furthermore, there are quite a number of aspects which need addressing. Some of these aspects are specific to particular types of equipment. So, for example, although a disk drive is one of the most challenging components to protect from mechanical shock, since it's quite specialised, we won't dwell on it here. If you're intrigued, though, rugged laptop

A variety of Bulgin waterproof connectors

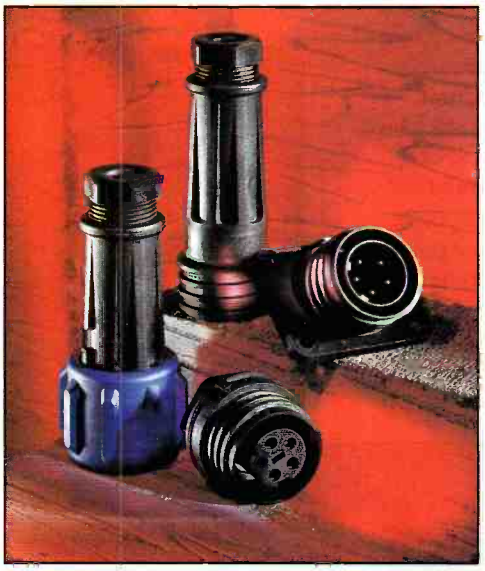


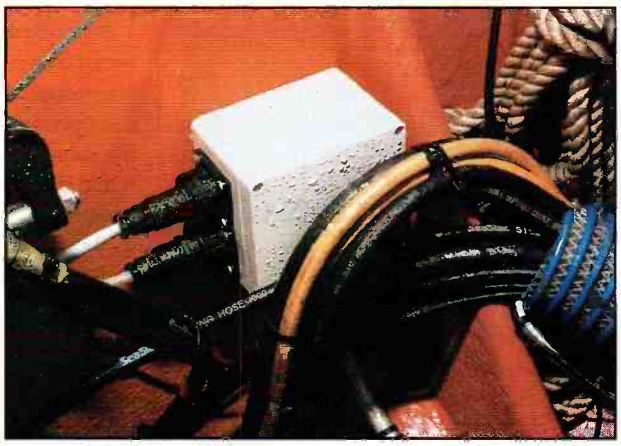
manufacturers have isolated disks from the main chassis using a neoprene gasket to absorb the shock, others have surrounded the whole disk in a gel-type mounting, whereas others have totally replaced it with a solid state alternative. More generally, though, what can be done to protect equipment from shock?

The first answer to this question is little more than common sense – practice the highest standards of electronic construction. So, for example, whereas dry joints are always bad news, these are much more likely to become points of failure if the equipment is subjected to rough handling. Similarly, although strain relief on cables should always be employed, this becomes all the more desirable in the realm of rugged equipment. I won't dwell on all of this here, after all this should be second nature to an experienced engineer, but if in doubt do read up on good constructional techniques.

Let's now give some thought to printed circuit boards. A major cause of failure is flexing of circuit boards and the expansion and contraction caused by heating and cooling cycles. These are effects which are more significant with large circuit boards so one of the golden rules is to make PCBs as small as possible. For this reason, the adoption of surface mount techniques is generally considered to be an important element of ruggedisation. Having said this, although this is undoubtedly true in a large scale manufacturing environment, do bear in mind that hand construction using surface mounted components can be problematic. And a poorly built-up surface mount board could end up being less reliable than one made using conventional components. Unless you do have the necessary skills, therefore, you should consider having the board built up by someone with suitable expertise. Heavy components should be given special consideration since they make the board more prone to flexing and vibration, especially when subjected to the low frequency vibrations in a motor vehicle. If at all possible, heavy components such as transformers should be positioned near the edge of the board to minimise these effects as much as possible. Also, consider additional support for the PCB in the vicinity of heavy components. In fact, adequate support for the PCB is paramount whether or not heavy components are present. Unfortunately, though, the requirements here may conflict with those involved in waterproofing so you may need to make some compromises. Waterproof equipment boxes often have card guides but relying on these alone means that the PCB is only supported along its edges and is, therefore, free to flex. By adding additional support pillars this flexing could be reduced but at the cost of making additional holes in the box. And unless special precautions are taken, this will impact the degree of waterproofing provided. One solution is to fill the box with some sort of filler that will act as a cushion around the PCB and its associated components. In theory this could be a loose fill such as polystyrene beads but the fact that most waterproof boxes have hollow lids means that it would be extremely difficult to ensure that the enclosure is totally full. Although I haven't used it in practice, polyurethane foam could well prove suitable and is well worth experimenting with. This is available from DIY shops and is sold as a general purpose filler. To avoid any possibility that the foam may affect the components or corrode the copper tracks, it would be a wise precaution to apply a good layer of conformal coating first.

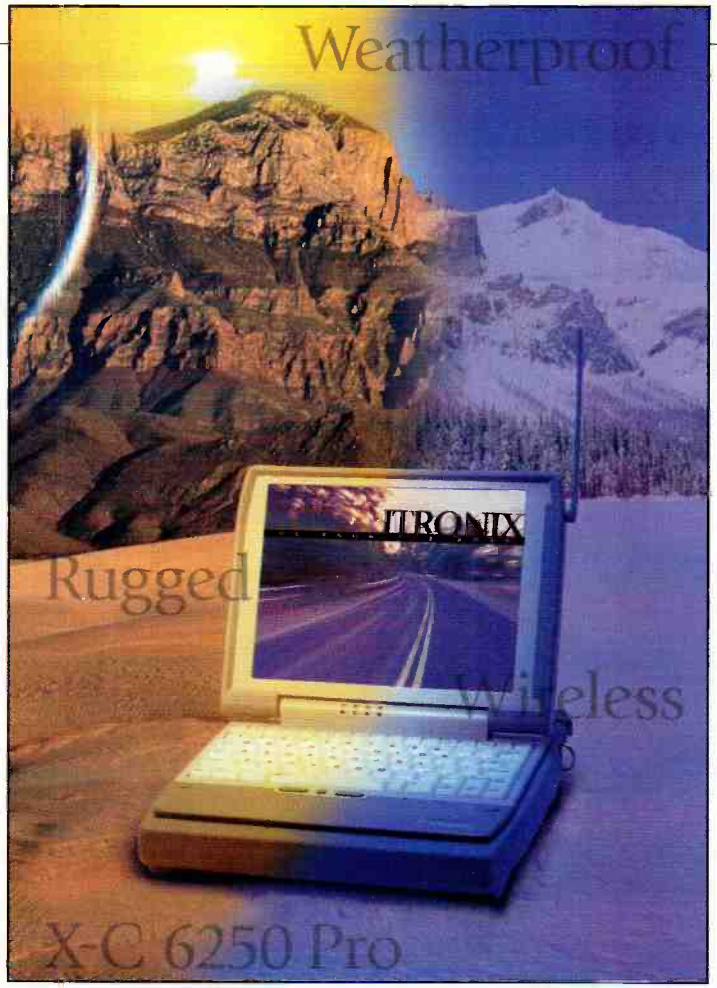
The other main consideration is the enclosure and the panel mounting components. Waterproof ABS boxes are reasonably tough although, for especially hazardous environments, you could consider making a neoprene envelope or "jacket" to surround the box. Neoprene is the rubber-like material which is used for manufacturing wetsuits and can be obtained from shops providing equipment for diving and other outdoor pursuits. Joints are made





Clockwise from top left: Bulgin waterproof multipole connectors. Electrical and RF connections on an inshore rescue boat. Typical rugged waterproof push buttons from Bulgin. Buccaneer connector used to connect the traffic-flow sensor back to the control cabinet on the Trafficmaster system.

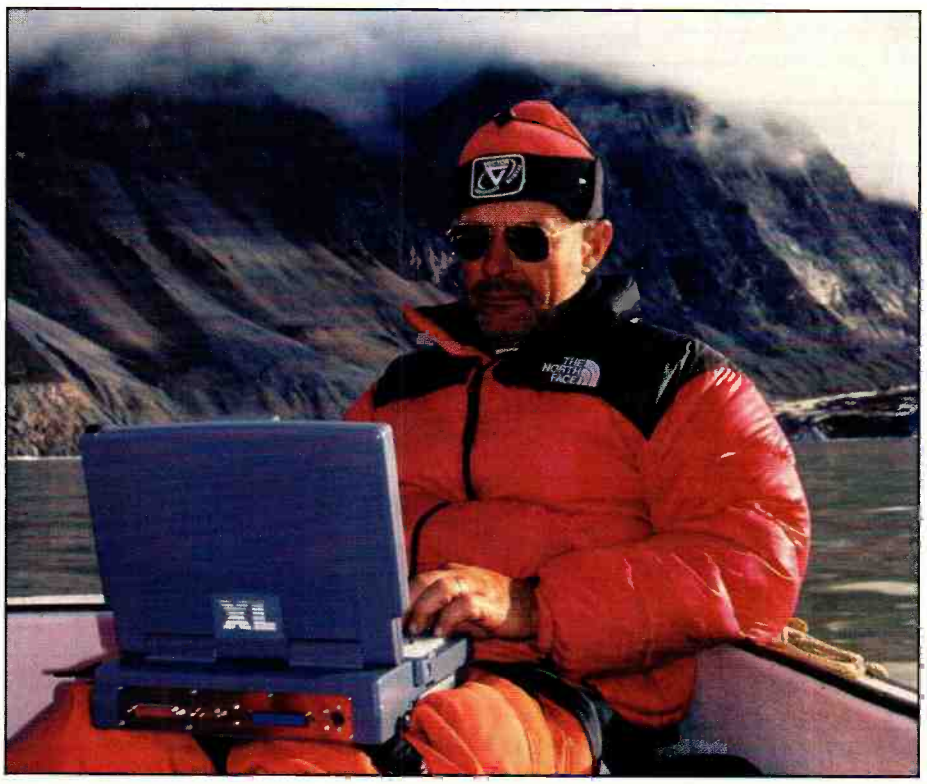
using a special neoprene adhesive which you can obtain from the same shop as the neoprene. It would be wise, though, so put Velcro along one of the edges to allow the box to be removed, for example to change the batteries. Turning now to the panel mounting components, the golden rule is to select components with as low a profile as possible or, failing this, to provide some sort of additional protection. If you're also needing to find components with the necessary degree of waterproofing, though, a degree of compromise may be inevitable. Nevertheless, it's clear that pushbuttons are preferable to rocker switches and that toggle switches are the least appropriate. So-called vandal resistant switches – which are both waterproof and resistant to shock – are available, at a price. These rugged switches tend to be momentary action, normally open pushbuttons so their use may influence the electronic design in favour of latching circuitry. Where it is necessary to use higher profile switches – rotary or rocker switches, for example – consider providing some protection for the switch. One solution is to mount the switch through a small piece of U-channel metal which protrudes above the panel and so would protect the switch from a knock. Incidentally, while on the subject of rotary switches, those with metal spindles are far more robust than the more common types with plastic shafts. Some of these are also waterproof.



A promotional photograph of the Itronix laptop showing that it could be used in hostile climates

Miscellaneous Design Considerations

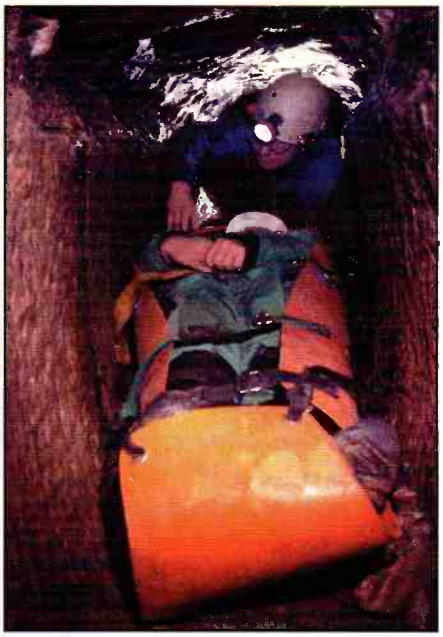
In addition to ensuring adequate protection against water and mechanical shock, there are various other aspects which you should consider. For example, although the whole emphasis of this article is ruggedisation, do remember that prevention is better than cure. So, ensure that your equipment will withstand water, certainly, but also try to make sure it doesn't get dropped in a river. And I'm not just suggesting that, as a user of the equipment, you should take adequate care of it. As a designer, you can help to prevent accidents from happening in the first place. So, for example, if the equipment is hand-held, how about providing it with a wrist strap or lanyard? This is common, for example, on hand-held GPS receivers, even those which are designed with the rigours of the great outdoors in mind. Colour could be equally important, especially if the equipment is going to be used, for example, on a muddy building site. However tough you manage to make the equipment, expecting it to survive being driven over by a JCB is asking a lot. So make it visible by painting it orange or yellow – once again, much of the commercially available rugged equipment is brightly coloured. Also pay due attention to ergonomics. This sort of equipment will often be used in far from ideal environments so do all you can to give the user a helping hand. Fiddly little controls can be difficult at the best of times. If you're standing on the deck of a ship with waves breaking over you, though, you want equipment which is as simple and as quick to use as possible. Similarly, if you're wearing gloves or your fingers are numb with the cold, large and widely separated switches are a must.



A Real Application

To close, I thought you might be interested in how I have come to gain this sort of experience in the design and small-scale manufacture of seriously tough equipment. Throughout the UK, teams of volunteers provide help for potholers who get into difficulty underground. And effective communication from a surface controller to the underground rescuers is often key to a successful rescue. Over the last 15 years or so, techniques for communicating through rock have been established. To cut a long story short, although the units are referred

Left: This laptop, the PCMobile produced by Cycomm, has been designed to operate at particularly low tempreatures and has been used on arctic expeditions.



Left: Members of the Lake District Search and Mountain Rescue Association at a rescue. Photo courtesy of Simoco
Above: The Derbyshire Cave Rescue Association in a cave rescue (and below) using a rugged cave radio.

to as cave radios, they actually operate by low frequency induction. Needless to say, caves and potholes must be about the most electronics-unfriendly environments imaginable so issues of waterproofing and ruggedisation are paramount. Much of my appreciation of rugged electronics has been gained through editing a journal dedicated to cave radio and electronics and being a member of a team involved in the design of a new cave radio. This radio, based on an electronic design by radio amateur John Hey, G3TDZ, is now in the process of being distributed to the UK's cave rescue teams and promises to provide reliable communication for many years to come. For more information on cave-radio and rugged electronics, point your browser to www.bcra.org.uk/creg/ which is the Web site of the Cave Radio & Electronics Group, a special interest group of the British Cave Research Association.

It's unlikely that you'll have a need to design electronic equipment for use underground, admittedly. However, I trust that the techniques described here will be equally applicable to the design of any rugged equipment, whether the intended application is outdoor data logging, geophysics, surveying, or whatever. I also trust that the information on choosing rugged equipment will be relevant to climbers, hikers, hot air balloonists, canoeists, and any other outdoor enthusiast who ever needs to use a GPS receiver, mobile phone, two-way radio, digital camera or laptop in the great outdoors. Accidents do happen, certainly. By using appropriately designed equipment, though, these accidents might not be quite as expensive or as catastrophic as you might expect.

	1st Figure Ingress of Solid Objects	2nd Figure Waterproofing
0	No special protection	No special protection
1	Protected against solid objects up to 50mm e.g. accidental touch by hands	Vertically falling drops of water, e.g. condensation
2	Protected against solid objects up to 12mm, e.g. fingers	Direct sprays of water up to 15∞ from the vertical
3	Protected against objects over 2.5mm, e.g. tools	Direct sprays of water up to 60∞ from the vertical
4	Protected against objects over 1mm, e.g. tools, wire and small wire	Water sprayed from all directions
5	Protected against dust – limited ingress (no harmful deposit)	Low pressure jets of water from all directions
6	Totally protected against dust	Jets of water from all directions, e.g. on-board ship in heavy seas
7	Not applicable	Immersion to a depth of 1m for 30 minutes
8	Not applicable	Immersion to >1m and/or for a longer period (as specified)

Table 1. IP Numbers as Defined in DIN EN 40050

RS232 IO Control Board

PART 2

by R.Grodzik

As with any project of any complexity, 'bugs' both hardware and software do arise, so it is not surprising that a few have been found. These are:

A 10μF capacitor should be connected across the reset switch to ensure reset of the 8031 processor on power on (+ve side to the Vcc). This is due to the behaviour of my PC and the subsequent powering up of the external PSU that supplies the power to the RS232IO board. i.e. during power on, the PC's plug and play software switches on the COM port to check if an external device is connected - so the PSU switches on briefly. If the hardware handshake lines on the COM port are connected together, plug and play assigns the com port exclusively to another device and so preventing other devices operating. So ensure that the handshake line - DTR/DSR and CTS/RTS are open and not strapped together.

The AC on/off circuit comprising of IC8 (MOC3041) and the triac (IC9),worked fine upto a 100 watt load - my hairdryer-motor only with the heating element switched off. When the load was increased by switching on the heat it was found necessary to reduce the value of R6 (the LED voltage dropping resistor) to 220R. Always use a load to test this circuit, otherwise it will not work. And remember that the small heatsink was designed for small lighting/AC. motor circuits so don't go connecting it to your washer/dryer!

The limiting resistor R3 which feeds alarm switch transistor BS170 may be omitted, and the RTS line (pin 7) of the D-type connector strapped directly to the transistors gate with a small wire link.

As to the software bugs, they were too numerous to mention since the PC software driver (written in assembler) and the RS232IO board control software (written in assembler) were of some complexity. I am now happy to report that all of them have been ironed out.

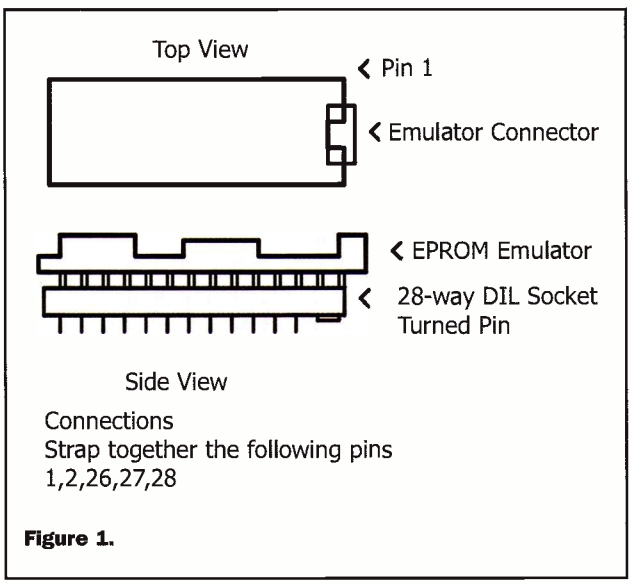


Figure 1.

LED Monitoring and interface board.

This board consists of a series of low current LED's connected directly to the 8155 PIO lines, monitoring Port A and Port B. After consulting the chip's data sheet it was found that each line could sink/source 2.5mA which is sufficient to light a low current led without the need for a cmos/ttl driver. This board also has additional monitoring functions:

- A green led power indicator connected directly to the 5-volt supply via a limiting resistor.
- A red led alarm indicator connected via the ribbon cable and plug3 to the PC0 line of the 8155.This is activated and flashes whenever the alarm circuit comprising of a microswitch (N.C.), the INT0 interrupt pin of the 8031 and a 12K resistor is broken - switch operates. Normally the INT0 line (pin 12) is held at ground by R5. When the microswitch operates, a logic level transition from low to high causes the 8031 to interrupt, and service an interrupt service routine i.e. sends an alarm code back to the PC and also flashes the red led on the monitoring board.

The interface board is also provided with a 5 volt power supply and a prototyping area allowing relay circuits etc. to be driven by the 16 output lines via transistor buffers or open collector circuits.

RS232IO Software

This is of considerable size, filling the 2048 byte capacity of the 2716 EPROM with a couple of bytes to spare, so at 1200 lines of source code is too large to be published in these pages. However I shall attempt to describe the algorithmatic structure of the software and provide software examples to test different parts of the board.

Codes

The entire project works on the fact that codes (control bytes) are sent from the PC's serial COM1 port when different parts of the menu are clicked on by the mouse. These codes are used in a look up table (in the EPROM) to select subroutines by the 8031 dependent on the function required. The lookup table is of considerable size since they have to accommodate the various permutations of driving 2 stepping

motors simultaneously - stop/go/fast/slow/forward/reverse. Simple maths shows that there are 64 possible combinations and so 64 subroutines had to be written! However, this means that the PC can be dispensed with and the ASCII string generator may be used to send pre-programmed codes to the RS232IO board and control say the motors. (use a spare pin on the D-type connector to supply a 5-volt supply from the RS232IO board to the string generator). Hopefully a joystick (PIC-based) will be designed to perform the same functionality, So included here are a full list of codes: (9600,n,8,1)RS232)

CODE LIST:
==========

ON	PORTA0	AD	PORTB0 A3
OFF	PORTA0	91	PORTB0 87
ON	PORTA1	AF	PORTB1 A5
OFF	PORTA1	93	PORTB1 89
ON	PORTA2	B1	PORTB2 A7
OFF	PORTA2	95	PORTB2 8B
ON	PORTA3	B3	PORTB3 A9
OFF	PORTA3	97	PORTB3 8D
ON	PORTA4	B5	PORTB4 AB
OFF	PORTA4	99	PORTB4 8F
ON	PORTA5	B7	PORTB5 AE
OFF	PORTA5	9B	PORTB5 92
ON	PORTA6	B9	PORTB6 B0
OFF	PORTA6	9D	PORTB6 94
ON	PORTA7	BB	PORTB7 B2
OFF	PORTA7	9F	PORTB7 96

A.C. MAINS
ON 072H
OFF 056H

RESET 00

PORTA OFF 02
PORTA ON 01
PORTB OFF 04
PORTB ON 03

MOTOR A
FAST AA SLOW C6
FWD AC REV C8
GO 28 STOP 0C

MOTOR B
FAST 80 SLOW 9C
FWD 82 REV 9E
GO C2 STOP A6

Embedded Software Development.

There is a Forum on the Electronics and Beyond Website, which I hope will be freely used by readers, since it helps contributors to the magazine to gauge what kind of projects should be included. Software development for embedded controllers such as the PIC and the 8031 is easier today than it was when I started on this 'white

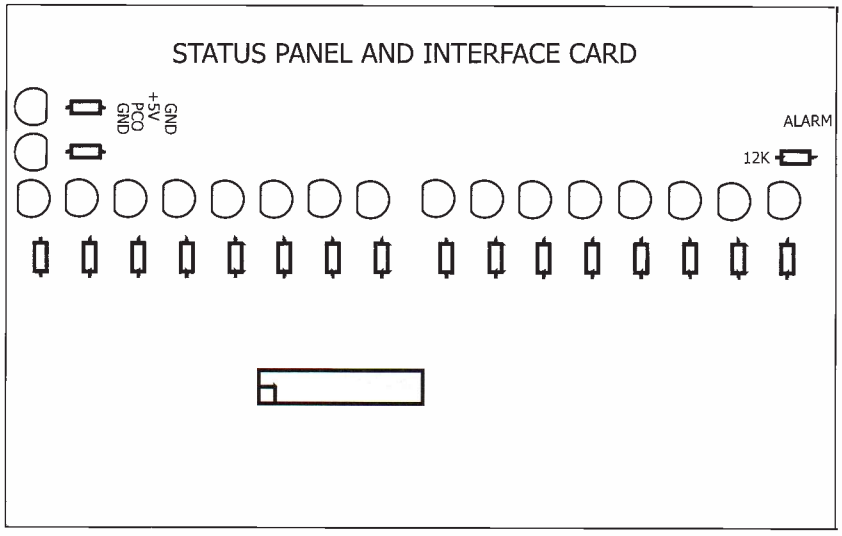


Figure 2. Led panel indicator board layout

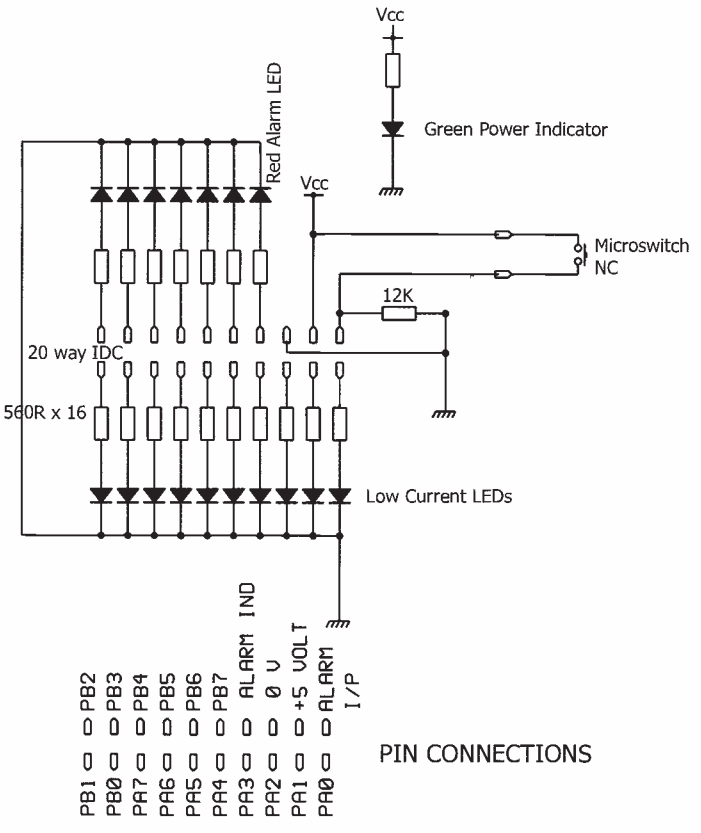
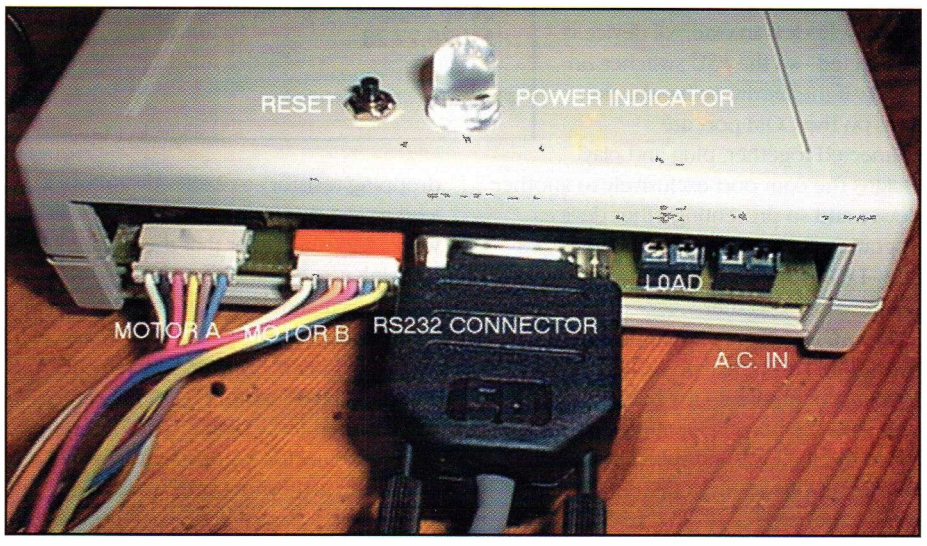


Figure 3. Panel indicator LED wiring diagram



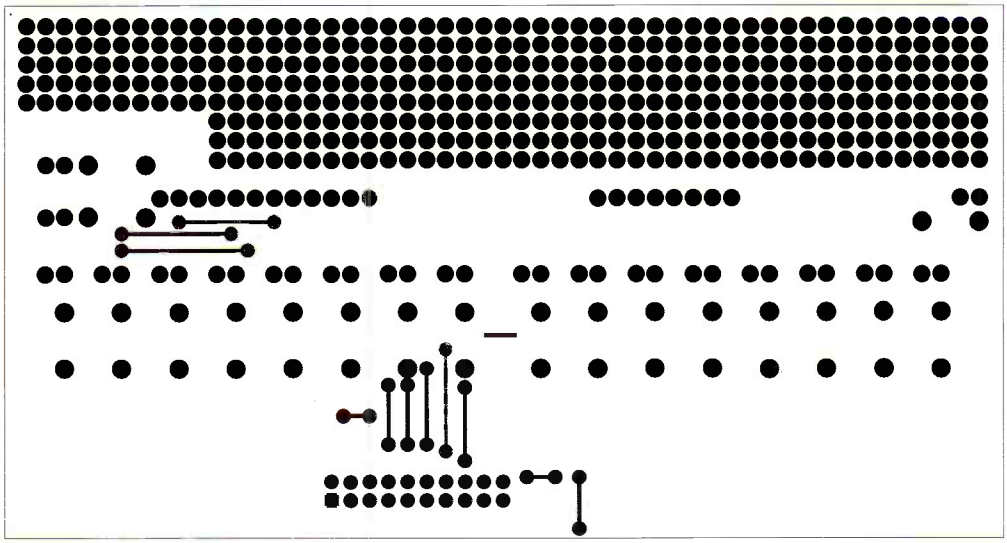


Figure 4. LED PCB top side

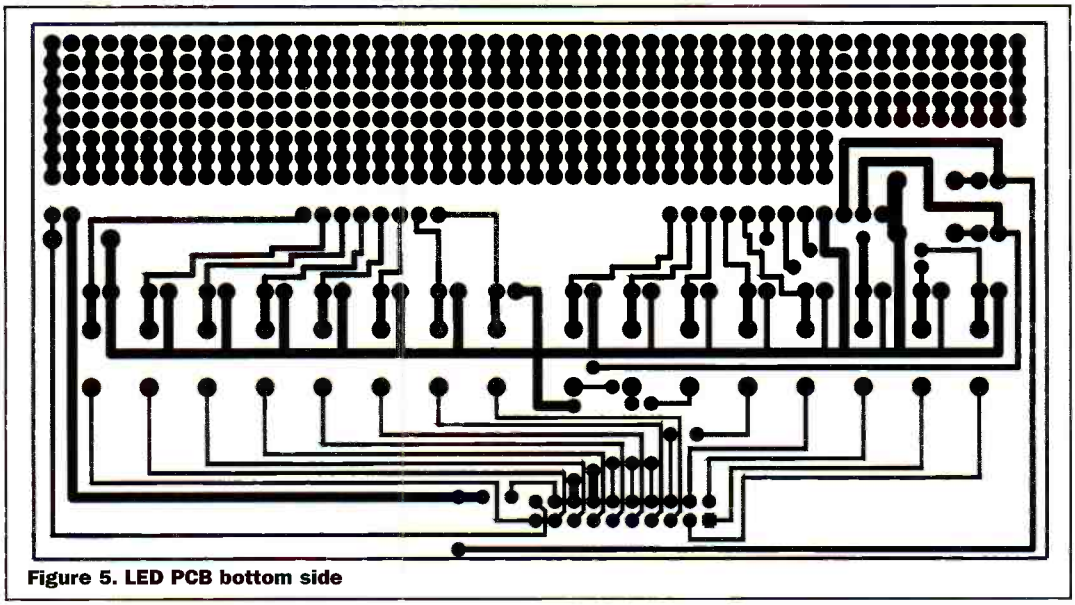
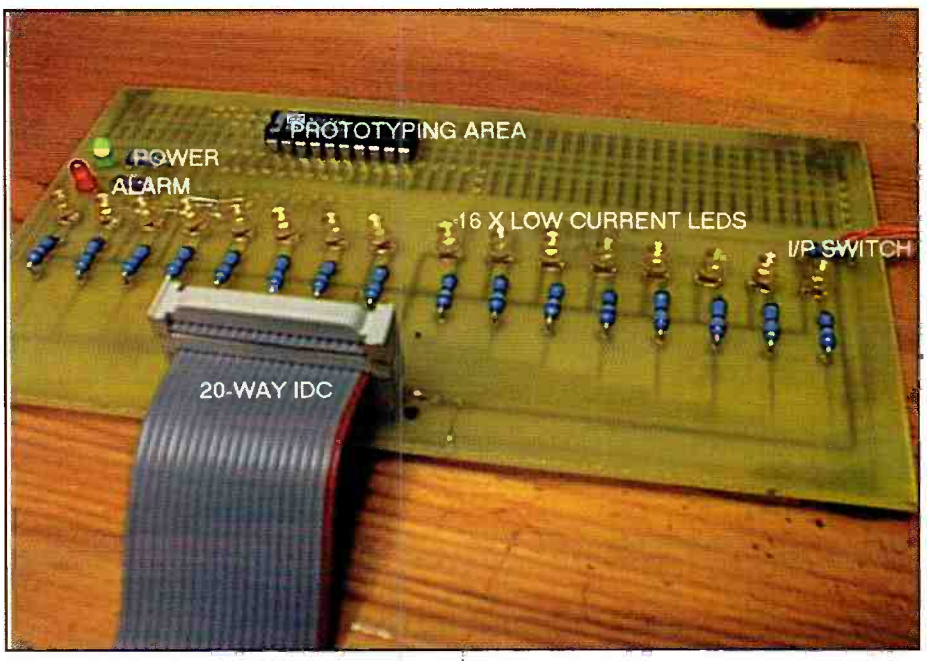


Figure 5. LED PCB bottom side



art' many years ago. Then I was equipped with an instruction set and had to tap in the opcode/ operands via 8 binary switches. Eventually I could enter whole bytes at a time, being displayed on 7-segment display! What joy.

Today software simulators are cheap (under 50 quid) and will run on any PC, so for example, software timing loops can be accurately measured before committing to firmware code. So that's fine but how does one test the EPROM software and get it from the PC to the target board? The answer is to use an EPROM emulator that connects between the PC's parallel port and the EPROM socket of the board. Object code is then simply sent from the PC and resides in flash/eeprom memory of the emulator. When the firmware has been successfully debugged it can then be permanently burnt into an EPROM. I used an EPROM emulator available from Maplin Electronics (order code UT63T) Part No.27MR512-120. This emulator has an 8Kbyte capacity and therefore had to be adapted for the 2 K-byte wide 2716 which has only 24 pins opposed to the 28 pins of a 8K-byte EPROM. See Figure 1.

A 28 dil turned pin socket was used with pins 1,2,27,28 removed. This forms a 24-pin socket that is required by the 2716 eprom. A wire connection on the underside of the socket strapped together pins 1,2,26,27,28.The EPROM emulator then sits on this socket. P.S. Don't forget to wear a static earth strap when handling this device.

A batch file sends 2kbytes of object code (TRY.OBJ) from the PC to the target board:

MICROM TRY.OBJ 2764 BIN 1800 HI 1 NV 1 0X3456

The 1800 is a hex offset so that the 2kbyte block is located in the correct memory map of the emulator.code 0x3456 is a unique i.d. assigned to an individual emulator by the manufacturer. Other emulators are available which are extras to production eprom programmers, but be prepared to pay several hundred pounds.

A pre-programmed EPROM, together with PC software driver on disc is available from: R.Grodzik (Micros) 53 Chelmsford Road Bradford West Yorkshire BD3 8QN England. Price £20.00 sterling P&P inc. Also see the authors web page at: **http://members.netscapeonline.co.uk /dgrodzik**

Test programs

Included on the next page are several short programs to test the functionality of the RS232IO board:

```
;ALARM.ASM
This program flashes the red led on the indicator card when the
microswitch is pressed. At the same time the PC alarm indicator
lights and a simple audible tone is produced on the PC.

#INCLUDE SFR51.EQU


.ORG 0
        LJMP START
.ORG 3                  ;INTERRUPT SERVICE ROUTINE GOES HERE

      CLR ES            ;OISABLE FURTHER INTERRUPTS
      CLR TR1           ;TIMER 1 OFF

      MOV A,#1
      MOV DPTR,#0803H   ;PORT A
      MOVX @DPTR,A      ;OISPLAY BYTE

      RETI              ;RETURN TO BACKGROUND PROGRAM

.ORG 0100H
START:
      ACALL DELAY
      SETB EX0
      CLR IT0
      SETB ES           ;ENABLE RECEIVE DATA INTERRUPT

      SETB TR1          ;TIMER 1 ON

      MOV A,#0FH
      MOV DPTR,#0800H
      MOVX @DPTR,A
      ACALL DELAY

      SETB EA           ;ENABLE GLOBAL INTERRUPT

LOOP:NOP
      LJMP LOOP

DELAY: MOV R1,#$FF
LOOPX: MOV R0,#$FF
INLOOP:DJNZ R0,$
       DJNZ R1,LOOPX
       RET

.org  0800H
.END


;MOTOR.ASM
This program simply tests both stepper motors. The speed is
adjusted by writing different values into R6.


#INCLUDE SFR51.EQU

.ORG 0h
HERE:

         LCALL DEL
         MOV P1,#088H
         LCALL DEL
         MOV P1,#0CCH
         LCALL DEL
         MOV P1,#044H
         LCALL DEL
         MOV P1,#066H
         LCALL DEL
         MOV P1,#022H
         LCALL DEL
         MOV P1,#033H
         LCALL DEL
         MOV P1,#011H
         LCALL DEL
         MOV P1,#099H

     SJMP HERE


DEL:
    MOV R6,#5   ;FAST SPEED
                ;MEDIUM 10
                ;SLOW  48

D2: DEC R6
    MOV R7,070H
D1: DEC R7
   CJNE R7,#0,D1
   CJNE R6,#0,D2
   RET


.ORG 0800H

.END


;RAMPDOWN.ASM
;Start at maximum speed (100Hz rate),reduce speed to a minimum
;and then stop

#INCLUDE SFR51.EQU

.ORG 0h

         MOV R0,#10    ; STEP VAL 50    ;50 X4 STEPS = 20
STEPS
                       ;=1 REVOLUTION
         MOV R1,#3     ;INITIAL SPEED
AGAIN:   PUSH 1
        ACALL STEPS
         POP 1
         INC R1
         CJNE R1,#24,MORE
         SJMP STOP
MORE:    MOV R0,#10     ;STEP VAL
         AJMP AGAIN

STOP:   MOV P1,#0
FOREVER:SJMP FOREVER

STEPS:
HERE:
         LCALL DEL        ;4 STEPS/CYCLE
         MOV P1,#088H
         LCALL DEL
         MOV P1,#0CCH
         LCALL DEL
         MOV P1,#044H
         LCALL DEL
         MOV P1,#066H
         LCALL DEL
         MOV P1,#022H
         LCALL DEL
         MOV P1,#033H
         LCALL DEL
         MOV P1,#011H
         LCALL DEL
         MOV P1,#099H
          DJNZ R0,HERE
          RET



DEL:    MOV A,R1
        MOV R6,A

   ;MOV R6,#3   ;FAST SPEED
                ;MEDIUM 10
                ;SLOW  48

D2: DEC R6
    MOV R7,070H
D1: DEC R7
   CJNE R7,#0,D1
   CJNE R6,#0,D2
   RET


.ORG 0800H

.ENO


RAMPUP.ASM

  ;INCREASE SPEED EVERY HALF REVOLUTIION AND THEN KEEP  MAX
SPEED

#INCLUDE SFR51.EQU

.ORG 0h

         MOV R0,#25    ;STEP VAL       ;50 X4 STEPS = 200 STEPS
                                        ;=1 REVOLUTION
         MOV R1,#24    ;INITIAL SPEED SLOW
AGAIN:   PUSH 1
        ACALL STEPS
         POP 1
         DEC R1
         CJNE R1,#3,MORE
         SJMP RUN
MORE:    MOV R0,#10     ;STEP VAL
         AJMP AGAIN

RUN:     MOV R0,#5
         MOV R1,#3
         ACALL STEPS
         SJMP RUN

STEPS:
HERE:
         LCALL DEL        ;4 STEPS/CYCLE
         MOV P1,#088H
         LCALL DEL
         MOV P1,#0CCH
         LCALL DEL
         MOV P1,#044H
         LCALL DEL
         MOV P1,#066H
         LCALL DEL
         MOV P1,#022H
         LCALL DEL
         MOV P1,#033H
         LCALL DEL
         MOV P1,#011H
         LCALL DEL
         MOV P1,#099H
          DJNZ R0,HERE
          RET



DEL:    MOV A,R1
        MOV R6,A

   ;MOV R6,#3   ;FAST SPEED
                ;MEDIUM 10
                ;SLOW  48

02: DEC R6
    MOV R7,070H
01: DEC R7
   CJNE R7,#0,01
   CJNE R6,#0,D2
   RET


.ORG 0800H

.ENO
```

Note that the relationship between stepper motor speed and delay time between steps is not linear and follows an exponential curve.
So, some room for development here!.

```
RECEIVE.ASM
This program tests the alarm led and displays the binary pattern
on portA of bytes sent from the PC.

#INCLUDE SFR51.EQU


.ORG 0
        LJMP START

.ORG 023H               ;INTERRUPT SERVICE ROUTINE GOES HERE

      CLR ES            ;DISABLE FURTHER INTERRUPTS
      CLR TR1           ;TIMER 1 OFF

      MOV A,SBUF
      MOV DPTR,#0801H   ;PORT A
      MOVX @DPTR,A      ;DISPLAY BYTE

      SETB TR1          ;TIMER 1 ON
      SETB ES           ;ENABLE INTERRUPTS
      CLR RI            ;CLEAR RECEIVE BYTE FLAG

      RETI              ;RETURN TO BACKGROUND PROGRAM

.ORG 0100H
START:
      ACALL DELAY

      MOV SCON,#050H    ;SERIAL MODE 1
      MOV TMOD,#020H    ;TIMER 1  8-BIT AUTO RELOAD
      MOV TH1,#0FOH     ;TIMER RELOAD VALUE FOR 9600 BAUD-
11.0592
      SETB ES           ;ENABLE RECEIVE DATA INTERRUPT
      SETB TR1          ;TIMER 1 ON

      MOV A,#0FH
      MOV DPTR,#0800H
      MOVX @DPTR,A
      ACALL DELAY

      SETB EA           ;ENABLE GLOBAL INTERRUPT

LOOP:NOP
      ACALL DELAY
      MOV A,#1
      MOV DPTR,#0803H
      MOVX @DPTR,A
      ACALL DELAY
      MOV A,#0
      MOV DPTR,#0803H
      MOVX @DPTR,A
      LJMP LOOP

DELAY: MOV R1,#$FF
LOOPX: MOV R0,#$FF
INLOOP:DJNZ R0,$
       DJNZ R1,LOOPX
       RET

.org  0800H
.END



TRANSMIT.ASM
This program sends a swirl ascii pattern form the RS232I0 board
to the PC.


#INCLUDE SFR51.EQU

.ORG 0h
        MOV A,#030h
CYCLE:
        ACALL TXD
        INC A
        MOV P1,A
        ACALL DEL
        LJMP CYCLE

                        ;TXO SUBROUTINE

TXO:  MOV SCON,#050H    ;SERIAL MODE 1,RECEIVER ENABLED
      MOV TMOD,#020H    ;TIMER 1  8-BIT AUTO RELOAD
      MOV TH1,#0FDH     ;TIMER RELOAD VALUE FOR 9600 BAUD-
11.0592

      CLR EA            ;DISABLE GLOBAL INTERRUPT
      MOV SBUF,A      ;LOAD SERIAL BUFFER WITH DATA
      SETB TR1        ;TIMER 1 ON
LOOP: JNB TI,LOOP     ;IF FLAG TI IS SET,BYTE HAS BEEN
TRANSMITTED
      CLR TR1         ;TIMER 1 OFF
      CLR TI          ;CLEAR BYTE RECIEVED FLAG
      RET             ;RETURN TO CALLING PROGRAM

DEL:MOV R1,#$95
LOOP2:MOV R0,#$F
INLOOP:DJNZ R0,$
       DJNZ R1,LOOP2
       RET

.ORG 0800H
.END
```

MIDI MATRIX 2

PROJECT

Neil Johnson describes the design and construction of a versatile eight-channel MIDI routing unit for the home or small studio.

Part 1

The world of electronic music consists of gadgets and cables. Gadgets are fun - synthesisers, mixers, effects, and a myriad of other weird and wonderful things. Cables, on the other hand, are not so fun, especially when it is time to rearrange the wiring of even the most basic studio.

Several solutions have been developed over the years. The most successful and easy to use are based on a patching arrangement, either using individual patch leads, or an electronic version using a variation of the "telephone exchange" principle - lots of inputs, lots of outputs, and many electronic or electro-mechanical switches between them.

In a typical small project or home studio there are two types of cable: audio cables, carrying audio signals between gadgets, and MIDI cables connecting all manner of computer-controlled gadgetry together. Unless considerable forethought and planning is undertaken, it is highly likely that mostly MIDI cables will, at some time or other, need to be moved. Most audio cables, however, once arranged to feed everything into the main mixer, tend to stay put.

The original MIDI Matrix had six channels and six rotary switches. Routing consisted of setting the switches to the desired positions. While simple and robust (the original unit has lasted over six years) it is not very easy to remember the switch settings for the various patch configurations - especially if, like the author, you have a poor memory!

So, as part of a studio upgrade plan it was decided to revamp the MIDI Matrix, giving the old idea a new spin and bringing it into the 21st century.

The Next Generation

The MIDI Matrix 2 (MM2) is an eight-channel programmable MIDI routing unit, with enough storage for sixty-four preset patches in an internal non-volatile EEPROM. Patches can be selected, edited and saved from the front panel. Patches can also be selected by Program Change commands received from a MIDI device (for example, a computer or a synthesizer).

Ease of use was a key consideration during the design stage. All the major functions have their own dedicated button, requiring only a small display for additional information. Also, an active LED display, rather than a passive LCD, greatly improves the readability of the display during use. Most studio gadgets these days have LCDs, often backlit, resulting in narrow viewing angles, fading contrast and backlights that last only a few years.

Blocks Away

Cast your eyes over the system block diagram shown in Figure 1. The system is split into two main sections, dealing with the user interface and the MIDI routing respectively. The heart of the system is the microcontroller. For reasons familiar with most constructors, the device chosen for this project is the Intel 8031 or compatible (i.e. 8032, 8051, Dallas 80C320, etc). The reason? Well, two in fact: the author had one at the bottom of his semiconductor junk box, and after a clear-out at work a Keil ANSI C compiler was made available for development.

The microcontroller starts with a reset from the on-board power-on reset circuit. The ROM contains the program code for the microcontroller, while the serial EEPROM stores the current MIDI channel number and the sixty-four patch memories, ready for instant recall by the user.

Moving up to the user interface, the LED display and button LEDs are driven by a four-way multiplexed display driver. This

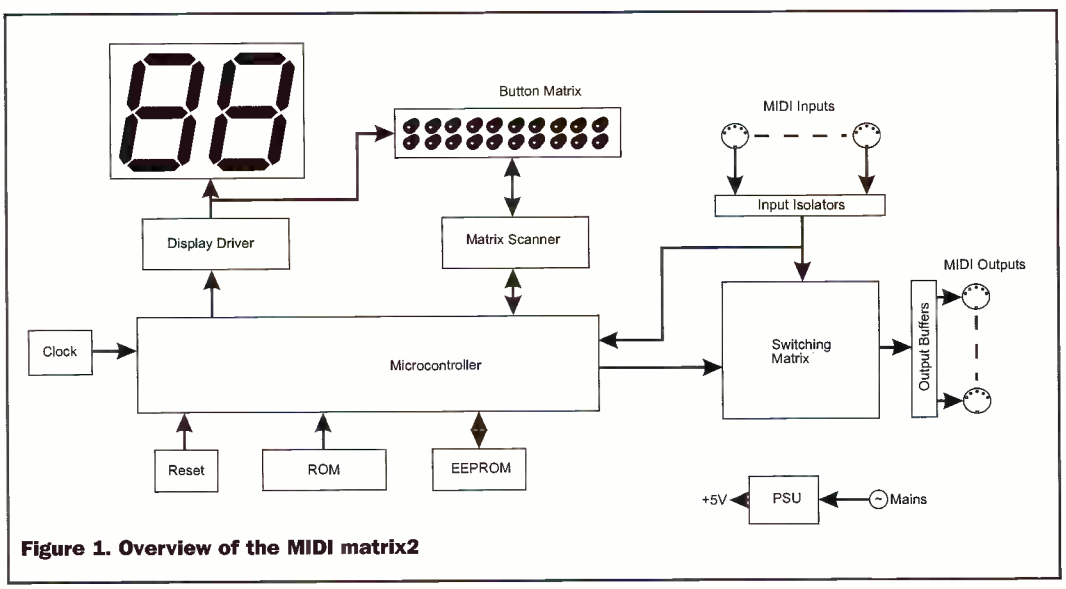


Figure 1. Overview of the MIDI matrix2

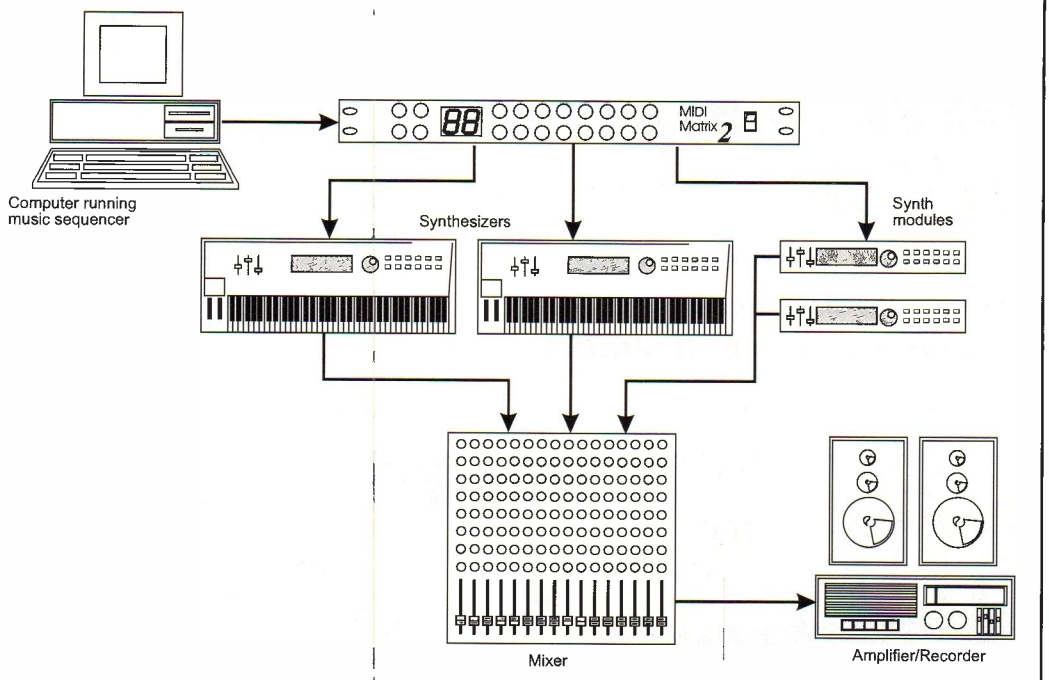


Figure 2. Typical MIDI based studio setup

method has two attractive features. Firstly, having one quarter of the LEDs on at a time reduces the current drawn by the display. Secondly, the number of wires from the driver to the display board is also reduced by a considerable margin. This project has thirty-two front panel LEDs: a direct drive method would need thirty-three wires, whereas the multiplexed method used here reduces this to twelve wires (four common-anode sources, eight cathode sinks).

The button scanning matrix works on a similar principle. There are twenty buttons to scan, in four banks of five, needing a total of nine wires between the front panel and the scanning circuit. Extra circuitry is included to ensure that multiple button presses are processed correctly.

The second main section of the MM2 is the MIDI routing and buffering section. Here, eight MIDI inputs are opto-isolated and buffered before being fed to the eight inputs of the routing matrix. Input channel eight is also taken to the microcontroller to allow remote control from a computer or keyboard (either a synthesizer of a master keyboard). The eight outputs of the routing matrix are buffered before being brought back out to the world through the back panel connectors.

The software running on the micro-controller drives the entire system. It

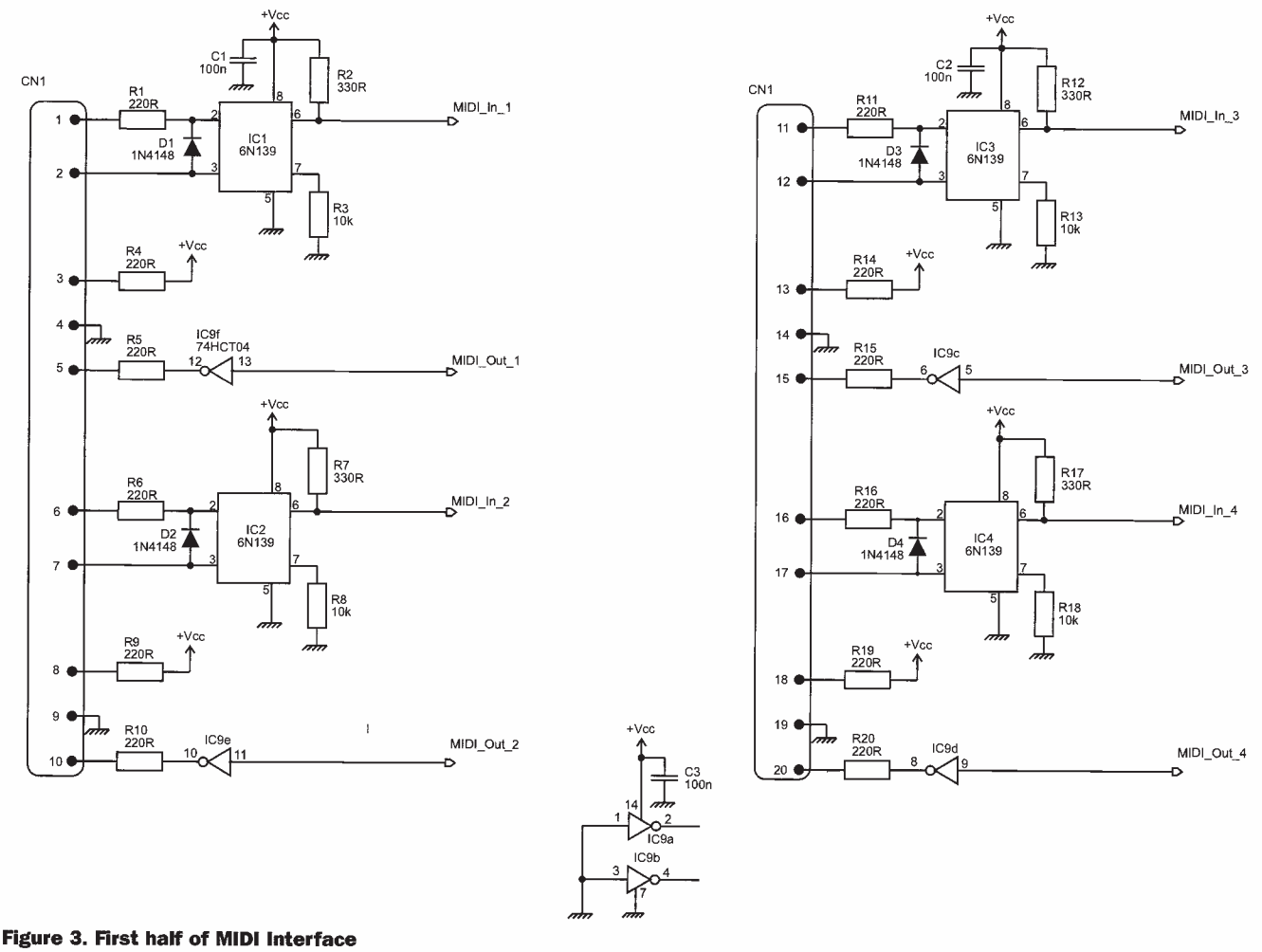


Figure 3. First half of MIDI Interface

A Brief Guide to MIDI

MIDI (Musical Instrument Digital Interface) is a communications system for passing control messages between electronic musical instruments, computers, recorders, lighting controllers, effects units, and so on. It was born in 1982, the child of a number of synthesizer manufacturers, and was helped into the marketplace with the launch of the immensely successful Yamaha DX7 keyboard.

MIDI uses a serial data format (one start bit, eight data bits, one stop bit, no parity) operating at 31,250 Baud. A '0' is represented by a minimum current of 5mA, and a '1' - the idle state - by 0mA. All MIDI inputs are opto-isolated (to avoid ground loops) and the current is specified to drive the input of a high-speed opto-isolator such as the HP 6N138 or Sharp PC-900.

The length of each message varies depending on what data it is carrying and the priority the message has over other messages. In general, MIDI carries "event" information - which key was played, how hard it was played, time events, status messages, etc. MIDI can also carry other application-specific data in SysEx messages, but the relatively slow transfer rate makes this prohibitively slow for large amounts of data (e.g. large samples from a sampler into a computer).

multiplexes the display, scans and debounces the buttons, drives the MIDI matrix, receives and interprets MIDI command messages, manages the data in the EEPROM, and provides the user with a selection of menus and facilities for operating the unit.

Supporting the system is the power supply unit (PSU). This project is mains-powered, avoiding the use of wall-wart power supply blocks that are the bane of most studios. The author is proud of the fact that he has no external power supply blocks in his studio set up - although how long this desirable situation is likely to continue is another matter.

Figure 2 puts the MM2 into context with the rest of a small studio. On the left is a computer running some sort of sequencing software (Cakewalk, Cubase, etc). It provides one or more MIDI channels to control the rest of the studio, consisting of keyboards (top), synthesizers and samplers (right) and effects units (bottom). Finally, the mixer brings together the audio signals from the various units, producing the final output for listening or recording.

The mixer is shown connected to the MM2 to provide for mixer-automation control from the computer. This system is now available on many analogue mixers and all digital mixers, with the more expensive versions proving moving-fader automation.

Circuit Description

Figures 3 and 4 show the eight MIDI input opto-isolators and output buffers. MIDI uses a 5mA current loop to carry data between units (see separate box). Taking MIDI channel one as an example, the MIDI input current comes in through pin 1 of CN1, through R1 and the LED in IC1 (a high speed opto-isolator), and back out through pin 2. Diode D1 protects the LED in IC1 from reverse currents. R2 is the collector load resistor for IC1's open-collector output, while R3 provides bias for the Darlington output stage, reducing the turn-off time of the output.

The MIDI output circuit consists of R4, R5 and one-sixth of IC9. The hex inverting buffer provides the current switching capacity, while the resistors, together with the matching receiver resistor and LED, limit the current to the required 5mA.

The remaining seven MIDI channels operate in the exactly the same way. The unused inputs of IC9 and IC10 are tied low. Each has their own supply decoupling capacitor, as does each opto-isolator.

The microcontroller heart of the system

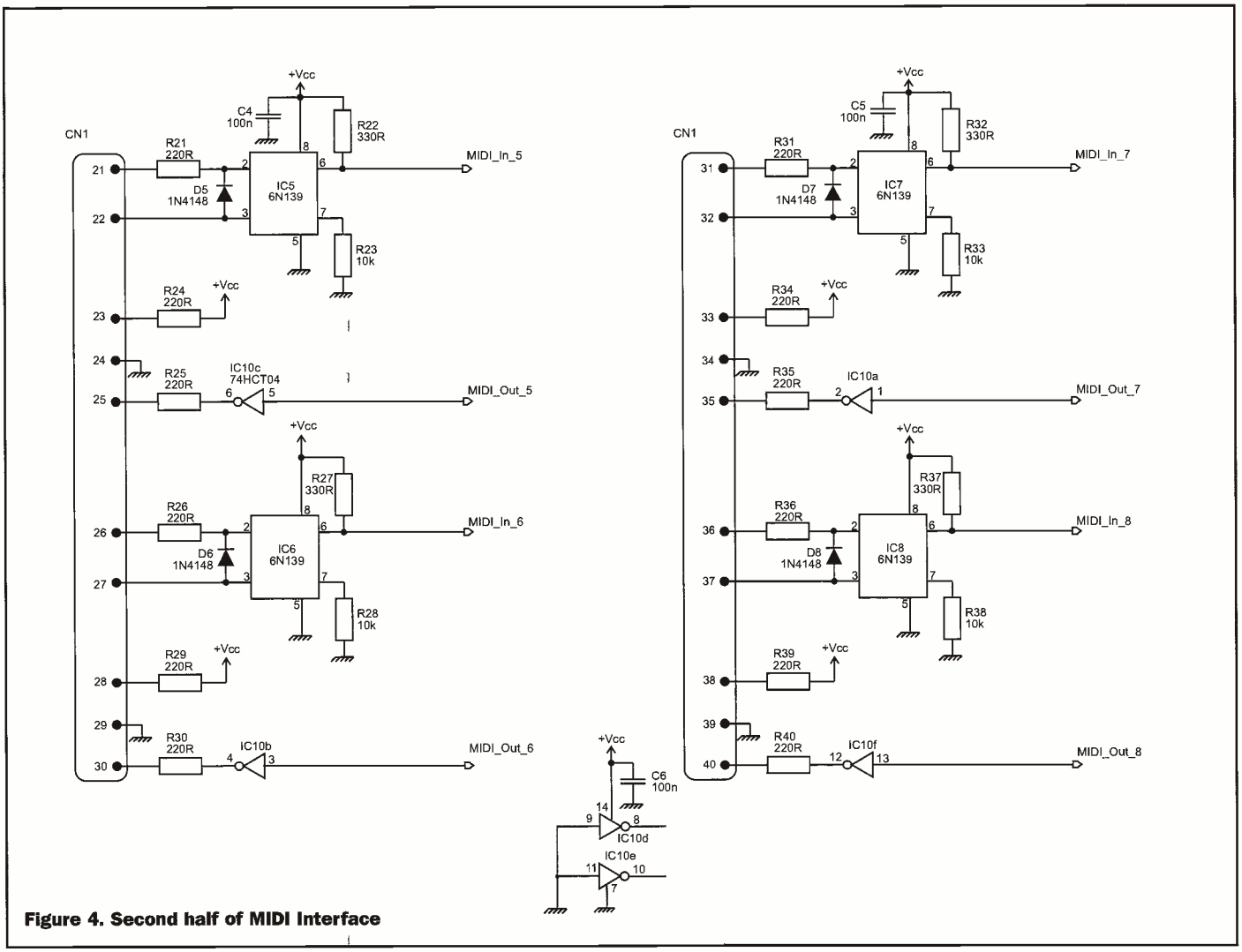


Figure 4. Second half of MIDI Interface

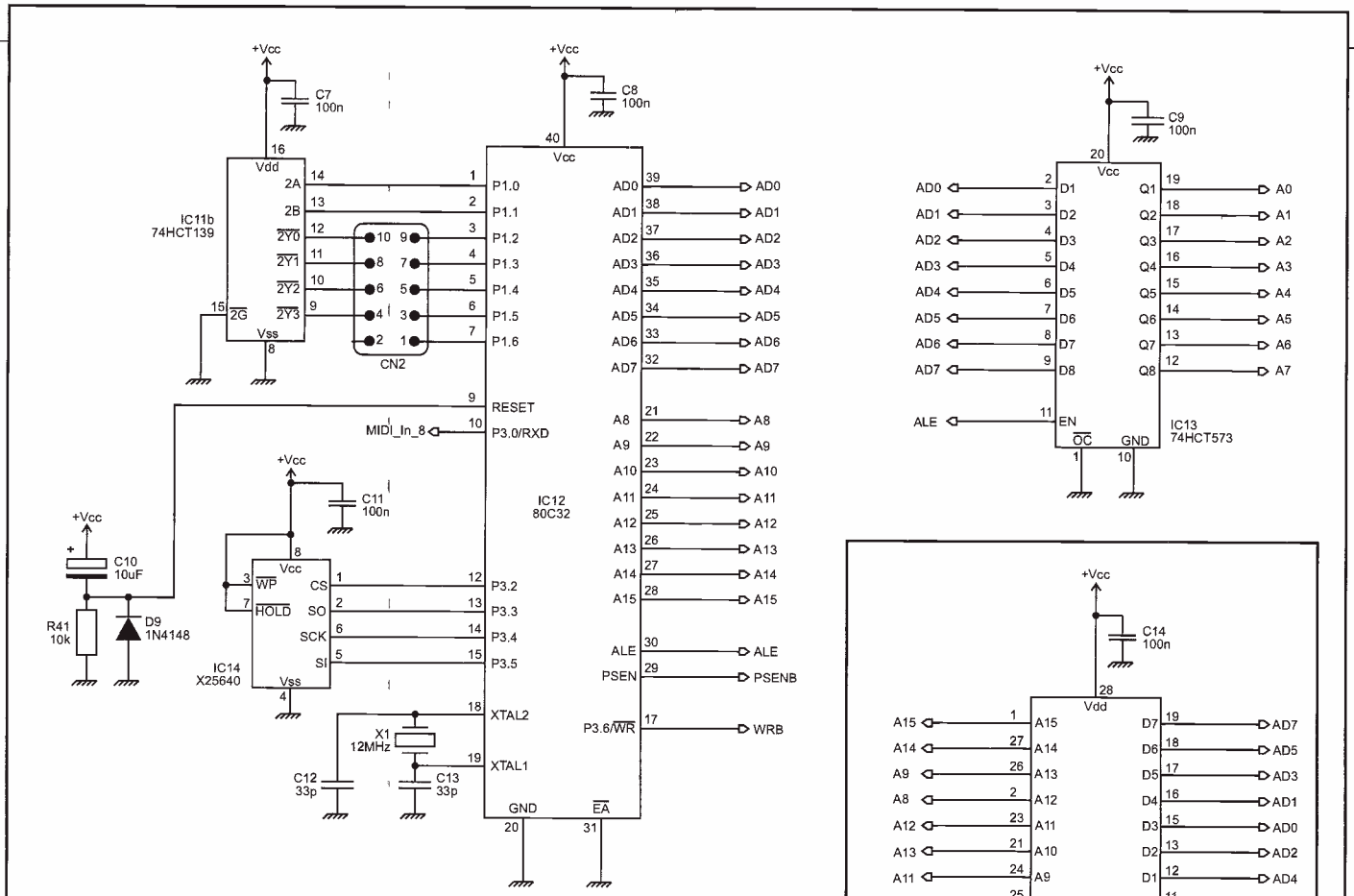


Figure 5. The brain of the MIDI Matrix- The microcontroller

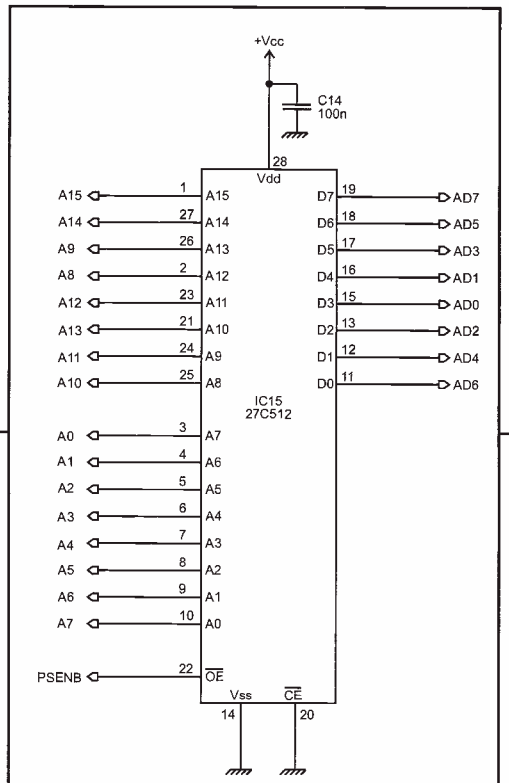


Figure 6. EPROM connections. Note the mismatch between device pin functions and the connections to the microcontroller. See text for explanation.

is shown in Figure 5. R41, D9 and C10 provide a power-on reset pulse to the reset input of the microcontroller, IC12. The non-volatile EEPROM connects to the microcontroller through four dedicated pins. Both the Write Protect and Hold functions are not used in this circuit, and are wired high. The processor's clock is generated by X1, with C12 and C13 providing the correct loading for the crystal, ensuring stable oscillation and guaranteed start-up behaviour.

The keyboard connects directly to CN2. Scanning is implemented with one half of IC11 (to provide the four column select lines) with the five row sense lines returning to the microcontroller through pins 3 to 7.

The 80C32 family of microcontrollers multiplexes the lower half of the address bus with the data bus. This extra complication arises from the designer's efforts to fit the device into a 40-pin package. This scheme was also used on the once-popular 8085 microprocessor, and latterly on the 8086. During memory accesses the lower half of the address bus is latched by IC13. The ALE (Address Latch Enable) signal holds the latch during the data read or write half of the memory access cycle.

The program code is stored in an EPROM (Figure 6). The strange connection pattern results from remapping the pinouts to help simplify the PCB layout. During software development, a program was written to automatically convert the programming files to suit the non-standard connections. This bizarre non-ideal system was used extensively during the early days of microprocessors, with double-sided PCBs and hand-laid track routes. Today, with multi-layer PCBs, advanced CAD software and surface mount devices, it is much easier to design systems with ideal circuit configurations.

The MIDI routing matrix itself, together with the multiplexed LED driver, will be shown in Figure 7 next month. All MIDI inputs and outputs connect to the large CPLD (complex programmable logic device) IC16, a Lattice Semiconductor ispLSI 1016E. Figure 8 (shown next month) the top-level structure of the CPLD design.

Each MIDI output is connected to one of the MIDI inputs through an 8-input multiplexer. In side the CPLD are eight such multiplexers, together with the latches and address decoding logic for mapping the registers into the microcontroller's external data memory.

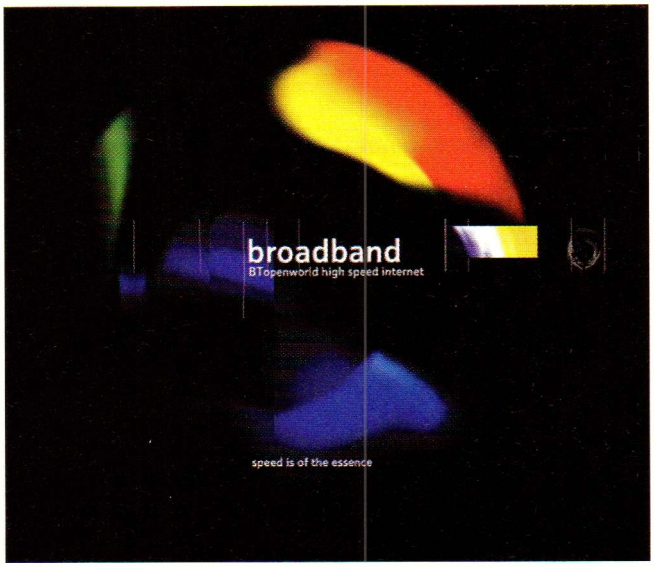
The CPLD also contains the display registers for driving the multiplexed display. There are three 4-bit display registers - two for the eight cathode drivers, and one for the anode drive selector (the other half of IC11). The cathode drive circuit (IC17 and resistors R42-R49) sinks the current from one cathode on each of its eight lines. The four anode drive transistors (Q1-Q4) supply current to one of the four common-anode lines. This circuit drives all thirty-two LEDs in four banks of eight, split as: left digit and mode button, right digit and mode button, top select row, and bottom select row.

The PSU (Shown in Figure 9 next month) is a basic transformer-rectifier-voltage regulator unit. The regulator is protected from reverse voltages by D14. This is good practice, especially as these low-cost 3-terminal regulators do not include this degree of protection, and is very susceptible to reverse voltages. If the suggested size of case is used it is recommended that the specified transformer is used.

TO BE CONTINUED

@internet special

8 page pull-out



BT Under Fire (again)

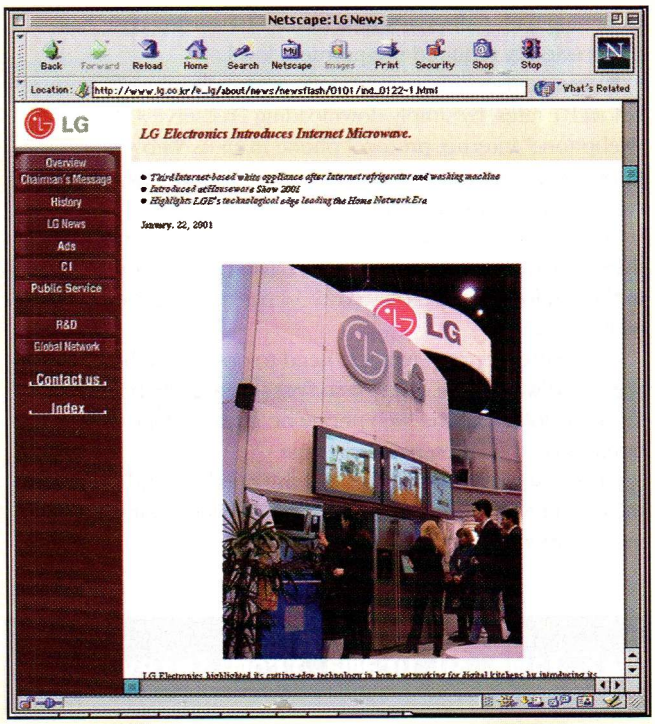
BT has hit the headlines recently — not only for falling share prices, but also because it has been accused by some of its competitors that it is acting uncompetitively and hence illegally in its approach to installing ADSL connections. ADSL (asynchronous digital subscriber line) is the UK's variant of the digital subscriber line (DSL) high-speed Internet access system that BT has opted for as the next-generation of consumer and small business connections. DSL is an always-on access system — as long as the DSL modem is connected to the DSL line and turned on, the modem is connected to the Internet. Any computer connected to the DSL modem via an Ethernet connection is therefore connected to the Internet too. If you have an Ethernet hub and a router, all computers connected to the Ethernet network have simultaneous Internet access. DSL is also flat-rate — in other words, users pay a single line rental for the service, no matter how long or how many computers actually use the Internet. This is an ideal access method therefore, for small businesses, schools, home users and so on.

ADSL is a method that uses existing landlines between local exchanges and customers' premises. In this respect, it's a good solution as it doesn't require new cabling — an otherwise expensive option that would appear to give ADSL the edge over other high-speed Internet access technologies such as cable modems. Instead, high-speed digital equipment needs to be installed at the local exchange, and digital repeaters (where required) are positioned in BT's local loop street equipment boxes.

Under recent legislation, BT is supposed to make its services available to some of its competitors. This includes its ADSL offering. Several competing Internet suppliers (AOL and Freeserve, to name a couple) have taken BT up on this, under agreed terms and conditions.

BT's problem is that it can't seem to install its equipment fast enough. No big deal, you might think — it's just a question of waiting, after all it's bound to be on a first-come, first-served basis. But there's the rub. It has been suggested by some of BT's competitors that this is not the case. They argue that BT is installing more equipment for its own users, than it is for its competitors' users.

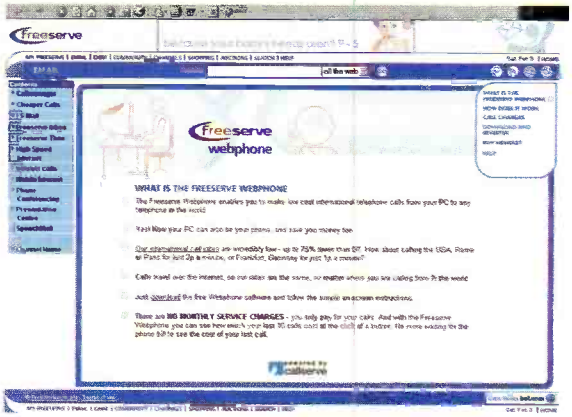
AOL and Freeserve cite the fact that BT is installing ADSL into between 300 and 500 customers' premises a day, while AOL is allocated just 20 installations a day, and Freeserve gets a mere 16 installations a day. Overall, the figures seem to bear this out. Of the existing 30,000 installations of ADSL, some 20,000 of these are customers of BT's BTOpenWorld service. The remaining 10,000 belong to all of BT's competitors' customers. At the moment, BT disputes the fact that it is uncompetitive, but such figures do indicate that they have been. It's now up to Oftel, the telecommunications watchdog, to rule on the argument.



It had to happen of course. At some stage white goods — kitchen appliances such as cookers, fridges, washing machines, and so on — would get connected to the Internet. Manufacturers have been talking about it for a while, but no-one till recently has been keen to introduce products that make the necessary steps to get Internet connected. LG Electronics, though, appears to be the first with its range of Internet-savvy appliances. Third in the range — an Internet microwave oven — was released in January. The other appliances in the range are an Internet fridge and an Internet washing machine. The Internet microwave oven features a modem and LCD touch screen, so that users can access Web sites for cookery information and recipes, as well as giving the ability to download automatic cooking data to allow automatic control.

LG Electronics plans to continue the range over the future, and other companies are already joining in with the hype, so expect much more to come.

Cheap Talk from Freeserve



More talk for less money is the latest scheme from Freeserve. It has partnered up with Europe's first Internet telephony provider Callserve, to offer its 3.8 million unique users low cost calls to any telephone in the world from their PCs.

To help promote the new Webphone, Freeserve is co-launching with Callserve a new lower £10 starting cost, half the previously required pre-payment level.

Freeserve users can save pounds, with calls up to 75% below BT rates, by simply downloading Freeserve's 'Webphone' Internet protocol phone from its Web site. Phone balances can be checked at anytime, including the cost of a user's last ten calls.

Subscribers can make national and international calls from their PC to anywhere in the world. Calling a long lost relative in the US, for example, only costs 3p per minute, compared with BT's 21p.

To use the service, members need to download the Freeserve Webphone from **<www.freeserve.com>** that can be found by following the Web phone or 'cheap phone calls' hotlinks on the Freeserve homepage.

Once installed, users simply dial the numbers and press the call button in exactly the same way as when using a mobile phone.

Real Time 3D Drama from Televirtual

Televirtual at **<www.televirtual.com>**, the UK company which launched the world's first computerised TV presenter, has broken new ground with a system which produces multi-character TV animated drama, live and as it happens.

Described by Televirtual founder Tim Child, as a real-time animation pipeline, or RAP system, the computer-hosted package allows a variety of complex 3d characters, to move, speak and interact, in a selection of virtual sets.

The RAP system, which also allows real-time lighting effects, sound and lipsynch speech generation, was demonstrated to BBC programme chiefs at Television Centre recently, and Televirtual plan to demonstrate the system to production companies and Animation Rights holders in London during February.

iTunes Downloads Top 275,000 in First Week

Apple claims that downloads of iTunes, its easy to use jukebox software, topped 275,000 in the first week since it was made available to Mac users as a free download at **<www.apple.com/itunes>.**

Exclusively for the Mac, iTunes lets users import songs from their favourite CDs and compress them into the popular MP3 format and store them on their computer's hard drive.

The application also allows users to organise their music using powerful searching, browsing and play list features.

AOL Launches Mail Alerts Service

AOL has announced the availability of the AOL Mail Alerts service. The service, part of the AOL Anywhere initiative, offers AOL's more than 26 million members the option of sending a message to their text-enabled digital mobile phone or alphanumeric pager when a designated message has arrived in their AOL e-mail box.

The new AOL Mail Alerts service offers AOL members the convenience of knowing when they've received an important e-mail, extending AOL's ease-of-use and convenience to members who are on the go by keeping them connected to their AOL e-mail even while away from their PC.

For further details, check: **<www.aol.co.uk>.**

Test Drive Rich Media without Limits

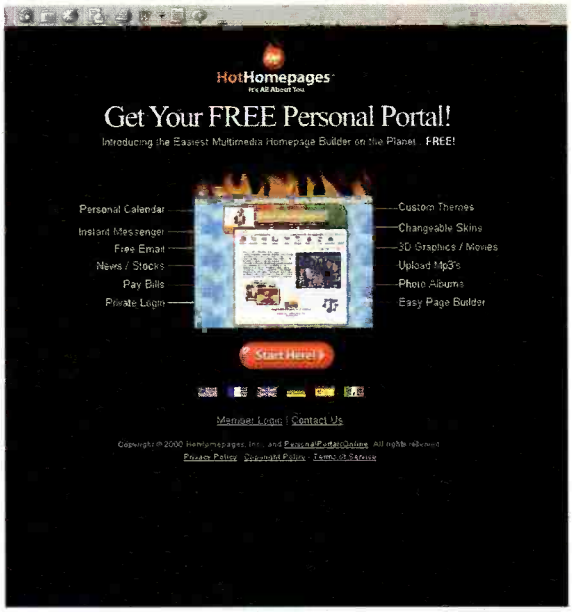
Intensifi's Web site at **<www.intensifi.com>** has been developed to demonstrate Synchronised Web Communication - synchronised sight, sound and speed in Web commerce. The site showcases a fast, multimedia experience that flows with the users' navigation of the site.

IntenseSound, the technology behind the Intensifi site, is a unique Web enhancement tool that allows visitors to Web sites to hear an instantaneous audio narrative that is synchronised with the visual content they see

From any page on the site, audio is available by clicking the blue audio button in the upper left corner of each page. The user can then determine how the audio should be delivered, either via the Web using Voice over IP (VoIP), or by telephone.

A major source of frustration for Web site visitors is the amount of time it takes for pages to load. One of the biggest challenges for Web sites today is to improve the speed of the user experience regardless of connection speed.

Novice Web Site Builder Unveiled

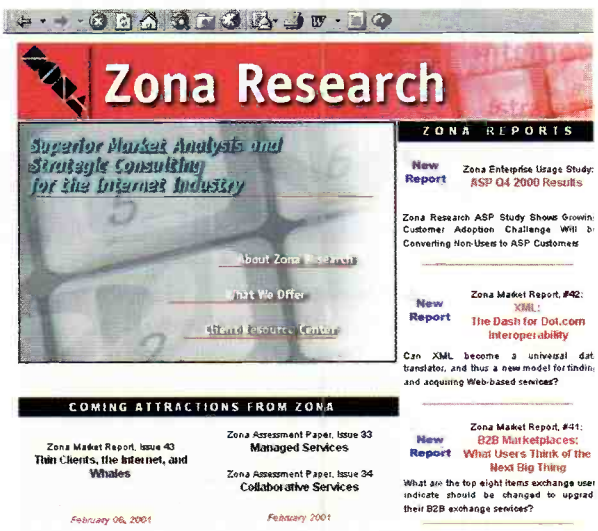


The new buzzword in the world of online commerce is stickiness; the art of attracting and retaining users on a Web site in a medium where people frequently jump from site to site in a matter of seconds.

And that's what HotHomepages at **<www.hothomepages.com>**, a new vehicle for online Web site and personal portal building, plans to offer.

The applications' integrated platform offers users a broad range of secure and public features that will turn their own personal portal into a complete customised Web site, community centre, shop module, communication resource and life manager.

XML: The Dash for Dot.com Interoperability



When the history of Web-based e-commerce is written, XML may be regarded as a more important development than HTML in accelerating business on the Web.

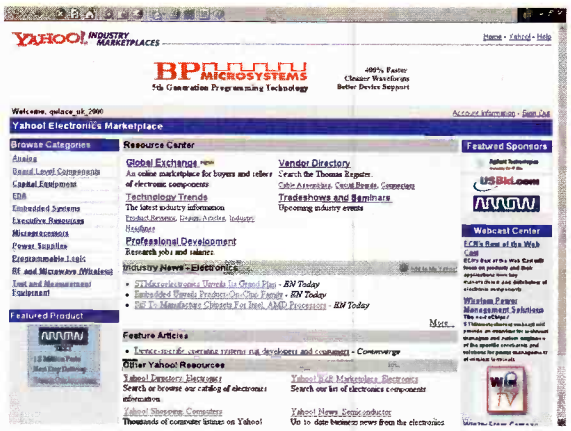
The reason is that XML promises to do for Web application interaction what HTML did for the human reading of Web-based documents. XML will be able to bridge the islands of information locked away in incompatible computing systems to provide a freer interchange of data between these formerly isolated systems.

Through the efforts of many industry consortia, XML has found a place in industries as diverse as medicine, insurance, electronic component trading hubs, petrochemicals, forestry and finance, to name a few. The promise of XML is multifaceted and huge, but has it achieved serious acceptance in the corporate world?

To answer this question, Zona Research announces the release of its latest Zona Market Report, XML: The Dash for Dot.com Interoperability. This report is packed with primary research from interviews with decision-makers who are currently deploying XML based solutions or plan to do so during 2001.

For further details, check: **<zonaresearch.com>**.

Yahoo! Launches Industry Marketplaces



Yahoo! has launched Yahoo! Industry Marketplaces at **<industrymarketplaces.yahoo.com>**, a business-to-business destination for information and services that enable industry professionals to research products, find the latest industry news and make purchasing decisions.

The initial launch of Yahoo! Industry Marketplaces includes three areas: Electronics, IT Software and IT Hardware. Each marketplace will provide business owners and professionals with targeted, in-depth information and services, research capabilities from product databases, industry-specific news and a rich-media Webcast centre.

The Electronics Marketplace at **<industrymarketplaces.yahoo.com/electronics>** is a targeted location for business users to find product information, research sellers and buyers of specific components and keep up to date on the latest electronic industry news and trends. The Electronics Marketplace Resource Centre features:

- A procurement site co-branded with USBid, a premier e-commerce provider of content, community, and commerce for the electronic component sourcing community, which provides a global online exchange for the purchase of electronic components.
- Headlines from Cahners Business Information, one of the largest provider of business information, including the latest electronics industry news, feature stories and product reviews. Users can personalise and add news content to a My Yahoo! **<my.yahoo.com>** page and have the latest industry specific headlines at their fingertips.
- A comprehensive supplier database featuring product headings from Thomas Register, which allows users to search for sources of industrial products and services through a directory of 168,000 manufacturers.
- A Webcast Centre, which will feature streamed video and audio programming of industry-specific information, including: video product releases, Internet-only shows, product training and instructional seminars.
- Professional development tools and information on upcoming tradeshows and seminars.

Symantec Service Checks PC Vulnerabilities

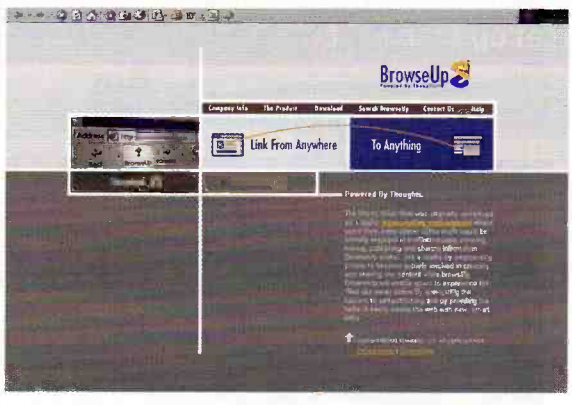
The Symantec Security Check at **<www.symantec.com>** has analysed the levels of Hacker Protection, Privacy Protection and Virus Protection for more than 2.2 million PCs, since this free Web-based tool was first launched in March 2000.

More than 220,000 of those unique users have submitted their results for an ongoing comparative survey which shows that a large portion of participants are vulnerable to hackers, only half use leading anti-virus protection and a surprising 82% are open to a common privacy leak.

Nearly 40% of survey participants have open ports that could be exploited by hackers. Hackers commonly use automated scanning tools to find vulnerable computers across the Internet.

Symantec Security Check runs a series of tests to assess vulnerability to this common hacking activity and provides a detailed report to the user of any potential vulnerabilities discovered.

BrowseUp Releases Beta Version of Web Platform



BrowseUp at **<www.browseup.com>** has released a beta version of its new Web platform. By downloading BrowseUp's software users will be able to create their own links to or from any Web site for other users to follow.

These links can be added to content objects such as images, text paragraphs, or whole pages.

For example, if a user wants to make a link from a famous news site to his own Web page, it is as simple as dragging a picture from that news site and dropping it onto his own site. This creates a content level link that other users can follow.

sandCULTURE Launches Internet Remote Control

sandCULTURE at **<www.sandculture.com>** streamlines users' online experience through a free integrated remote control called the sandBAR. This aggregates many of the most compelling functions currently available on the Internet.

The sandBAR allows users to place free long-distance calls over the Internet, tailor individualised MP3 playlists, set online radio station lists, access chat rooms, message other sandBAR users and access current news, stock quotes and weather information.

All sandBAR users receive a free Web-based e-mail account, which they can access both through the application and the Web. All these features are neatly organised and easily accessible through a compact, visually appealing and easy-to-navigate desktop application.

Users can customise the look and feel of many sections of the sandBAR resulting in a highly personalised user experience.

Internet Hosts Reach 100 Million

Communications software and solutions provider Telcordia Technologies at <www.telcordia.com> claims that the number of Internet hosts has reached 100 million and has grown by 45% in the past year.

Internet hosts include network elements such as routers, Web servers, mail servers, workstations in universities and businesses, and ports in modem banks of Internet Service Providers (ISPs). The number of hosts is considered one of the most accurate measures of the size of the Internet.

The Telcordia Internet Sizer at <www.netsizer.com> is a Web-based tool that measures and forecasts a variety of Internet statistics, produces Internet host counts. New Internet statistics under exploration at Telcordia point to the possibility of relationships among Internet growth, electronic commerce and economic changes.

Even with such a high expansion rate, Internet growth may rapidly accelerate. Wireless access to the Internet has the potential to create a new surge of Internet growth, and future applications, which may require IP addresses even for home appliances, may also spur dramatic increases in rates of growth.

3 Million New Home Internet Users In 2000

There are now more than 11 million people using the Internet at home, according to Internet monitoring company NetValue at **<www.netvalue.com>**. Home Internet users now number 11,599,000, an increase of more than 3,000,000 users from December 1999, according to NetValue's latest results for December 2000.

The number of women online has increased by 1,288,000, to 4,656,000 users, making up 40% of the home Internet audience. Silver surfers (50+ users) have grown by more than 680,000 users to 2,235,000, with kids online (14 and under) now accounting for just under 600,000 users.

Internet activity has increased for all users over the last year. On average, users went online for 4.2 more sessions a month in December compared with at the same point last year. Silver surfers connected to the Internet for an average of 12.5 days, 1.6 days longer than in December 1999.

December saw traditional retailers enjoy huge success on the Web - visitors to **<argos.co.uk>** reached 694,790, or 6% of the home Internet population. Of the most visited general retail sites in December, six out of ten were high street retailers.

Argos was the most visited general retailing Web site, followed closely by **<comet.co.uk>** with 5.4% reach and **<tesco.com>** with 4.8%. **<next.co.uk>** entered NetValue rankings for the first time with over 150,000 users, or 1.3% of all UK home Internet users.

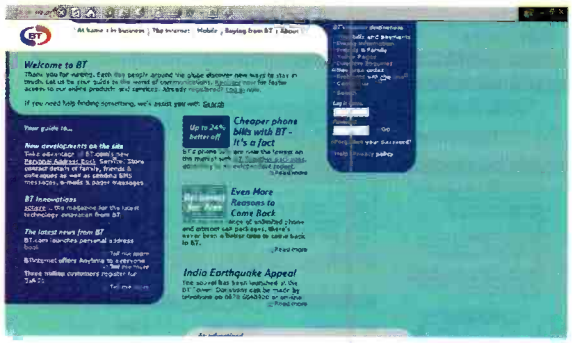
Letsbuyit.com at **<www.letsbuyit.com>**, who last month filed for bankruptcy, was the sixth most visited general retail Web site in December, with 442,650 unique visitors. Letsbuyit.com's audience was down from 467,530 users in November but up from 239,000 users in October.

High street retailers who operate an etailing arm will be relieved to see that their online strategy seems to be paying off, perhaps indicating that consumers have more confidence in established off-line brands. In the last 12 months, visitors to **<argos.co.uk>** have increased by more than 400,000, with visitors to **<comet.co.uk>** increasing almost four times over the same period.

Strong sales for mobile phones pre-Christmas was underlined by the growth in the number of visitors to telecoms Web sites. 34.3% of users, or 3,980,000 visitors, went to a telecoms Web site in December, up by almost 1 million since November.

BT at **<www.bt.co.uk>** was the most visited site, with **<boltblue.com>** in second position. Nokia.com at **<www.nokia.com>** attracted 4% of users, 2.8% visited **<orange.co.uk>**, 2.7% visited **<vodafone.co.uk>**, and 1.7% visited **<carphonewarehouse.com>**

BT.com Asks Jeeves to Help Customers

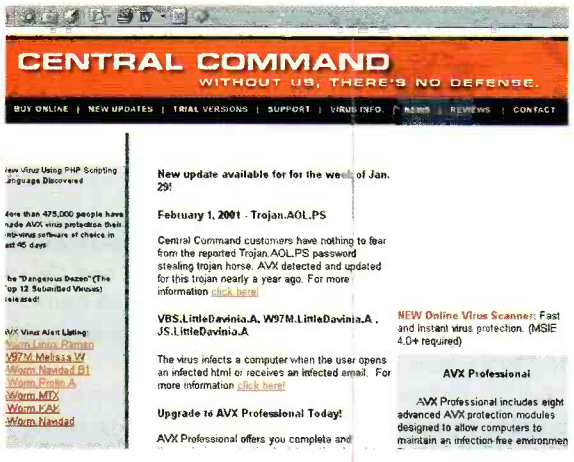


Jeeves Answers, the intuitive question and answering service from Ask Jeeves, is now available on BT.com at **<www.bt.com>**, to support the thousands of visitors interacting online with BT every day.

BT has worked with Ask Jeeves to provide visitors to BT.com with a more human interface where they can ask questions using everyday language and receive back accurate, relevant answers, regardless of their level of Internet experience.

Visitors can now ask questions such as 'What is BT Together?', 'What can SurfTime do for me?' or 'What is the best way to pay my bill?'.

Central Command Discovers New Virus Strain



Central Command at **<www.avx.com>** has announced the discovery of PHP.NewWorld, the first virus using the Hypertext Preprocessor (PHP) scripting language to infect computer systems.

PHP.NewWorld is spread to a system when executing an infected script.

PHP is one of the most popular scripting languages used in the development of e-commerce and heavy content Web sites. It gained its popularity thanks to its user-friendly programming features, and the incorporation of cross platform compatibility between Windows, Linux, and UNIX environment features included within the language.

DigitalCandle Seeks Out Developers

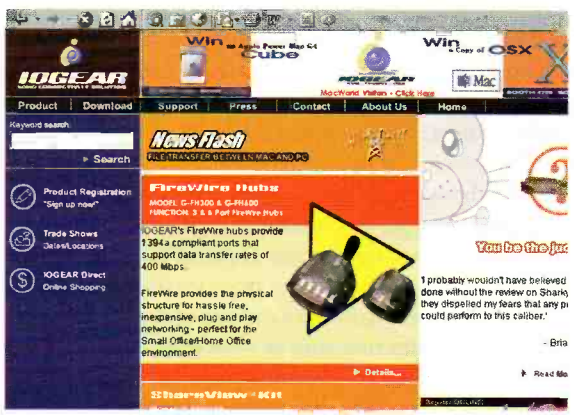
Have you got a knack for writing software? DigitalCandle, a shareware software site, is looking for a few good developers to add to its collection of innovative shareware applications available at **<www.digitalcandle.com>**.

Developers that sign up with DigitalCandle now through April 2, 2001, will receive all of the benefits of DigitalCandle's payment processing and marketing services for 10% of sales.

Whether developing software for a hobby or wanting to increases one's cash flow, opportunities exist to profit from innovative shareware products.

However, knowing how to write code does not guarantee knowing where or how to market, distribute or sell the resulting product - not to mention how difficult and time-consuming the process can be. Enter DigitalCandle with a solution to meet the needs of independent software developers.

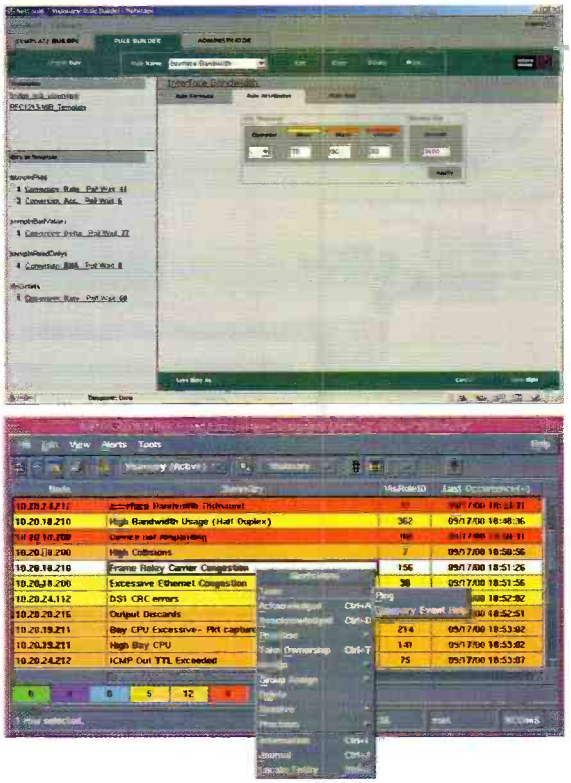
Turn One Computer into Two



Iogear at <www.iogear.com> has released ShareView Version 2.8; a hardware and software package that turns one Windows 98 machine into two independent workstations.

Two people can access Microsoft Word or Excel, or surf the Web simultaneously using one Internet connection. It is also possible to share a printer, scanner, or any other peripherals attached to the computer.

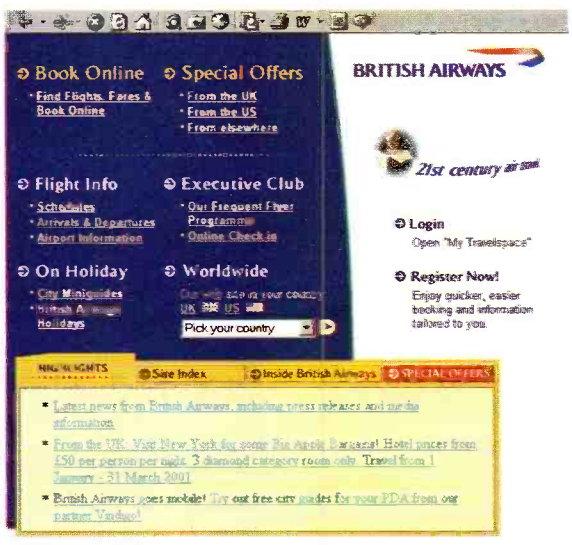
Micromuse Introduces Netcool/Visionary



Micromuse has announced Netcool/Visionary Version 2.0 software, the newest release of its network problem diagnosis application. The Netcool/Visionary v2.0 product includes enhanced performance, support for new technologies and the ability for users to add their own models and rules.

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

WAP Away Queues



British Airways at **<www.britishairways.com>** is the first UK airline to introduce a facility which allows frequent flyers to use their WAP phones to check-in for flights out of the UK. They are the first airline in the world to enable passengers to select their seat via a graphical seat map on their handset.

In addition, any WAP phone user will be able to look up flight availability and view up-to-the-minute flight arrivals and departures information for any British Airways flight.

Subscribers to the service will be able to check-in using the pictorial seat selection tool on the WAP phone, arrive at the airport, collect their boarding pass from a self-service kiosk in a matter of seconds, leave their luggage at the fast bag drop and go straight to the boarding gate.

3G Project for Deaf Launches

January saw the start of the world's first 3G (Third Generation) project for the deaf - WISDOM (Wireless Information Services for Deaf People on the Move). In the three-year, £3.6 million project, deaf people will for the first time, have an opportunity to help shape the next generation of mobile telecommunications, to make it an inclusive and all-encompassing technology.

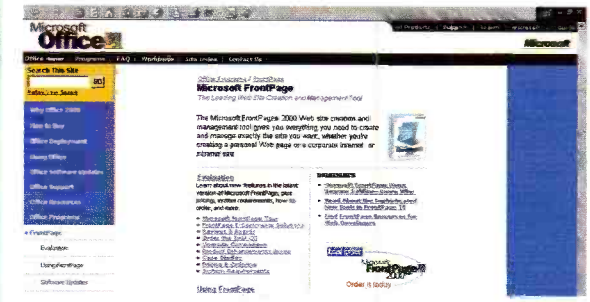
Funded and sponsored by the European Commission Directorate-General Information Society, WISDOM brings together ten key partners from the mobile communications industry, research and deaf organisations, to investigate the problems deaf people encounter with mobile communications and develop practical visual communications services over 3G networks.

The WISDOM partners Vodafone UK Limited, Ericsson España Research Department (EEM), Motion Media, research centres in the University of Bristol and Aachen University of Technology (Germany), Omnitor and Envilogg (Sweden), the Örebrö Tolkcentralen Interpreters Centre and deaf organisations in Sweden (Vaestanvik Resours). The UK (British Deaf Association), will focus on providing terminals, applications and services for deaf people on the move.

Specific emphasis will be placed on providing video sign language information to deaf people anywhere, anytime and sign language relay as well as remote interpretation services so that deaf people can communicate with hearing people and vice versa.

For further details, check: **<www.vodafone.co.uk>**.

Microsoft FrontPage Surpasses 5 Million Users



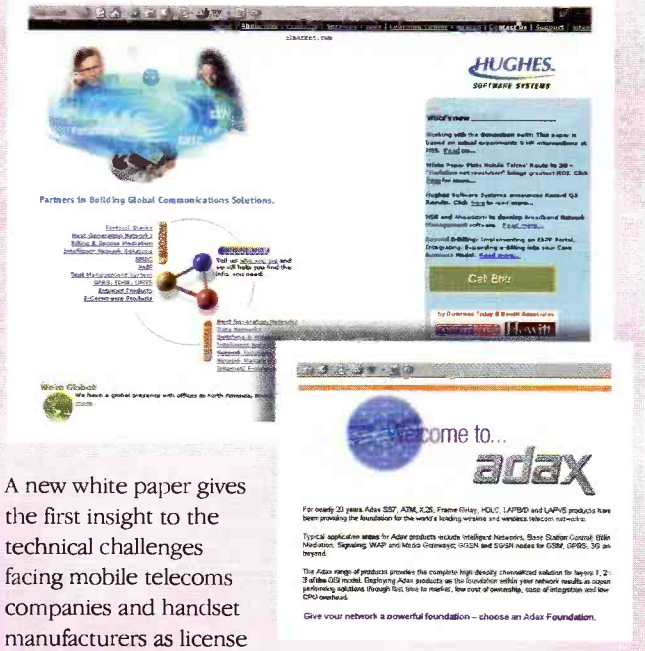
Microsoft claims that the installed base for its FrontPage Web site creation and management tool at **<www.microsoft.com/frontpage>** has soared to more than 5 million users - more than a 40% increase since October 1999.

Strong support from both Internet service providers and independent software vendors has helped establish FrontPage as the leading Web site creation and management tool for both novices and experienced Web-site developers.

Since Microsoft's acquisition of FrontPage from Vermeer Technologies in 1995, the tool has received numerous awards, including the 15th annual Computer Shopper's Choice award and PC Magazine's Editors' Choice award.

Business users, consumers and Web professionals continue to use FrontPage 2000 in new and innovative ways for creating professional Internet and intranet sites faster and more easily. Its ease of use and seamless integration with Microsoft Office applications make a good choice for creating small and large business Web sites.

White Paper Plots Route to 3G



A new white paper gives the first insight to the technical challenges facing mobile telecoms companies and handset manufacturers as license holders struggle toward 3rd Generation (3G) mobile phone services.

"GSM to 3G: Evolution or Revolution?" takes a pragmatic look at the technologies and standards proposed by the industry, plotting the best route through the maze. Adax and Hughes Software Systems jointly authored the paper.

For further details and a copy of the paper, check: **<www.adax.co.uk>** or **<www.hssworld.com>**.

Site Survey

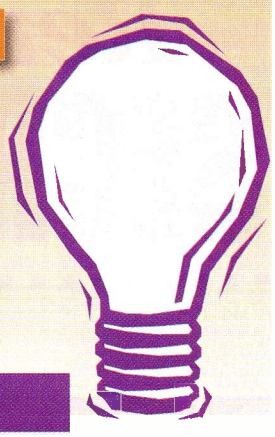
Destinations of the month

Cooking is a doddle if you've got the recipes and the right ingredients. However, creating something that's simple to make, yet wholesome, nutritious and fast isn't always that easy. If you're looking for recipes that are out-of-the-ordinary, yet don't take forever to prepare, try Campbell's Kitchen, at: **<http://www.campbellkitchen.com>**. All the recipes are based around Campbell's range of soup products, so ingredients can be picked up from your local shop. That's not to say the recipes are bland, however, as some of the concoctions are positively exotic. You can sign up to receive new recipes by email, as they appear, and you can send in your own recipes for inclusion.

A great site for young and old kids is Fun School, at: **<http://www.funschool.com>**. There are lots of educational games, aimed mainly at pre-school and kindergarten age groups, although older children are catered for too. You can learn to type, write and read in a fun way, download pictures to print and colour and improve memory skills and much more beside. Despite it being a US-based Web site, there is much material here relevant to the UK. Children will have so much fun they won't even realise they are working°

Finally, one for the men this. If you're err° well hung then you might be aware that it's a tremendous drawback. For example, some 1.5% of home accidents are caused by men in your condition. Checkout: **<http://www.lpsg.com>** if you're in this category (or not, if you just want to browse). Funny thing is, we think the Web site is being serious, although it's tremendously hard to keep a straight face when you read the information it holds.

COMMENT



by KEITH BRINDLEY

As I write this month's column, an appellate court in the US is about to rule whether the Napster music swapping service can continue to allow its users to download music files freely. Currently, users merely need to log on to a Napster Internet server using the freely available client software, searching for particular music tracks of their choice, then download the tracks directly to their computers for playing, copying, recording onto tape, or writing to CD. The system works because there are thousands of users all logged on to Napster servers at the same time, all with tracks available for others to download. In effect, Napster simply provides the means whereby users can swap their tracks with other users. No tracks are actually stored on Napster's servers, instead they are all stored as MP3 format files on users computer hard drives. All that users need to do to play these MP3 files is to have an MP3 player on their computer along with the files. As all modern personal computers have a basic MP3 player built in to the operating system, this is a simple thing to achieve. At the time I write this there are some 3000 users online, with a total number of 600,000 music tracks. I'm informed that, at other times, particularly evening and weekends (when there are more US users online), over 1.5 million tracks are available for download through the Napster service.

Now obviously, the large record companies — including Sony (and there's a reason for highlighting Sony, which I'll come to soon) don't like the idea of users being able to swap music. Copyright protection implies that music remains the property of the original writer of the music, and that purchasers of CDs merely buy the facility to listen to the music on a personal basis. So, as far as the record companies are concerned, music swapping is illegal.

Napster, on the other hand, contends that it is not illegal to allow your friends to hear music from a CD that you buy, and that the difference is simply that each Napster user has thousands of 'friends', so exchanging music this way is not illegal. Napster points to a precedent too, where the US television companies asked for a court ruling that recording of live television programmes should be made illegal. In that event, the court threw out the request, finding in favour of — would you believe it? — Sony (who wished to ensure that sales of its videocassette recorders continued).

The Sony boot is on the other foot now, as you might expect, As the corporates see the possibility of reduced profits due to music swapping. The decision from the US 9th Circuit Court of Appeals is quite simple — whether to uphold a federal court's July 2000 injunction that orders Napster to shut down pending that actual trial against Napster. Previously, Napster had appealed against the federal court decision and won a temporary stay against the injunction.

The problem for the music corporates however is not just Napster. In effect, if the US court rules in favour of the corporates (which may already have occurred by the time you read this) then Napster could be no longer in operation. No, the problem for the music corporates is that there are already other systems that will take over where Napster leaves off. The situation has been likened to a fairground shooting stall, where you attempt to fire at ducks. As you hit one duck, the next pops up. You hit the next, and the one after that pops up. Technically, the corporates simply cannot win.

Already there are three systems that can take up the Napster helm: Gnutella, Freenet, and Hotline. We'll go through these one by one. Gnutella is a distributed system, in that it does not use servers as such, instead each user becomes a server with the result that there is no central company (like Napster) that can be taken to court. Freenet offers a similar situation, except that not only are users distributed, but the actual files they share with other users are distributed. In other words, particular files that users download come from many other users around the network, and so individual users cannot be identified as having shared their files. The other main difference from Napster is that both Gnutella and Freenet can be used for files other than music files: pictures, movies, and even complete programs can be swapped this way.

The last system, and the one I want to highlight here, is Hotline. Like Gnutella and Freenet, Hotline can be used for any digital data files — music, pictures, and programs. Indeed there are several sites on the Hotline network that offer the ability to upload and download complete commercial applications, and even whole videos of movies.

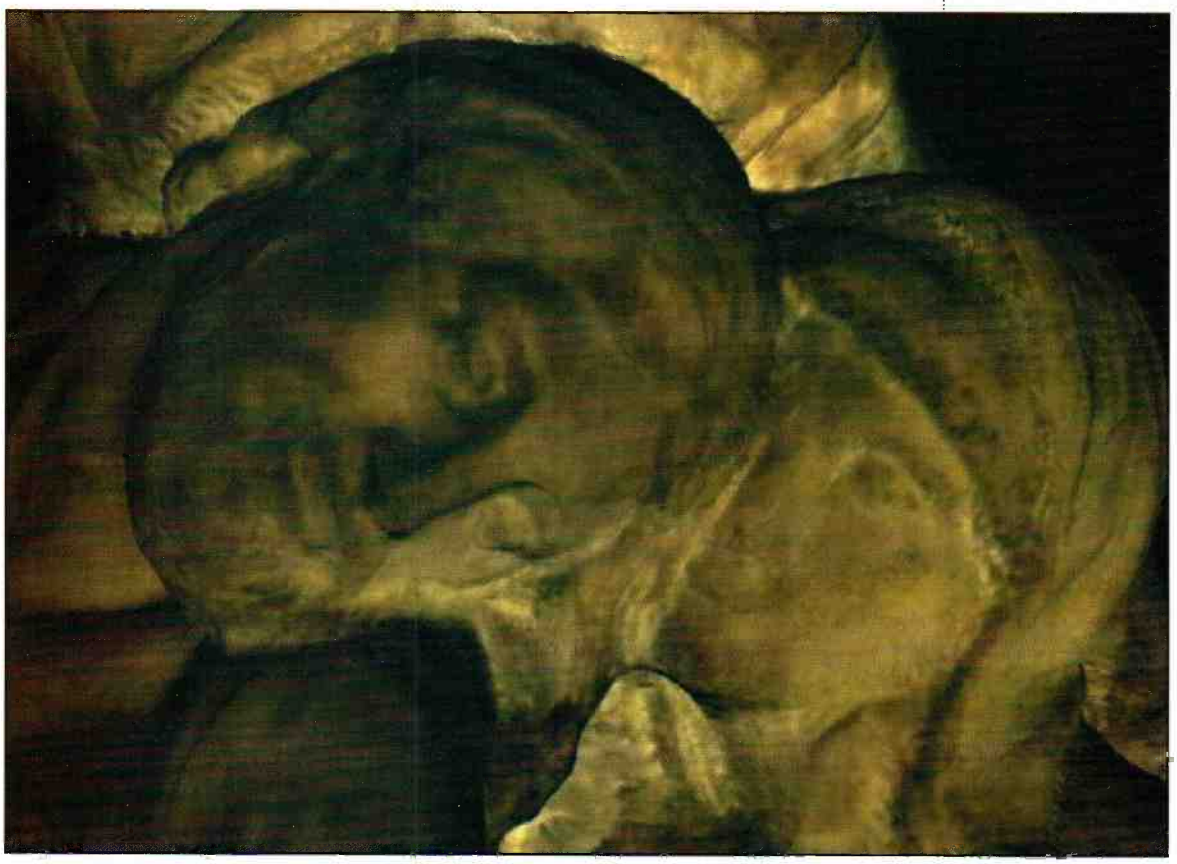
To use Hotline, like with the other swapping utilities, you need a client piece of software. This is available from the Hotline HQ Website, at: **<http://www.bigredh.com>.** Just follow the Download Hotline link on the home page — there are versions of both the client and the server programs for both Macintosh and Windows based personal computers. Once downloaded and installed, the client allows you to log on to the Hotline network, then upload files to, and download files from any of the servers on the system. Some servers are set so that casual users (guests) can't download, and an account is needed. Some are set so that guests need to upload files before they can download.

Searching for particular files you want is reasonable easy, several Web-based search engines allow you to enter a file or program name and search all the online servers via your Web browser. HotlineHQ is one such search engine, at: **<http://www.hotlinehq.com/search.html>.** Once you've located a server with the file you want, you simply log on to it using the client and download. As the system is invariably busy, it's likely that your requested download will be put in a queue, and be downloaded as soon as a download slot becomes vacant — this will doubtless change as more and more servers come online.

In conclusion, however, it's not the fact that Hotline, or Gnutella, or Freenet allow free access to users, giving them the ability to download and use copyrighted material. It's not even the fact that it is arguably possible for the copyright owners to be able to close down such systems (actually, it is totally impossible in some of these cases). The point is that modern copyrighted information is digital. Once digitised (and the copyright owners themselves have resorted to digitisation for their own convenience), the information becomes unavoidably accessible freely. Nothing the copyright owners do will prevent that. If it's not Napster, if it's not Gnutella, Freenet or Hotline, it's another system.

Revealing the SECRETS IN ART

by Douglas Clarkson



Detail from digital statue Image.
Photo Courtesy IBM Research

In the world of the arts, in terms of preservation of artefacts it is both the best of times and the worst of times. In one sense it is the best of times since there is the availability of modern techniques of analysis and preservation of works of art. In another sense it is very much the worst of times on account of the great swathe of modern methods used for reproducing art which are often of suspect preservational value.

It is certainly fascinating to consider the range of modern tools which the contemporary art restorator/curator can use to help direct the preservation of works of art and in numerous circumstances try to resolve conflicts relating to fraud. It is also relevant to consider some of the problems that will be current in the future in terms of preservation of contemporary art.

Infra Red Image Analysis

One method of analysis relates to the use of infrared imaging in order to penetrate more deeply into the structures of paintings. Use can be made of TV camera systems with enhanced spectral range to detect in the infrared. Usually these systems, however, do not have the required spectral extent and a large picture can only be represented as a mosaic of relatively small field of view images. Standard CCD cameras, for example, register to just around 1.1 microns and do not provide enough spatial resolution.

Recently scanning systems using IR reflectography have been developed in Italy where a detector head with sensitivity in the range 1 to 1.7 microns is scanned mechanically across a relatively large surface area - producing in the process an image of sub surface structures such as charcoal sketches. This would be the initial artist's sketches for the completed work. The dynamic range of the device allows for around 4000 levels of grey scale to be detected. With interfacing to standard PC systems, high quality ink jet images can readily be produced for analysis.

They also provide very relevant information for the art historian where specific initial ideas at the sketch level can be observed to carry through to the final image. In instances of overpainting of original surfaces, such imaging can prove of exceptional value - even to the point of revealing hidden signatures of the original artist.

It can often be the case that degeneration of pigments and discolouration of surface varnish layers can suppress detail visible when a painting was initially painted. The method of infra red examination can therefore provide an indication of intended appearance.

In terms of determining forgeries, such a method can be used to determine the degree of underpainting used by an artist in the fluid stage of painting development. If such stages are poorly developed, this will tend to indicate a lack of originality in the particular work of art.

Neutron Activation

There has been a very large growth in the market for archaeological artefacts. Items which once would have been sought after exclusively by the world's museums are increasingly finding their way into private collections and accordingly, the market for fakes and illegal export items has also grown. It is a basic property of most archaeological items that they tend to be made of elements, which have 'finger print' characteristics.

The method of neutron activation provides an ideal method for measuring the element composition of artefacts and hence determines the true nature of their origin. Small samples from the artefact are exposed to a high neutron flux within a nuclear reactor. When a specific element absorbs a neutron without otherwise disturbing the nucleus, it transforms to an isotope of the original element that in most circumstances will radiate characteristic

gamma radiation. This in turn allows the relative concentrations of such elements to be determined. Accurate measurements can be made on a sample less than a millimetre in size. This reflects in part the improved sensitivity of gamma ray detectors.

Such a technique can be used, for example, to differentiate between 'modern' silver of relatively high purity and 'classical' silver with higher levels of lead. Within archaeology, the clay of pottery can be matched to specific locations of origin - allowing in the process the growth of cultures and associated commerce to be mapped out in some cases thousands of years after their pre-eminence.

Such testing has been used to identify the origin of copper in North American archaeological sites. It had been thought that this copper was traded over distances of thousands of miles from sources in Michigan's Upper Peninsula though the evidence of neutron activation indicates that additional sources included the Northern Appalachians.

The Conservational Analytical Laboratory in the USA which maintains links with the National Institute of Standards and Technology, processes in excess of 2000 samples for neutron activation each year.

X- Ray Analysis

One of the most widely known techniques of picture examination - that of X-rays can be used to detect earlier paint layers. While relatively energetic X-rays are required for conventional medical X-rays, such picture scanning uses typically X-rays of lower energy that will be more readily absorbed by the thin layer of canvas.

Where paint has been damaged or flaked off this is characterised by darker areas of film exposure. Tears and holes in the painting surface appear as much darker areas of rendition.

Some pictures, however, are literally X-ray proof. Van Eyck used a protective covering of white lead on the back of his paintings. This has in turn encouraged forgers to treat old canvas supports with adhesive white lead mixtures and pass works off as attributed to him.

The methods of painting used in the schools of the great masters, however, lend themselves to such X-ray investigation. The use of paint and associated materials with diverse chemical compositions allows differentiation between surface optical image and equivalent X-ray absorption image. For pictures produced by more modern techniques, however, using modern paint products, such differentiation is usually much less useful.

One of the more interesting instances of X-ray examination was that of the 'Blue Boy' portrait by Thomas Gainsborough in the late 18th century. X-ray examination of the image had initially been undertaken in 1939 to reveal it was originally used to start a portrait of an older man. Subsequent X-ray examination of the portrait revealed that a white shaggy dog had been removed from the lower right corner (http://www.s-t.com/daily/11-95/11-13-95/xrayart.htm).

The use of such a technique can highlight elements of picture development. Figures in the initial plan may be missing in the final image. The position of hands can change to improved effects of image focus. Complete pictures can be overpainted. This could, for example, indicate that a commission had fallen through and the image was unable to be sold.

The technique of X-ray fluorescence seeks to determine structural details indicated by re-emission of X-rays from initially incident X-rays. In general, both techniques can be considered to be non-destructive in their effect on the painting.

Reconstructed image from entire statue.
Photo Courtesy IBM Research

Microscopic Examination

Perhaps not an altogether new modern high tech method, microscopic examination of paint layers taken from very small samples of a picture can reveal a great deal about the history of a painting. A section of paint no bigger than a pinhead is typically abstracted from the painting and encapsulated by polyester resin. A thin slice through the encapsulated paint fragment is then produced in order to examine the individual paint layers.

The identification of series of layers of original canvas, chalk treatment, initial painting layers, over painting layers and possible multiple layers of varnish can prove invaluable when pictures are being restored. Such processes could involve the removal of varnish layers and specific overpainted layers.

The use of low vacuum scanning electron microscopy is also a useful tool in the determination of elements within paint fragments. X-ray spectra from the scanning bean can provide elemental analysis of paint composition.

The Pieta Project

Under the wing of IBM Research, a certain Dr Jack Wasserman of Temple University in the USA has been taking a great deal of interest in Michelangelo's Florentine Pieta. This was a very significant marble sculpture, which was very likely initially intended to be used in Michelangelo's tomb monument. Finding that existing photographic techniques provided an unsatisfactory method of both appreciating and 'preserving' the image, Dr Wasserman used state of the art computer scanning techniques to create an image archive that would assist in resolving many of the hidden agenda of the marble masterpiece.

Data was principally captured by a series of six black and white cameras that captured the image of a striped pattern

projected onto the statue by a flash unit. In addition, information about colour reflectance was obtained by using five additional colour images using a single colour camera but with the field of illumination lit in turn by a separate series of five lights. To assist in alignment of scan areas, an array of laser dots was projected on the statue to provide fixed landmarks. Each scan area was typically 20 by 20 cm in size.

Software has been developed which allows the user to select specific angles of view and direction of illumination light to observe the detail of the statue in a much more flexible way. Also, specific elements of the statue - such as the modifications made by Tuber Calcagni - can be removed to allow visualisation of the structure while it was totally attributed to Michaelangelo.

This indicates how modern technology can be used to considerable effect to allow artistic appreciation and art history study of such important items of sculpture.

The three dimensional scanning and surface colour determination of smaller objects can now be undertaken with the use of state of the art laser scanner devices.

Towards Permanence in Digital Printing

The goal of the great masters was to achieve permanence for their products. In terms of major commissions for the Church and wealthy patrons, a key element was to make this last as long as possible - certainly for many hundreds of years. Due to the care that was lavished in producing paints and pigments that would withstand the ravages of time, many paintings and frescoes of 500 years ago look today as fresh as the day they were painted.

While there has always been a keen interest within the art community in the preservation of contemporary art, the addition of many new producers of art using digital techniques while providing an expansion of artistic expression could also lead to future disappointment as works of the 20th century begin to deteriorate under light exposure early in the 21st century.

The problem relates to the rapid evolution of products in terms of digital colour printing in the context of paper preservation and ink/colour fastness. Where someone is producing a diagram of sales figures for a monthly meeting, there is little interest in preserving the information for 100 years. Where, however, this is a limited edition printing of a 9 layer Photoshop creation, then preservation does matter.

As basic elements of preservation, laser printout should be stored below 40 degrees and printed surfaces should be prevented from contact from PVC files in order to prevent softening of toner. More caution is probably required for ink jets. Some sets of 'permanent' ink jet ink for high quality art reproduction have been criticised as not providing sufficiently vivid colours - in particular red. With inkjet printing, it is the combination of the ink and the paper that determines the degree of colour fastness.

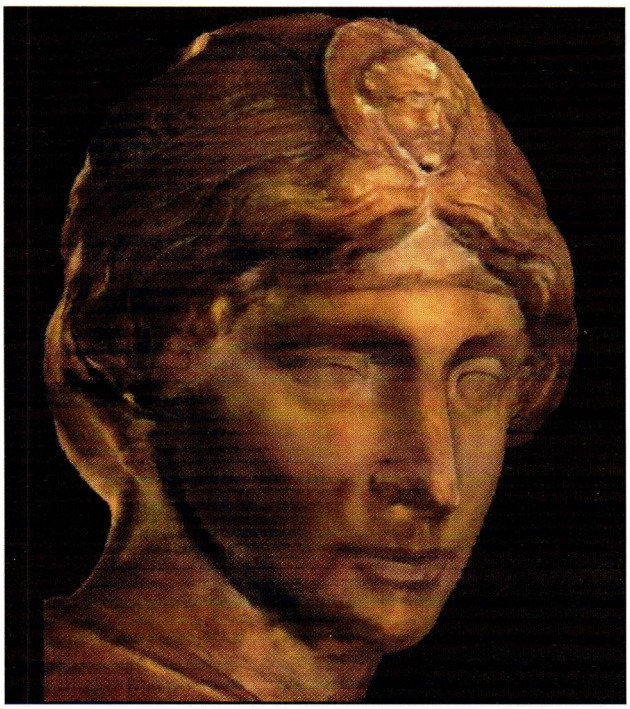
Most of the colour degradation takes place as a result of interaction with ultra violet light. It only, however, takes a small amount of organisation to conduct individual studies with respect to colour fastness with ink/paper combinations. Two representative samples can be printed - one is exposed to daylight containing elements of ultra violet while the other is kept in dark low temperature storage. At periodic intervals - say monthly, the condition of both images can be compared. Evidence of such colour fastness tests are likely to impress individuals considering the purchase of digitally produced images. Accelerated ageing can be also be initiated by use of high intensity lamps with simulated solar spectra. Such accelerated ageing would be a useful indication of long term preservation status with illumination under normal interior daylight conditions.

One of the difficulties of introducing more objective measurements to such exposure is to determine the effective 'action spectrum' of such UV radiation - i.e. to determine the relative effect as a function of wavelength.

Usually the glass in picture frames provides some absorption of ultra violet radiation and thicker glass will provide additional attenuation. Glass with very high UV block for picture conservation, however, remains very expensive.

Some digital artists are using high-end desktop printers - such as the Epson 3000 with non-Epson pigment sets such as Lysonic from the USA and DICO from Germany to achieve improved colourfastness.

A leading international expert on ink permanence is Henry Wilhelm who has provided details of his findings to the International Association of Fine Art Digital Printmakers. Some comments have been made, however, that permanence should not always be the prime consideration, especially when colour rendition of the most permanent ink may not be itself optimised.



Detail of head from digital reconstruction.
Courtesy IBM Research

The Big Virtual Gallery

We are all aware that galleries and museums are recording more and more of their works of art on the Internet. This trend is being closely monitored by many art historians, museum curators and art preservers to determine how significant such initiatives will be for finding a secure and safe refuge for many artefacts which in themselves have a finite lifetime. Surprisingly in respect of the printed word, there are severe problems. Paper made from wood pulp - particularly with an acidic content - will in time all turn to dust. Many books from 1850 onwards were printed on acidic paper and already are showing advanced signs of deterioration.

In Germany - the birthplace of the printed book - numerous regional initiatives are underway to try to introduce a degree of controlled preservation. More than anything these include training courses in the art of preservation of printed word. Significant projects in microfilming, de-acidifying of book volumes, etc are undergoing. The danger is, however, that at a global level, artistic and cultural heritage will be lost at different rates. There is particular risk of significant losses in the developing world, where there can be very much less in the way of state control of preservation of works of art. Political and social instability can also result in erosion of art preservation. It is only recently that the Hermitage Museum in St Petersburg in Russia opened its own preservation facility - courtesy of Coca-Cola.

Getting to the Fine Print

Almost as if to respond to the aspirations of the world's artistic community, IBM has recently demonstrated a mass production capability for colour 22 inch 200 pixels per

Surface image from visible light.
Photo Courtesy INOA Italy

Corresponding IR image showing detail of underpainting.
Photo Courtesy INOA Italy

inch (ppi) resolution. The typical resolution on 12 inch notebook screens is 82 ppi. With the product code-named Roentgen, there is probably already a waiting market for such technology in terms of displaying images within the broader art market. This will further enhance the value of on-line art/museum services either on secure services or on the Internet and provide another excuse to expand the RAM sizes of PCs to cope with such large image sizes.

Art Renovation Scandals

The field of art restoration is not without controversy. Competence in art restoration is very much close to national pride and can trigger uncomfortable reactions when unhelpful comments are made in one country about the art restoration in another. There is the long running saga of the Elgin marbles (or the Parthenon marbles for the Greeks). James Beck, professor of Art History at Columbia University was taken to numerous Italian courts for criticising the competence of Gianni Caponi in 'restoring' Della Quercia's head of Ilaria - one of the foremost jewels in the crown of Italian renaissance sculpture. James Beck had claimed that the sculpture had been treated with an epoxy resin compound and surface discolouration removed with high-pressure water jet and plastic spheres to produce a bleached, eroded surface. James Beck in his book 'Art Restoration' gives an account of his Italian adventures and good account of suspect science in art restoration - referencing also the current renovation of the Sistine Chapel in the Vatican.

Summary

As documents of the computer age pass now into national cultural archives, there is increasing interest and concern in their degree of permanence. We have already inherited a vast collection from ages prior to this and have developed extensive technologies to preserve this for future ages. Care really does need to be taken to ensure that the art and recorded heritage of today will have a future.

Points of Contact

www.s-t.com/daily/11-95/11-13-95/xrayart.htm

www.research.ibm.com/pieta_overview.htm

www.research.ibm.com/thinkresearch/pages/2000/20011_roentgen.shtml

www.knaw.nl/ecpa/publ/jurgens.html

www.harrypalmergallery.ab.ca/permanence.html

www.si.edu/scmre/94inaa.html

www.sciam.com/0896issue/0896revcom1.html

www.ino.it/%7Eluca/rifle/riflescanner_en.html

www.rc.net/standard/sacredheart/stat-exam.html

Further Reading

- False impressions: the hunt for big-time art fakes - Thomas Hoving, Simon and Schuster, 1996
- Art crime - John Conklin, Praeger, 1994
- Art restoration: the culture, the business and the scandal - James Beck and Michael Daley, John Murray, 1993.
- Art restoration - Francis Kelly, David & Charles, 1971
- 'An investigation into the archival properties of colour photocopies and inkjet prints - Summary of a project undertaken at Camberwell College of Art as part of a BA in Paper Conservation', Spring 1996, Anna Hillcoat-Imanishi, V&A Conservation Journal, January 1999, 30
- 'Conservation considerations with the acquisition of computer generated works of art on paper', H.Norville-Day and Shulla Jacques, from the IPC/Society of Archivist's Conference: Care of Photographic, Moving Image and Sound Collections, 1998, York, Abstracts

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.

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

2 April. Strategic Alliances for Clicks & Mortar, The Dorchester Hotel, London. Tel: (020) 7840 2700.

2 April. E-Commerce Applications, The Hatton, London. Tel: (020) 7827 6000.

2 April. e-commerce Expo, NEC, Birmingham. Tel: (020) 8449 1007.

3 April. m-business Expo, NEC, Birmingham. Tel: (020) 8 449 1007.

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.

4 April. Electronic B2B, The Hyatt Carlton Tower Hotel, London. Tel: (020) 7553 1000.

5 April. Mobile Location Based Services, Holiday Inn London – Victoria. Tel: (020) 7368 9300.

9 April. Convergence, Olympia National Hall, London. Tel: (01244) 881777.

9 April. SoHo Show, London Olympia National Hall. Tel: (01244) 881777.

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

10 April. Comms Dealer Expo, NEC, Birmingham. Tel: (01932) 779100.

24 April. Webcom 2001, Excel, London. Tel: (020) 8987 7745.

24 April. Customer Service and Support, Olympia 2, London. Tel: (01273) 836 800.

24 April. Infosecurity Europe, National Hall, Olympia, London. Tel: (020) 8449 1007.

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

25 April. Web-Enabled Collaborative, London. Tel: (020) 8879 3355.

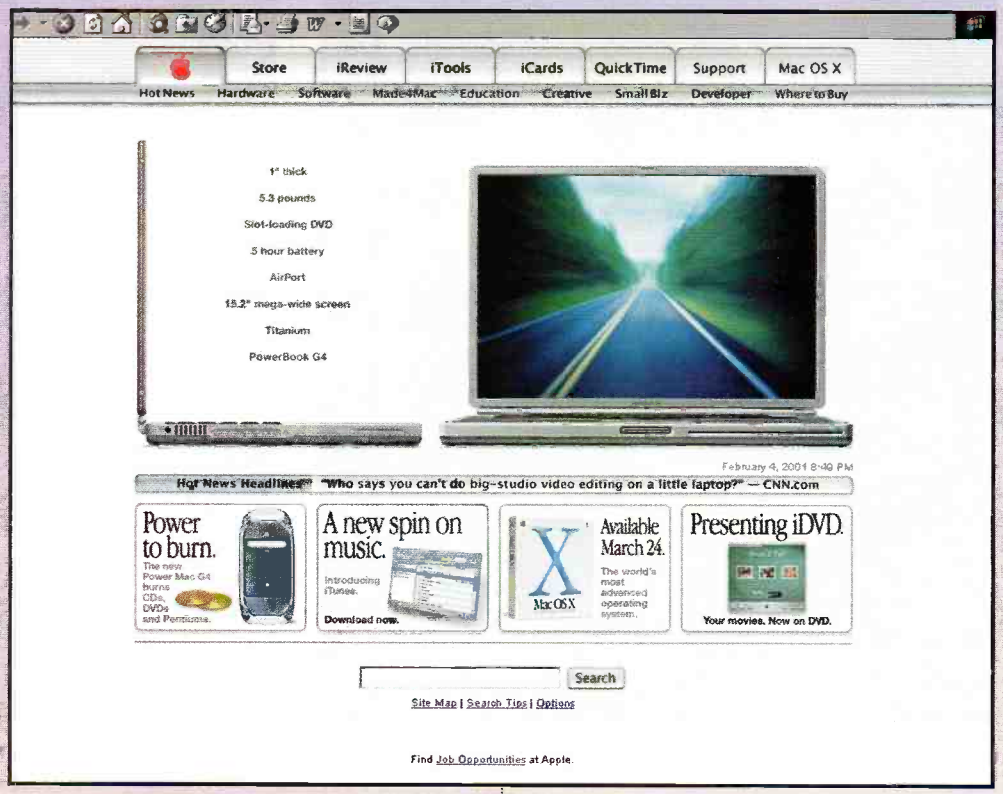
May 2001

11 May. SoHo Show Birmingham, Birmingham. Tel: (01244) 881777.

11 May. Small Office Home Office Show, Birmingham. Tel: (01244) 881777.

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

What's On?



Macworld Draws Record Crowd

Over 93,000 people attended the Macworld Conference & Expo in San Francisco in January, making it one of the largest gatherings of Mac fans ever.

In addition to the show's record attendance, more than a quarter of a million people tuned into the live QuickTime stream of the Macworld keynote delivered by Steve Jobs, Apple's chief executive.

During the keynote, Jobs unveiled the following new products:

- A new Titanium PowerBook G4.
- A Power Mac G4 line featuring the revolutionary combination CD-RW/DVD-R SuperDrive for reading and writing both CDs and DVDs.
- iTunes, the world's best and easiest to use jukebox software.
- iDVD, an application that lets consumers quickly and easily creates professional looking DVDs.
- DVD Studio Pro, a DVD authoring tool.

The keynote was streamed over Apple's QuickTime TV network, which delivers broadcast quality and high levels of reliability and includes Apple's QuickTime 4 player.

The QuickTime 4 player for Macintosh and Windows users is available free at <www.apple.com/quicktime>.

Wakefield to Host Acorn RISC OS Show

For the sixth time members of the Wakefield Acorn Computer Group are organising their Acorn/RISC OS Show on the weekend of 19 and 20 May. Once again the venue will be the Thornes Park Athletics Stadium, Horbury Road, Wakefield.

At 10:00hrs on Saturday the show will declared open by The Mayor of Wakefield and will remain open until 17:00rpm. On Sunday

the show will be open from 10:00hrs until 16:00hrs.

Advance tickets, which allow entry to the show on both days without extra cost, can now be booked at discount rates and post-free.

Adult tickets cost £2.50 which rate also covers OAPs and RISC OS Foundation members. Juniors aged between 6 and 16 years pay £1.50, whilst Children under 6 are admitted free.

On the door prices are £4.00 for Adults and £2.50 for Foundation, OAPs and Juniors aged between 6 and 16. All tickets are valid on both days.

For further details check: **<www.wacg.org.uk/show>.**

Intel's Barrett Charts Course for Extended PC Era

As the opening speaker at the 2001 Consumer Electronics Show, Intel President and CEO Craig Barrett introduced the Extended PC Era, setting the stage for a future in which more consumer products go digital and interconnect with powerful home PCs.

"The PC is at the centre of the digital universe and the universe is expanding," Barrett said, adding that in the near future one billion PCs will be connected to the Internet.

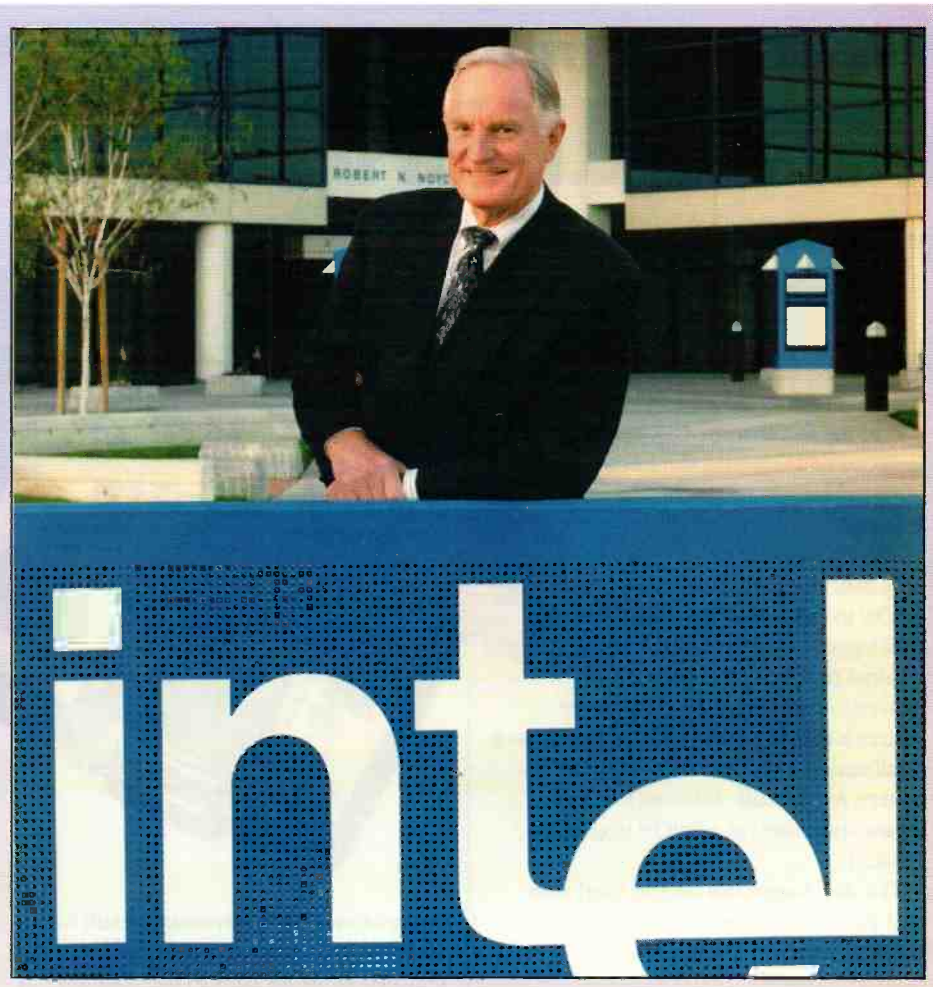
"In the Extended PC Era, the combination of powerful and versatile Intel Pentium 4 processor-based PCs and a vast array of digital products will help consumers use their home PCs and the Internet in new, exciting ways. This emerging consumer scenario is what we call PCX - the PC to the power of X."

To illustrate how consumers can fully realise the benefits of the Extended PC, Barrett showcased demonstrations on Intel Pentium 4 processor-based PCs.

Using digital cameras, toys, camcorders, books, personal audio products and PDAs, he displayed how mainstream digital gadgets deliver their full value when linked to a powerful PC.

Barrett also demonstrated how the power of the Pentium 4 processor can save time for consumers who enjoy ripping music tracks, processing images, editing their own home digital movies, and interacting with 3D environments.

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

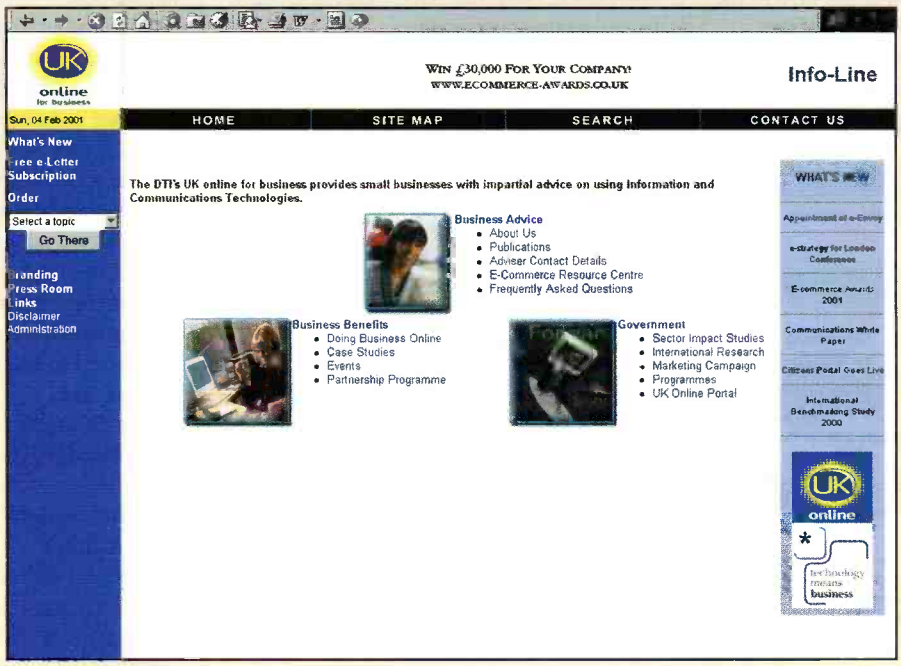


Search is on for E-Commerce Champion

E-Minister Patricia Hewitt has launched the new 'UK Online for Business' and 'InterForum' E-Commerce Awards for small and medium sized firms (SME's).

The annual awards, which are sponsored by the Royal Banks of Scotland and Cisco Systems, and supported by the Daily Express, recognise and reward excellence in the use of electronic business amongst SME's. The awards are open to any UK-based company and the closing date for entries is 18 May 2001.

The winner will be selected following 11 regional heats across England, Wales, and Northern Ireland. Scottish companies have their first heat via the 'Winners at the Web' Awards **<www.wow.org.uk>**.



The national final will be held at the Grosvenor Hotel, Park Lane, London, in July. All dates, times and location details will be announced on the Web site at **<www.ecommerce-awards.co.uk>** once they are confirmed.

The overall winner will receive £30,000 and each of the regional heat winners will be awarded £5,000 with regional runners up prizes of £2,000 and £1,000. For the first time this year, companies can be nominated by their employees, business partners, customers, or even friends and family.

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

Catching Analogue data into
PSION PALMTOPS AND PCs

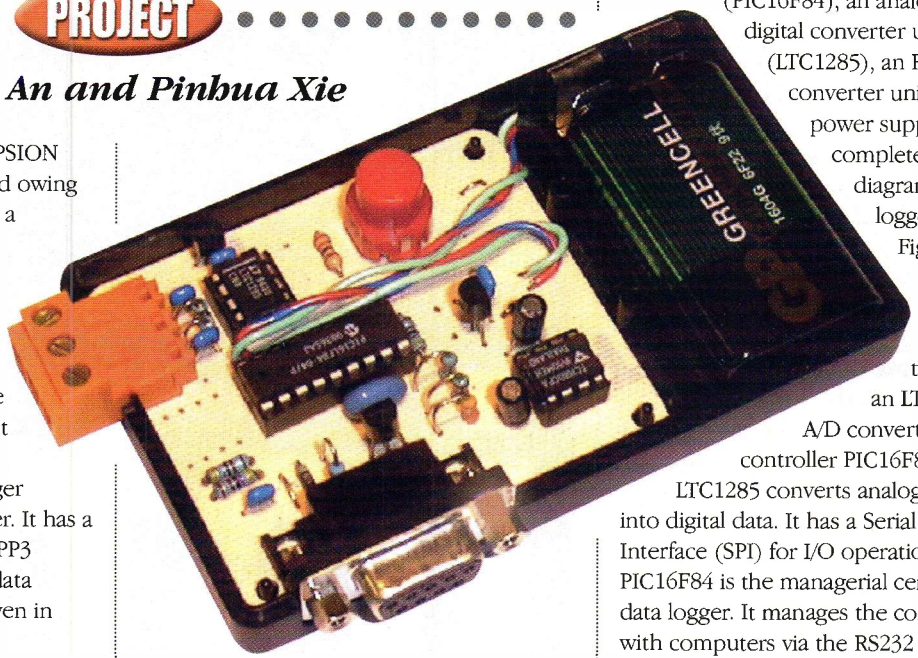
PROJECT

By Pei An and Pinhua Xie

It is very easy to interface the PSION palmtops to the external world owing to the fact that the PSION has a standard RS232 port and it has a powerful built-in programming language.

This article describes a serial port data logger that allows a PSION to catch analogue data. The data logger has one analogue input channel (0-2.5V with a 12-bit A/D conversion accuracy. The data logger utilizes a PIC16F84 micro-controller. It has a small size and is powered by a 9V PP3 battery. A schematic showing the data logger connected to a PSION is given in Figure 1.

The data logger can be also used with IBM PCs or other palm-top organisers having a standard RS232 port.



Operations of the data logger

The data logger is connected to the RS232 port of a host computer via a serial cable. After the data logger is powered on or reset, it enters a waiting state during which it waits for the computer to issue a command byte (=15h).

After the computer sends the byte to the data logger through the TX line of the RS232 port, the logger accepts the command and carries out an A/D conversion. After a conversion result is available, the logger transmits the conversion results back to the computer in two byte transmissions via RX line of the RS232 port. The first byte is the upper 4 bits of the conversion result and the second byte is the lower 8 bits. After the two bytes are transmitted, the data logger flashes its LED once to indicate that a conversion and data transfer cycle is completed. Next, the data logger goes back to the waiting state again.

The RS232 data format is as follows: 9600 Baud rate, 8 data bits, 1 stop bit and no parity check bit.

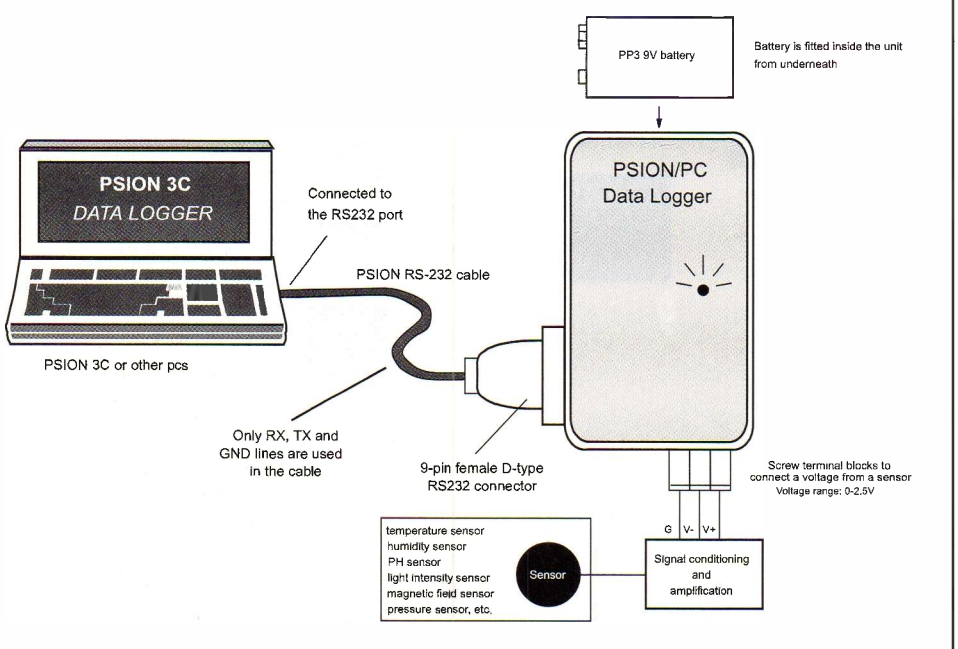


Figure 1. PIC based Psion/PC single channel data logger system

Hardware of the logger

The block diagram of the data logger is given in Figure 2. The system contains 4 units. They are a central control unit (PIC16F84), an analogue to digital converter unit (LTC1285), an RS232/TTL converter unit and a power supply unit. The complete circuit diagram of the data logger is given in Figure 3. The system utilises only two key ICs: an LTC1285CN8 A/D converter and a PIC controller PIC16F84. The LTC1285 converts analogue signals into digital data. It has a Serial Peripheral Interface (SPI) for I/O operations. The PIC16F84 is the managerial centre of the data logger. It manages the communication with computers via the RS232 port and it controls the operation of the A/D converter.

PIC16F84

The central control unit is based on a Microchip PIC16F84 peripheral interface controller. The 16F84 has an EEPROM memory (electrically erasable memory) to store the program. This makes it particularly useful for system development. This is the reason why it is adopted for this application.

The pin-out, the internal block diagram and the organization of file registers of the PIC16F84 is shown in Figure 4. Pin 14 and pin 5 are connected to the positive and negative rails of a power supply. The supply voltage range is 2 to 6 Volts. The power supply current is typically 2mA at 5V and 4 MHz clock frequency. This drops to several tens of mA when the IC is in standby mode. Pin 4 is the master clear. It must be high in normal operation. Pin 15 and 16 are connected to a crystal or ceramic resonator up to 4MHz.

The PIC16F84 contains the following main functional units:

- an 1kbyte 14-bit wide EEPROM to store instructions
- a 64 8-bit wide EEPROM to store data
- 15 (8-bit) special function hardware file registers (RTCC, OPTION, PCL, STATUS, FSR, PORTA, PORTB, TRISA, TRISB, EEDATA, EECON1, EEADR, EECON2, PCLATH, INTCON)
- 36 (8-bit) general purpose file registers (0C to 2F)
- an 8-bit accumulator, w

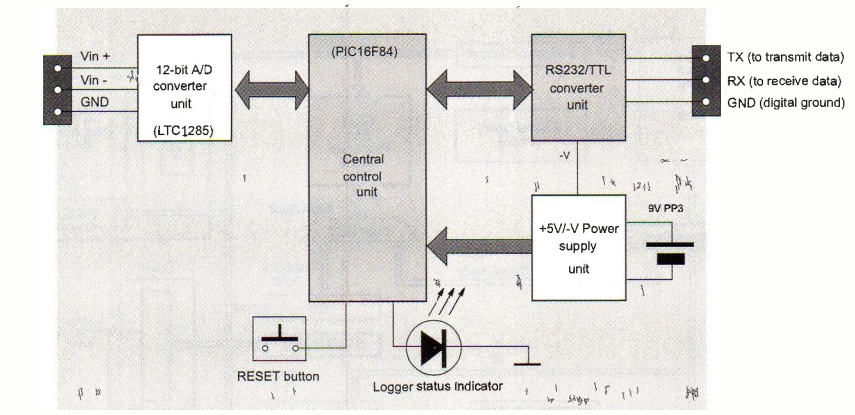


Figure 2. Block diagram of the data logger for Psion/PC computers

For PIC programming, there are only 35 single word instructions (assembly language), which makes the programming easy to learn. For more details of the hardware and the instruction set of the PIC16F84, please refer to the manufacture's data sheet (Reference 1).

For programmers who are very familiar with Basic or C language, Basic-like or C-like programming languages for the PIC can be used. With these high-level languages, many functions are built into the language. Also the compiler itself performs many low-level tasks like allocating memory spaces.

In the present circuit, the PIC works in the crystal oscillator mode. A 4MHz ceramic resonator is used (see Figure 3). I/O lines of the PIC16F84 are used as shown in Table 1.

- Port A (5 lines). Each line can be set as an input or output. RA4 is used also by timer/counter module. If configured as outputs, they sink 25mA and source 20mA
- Port B (8 lines). RB0 is also used as an interrupt input. If configured as outputs, they sink 25mA and source 20mA
- Four interrupt sources: External INT pin, RTCC timer overflow, PB4 to PB7 change status and data EEPROM write complete.
- 8-bit real time clock/counter with 8-bit programmable pre-scaler
- a watchdog timer

Table 1.

Port A

RA0 (pin 17)	serial data output from the PIC (connected to RX of the RS232 port)
RA1 (pin 18)	serial data input to the PIC (connected to TX of the RS232 port)
RA2 (pin 1)	RA3 (pin 2) and RA4 (pin 3): not used

Port B

RB0 (pin 6)	and RB1 (pin 7): not used
RB2 (pin 8)	control of the logger status LED (output)
RB5 (pin 11)	serial data output (Dout) from the LTC1285 (input)
RB6 (pin 12)	serial clock (CLK) of the LTC1285 (output)
RB7 (pin 13)	enable (-CS) of the LTC1285 (output)

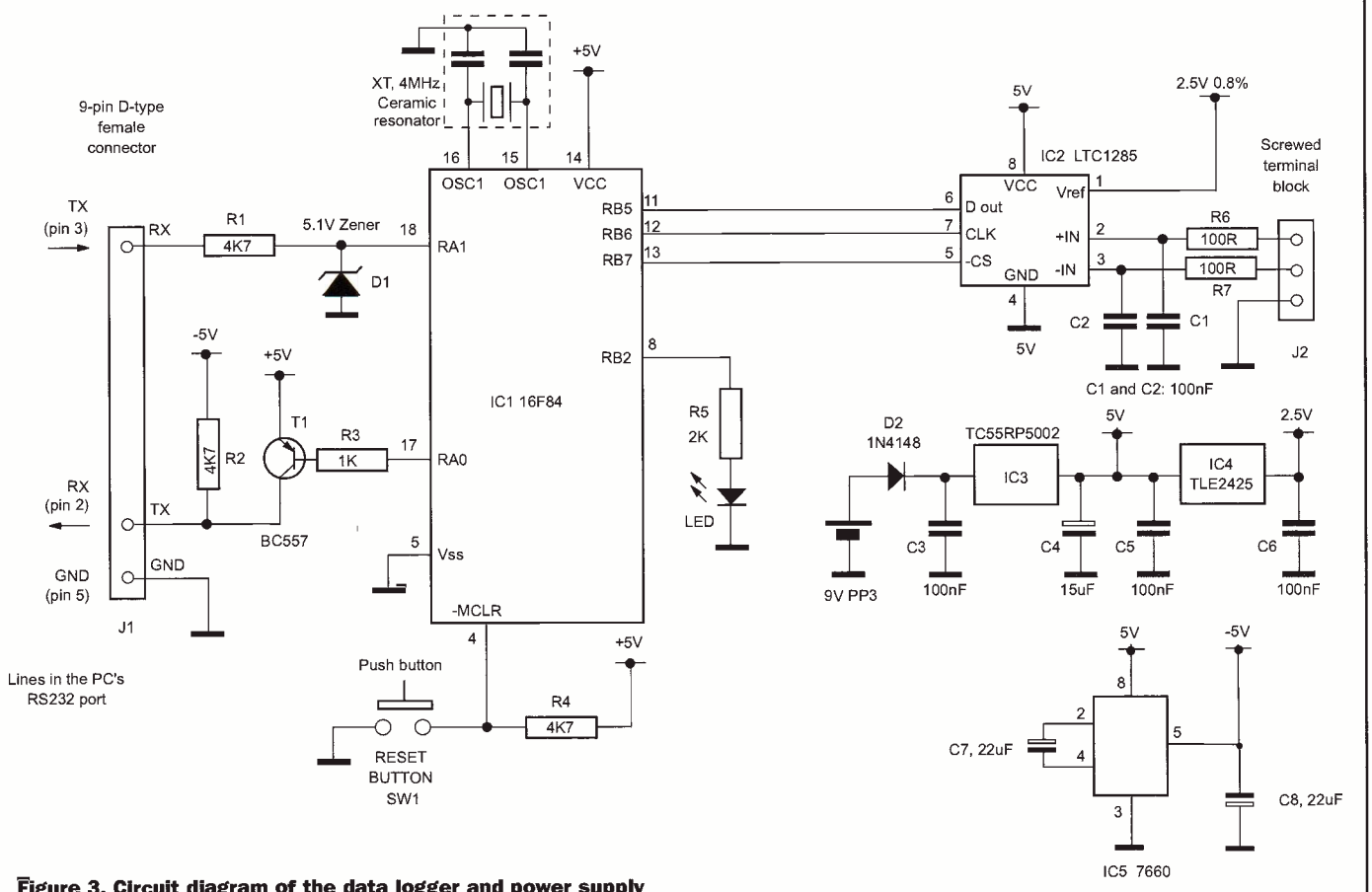


Figure 3. Circuit diagram of the data logger and power supply

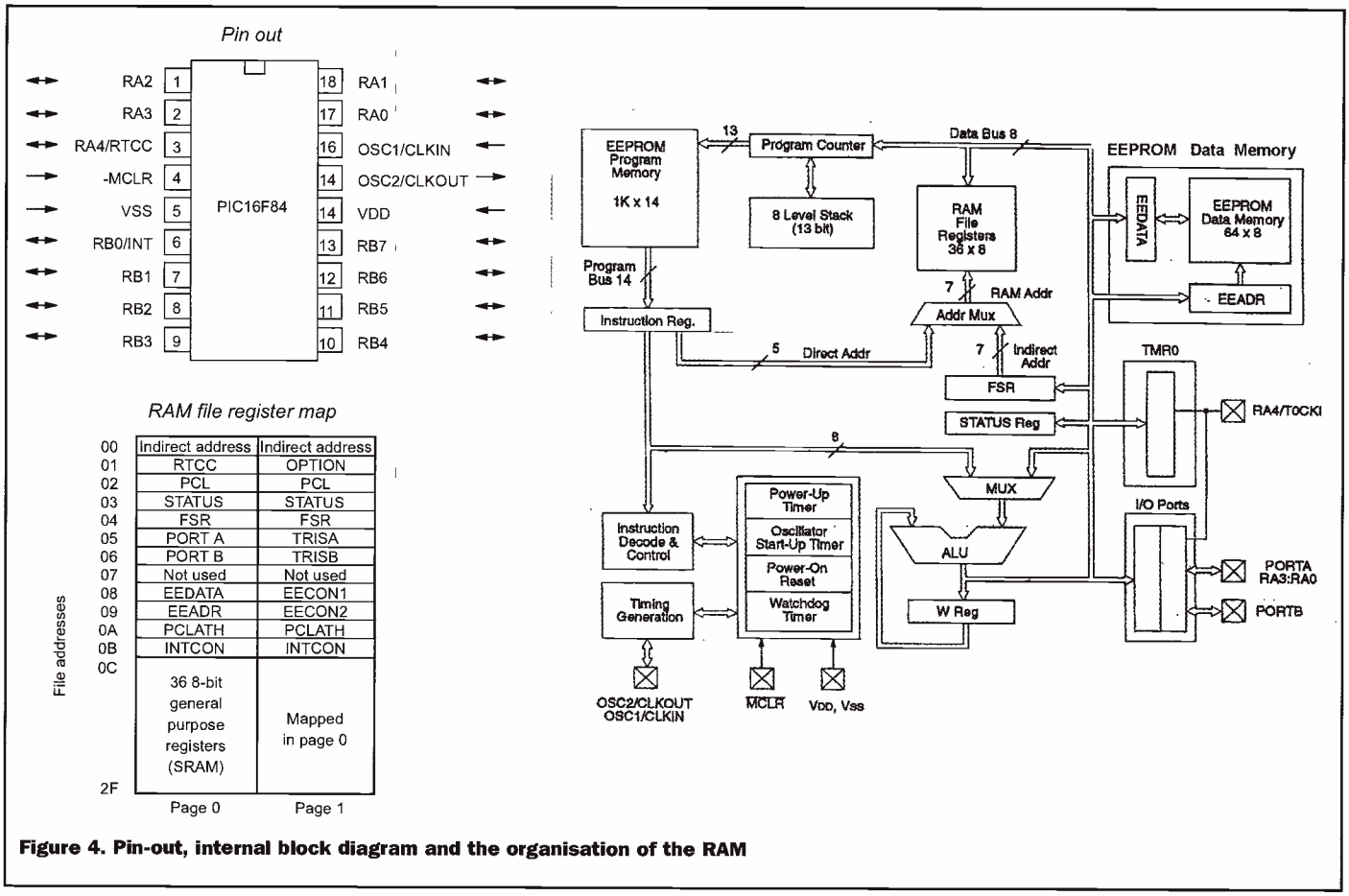


Figure 4. Pin-out, internal block diagram and the organisation of the RAM

Analogue to digital converter unit (LTC1285CN8)

The analogue to digital converter unit utilises an LTC1285CN8 12-bit successive approximation A/D converter. The pin-out and internal block diagram of the IC is shown in Figure 5. It requires a power supply 2.7V to 6V. Pin 8 and pin 4 are connected to the positive and negative rail of the power supply. Pin 4 is the reference voltage input. The typical supply current to the chip is 260mA at a sampling rate 6.6kHz with a power supply of 2.7V. When it is in standby mode, the supply current drops to several nanoamps. The LTC1285 has a differential analogue input (pin 2 and pin 3) and the analogue input leakage current is typically 1mA. For more details of the chip, please refer to the manufacture's data sheet (Reference 2).

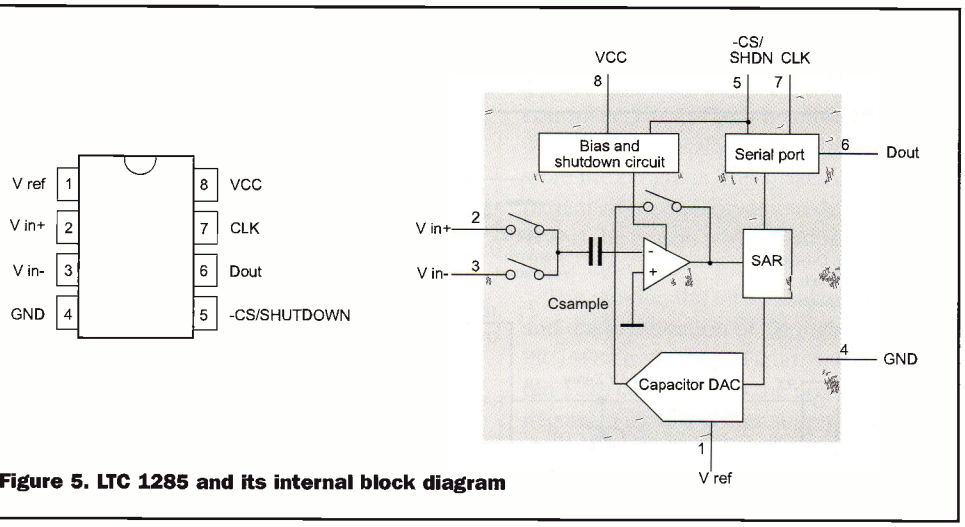


Figure 5. LTC 1285 and its internal block diagram

The LTC1285 communicates with other circuitry through a 3-wire SPI serial interface. These three wires are -CS/SHDN, CLK and Dout. -CS/SHDN (pin 1) low selects the chip and initiates data transfer. If the pin is at a high state, the converter is in the standby mode. CLK (pin 7) is the clock input. It synchronises the serial data transfer and determines conversion speed. At the falling edge of CLK, each bit of an A/D conversion result (12 bits) is sent out from Dout pin (pin 6).

The operating sequence of the LTC1285 is shown in Figure 6. Data transfer is initiated at the falling edge of the chip select -CS/SHDN (pin 1). After -CS falls the second CLK pulse enables Dout. A null bit (logic 0) appears on the Dout (pin 6) firstly. At the next 12 falling edge of the clock, the 12 bits of the A/D conversion result appear on Dout one by one.

In the present circuit, -CS, Dout and CLK are connected to the RB7, RB5 and RB6 of the PIC. The PIC sets RB7 (-CS) and RB6 (CLK) as output lines. RB5 is set as an input.

RS232/TTL translator unit

The function of this unit is to perform voltage conversions between RS232 and TTL levels. From the circuit diagram, we see that the RX line (the line from which the logger receives data, RS232 voltage level) is converted into a TTL voltage level using a simple voltage clamp circuit based on R1 and a Zener diode D1. This converter does not have an inverting action. A TX signal (output from the logger, RS232 voltage level) is generated by a circuit consisting of R2, R3 and T1. The circuit requires a positive and a negative power supply. The former is from the +5V power supply of the data logger board. An on-board voltage inverter, TC7660, generates the latter.

The pin-out the RS232 port on the PSION 3C is given in Figure 7. If the data logger is to be connected to the PSION computer, a cable as shown in Figure 8 is needed. You could make one yourself.

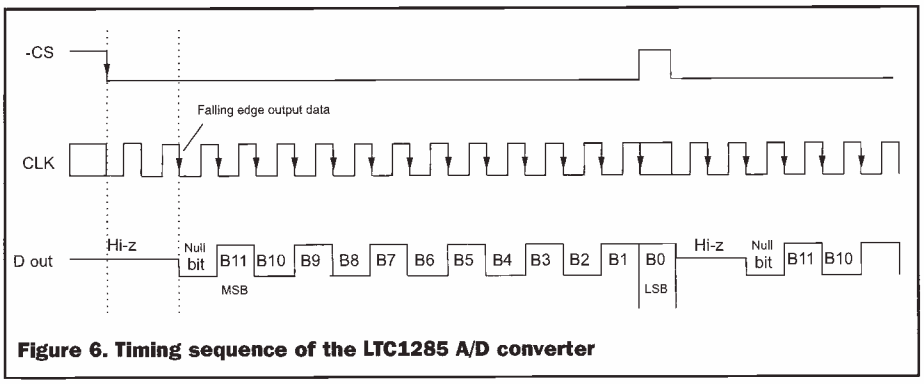


Figure 6. Timing sequence of the LTC1285 A/D converter

There are only three wires to connect. It is noted that the standard PSION 3C serial cable has a 9-pin D-type female connector at the end. The connector on the data logger is also a 9-pin D-type female connector. A gender converter should be used in this case to allow the cable to be connected to the data logger. Figure 8 also shows how this converter can be constructed. Care should be taken when making the cable and the gender converter to ensure that the transmit line from the PSION goes into the receive line of the data logger. The transmit line from the PSION computer goes into the receive line of the PSION computer.

The pin-out of the RS232 port on a PC is given in Figure 9. If the logger is to be connected to an IBM PC, a standard RS232 cable is used. The details of the RS232 port and how to use it can be found in Reference 3.

Power supply unit

The circuit of the power supply unit is given in Figure 3. The power supply is a PP3 9V battery. It is regulated into a +5V power supply using a TC55RP5002EZB regulator. The TC55RP is a 5V fixed voltage regulator with a maximum supply current 30mA. It offers a very low dropout voltage of 100mV and a quiescent current of 3.5mA. The +5V supply is converted into +2.5V by the TLE2425 2.5V voltage reference IC. The 2.5V reference voltage is used by the A/D converter. The TC7660 converts the +5V voltage into a -5V voltage.

Construction of the logger

The data logger is constructed on a single-sided PCB board and is housed in a slim size box. Figure 10 gives the component layout and Figure 11 shows the assembly of the logger inside the box.

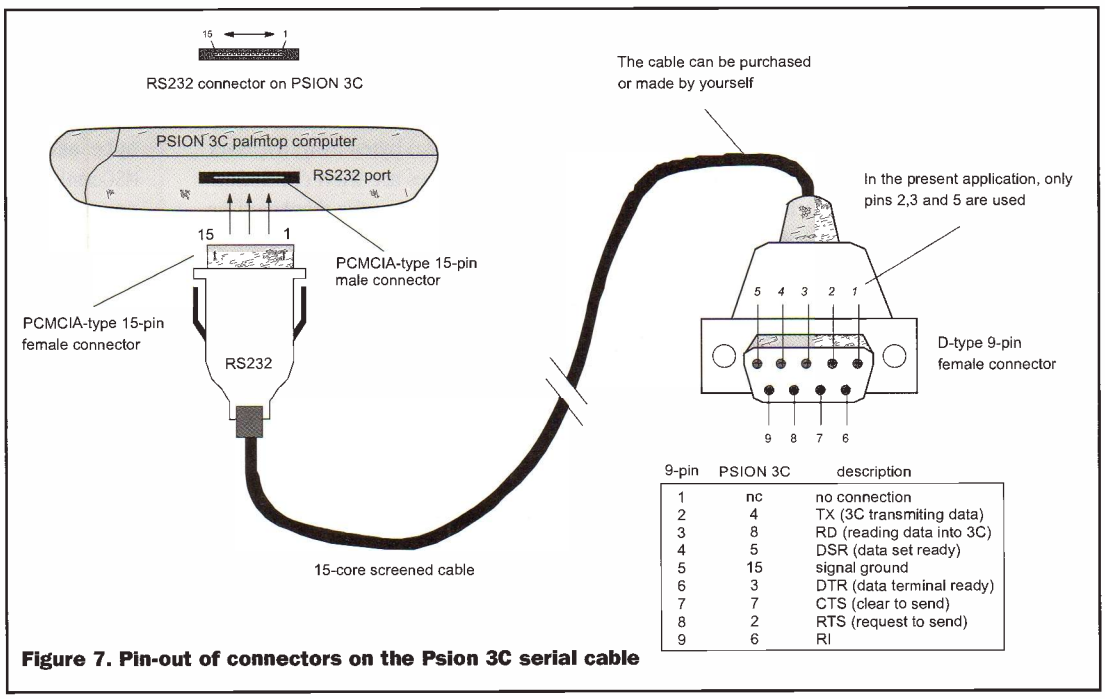
PIC software development

After pressing the reset button or the power to the data logger being turned on, the data logger enters the waiting procedure, during which it constantly monitors the serial data input line of the RS232 port through PA1 (pin 18).

Once a command byte 15h is received, the data logger begins the A/D conversion procedure. The A/D converter is activated and the A/D conversion result is loaded into the PIC. Next, the PIC transmits the A/D conversion result back to the host computer in two separate byte transmissions. The two bytes represent a 12-bit A/D conversion data. The upper 4 bits are sent first and the lower 8 bits are sent next. The PIC sends out the bytes serially via RA0 (pin 17) and communication between the host computer and the PIC has no handshakes.

The PIC software can be written in assembly language and in Basic-like or C-like languages. The present program is written in BASIC PRO language from Micro Engineering Lab (References 4 and 5). The complete PIC software is written using PIC BASIC Pro and is given in Program List 1.

The PIC BASIC compiler is a programming language that makes it very easy and quicker



9-pin	PSION 3C	description
1	nc	no connection
2	4	TX (3C transmiting data)
3	8	RD (reading data into 3C)
4	5	DSR (data set ready)
5	15	signal ground
6	3	DTR (data terminal ready)
7	7	CTS (clear to send)
8	2	RTS (request to send)
9	6	RI

Figure 7. Pin-out of connectors on the Psion 3C serial cable

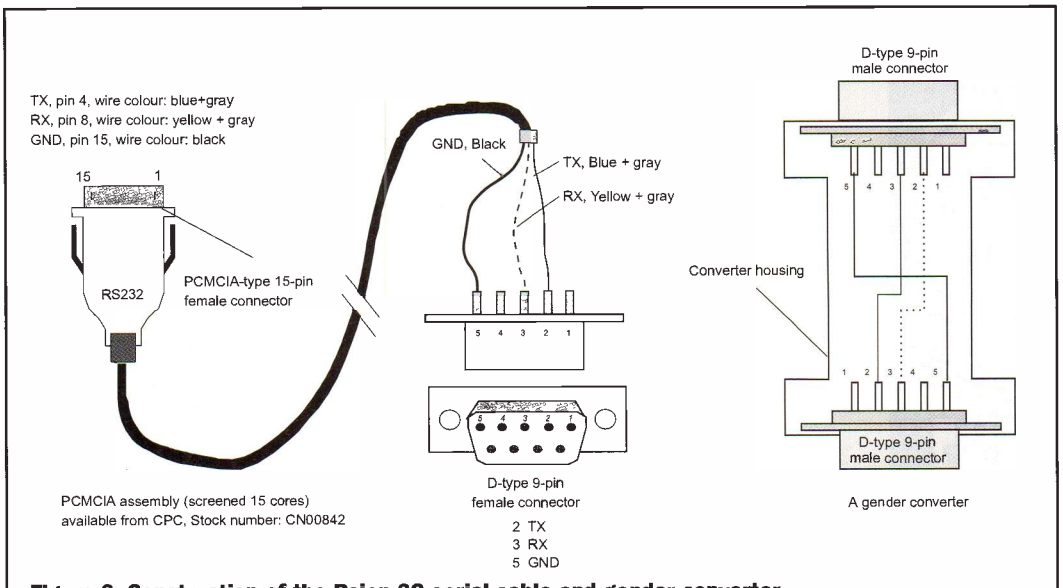
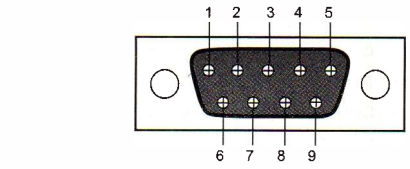
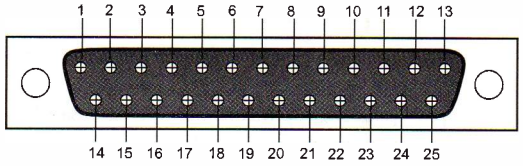


Figure 8. Construction of the Psion 3C serial cable and gender converter



(a) 9-pin male socket viewed from the back of the computer



(b) 25-pin male socket viewed from the back of the computer

Pin functions of the RS232 connectors

25 PIN	9 PIN	NAME	DIRECTION (FOR PCS)	DESCRIPTION
1		*Prot*	-	Protective ground
2	3	*TD*	OUTPUT	Transmit data
3	2	*RD*	INPUT	Receive data
4	7	*RTS*	OUTPUT	Request to send
5	8	*CTS*	INPUT	Clear to send
6	6	*DSR*	INPUT	Data set ready
7	5	*GND*	-	Signal ground (common)
8	1	*DCD*	INPUT	Data carrier detedt
20	4	*DTR*	OUTPUT	Data terminal ready
22	9	*RI*	INPUT	Ring indicator
23		*DSRD*	I/O	Data signal rate detector

Figure 9. Pin-out of the RS232 port on PCs

for you to program a wide range of powerful Microchip's PIC micro-controllers. The Basic-like structure is much easier to read and write than the assembly language. It is a viable alternative to assembly language. The PIC BASIC compiler gives you direct access to all the PIC micro-controllers' registers (I/O ports, A/D converters, Hardware serial ports etc.). It automatically takes care of memory allocation and page boundaries and memory banks. It also provides many built-in commands to do various things that will save a programmer many hours to develop in the assembly language.

PSION link software

The demonstration OPL program is very simple. Firstly, it sends a command byte 15h to the data logger. After this it reads two bytes from the data logger. The two bytes are then combined into a voltage. The voltage is then displayed on the screen. There are plenty of explanations given in the Program List 2. The use of the OPL programming language can be found in Reference 6.

TP6 PC link software

The program for PCs is written in Turbo Pascal 6 for DOS (Program List 3). Firstly, it sends a command byte 15h to the data logger. After this it reads two bytes from the data logger. The two bytes are then combined into a voltage. The voltage is displayed on the screen. The details of how PC software controls the RS232 port can be found in Reference 7.

VB5 PC link software (Reference 8)

Details of programming the RS232 port on PCs using Visual Basic programming language can be found in Reference 8. The program source code in VB5 is given in Program List 4. Some of the commands used in the present project are explained below:

A PC may have a number of COM ports. Each port has a logic name COM1, COM2 or COM3. To select a port, use the following command:

```
MSComm1.CommPort = 4 'here COM4 is
selected
```

Then the port is configured to treat the input data byte as binary and the port is opened:

```
MSComm1.InputMode =
comInputModeBinary
MSComm1.PortOpen = True
```

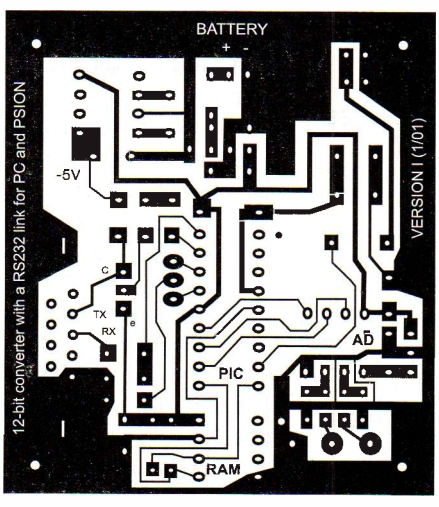
To output data from the COM port, use the following command:

```
MSComm1.Output = Chr$(1 * 16 + 5)
'15H is output from the COM port
```

Finally to read data from the COM port, the following commands are used:

```
MSComm1.InputLen = 1        'When
reading data from the COM, read one
byte each time
MSComm1.InBufferCount = 0   'The
count of byte in the input buffer is
cleared = 0

Do
    DoEvents
Loop Until MSComm1.InBufferCount = 2
'Check number of bytes in the input
buffer
'If it is 2, it means two bytes are
received
volt = (AscB(MSComm1.Input) * 256 +
```



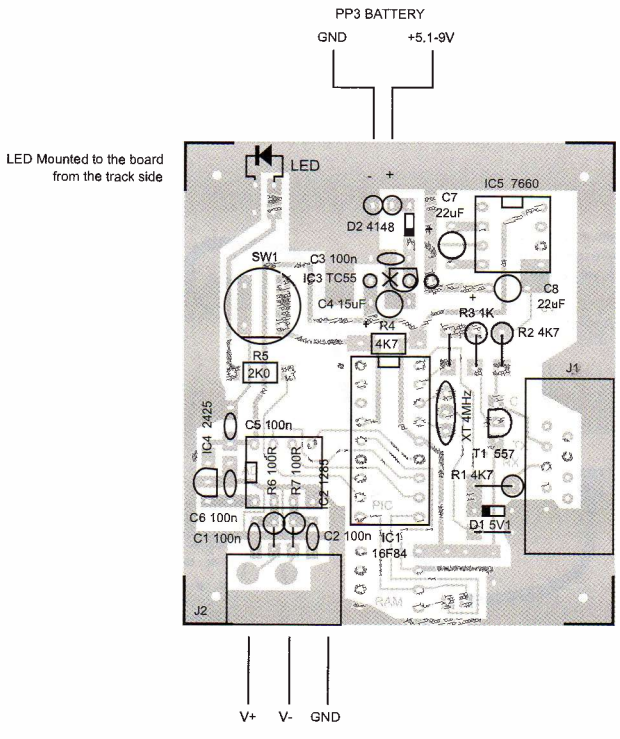


Figure 10. Pin-out of the RS232 port on PCs

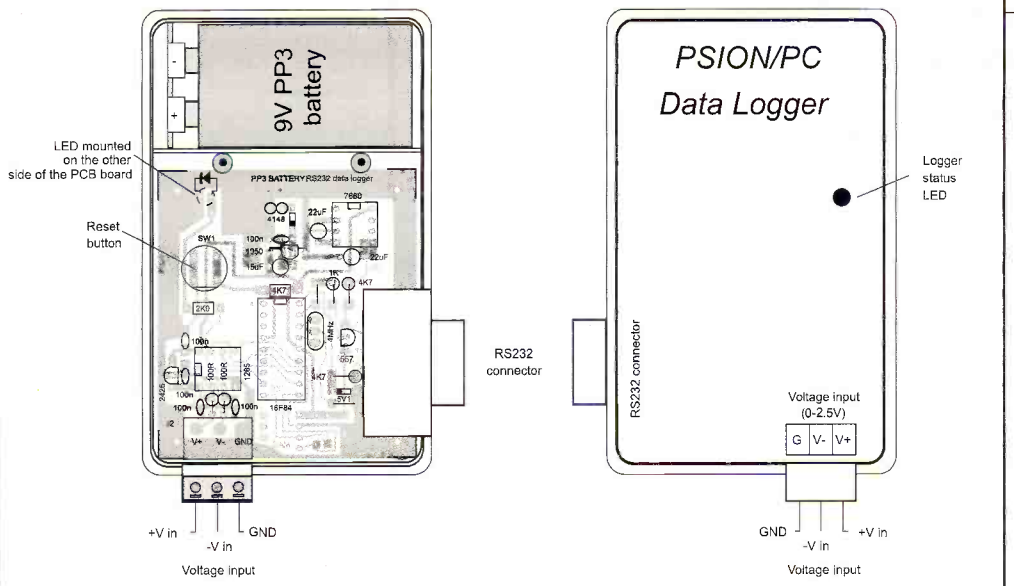


Figure 11. Assembly of the data logger

```
AscB(MSComm1.Input)) / 4096 * 2.5
'The first MSComm1.input reads the
'1st byte and the second
'MSComm1.input reads the 2nd byte.
```

Technical support

Kits including all necessary components (pre-programmed PIC) to construct a complete data logger are available from the authors. Please make your enquiry to Dr. Pei An Tel/Fax/Answer: +44-(0)161-477-9583, e-mail: pan@intec-group.co.uk

References

1. PIC16F84 data sheet, Microchip Technology Incorporated **<www.microchip.com>**
2. LTC1285 data sheet, Linear Technology Incorporated **<www.linear-tech.com>**
3. PC Interfacing - Using Centronic, RS232 and game ports, Pei An, Newnes, Butterworth-Heinemann, 1998, ISBN0240514483 **<www.intec-group.co.uk>**
4. User manual of PicBasic Pro compiler **<www.picbasic.co.uk>**
5. Experimenting with the PICBASIC PRO compiler, Les Johnson, A Crownhill Publication **<www.crownhill.co.uk>**
6. Programming manual for PSION series 3 **<www.psion.com>**
7. Real-world Programming with Visual Basic, Anthony T. Mann, SAMS publishing ISBN 0-672-30619-0
8. PC interfacing, communications and windows programming, William Buchanan, Addison-Wesley, ISBN 0-201-17818-4

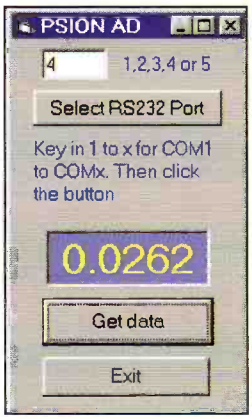


Figure 12. Screen dump of the VB5 driver

PARTS LIST

Resistors

0.25W, 1% metal film resistors

R1	4K7
R2	4K7
R3	1K0
R4	4K7
R5	2K
R6,R7	100R

Capacitors

C1,2,3, 5,6	100nF ceramic disc
C4	15uF electrolytic capacitor
C7,8	22uF electrolytic capacitor

Semiconductors

IC1	PIC16F84 micro controller
IC2	LTC1285 A/D converter
IC3	TC55RP5002EZB +5V low power voltage regulator
IC4	TLE2425 2.5 voltage reference
IC5	7660 voltage inverter
D1	5V1 zener diode
D2	1N4148
LED	3mm diameter, 1mA low current LED
T1	BC557 pnp transistor

Others

J1	9 pin D-type female connector
J2	3-way detachable screwed terminals
SW1	push button switch
XT	4MHz ceramic resonator (3 pin device)

PCB board

9V PP3 battery

Program List-1 (PIC program in PicBasic)

```
TX        VAR PORTA.0        'define line for transmit
RX        VAR PORTA.1        'define line for receiver
LED       VAR PORTB.2        'define line for LED

CS        VAR PORTB.7        'define lines for SPI bus of the A/D converter
CLK       VAR PORTB.6
DOUT      VAR PORTB.5

datafpc   VAR BYTE  'define variables to be used
datatpc   VAR BYTE
j         VAR BYTE
datal     VAR BYTE
datah     VAR BYTE

'*************START OF PROGRAM*************
DEFINE OSC 4
LOW LED
LOW CLK
HIGH CS
INPUT DOUT
GOTO START

'****FLASH LED SUB
FLASH:    HIGH LED
          PAUSE 100
          LOW LED
          RETURN

'****RECEIVE DATA FROM PC
RX_PC:
          SERIN2 RX,16468,[datafpc]     '9600, no RS232 driver
          RETURN

'****TRANSMIT DATA TO PC
TX_PC:
          SEROUT2 TX,84,[datatpc]                '9600, no RS232 driver
          RETURN

CLKPULSE:
          @ BSF PORTB.6
          PAUSEUS 10
          @ BCF PORTB.6
          PAUSEUS 10
          RETURN

'****A/D CONVERTER
AD:       @ BCF PORTB.7       'LOW CS
          PAUSEUS 10
          GOSUB CLKPULSE : GOSUB CLKPULSE
          GOSUB CLKPULSE : datah.3=DOUT
          GOSUB CLKPULSE : datah.2=DOUT
          GOSUB CLKPULSE : datah.1=DOUT
          GOSUB CLKPULSE : datah.0=DOUT
          GOSUB CLKPULSE : datal.7=DOUT
          GOSUB CLKPULSE : datal.6=DOUT
          GOSUB CLKPULSE : datal.5=DOUT
          GOSUB CLKPULSE : datal.4=DOUT
          GOSUB CLKPULSE : datal.3=DOUT
          GOSUB CLKPULSE : datal.2=DOUT
          GOSUB CLKPULSE : datal.1=DOUT
          GOSUB CLKPULSE : datal.0=DOUT
          @ BSF PORTB.7       'HIGH CS
          datah.7=0
          datah.6=0
          datah.5=0
          datah.4=0
          RETURN

'****TRANSMIT A/D RESULT BACK TO PC
TXAD:
          GOSUB AD
          datatpc=datah
          GOSUB TX_PC
          GOSUB FLASH
          datatpc=datal
          GOSUB TX_PC
          RETURN

'*************MAIN PROGRAM*************
START:    PAUSE 100
          GOSUB FLASH
ST1:
          GOSUB RX_PC
          IF datafpc=$15 THEN GOSUB TXAD
          GOTO ST1
```

Program List-2 (PSION 3C data logging program)

```
PROC RS232logger:
REM PSION 3C OPL test program for RS232 data logger
REM COPYRIGHT to Pei AN, 20/4/98
REM handshake setting: None

REM define local variables to be used in the program

        LOCAL term&,baud%, parity%, data%
        LOCAL stop%, hand%, frame%,srchar%(6)
        LOCAL d1%,d2%, dummy%,err%,ret%,len%
        LOCAL voltage

REM open the RS232 channel
        LOPEN "TTY:a"

REM dedine RS232 configuration parameters
REM RS232 setting: 9600, 8 bit, no parity, 1 stop, no handshake
        baud%=15 : parity%=0 : data%=8
        stop%=1 : hand%=4   : term&=&04002400
        frame%=data%-5
        IF stop%=2 : frame%=frame% OR 16 : ENDIF
        IF parity% : frame%=frame% OR 32 : ENDIF
        Srchar%(1)=baud% OR (baud% * 256)
        Srchar%(2)=frame% OR (parity% * 256)
        Srchar%(3)=(hand% AND 255) OR $1100
        Srchar%(4)=$13

REM config the RS232 port
        err%=IOW(-1,7,srchar%(1), dummy%)

REM PSION output a command to data logger
REM PSION then inputs two data bytes

        CLS
        FONT 8,8
        STYLE 16

        AT 15,1
        PRINT"PSION   DATA   LOGGER"

DO
        LPRINT CHR$(21);          REM output a command byte
        len%=1                    REM number of data read =1
        ret%=IOW(-1,1,d1%,len%)  REM input upper 4 bits from logger
        ret%=IOW(-1,1,d2%,len%)  REM input lower 8 bits from logger
        voltage=((d1% AND 15)*256+d2%)*2.5/4096  REM construct conversion data
        AT 13,3
        PRINT "INPUT  VOLTAGE  [V]: ";FIX$(voltage,3,6)
        pause 2                   REM a short pause
        UNTIL KEY$=CHR$(13)
ENDP
```

Program List 3 (TP6 data logger program)

```
Program RS232_data_logger;
{Software driver for PSION/PC RS232 data logger}
{The COM port is configured as Baud rate: 9600/4800/2400/1200
 Data bit length:8;  Parity Check: None; Stop Bit: 1  }
{Copyright to Pei An and Pinhua Xie, 20/4/98}

uses
    dos,crt,graph;
var
    RS232_address,com_number,number_of_COM,code:integer;
    dummy:byte;
    loggerdata: real;


Procedure detect_RS232;
{Universal auto detection of COM base address. User section of RS232 port}
{ $0000:$0400 holds the printer base address for COM1
  $0000:$0402 holds the printer base address for COM2
  $0000:$0404 holds the printer base address for COM3
  $0000:$0406 holds the printer base address for COM4
  $0000:$0411 number of parallel interfaces in binary format}
var
   COM:array[1..4] of integer;
   kbchar:char;
begin
      clrscr;
      COM_number:=1; {defaut printer}
      number_of_COM:=mem[$0000:$0411]; {read number of parallel ports}
      number_of_COM:=(number_of_COM and (8+4+2)) shr 1;
      COM[1]:=memw[$0000:$0400];       {Memory read procedure}
      COM[2]:=memw[$0000:$0402];
      COM[3]:=memw[$0000:$0404];
      COM[4]:=memw[$0000:$0406];
      textbackground(blue); clrscr;
      textcolor(yellow); textbackground(red); window(10,22,70,24); clrscr;
      writeln('Number of COM installed    :  ',number_of_COM:2);
      writeln('Addresses for COM1 to COM4:  ',COM[1]:3,'   ', COM[2]:3,'   ', COM[3]:3,'   ',
COM[4]:3);
      write('Select COM to be used (1,2,3,4)    :  ');
      delay(1000);
      if number_of_COM>1 then begin   {select COM1 through COM4 if more than 1 LPT installed}
        repeat
            kbchar:=readkey;                {read input key}
            val(kbchar, COM_number, code);   {change character to value}
        until (COM_number>=1) and (COM_number<=4) and (COM[COM_number]<>0);
                              end;
      clrscr;
      RS232_address:=COM[COM_number];
      writeln('Your selected RS232 interface:  COM',COM_number:1);
      write('RS232  Address                :  ',RS232_address:4);
      delay(5000);
      textbackground(black); window(1,1,80,25); clrscr;
end;


Procedure Write_interrupt_enable(RS232_address, Output_byte: integer);
{to enable interrupt indentification register on certain conditions
 output_byte=1, to generate an interrupt flag when a valid serial data is received}
begin
    Port[RS232_address+1]:=Output_byte;
end;


Function Read_interrupt_identification(RS232_address:integer):integer;
{to read interrupt identification register to check if an interrupt is pending}
begin
      Read_interrupt_identification:=Port[RS232_address+2]
end;


Procedure initialize;
{initialize COM to be 9600, no-parity check, 8 bit data and 1 stop bit}
{initialization is made by INTR($14)  dx=COM_number-1 for COM_number
 Bit functions of al register:
     Bit 7,6,5: set Baud rate       111=9600
     Bit 4,3  : set parity          00 =none parity
     Bit 2    : set stop bit        0=1 stop bit
     Bit 1, 0 : set data bit number 11=8 bit}
var
   register:registers;
begin
     with register do begin
          ah:=0;    al:=128+64+32+0+0+0+2+1;    dx:=COM_number-1;
          intr($14, register);
                    end;
end;


Procedure write_port(dummy_address, databyte:byte);
{Output the databyte:byte to Port[RS232_address]}
begin
     port[RS232_address]:=databyte;
end;


Function Input:byte;
{Input data from Port[RS232_address]}
begin
     Input:=port[RS232_address];
end;


Function data:byte;
{to read data from COM port with valid-data-received detection}
var
   d1x,d2x:array [1..1005] of byte;
   datax:byte;
begin
      repeat until (Read_interrupt_identification(RS232_address) and 1) =0;
      {check if a valid serial data is received by the COM port}
      data:=input; {read the received data}
end;


Function voltage:real;
{read voltage from the logger}
var
   dummy,i,d1,d2:integer;
begin

     write_port(0,1*16+5);                    {send 15=1*16+5 byte to command the logger to
convert};
     d1:=data; delay(1); d2:=data; delay(1);    {receive two bytes from the logger}
     loggerdata:=(d1 and (8+4+2+1) *256 + d2)* 2.50/4096; {combine the two byte in a voltage}
     voltage:=loggerdata;
end;


Procedure Diagram;
{A diagram showing the layout of the data logger}
{showing the analogue conversion results}
begin
     window(1,1,80,25);
     Textbackground(blue);
     textcolor(lightblue);
     clrscr;
     repeat
          gotoxy(15,18); write('  PC sends 15h to logger ');
          delay(20000);
          gotoxy(15,18); write('                         ');
          textcolor(green);
          gotoxy(15,19); write('  Logger starts loggering');
          delay(20000);
          gotoxy(15,19); write('                         ');
          textcolor(red);
          gotoxy(15,20); write('  Logger sends data to PC');
          delay(20000);
          gotoxy(15,20); write('                         ');
          textcolor(red);
          gotoxy(24,15); write(voltage:6:3);
          textcolor(yellow);
     until keypressed;
end;

{*****************MAIN PROGRAM*********************}
begin
      detect_rs232; {check the number of RS232 ports installed on your pc}
      initialize; {initialize the selected RS232 port}
      write_interrupt_enable(RS232_address, 1);
      diagram;
end.
```

Program List 4 (VB5 data logger program)

```
Private Sub Command1_Click()
Dim volt As Single
    Sleep (10)
    MSComm1.Output = Chr$(1 * 16 + 5)
    MSComm1.InputLen = 1
    MSComm1.InBufferCount = 0
    Do
        DoEvents
    Loop Until MSComm1.InBufferCount = 2
    volt = (AscB(MSComm1.Input) * 256 + AscB(MSComm1.Input)) / 4096 * 2.5
    Label1.Caption = format(volt,"0.0000")
    End Sub

Private Sub Command2_Click()
    MSComm1.CommPort = Text1.text
    MSComm1.InputMode = comInputModeBinary
    MSComm1.PortOpen = True
    Sleep (100)
End Sub

Private Sub Command3_Click()
    End
End Sub

Private Sub Form_Load()
End Sub

Module1.bas
Declare Sub Sleep Lib "kernel32" (ByVal dwMilliseconds As Long)
```

Generating Single Photons FOR SECURITY

by Reg Miles

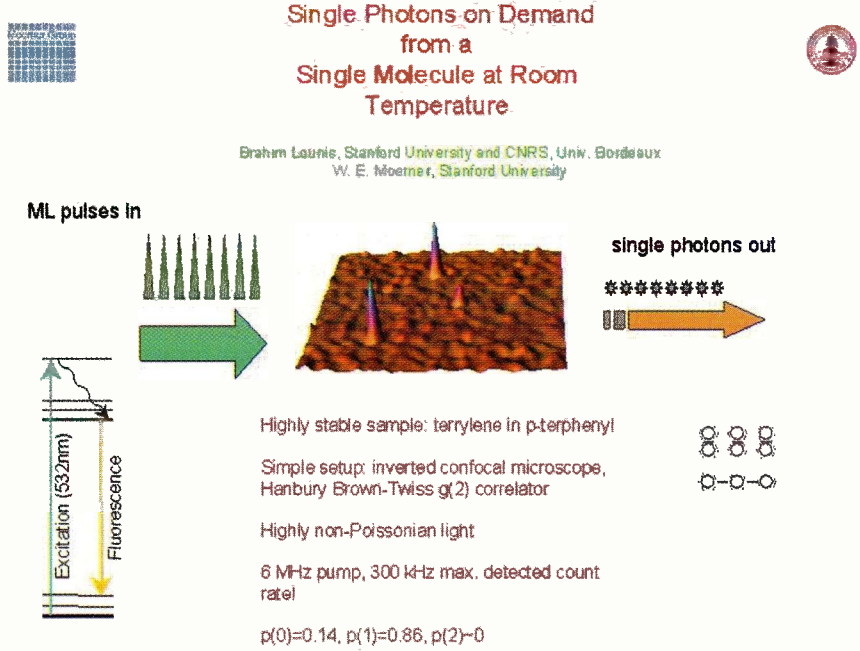


Figure 1.

Internet security is a big issue at present; and two research teams working independently have arrived at the same solution to tackle it - single photons. It would not stop an eavesdropper diverting single photons per pulse, but at least the recipient would be aware of it. The results also pertain more generally to the use of photons for quantum computation.

The first announcement came from researchers at Stanford led by chemistry Professor W. E. Moerner and visiting research associate Dr. Brahim Lounis, they were the first to use lasers to get single molecules to emit single photons on demand at room temperature. According to Dr. Moerner, 'You want to minimise the probability of emitting two [or more] photons for every pulse because that would allow an eavesdropper to split off one of those photons and read your key without your knowing it.'

Until their work, the only way to get single photons from a pulsed laser at room temperature was by attenuation - making the laser beam weaker and weaker until each pulse carried only a small number of photons. But attenuation is an inefficient way to produce single photons. 'You'll mostly get zero photons per pulse and then a small probability of one photon per pulse and an even smaller probability of two photons per pulse,' Dr Moerner says.

Their announced system is much more efficient. It can produce single photons 86 percent of the time. It produces no photons 14 percent of the time, and two photons, hardly ever. That nearly zero probability of two-photon emission could be used to ensure the immunity of quantum communications against hacker attacks. The question of whether a single photon 86 percent of the time is good enough for communications applications is put into perspective by Dr Moerner, 'It's far, far better than what [researchers] have now. It's a complex issue of what 'good enough' for applications is, but certainly big improvements in efficiency and simplicity help. What they typically work with now is single photon probabilities around 10 percent or less.'

The system in essence turns a single molecule into a light source. But a quantum mechanical light source, emitting only one photon at a time. 'The beauty of this whole idea is that it's so straightforward,' Dr Moerner says. 'A simple room temperature apparatus can generate this quantum mechanical light source.'

Short pulses of infrared laser light pass through a second harmonic generator that halves the wavelength and doubles the energy. The green light that emerges is then energetic enough for the experiment. It enters a scanning confocal microscope, which focuses the beam on a thin crystal flake. The flake is made of a very small number of single terrylene molecules embedded in a crystalline slab of p-terphenyl molecules. By moving the laser the beam can be aimed at a single terrylene molecule. Light hits the single molecule with the right amount of energy to pump it from its ground state to its excited state, causing it to release a single photon. See Figure 1.

For further information contact:
Dawn Levy, News Service (650) 725-1944;
e-mail: **dawnlevy@stanford.edu**

The second group of researchers was at the University of California, Santa Barbara. The eight UCSB researchers built a device called a Quantum Dot Single Photon Turnstile Device.' They are professors: Atac Imamoglu of Electrical and Computer Engineering (ECE) and of Physics, and Pierre Petroff and Evelyn Hu, both of ECE and Materials. The other authors have been either postdoctoral fellows or graduate students associated with one of the faculty members' laboratories, they are C. Becher, A. Kiraz, P. Michler, W. V. Schoenfeld, and Lidong Zhang.

The device itself is mushroom shaped and made out of semiconducting materials. The first step was to grow a block of semiconducting materials layer by layer. Petroff's postdoc Winston Schoenfeld made the layered material using the technique molecular beam epitaxy. The base is a substrate of Gallium Arsenide, the post is made out of Aluminum Gallium Arsenide, and the ultra-thin mushroom cap or microdisk (200nm thick) contains quantum dots of Indium Arsenide embedded in Gallium Arsenide. See Figure 2.

Incidentally, it was Prof Petroff who developed the techniques to self assemble quantum dots in 1993. And he holds the patent.

Hu and her graduate student Lidong Zhang took the block of layered material made by Petroff and Schoenfeld and shaped it into the device. The structure of the device is so important because that shape enables the removal of most of the material surrounding the quantum dots. Less material surrounding the quantum dots means less material to contribute contaminating background radiation. 'People have made micro-discs before,' said

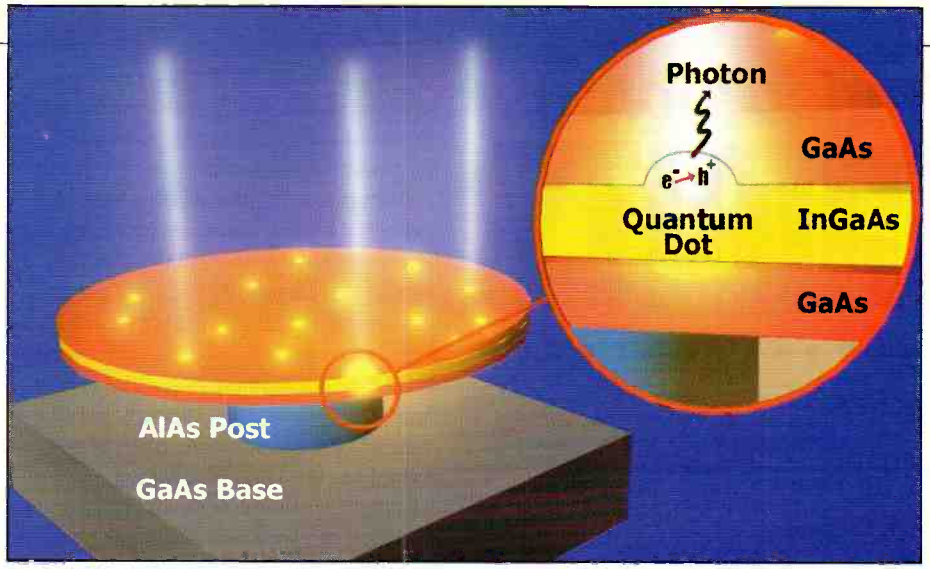


Figure 2. A quantum dot single-photon turnstile device prepares the way for quantum cryptography

Hu. 'What's new here is combining that device with the quantum dot and with a knowledge of what to look for.'

Imamoglu, his postdocs Michler and Christopher Becher, and his graduate student Alper Kiraz knew what to look for. And what they found when they used laser pulses to load the quantum dots with energy is a pattern of subsequent emission without peaking. The lack of peaking indicates the singleness of photon emission. Imamoglu clarifies the nature of the measurement. 'It is not that only one photon is emitted from a quantum dot, but that among several photons emitted is one particular kind of photon. The strong confinement enabled by the quantum dot structure ensures that the photons emitted are different, and we only look at the photon that is emitted at the lowest transition energy when the last electron-hole pair recombines.'

One disadvantage of the microdisk for quantum cryptography, apparently, is its lack of preferential output. But Imamoglu is confident that another shape, perhaps elliptical instead of circular, will cure that problem.

What intrigues Imamoglu is the relevance of single photon emission to quantum computing. Much of the theorising about quantum computing has focused on the use of the spin states of electrons. But in a soon to be published paper, computer scientist Many Knill and physicist Raymond LaFlamme of Los Alamos National Laboratory and Gerald Milburn of Queensland University in Australia show that quantum computing can be done with linear optical elements. The one missing piece, say the authors, is the availability of a single photon emission source.

Now, Imamoglu points out, 'This all-optical approach allows for a much faster way of doing real quantum operations. And photons are easy to deal with. We have a better chance of implementing a two-bit operation with this alternative scheme.'

For further information contact:
Jacquelyn Savani, (805) 893-4301
e-mail: **jsavani@engineering.ucsb.edu**

Whereas the Stanford system operated at room temperature, the UCSB one required cryogenic temperatures. However, in the former the single photon pulses were apparently polluted by additional photons from the background material. So there is still a long way to go.

TRANSISTOR Tales

by Gregg Grant

PART 3

The New Electronic Materials

The pervasiveness of the integrated circuit is such that - to many people - it seems as if the world of communications was always like this. It wasn't of course and more to the point, solid-state electronics research took many years to reach fruition. Most people imagine that the matter began in 1948, with the invention of the transistor. In fact the starting date - in so far as one can be determined - was the autumn of 1939, with the occurrence of a striking accident.

At Bell Labs, the metallurgists Henry Theuerer and Jack Scaff had begun the very slow cooling of hot silicon ingots, so as to avoid their cracking apart. In the course of this, the pair produced one sample in which two parts rectified in opposite directions!

Russell Ohl decided to investigate this accidentally created material. Using a neon lamp - the current of which was fed through a chopper - and an oscilloscope as his investigative kit, Ohl found that the ingot contained what would later be termed a p-n junction. By simply shining a torch on the material, Ohl noted '...the strikingly large photovoltaic effect of this junction.' [1]

A War in the Way

The Ohl-Scaff-Theuerer discovery was the high watermark of Bell Labs research up to 1939. Shortly, the allied war effort would swallow up huge amounts of research resources, human ones most prominently.

In the US, both industry and the universities became deeply involved in military research projects. Household names such as Du Pont, Westinghouse and Sylvania were joined by Bell Labs and universities of the standing of Purdue, Pennsylvania State and Harvard. The UK research effort had begun earlier of course, being conducted by the likes of the Telecommunications Research Establishment, the TRE; the General Electric Company, GEC, British Thompson-Houston and Pye Ltd., aided and abetted by Birmingham, Bristol and Oxford universities, to name but three. Much of this research was carried out in the field of semiconductors, particularly in their application to radar.

The success of wartime electronics research programmes - in fact the word electronics did not appear in any dictionary prior to 1940 - changed not only the relationship between industry and academia generally, but also the nature of research itself. Where formerly research had been undertaken mainly by one or two individuals in relative isolation, the urgency of war had meant that entire teams of people concentrated on particular problems.

This led to the multi-disciplined research team, in short a balanced blend of specialists whose expertise had something crucial to contribute to the matter under investigation. Presently of course this is the standard model as it were, but prior to 1940 or thereabouts it had been almost non-existent, although Bell Labs had occasionally hinted at such a concept where some of its projects were concerned. Shortly however, it would stop hinting.

The Transistor Team

In July 1945, Bell Labs created a Solid State Department, to carry out research that would - it was hoped - lead to new and improved components for use in radar and, above all, in communications equipment, which was Bell's principal business. This new department was further divided into sub-groups, the fifth of which, led by William Shockley, was dedicated to semiconductor research.

This sub-group was the epitome of the new thinking where research was concerned. Shockley and John Bardeen were theoretical, solid-state physicists, whilst Walter Brattain and Gerald Pearson

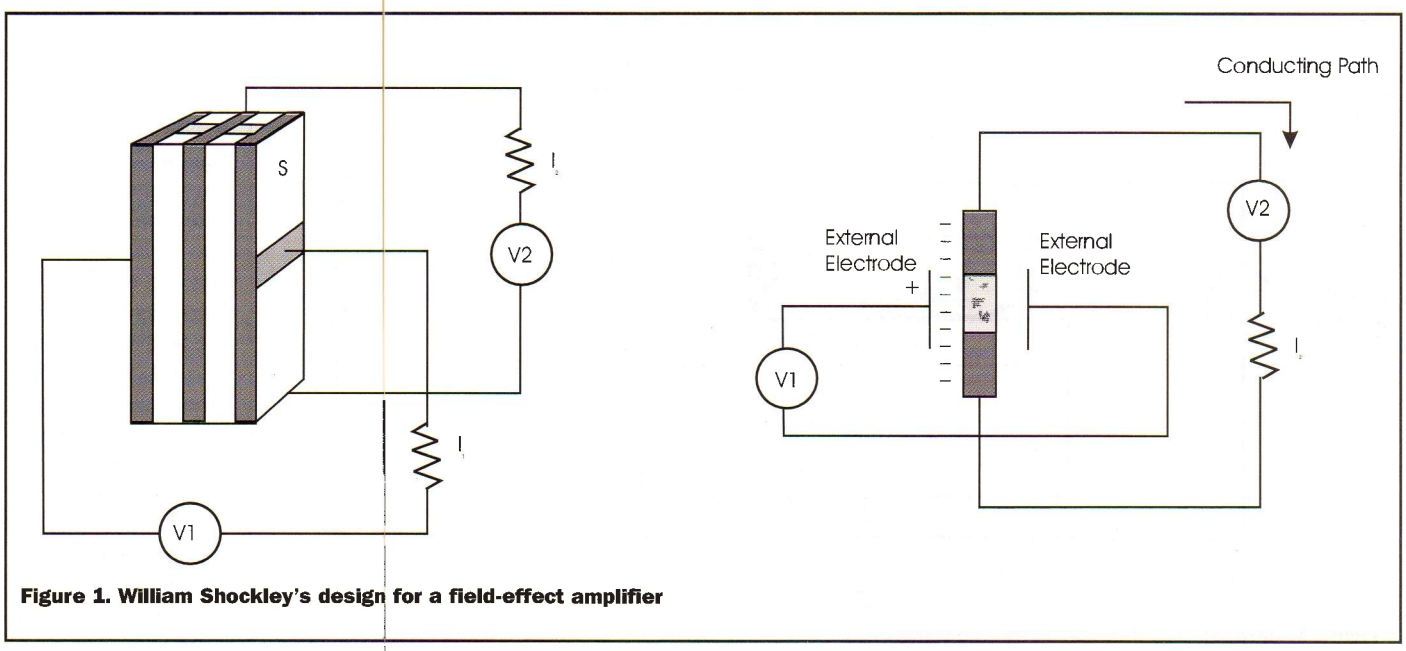


Figure 1. William Shockley's design for a field-effect amplifier

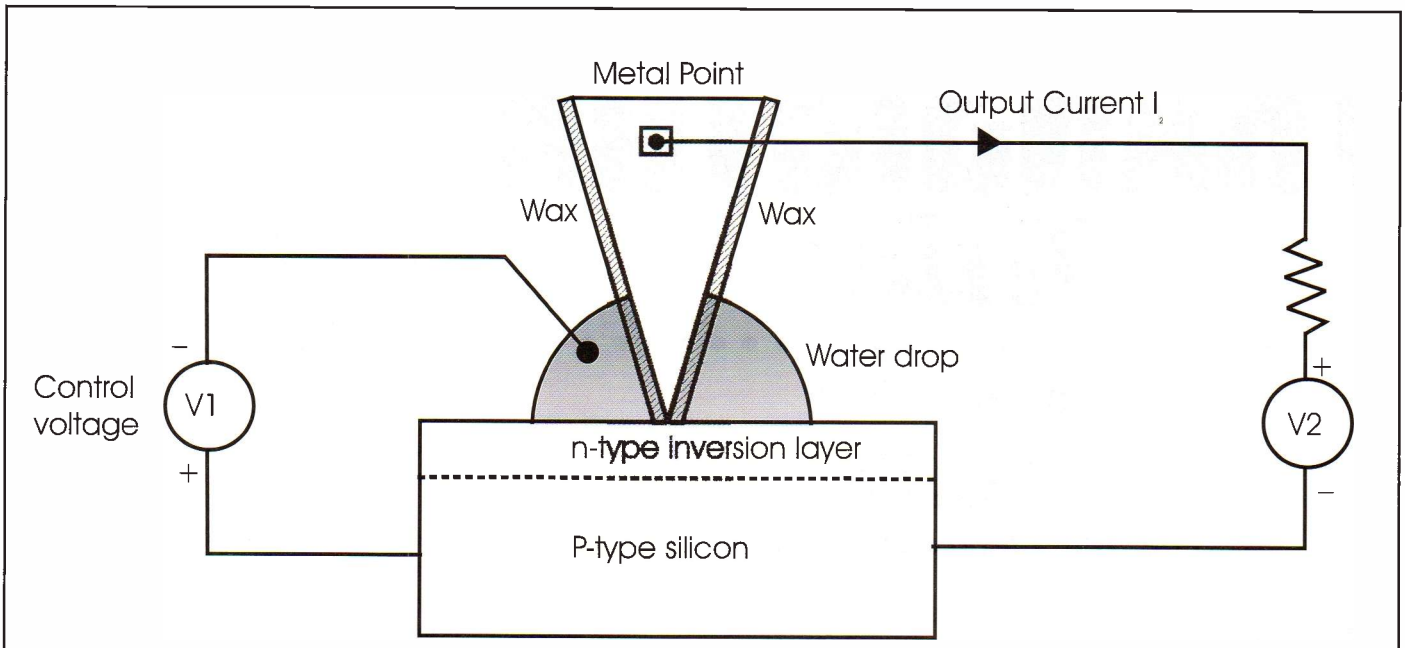


Figure 2. Bardeen's proposed field-effect amplifier of 1947

were both experimental physicists.

The latter pair had a decade's research experience in semiconductors behind them. Hilbert Moore was an expert in electronic circuitry and Robert Gibney was an experienced physical chemist. Finally, this coterie of expertise was rounded off by two technical assistants, Philip Foy and Thomas Griffith.

Effect amplifier, of 1945, shown in Figure 1.

In Figure 1 (a), input voltage V1 is applied to one or more of the plates located perpendicular to the silicon wafers, S, forming a parallel plate capacitor. This voltage repels or attracts the charge carriers in the semiconductor material, and the applied field alters the semiconductor's conductance, thus regulating the current

termed 'surface states,' therefore reducing the carriers available for the field effect.

This resulted in the surface electrons forming a barrier at the semiconductor's free surface, analogous to the junction of a metal-semiconductor rectifier, thus masking the semiconductor from the applied electric field on the control plates. This cancelled out the effect of the external field and considerably weakened the field effect.

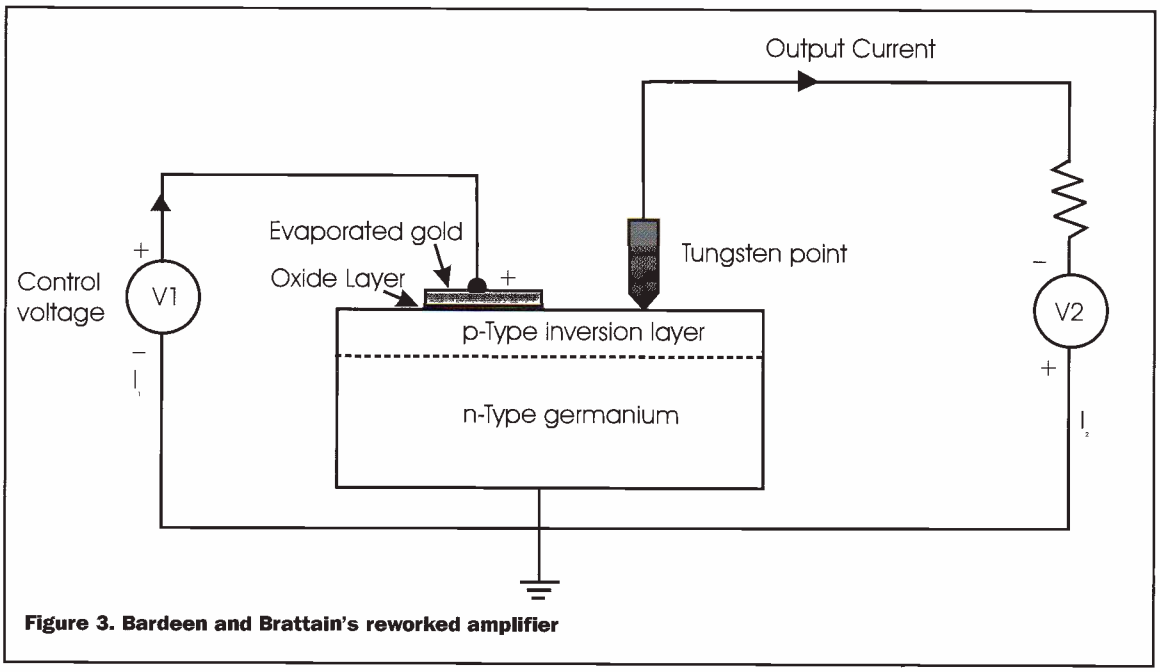


Figure 3. Bardeen and Brattain's reworked amplifier

From March 1946 to November 1947, Brattain, Pearson and Bardeen carried out extensive research into surface states and Pearson, early in this work, demonstrated the field effect. Later, in collaboration with Moore and Bardeen, Pearson took a sharp look at silicon, particularly the doping of the material with boron and phosphorus. He found that the boron atoms gave p-type conductivity (acceptors) and the phosphorus ones n-type conductivity (donors).

Brattain meanwhile carried out a series of experiments on the nature of the contact potential in both silicon and germanium. In the course of this, he noted that whilst studying contact potential charges on illumination with light, over a range of temperatures, accidental water condensation on the material surface caused hysteresis as the experiment went

The team's composition gave a sharp indication that the discipline of electronics was - thanks to wartime developments - moving into uncharted territory where the materials involved were concerned. Other, more familiar substances had properties that were well known, the obvious example, long familiar in electronics, being copper. With semiconductors however, matters were by no means so clear-cut. This was borne out by Shockley's Field-

through it.

With well-chosen circuit elements and appropriate voltages, an input signal would, it was thought, appear in an amplified form at the output, in this case I2V2. This design was tested by Brattain and Ohl - among others - but no output was evident.

One possible explanation for this failure came from Bardeen, who thought that electrons at the semiconductor material's surface could be trapped in what he

from high to low temperature.

Deciding to place his apparatus in a variety of electrolytes and dielectric liquids so as to circumvent the hysteresis, Brattain was astonished to discover that, on doing so, the photovoltaic effect increased. This was because the ions in the liquids were close to the surface, and so created an electric field of sufficient strength to negate the effect of surface state shielding.

Brattain demonstrated his 'technique' to Gibney who - in mid-November 1947 - suggested that Brattain '. . vary the DC bias on circuit while observing the light effect.' [2]

The pair discovered that varying the applied voltage also brought about a change in the photovoltaic effect where the liquids involved were electrolytes. Suddenly the research team were back at the beginning, at Shockley's field-effect amplifier. Indeed Bardeen put forward his idea for a similar such amplifier at about this time. This circuit is shown in Figure 2.

In the following month, Bardeen and Brattain replaced the water droplet of figure two with the oxide layer of figure three, as well as replacing the n-type inversion layer with one of p-type material.

Gibney's contribution was a '. . carefully evaporated. . circular spot of gold upon the somewhat thicker oxide film, which had been grown on the germanium using a steady applied voltage.' [3] This experiment failed because the oxide layer did not insulate, although the device did produce a modulated output current.

Finally, on the 16th of December, Brattain and Bardeen took up the latter's suggestion of placing both the contacts on the p-type inversion layer as close together as possible.

This experiment - probably the most important of the last century - is illustrated in Figure 4, which differed from that of Figure 3 in one way only: the construction of the inversion layer's contacts. Feeding a 1 kHz signal into the 'device' gave a power gain of 1.3 and a voltage gain of 15.

On Christmas Eve 1947, Bardeen wrote in his laboratory workbook that the 'device' had speech applied to it, and a definite gain in speech level had appeared on the oscilloscope. The demonstration was witnessed by the rest of the team, the experimental system having been set up by Hilbert Moore. The thermionic valve - the electronic equivalent of the gas-guzzling car - had been replaced at last.

On the 1st of July 1948, the New York Herald Tribune reported the Bell Labs invention, pointing out that although the new component was still in the laboratory stage, most engineers thought that it would revolutionise the electronics business.

The new device in fact would do much more than that. It would bring about an electronics explosion, whose consequences are still being felt today.

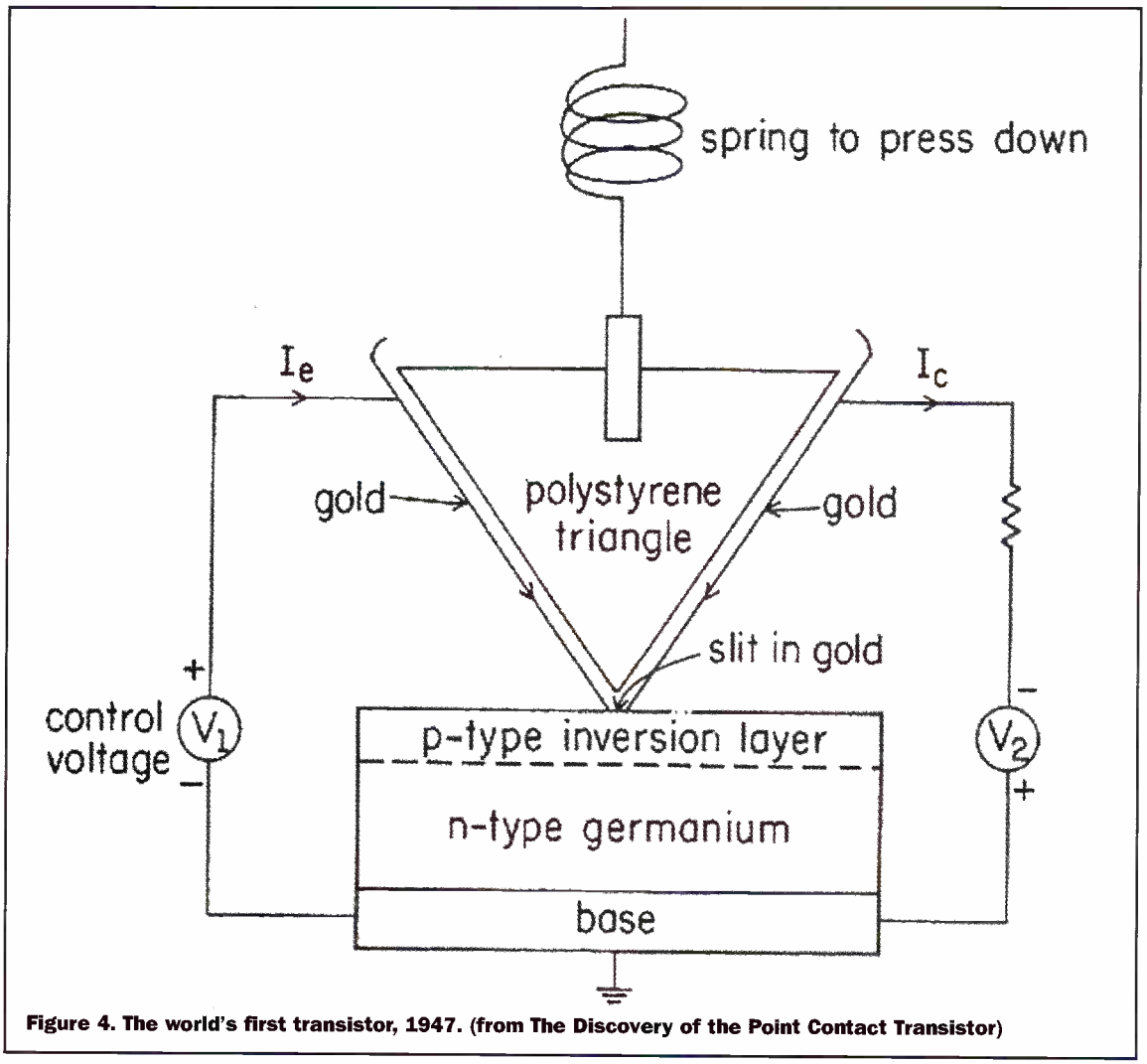


Figure 4. The world's first transistor, 1947. (from The Discovery of the Point Contact Transistor)

Beyond Silicon

Currently, the foremost semiconductor material is coming to the end of its active life, after little more than half a century. This is a unique situation, almost unheard of hitherto. Most materials used in the past had their advantages and drawbacks, yet they are almost all still with us, in one guise or another.

Silicon however is reaching the limit of what can be squeezed onto the small wafers of the substance used in integrated circuit, or IC, manufacture. The search is on for a material that can carry on, when silicon does finally reach saturation. So what will replace it?

One likely candidate is gallium nitride, which has been lauded as the most important new substance for use in electronics in the last fifty years. Professor Colin Humphreys, Cambridge University's professor of materials science, thinks that the new substance will have an important effect on Compact Disks, or CDs. This is because scientists have discovered a method of manufacturing blue lasers, which can write some four times more information onto a CD or optical disc than the red lasers currently in use.

The new material could also have an important role to play in transistor manufacture, giving new, powerful components - particularly for mobile phone base stations - and so increasing the range of the next generation of 'mobiles.'

References

1: Hoddeson, Lillian (1989): The Discovery of the Point Contact Transistor. The Regents of the University of California. Page 50.
2: Ibid [1], Page 67.
3: Op. Cit [1], page 1.

Op-Amp COOKBOOK

PART 2

Amplifiers and Active filters

Ray Marston looks at practical op-amp amplifier and active filter circuits in this second episode of this 4-part survey of op-amp principles and applications.

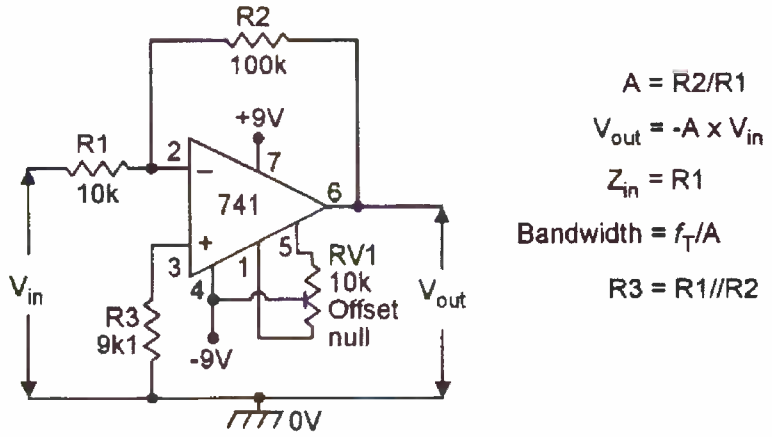


Figure 1. Inverting dc amplifier with offset-nulling facility and x10 voltage gain.

Last month's opening episode of this 4-part 'op-amp' series described the basic operating principles of conventional voltage-differencing op-amps (typified by the 741 type) and showed some basic circuit configurations in which they can be used. The present episode looks at practical ways of using such op-amps in linear amplifier and active filter applications.

When reading this episode, note that all practical circuits are shown designed around a standard 741-type op-amp and operated from dual 9V supplies. However, these circuits will usually work (without modification) with most voltage-differencing op-amps, and from any DC supply within that op-amp's operating range (allowing for possible differences in the op-amp's offset biasing networks).

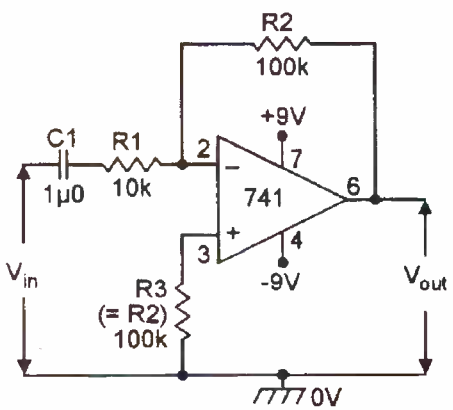


Figure 2. Inverting ac amplifier with x10 gain.

Inverting Amplifier Circuits.

Figure 1 show the practical circuit of an inverting dc amplifier with an overall voltage gain (A) of x10 (= 20dB), and with an offset nulling facility that enables the output to be set to precisely zero with zero applied input. The voltage gain and input impedance are determined by the R1 and R2 values, and can be altered to suit individual needs. The gain can be made variable, if required, by using a series combination of a fixed and a variable resistor in place of R2. For optimum biasing stability, R3 should have a value equal to the parallel values of R1 and R2.

Note that the Figure 1 circuit will continue to function if the RV1 offset-nulling network is removed, but it's output may offset by an amount equal to the op-amp's input offset voltage (typically 1mV in a 741) multiplied by the closed-loop voltage gain (A) of the circuit. So for example, if the circuit has a gain of x100, the output may be offset by 100mV with zero input applied. Also note that the circuit's bandwidth equals the f_T value (typically 1MHz in a 41) divided by the 'A' value, e.g., the Figure 1 circuit gives a bandwidth of 100kHz with a gain of x10, or 10kHz with a gain of x100.

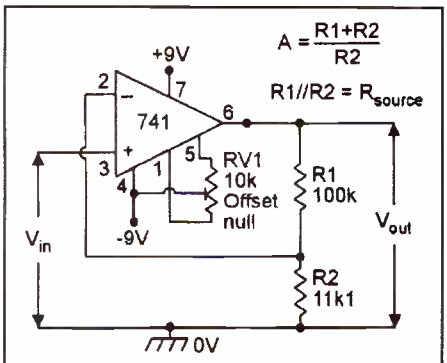


Figure 3. Non-inverting dc amplifier with offset-nulling facility and x10 gain.

The Figure 1 circuit can be adapted for use as an ac amplifier by simply wiring a blocking capacitor in series with the input terminal, as shown in Figure 2. Note in this case that no offset nulling facility is needed, and that (for optimum biasing) R3 is given a value equal to R2.

Non-Inverting Amplifier circuits.

An op-amp can be used as a non-inverting dc amplifier with offset compensation by using the connections shown in Figure 3.

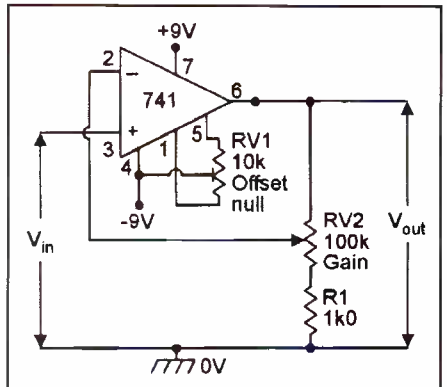


Figure 4. Non-inverting variable gain (x1 to x101) dc amplifier.

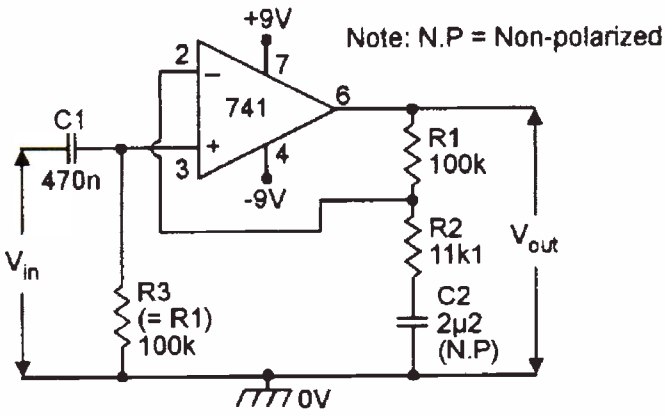


Figure 5. Non-inverting x10 ac amplifier with 100k input impedance.

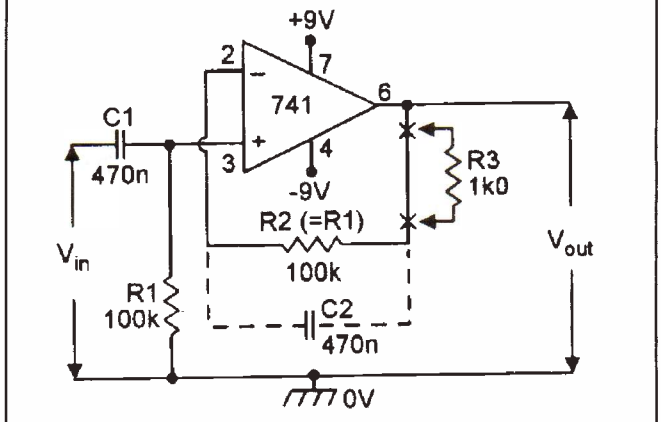


Figure 8. Ac voltage follower with 100k input impedance.

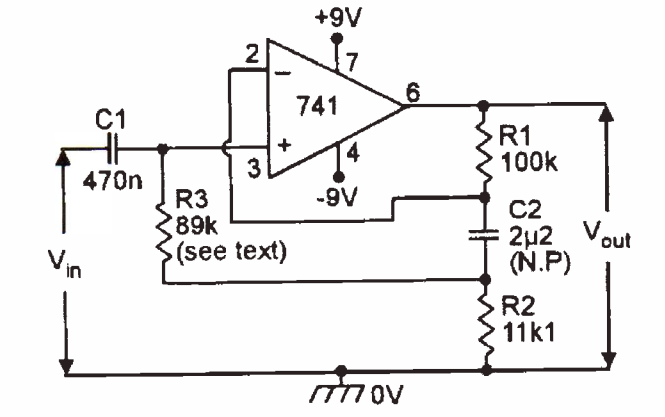


Figure 6. Non-inverting x10 ac amplifier with 50M input impedance.

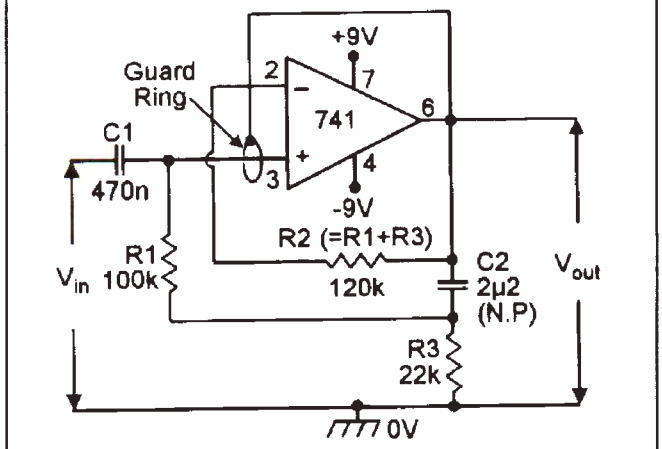


Figure 9. Ac voltage follower with 50M input impedance without the guard ring, or 500M with the guard ring.

This shows a x10 amplifier. The voltage gain is determined by the ratios of R1 and R2, as indicated. If R1 is given a value of zero, the gain falls to unity; alternatively, if R2 is given a value of zero, the gain equals the open-loop gain of the op-amp. The gain can thus be made variable by replacing R1 with a pot and connecting its slider to the inverting terminal of the op-amp, as shown in the circuit of Figure 4, in which the gain can be varied over the range x1 to x101 via RV2.

Note that, for correct operation, the input (non-inverting) terminal of each of these circuits must be provided with a dc path to the common or zero-volts rail; this path is provided by the dc input signal. In Figure 3, the parallel values of R1 and R2 should ideally (for optimum biasing) have a value equal to the source resistance of the input signal.

A major feature of the non-inverting op-amp circuit is that it gives a very high input impedance. In theory, this impedance is equal to the open-loop input resistance (typically 1M0 in a bipolar 741) multiplied by A_0/A. In practice, input impedance values of hundreds of Megohms can easily be obtained in dc circuits such as those of Figures 3 and 4.

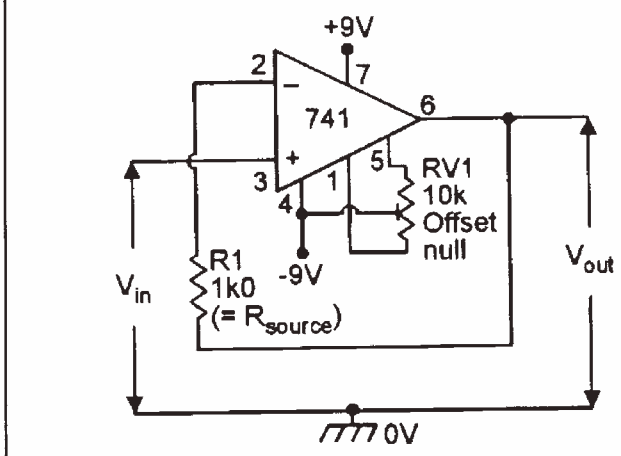


Figure 7. Precision dc voltage follower with offset null facility.

Figure 5 shows how the Figure 3 circuit can be modified for use as a x10 non-inverting ac amplifier by removing the offset biasing network, connecting the non-inverting terminal to ground via biasing resistor R3, and connecting the input signal via a blocking capacitor. Note that gain-control resistors R1-R2 are isolated from ground via blocking capacitor C2, which has negligible impedance at practical operating frequencies. The voltage gain is thus determined by the ratios of R1 and R2, but the op-amp's inverting terminal is subjected to virtually 100% dc negative feedback, thus giving the circuit excellent dc stability. For optimum biasing, R3 should have the same value as R1.

Note that the input impedance of the Figure 5 circuit equals the R3 value, and is limited to a few Megohms by practical considerations. Figure 6 shows how the basic circuit can be modified to give a very high input impedance (typically 50 Megohms). Here, the positions of C2 and R2 are transposed, and the low end of R3 is tied to the C2-R2 junction; as a consequence, near-identical operating (ac) signal voltages appear at both ends of R3. It thus passes negligible signal current and has an apparent impedance that is massively increased by

this 'bootstrap' action. In practice, the circuit's input impedance is typically limited to about 50 Megohms by leakage impedances of the op-amp's socket and the PCB to which it is wired. Note that, for optimum dc biasing, the sum of the R2 and R3 values should equal R1; in practice, the R3 value can differ from this ideal by up to 30%, and an actual value of 100k can be used in the Figure 6 circuit if desired.

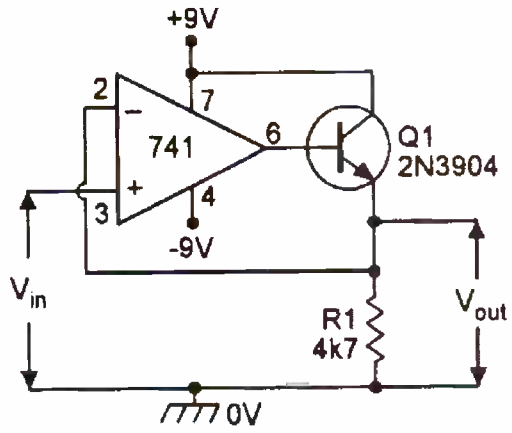


Figure 10. Unidirectional dc voltage follower with boosted output-current drive.

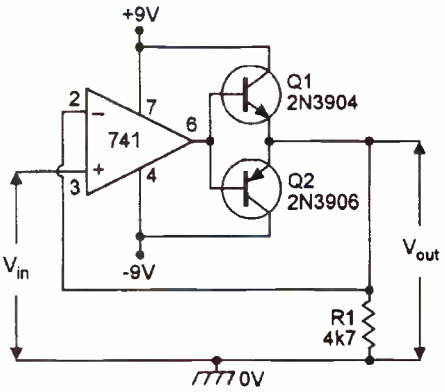


Figure 11. Bidirectional dc voltage follower with boosted output-current drive.

Voltage Follower Circuits

A voltage follower circuit produces an output voltage that is identical to that of the input signal, but has a very high input impedance and a very low output impedance. The circuit actually functions as a unity-gain non-inverting amplifier with 100% negative feedback. Figure 7 shows the idealised design of a precision voltage follower with offset biasing. Note that, for optimum biasing, feedback resistor R1 should have a value equal to the source resistance of the input signal.

In practice, the basic Figure 7 circuit can often be greatly simplified. Eliminating the offset biasing network, for example, adds an error of only a few mV to the output of the op-amp. Again, the value of feedback resistor R1 can be varied from zero to 100k without greatly influencing the circuit's accuracy. If an op-amp with a low f_T value (such as the 741) is used, the R1 value can usually be reduced to zero. Note, however, that many 'high f_T' op-amps tend towards instability when used in the unity-gain mode, and in such cases R1 should be given a value of 1k0 or greater to effectively reduce the circuit's bandwidth and thus enhance stability.

Figure 8 shows an ac version of the voltage follower. In this case the input signal is dc-blocked via C1, and the op-amp's non-inverting terminal is tied to ground via R1, which determined the circuit's input impedance. Ideally, feedback resistor R2 should have the same value as R1. If R2 has a high value, however, it may significantly reduce the circuit's bandwidth; this problem can be overcome by shunting R2 with C2, as shown dotted. If the latter technique is used with a 'high fT' op-amp, resistor R3 can be connected as shown to ensure circuit stability.

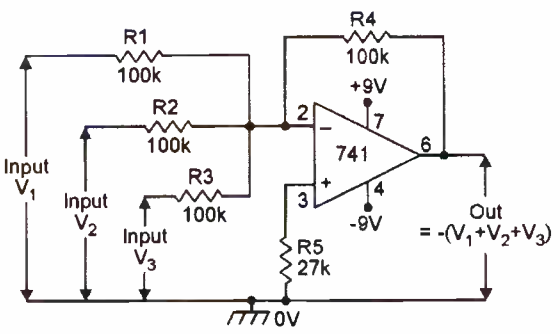


Figure 12. Unity-gain inverting dc adder.

If a very high input impedance is required from an ac voltage follower, it can be obtained by using the basic configuration shown in Figure 9, in which R1 is 'bootstrapped' from the op-amp output via C2, thus raising it's impedance to near-infinity. In practice, this circuit can easily give an input impedance of 50 Megohms from a 741 op-amp; this limit being set by the leakage impedance of the op-amp's IC socked and the PCB.

If an even greater input impedance is needed, the area of PCB surrounding the op-amp input pin should be provided with a printed 'guard ring'. This is driven from the op-amp output, as shown, so that the leakage impedances of the PCB, etc., are themselves bootstrapped and raised to near-infinite values. In this case the Figure 9 circuit gives an input impedance of about 500 Megohms when used with a 741 op-amp, or even greater if a FET-input op-amp is used.

Current-Boosted 'Follower' circuits

Most op-amps can provide maximum output currents of only a few milliamps, and this is the current-driving limit of the voltage follower circuits of Figures 7 to 9. The current-driving capacity of a voltage follower can easily be increased, however, by wiring a simple or a complementary emitter follower current booster stage between the op-amp output and the final output terminal of the circuit, as shown in the basic designs of Figures 10 and 11. Note that the base-emitter junctions of the transistors are wired into the negative feedback loop of the op-amp, to minimise the effects of junction non-linearity.

The Figure 10 circuit is able to source large currents (via Q1), but can sink only relatively small ones (via R1). This circuit can thus be regarded as a unidirectional,

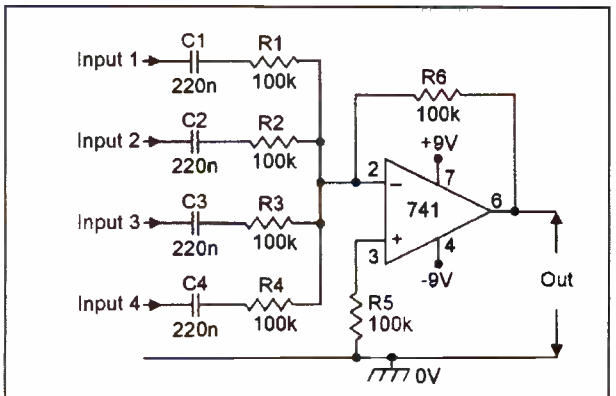


Figure 13. Unity-gain audio mixer.

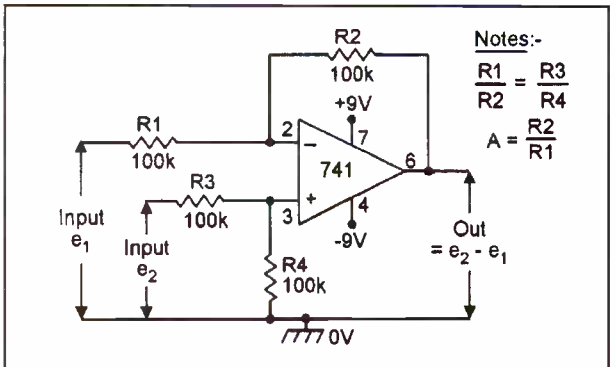


Figure 14. Unity-gain dc differential amplifier, or subtractor.

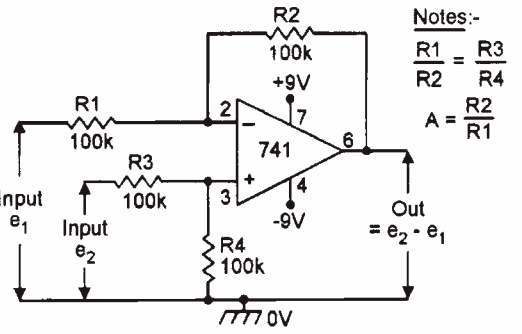


Figure 14. Unity-gain dc differential amplifier, or subtractor.

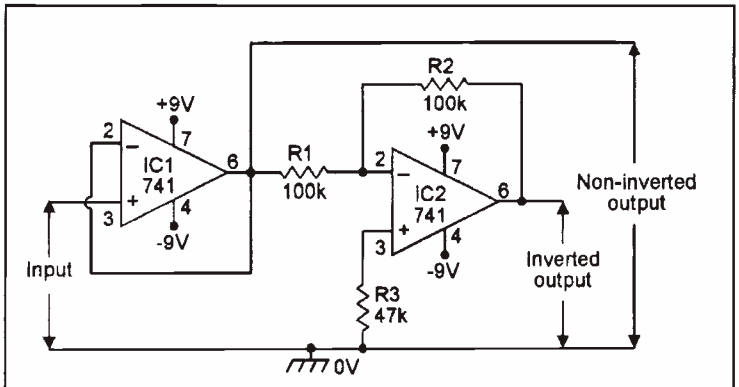


Figure 15. Unity-gain balanced dc phase-splitter.

positive-only, dc voltage follower.

The Figure 11 circuit can both source (via Q1) and sink (via Q2) large output currents, and can be regarded as a bidirectional (positive and negative) voltage follower. In the simple form shown in the diagram the circuit produces significant cross-over distortion as the output moves around the zero volts value. This distortion can be eliminated by suitably biasing Q1 and Q2.

In practice, the Figure 10 and 11 circuits have maximum current-drive capacities of about 50mA, this figure being dictated by the low power ratings of the specified transistors. Greater drive capacity can be obtained by using alternative transistors.

Adders and Subtractors

Figure 12 shows the circuit of a unity-gain analogue dc voltage adder, which gives an inverted output voltage equal to the sum of the three input voltages. Input resistors R1 to R3 and feedback resistor R4 have identical values, so the circuit acts as a unity-gain inverting dc amplifier between each input terminal and the output. The current flowing in R4 is equal to the sum of the R1 to R3 currents, and the inverted output voltage is thus equal to the sum of the input voltages. In high-precision applications, the circuit can be provided with an offset nulling facility.

The Figure 12 circuit is shown with three input connections, but can in fact be given any number of inputs (each with a value equal to R1), but in this case the R5 value should (for optimum biasing) be altered to equal the parallel values of all other resistors. If required, the circuit can be made to give a voltage gain greater than unity by simply increasing the value of feedback resistor R4. The circuit can be used as a multi-input 'audio mixer' by ac-coupling the input signals and giving R5 the same value as the feedback resistor, as shown in the 4-input circuit of Figure 13.

Figure 14 shows the circuit of a unity-gain dc differential amplifier, or analogue subtractor, in which the output equals the difference between the two input signal voltages, i.e., equals $e_2 - e_1$. In this type of circuit the component values are chosen such that R1/R2 = R3/R4, in which case the voltage gain, A, equals R2/R1. When, in Figure 14, R1 and R2 have equal values, the circuit gives unity overall gain, and thus acts as an analogue subtractor.

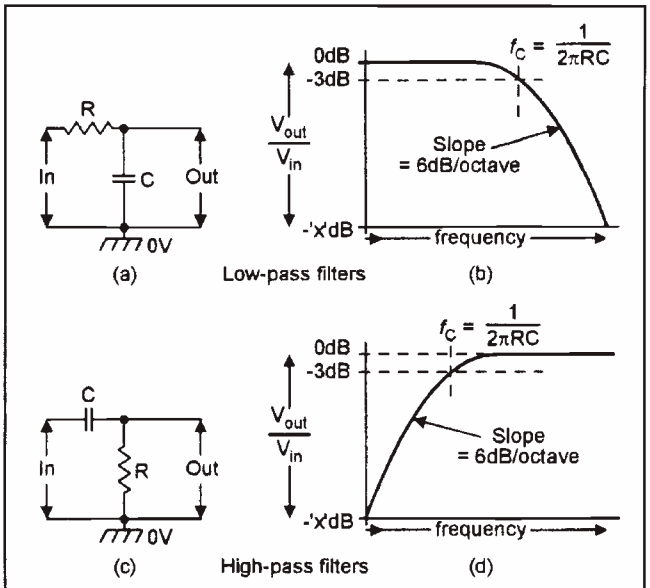


Figure 16. Circuit and response curves of simple 1st-order R-C filters.

Balanced Phase-Splitter

A phase-splitter has a pair of output terminals, which produce outputs that are identical in amplitude and form, but with one output phase-shifted by 180O (i.e., inverted) relative to the other. Figure 15 shows an easy way of making a unity-gain balanced dc phase-splitter, using a pair of 741 op-amps. Here, IC1 acts as a unity-gain non-inverting amplifier or voltage follower, and provides a buffered output signal that is identical to that of the input. This output also provides the input drive to IC2, which acts as a unity-gain inverting amplifier, and provides the second output, which is inverted but is otherwise identical to the original input signal.

Active Filters

Filter circuits are used to reject unwanted frequencies and pass only those wanted by the designer. A simple R-C low-pass filter (Figure 16(a)) passes low-frequency signals but rejects high-frequency ones. The output falls by 3dB at a 'break' or 'cross-over' frequency (f_C) of $\frac{1}{2\pi}$RC), and then falls at a rate of 6dB/octave (= 20dB/decade) as the frequency is increased (see Figure 16(b)). Thus, a simple 1kHz filter gives roughly 12dB of rejection to a 4kHz signal, and 20dB to a 10kHz one.

A simple R-C high-pass filter (Figure 16c) passes high-frequency

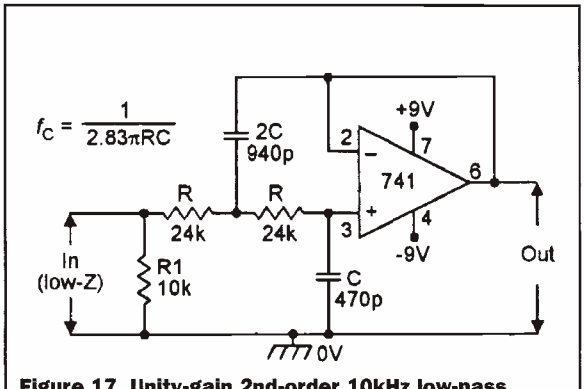


Figure 17. Unity-gain 2nd-order 10kHz low-pass active filter.

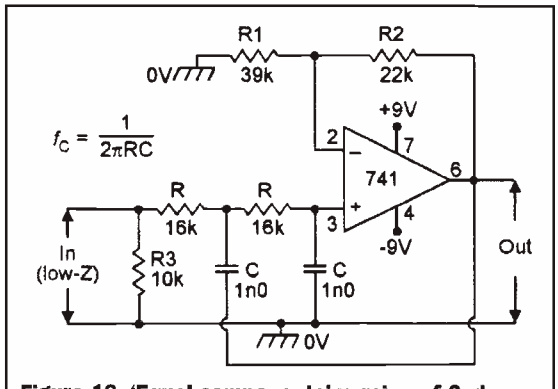


Figure 18. 'Equal components' version of 2nd-order 10kHz low-pass active filter.

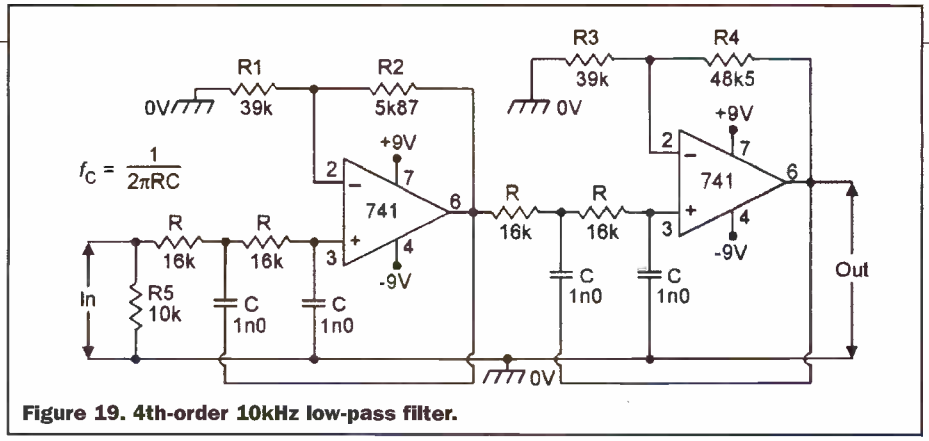


Figure 19. 4th-order 10kHz low-pass filter.

Note here that the op-amp is designed to give a voltage gain (4.1dB in this case) via R1 and R2, which must have the values shown.

Figure 19 shows how two of these 'equal component' filters can be cascaded to make a 4th-order low-pass filter with a slope of 24dB/octave. Note in this case that gain-determining resistors R1/R2 have a ratio of 6.644, and R3/R4 have a ratio of 0.805, giving an overall voltage gain of 8.3dB. The odd values of R2 and R4 can be made up by series-connecting 5% resistors.

signals but rejects low-frequency ones. The output is 3dB down at a break frequency of $\frac{1}{2\pi}RC$), and then falls at a 6dB/octave rate as the frequency is decreased below this value (Figure 16(d)). Thus, a simple 1kHz filter gives roughly 12dB of rejection to a 250Hz signal, or 20dB to a 100Hz signal.

Each of the above two filter circuits uses a single R-C stage, and is known as a '1st order' filter. If a number (n) of similar filters are effectively cascaded, the resulting circuit is known as an 'nth order' filter and has an output slope, beyond f_C, of (n x 6dB)/octave. Thus, a 4th order 1kHz low-pass filter has a slope of 24dB/octave, and gives 48dB of rejection to a 4kHz signal, and 80dB to a 10kHz signal. One way of effectively cascading such filters is to wire them into the feedback networks of suitable op-amp amplifiers; such circuits are known as 'active filters', and Figures 17 to 23 show practical examples of some of them.

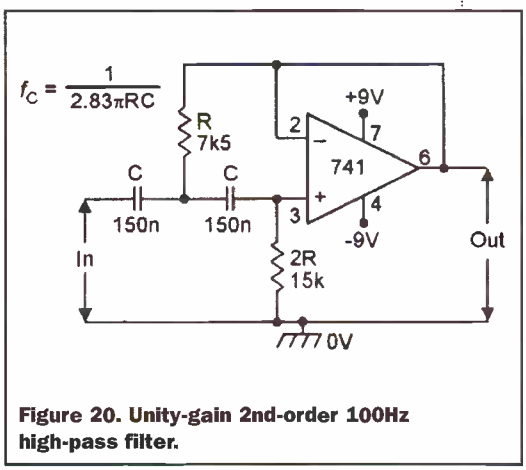


Figure 20. Unity-gain 2nd-order 100Hz high-pass filter.

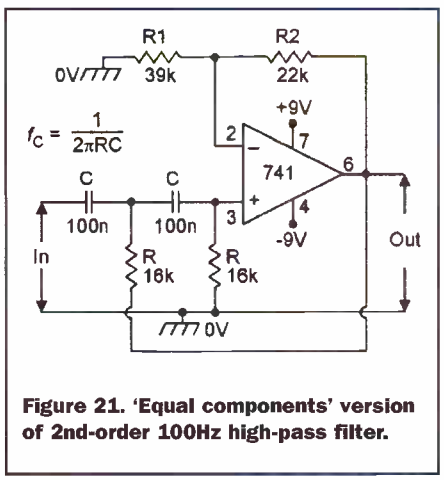


Figure 21. 'Equal components' version of 2nd-order 100Hz high-pass filter.

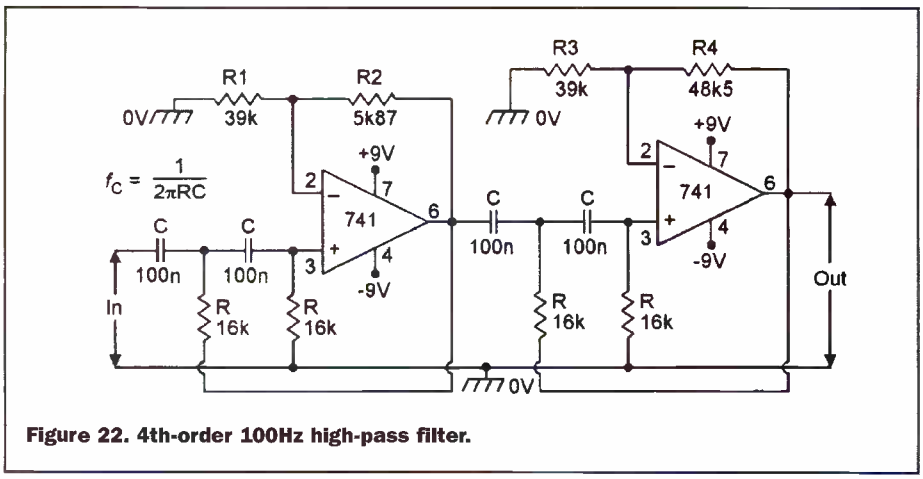


Figure 22. 4th-order 100Hz high-pass filter.

Active Filter Circuits.

Figure 17 shows the practical circuit and formula of a maximally-flat (Butterworth) unity-gain 2nd-order low-pass filter with a 10kHz break frequency; its output falls off at a 12dB/octave rate beyond 10kHz, and is about 40dB down at 100kHz, and so on. To change the break frequency, simply change either the R or the C value in proportion to the frequency ratio relative to Figure 17; reduce the values by this ratio to increase the frequency, or increase them to reduce it. Thus, for 4kHz operation, increase the R values by a ratio of 10kHz/4kHz, or 2.5 times.

A minor snag with the Figure 17 circuit is that one of its C values must be twice the value of the other, and this may demand odd component values. Figure 18 shows an alternative 2nd-order 10kHz low-pass filter circuit that overcomes this snag and uses equal component values.

Figures 20 and 21 show unity-gain and 'equal component' versions respectively of 2nd-order 100Hz high-pass filters. Figure 22 shows a 4th-order 100Hz high-pass filter. The operating frequencies of these circuits, and those of Figures 18 and 19, can be altered in exactly the same way as in Figure 17, i.e., by increasing the R or C values to reduce the break frequency, or vice versa.

Finally, to complete this episode of the series, Figure 23 shows how the Figure 21 high-pass and Figure 18 low-pass filters can be wired in series to make (with suitable component value changes) a 300Hz to 3.4kHz speech filter. This gives 12dB/octave rejection to all signals outside of this range. In the case of the high-pass filter, the C values of Figure 21 are reduced by a factor of three, to raise the break frequency from 100Hz to 300Hz. In the case of the low-pass filter the R values of Figure 18 are increased by a factor of 2.94, to reduce the break frequency from 10kHz to 3.4kHz.

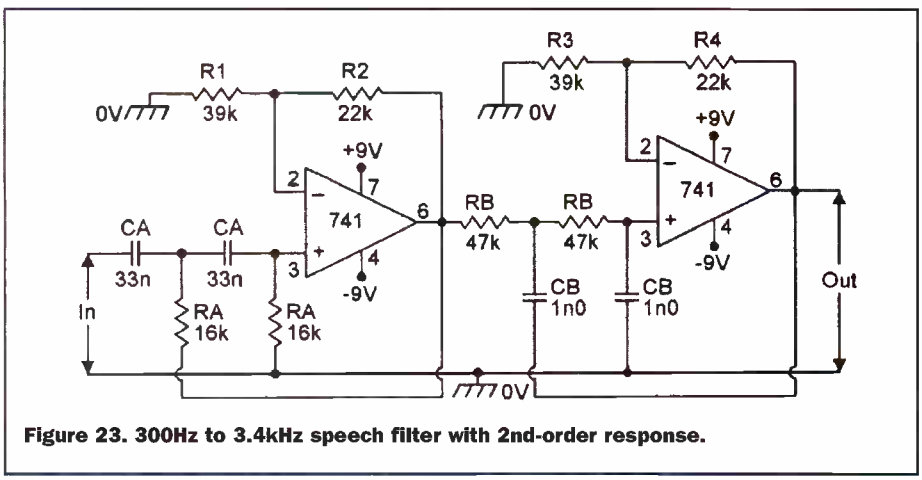
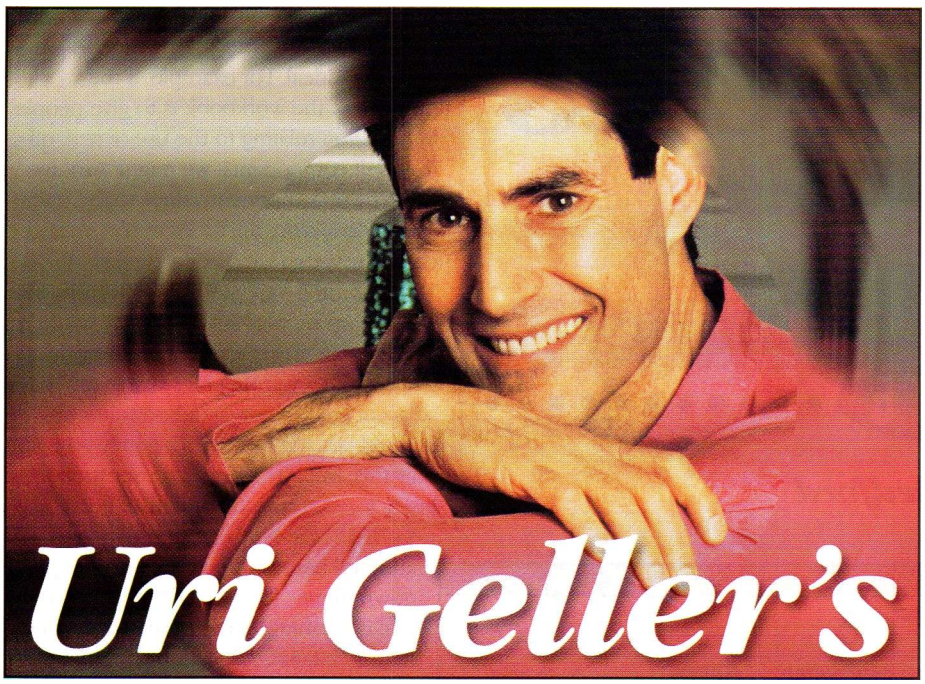


Figure 23. 300Hz to 3.4kHz speech filter with 2nd-order response.



Uri Geller's EXTENDED REALITY

In Two Minds

We often talk about being 'in two minds' about a decision we have to make. There may be a logical course of action and a less logical, even a crazy one, which for some reason we are not sure about is the one we eventually take and which turns out to have been the right choice in the end. In my December column I gave some examples of how' executive ESP' has been put to very profitable use by heads of major corporations and businesses.

It would be more correct to say that we are not really in two minds, but that there are two minds in us, which we can call the left one and the right one. We certainly have two separate brain hemispheres, and back in 1748 the Swedish scientist and mystic Emanuel Swedenborg noted in his diary that the left brain dealt with the 'appreciation of goodness' while the right one 'relates to the understanding of truth'.

It was not until more than two centuries later that Nobel laureate Roger Sperry carried out pioneering experiments with epileptics whose brain connections (the corpus collosum) had been severed so as to keep the electrical discharges that caused their seizures under control. Sperry found to his surprise that there were 'two separate conscious entities or minds' in their heads. The left one seemed to be in charge of logical thinking while the right one registered emotion and general impressions. With left handed people (like Swedenborg?); it was the other way round.

Before long the right brain became something of a New Age bandwagon, people tending to forget that we all have to use both our brains all the time - we would find normal living very difficult if we didn't. It seems more sensible to talk about left and right minds rather than brains, which generate what psychologists call R and A thinking, R for realistic appraisal and A for autistic in the sense of fantasy- dominated. There are both left - and right-minded extremists, people who load impeccably logical and sensible lives free from any trace of creativity of those who live in a fantasy world of their own. This is, just as well, for we need accountants as well as artists.

The trouble is that on the whole the left mind tends to dominate and does not always listen to what the right one is trying to tell it, This may not always have been so – we learned to draw and paint long before we could write. A reliance on right-mind intuition may have played an important part in the evolution and survival of early humans. Some even believe that we are getting back to a right-dominant state of mind thanks, oddly enough, to the wonders of modern technology. Computer expert Thomas Blakeslee believes, that with computers doing much of our routine and linear thinking for us, there will be less for our left minds to do, so they will be more receptive to what the right mind is trying to tell them.

There are all kinds of ways in which right-mind thinking can help us. One is hypnosis, A British doctor who visited the 19th century French hypnotist Ambroise Libeault noted that what he was doing was suppressing 'the reasonable and deliberative side of the patient's brain' (or rather, mind) and developing the 'emotional and instinctive' side - the right. The more the right mind dominated, the more successful the treatment was, Hypnotists today often use creative visualisation techniques to encourage patients to suspend logic and enter a non-verbal world, and there have been many reports of cures as a result.

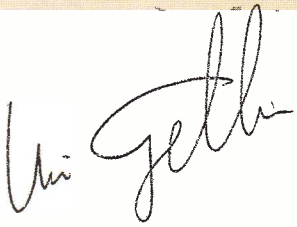
In Australia, Dr Ainslie Meares reported remarkable results after inducing extreme right mind dominance in his patients just by getting them into a state of deep relaxation and leaving them there for several hours, much as the early mesmerists, who did not make verbal suggestions, used to do. So probably did the ancient Greeks in their sleep temples. It seems our bodies know what to do with themselves if we get the conscious mind out of the way. This is best done by depriving it of anything to think about as in meditation, which I do every day and find it as important for my mind as my daily cycle is for my body.

Non-verbal instruction can be useful in sports training, as tennis coach Timothy Gallwey discovered with his 'inner game' method, in hich players were told to visualise their strokes rather than work them out logically. It has been used to teach very young babies to swim long before they can understand anything said to them, I hear that in Denmark, where education standards are very high, children are actually encouraged not to learn to read and write for several years, to give their right minds more freedom to develop.

Good examples of proper left-right mind integration are those of great inventors and discoverers. Again and again we read that they worked hard, slept on the problem, and the solution popped out soon after they woke up. It probably wouldn't have, of course, if they hadn't done the left-mind work first.

I particularly liked the cartoon in which a man complains to the boss that a colleague has just been given a pay rise although he spends most of his time staring out of the window. 'If you see what he sees when he does that,' was the reply, 'I'll give you a pay rise as well.'

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>



Excursions INTO EXCEL

PART 6

by Mike Bedford

	A	B	C	D	E	F	G	H
1	*This worksheet contains the caculations*							
2								
3		*Value #*	*Value*	*Units #*	*Multiplier*	*Actual*		
4	*Resistor*	1	1	2	1000	1000		
5	*Capacitor*	8	47	1	1E-12	4.7E-11		
6	*Inductor*	8	15	1	0.000001	0.000015		
7	*F1*	1	1	3	1000000	1000000		
8	*F2*	5	20	3	1000000	20000000		
9								
10	Circuit Configuration		1					
11								
12	Frequency	1000000	1760000	2520000	3280000	4040000	4800000	5560000
13	2 pi f	6283185	11058406	15833627	20608848	25384069	30159289	34934510
14	XL	94.2478	165.8761	237.5044	309.1327	380.761	452.3893	524.0177
15	XC	3386.28	1924.02	1343.76	1032.401	838.187	705.474	609.0423
16	X-series	3292.03	1758.144	1106.256	723.2683	457.4259	253.0847	85.02468
17	X-parallel	96.946	181.526	288.4947	441.2594	697.7062	1261.036	3753.603
18	X	3292.03	1758.144	1106.256	723.2683	457.4259	253.0847	85.02468
19	Z-series	3440.56	2022.639	1491.242	1234.146	1099.654	1031.529	1003.608
20	Z-parallel	956.829	869.2325	741.8353	586.0475	415.9727	245.3491	84.71901
21	Z	3440.56	2022.639	1491.242	1234.146	1099.654	1031.529	1003.608

A couple of months ago we looked at how to make your Excel workbooks easy to understand by the use of titles, comments, explanatory text, diagrams, equations and so forth. This month we return to the subject of usability and specifically on to how you can improve your workbooks by including controls such as list boxes and option buttons.

From a purely technical point of view, the example I've chosen this month is pretty simple. The aim of the workbook is to plot the impedance of a circuit containing resistance, inductance and capacitance over a range of frequencies. The user should be able to choose the values of the three components, specify the range of frequencies over which the response is to be plotted, and also define the circuit configuration. In particular, the user is to be given the choice of four configurations, namely the capacitor and inductor may be in series or parallel, and the resistor may be in series or parallel with the resulting LC combination. The following formulae are the ones that are needed:

$$X_L = 2\pi fL \qquad X_C = \frac{1}{2\pi fC}$$

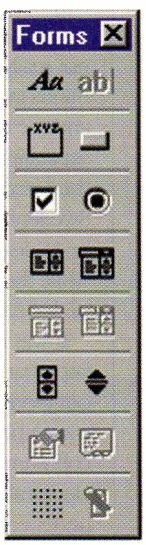
$$X_{series} = [\,X_L - X_C\,] \qquad X_{parallel} = \left[\frac{X_L X_C}{X_L - X_C}\right]$$

$$Z_{series} = \sqrt{X^2 + R^2} \qquad Z_{series} = \sqrt{\frac{XR}{X^2 + R^2}}$$

where X_L is the reactance of inductance L at frequency f, X_C is the reactance of capacitance C, also at frequency f, X_{series} is the combined reactance of X_L and X_C in a series configuration, $X_{parallel}$ is the combined reactance of X_L and X_C in a parallel configuration. Z_{series} is the impedance due to reactance X (either X_{series} or $X_{parallel}$) and resistance R in a series configuration, and $Z_{parallel}$ is the impedance due to reactance X (either X_{series} or $X_{parallel}$) and resistance R in a parallel configuration.

Given this information, you should find it reasonably easy to create an Excel workbook to produce the requisite graph of impedance against frequency. The user interface would be the sort of thing we've seen before in this series, i.e. the user would be expected to type values for R, L, C etc. into labelled cells. However, this really isn't ideal. For example, if the purpose of the workbook is to give people information relating to the use of real, off-the-shelf components, we might want to restrict the component values to the ones actually available. So, for example, in the case of resistors we'd be looking at 1R, 1R2, 1R8, 2R2, 2R7, 3R3, 3R9, 4R7, 5R6, 6R8, 8R2, 10R etc. up to, perhaps, 100M. We could put in some sort of error checking which would print a warning message in an adjacent cell if a non-standard value was entered but surely there's a better way. Not only this, but it's not exactly user friendly to insist, for example, that the user enter "4.7E-11" for 47pF. The solution I've adopted here is to provide a pair of pull-down menus for each of the variables, one containing all the permissible values (e.g. 1, 1.2, 1.8, 2.2, 2,7 up to 820) and the other the permissible units (e.g. W, kW, MW). Similarly, option buttons have been provided to allow the user to select one of four circuit configurations, each of which is shown using a circuit diagram. Here I describe how I created the spreadsheet and this includes details of two types of control, the combo box and the option button. However, there are lots of other controls that could be useful in various circumstances so I suggest you experiment with the others too. The information provided here should give you a head start in learning to use buttons, check boxes, list boxes, scroll bars and so forth.

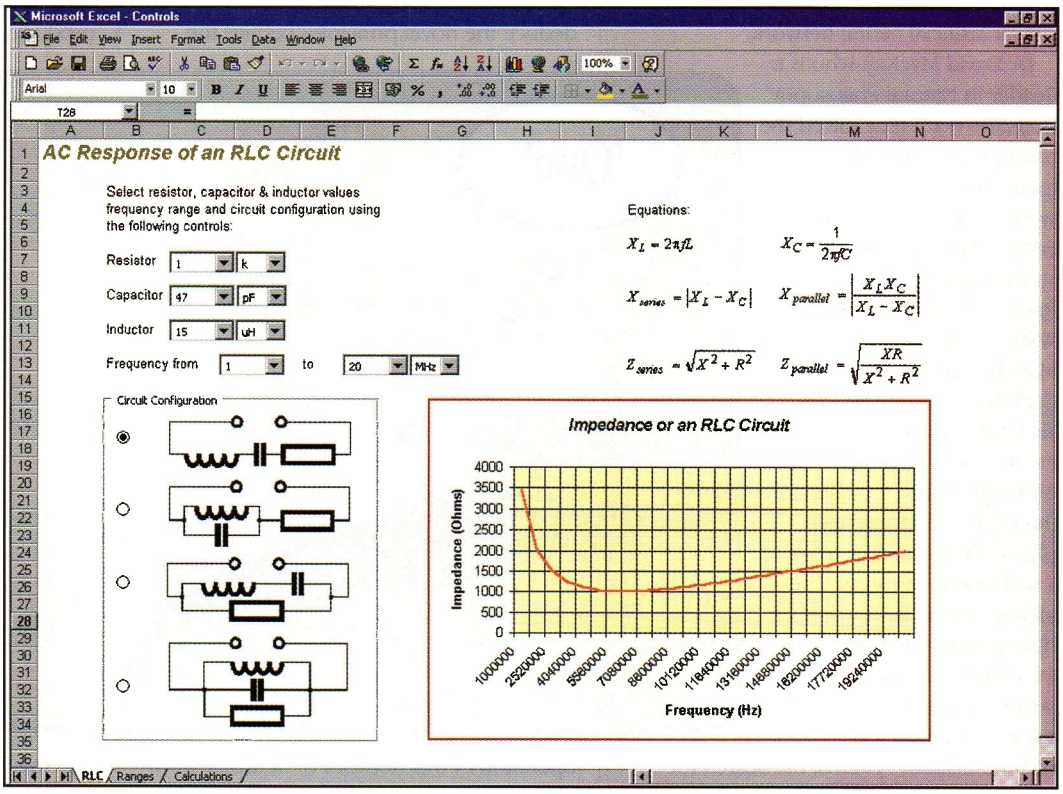
To return to this example, though, the first job is to rename the default three worksheets. This isn't absolutely necessary but it is more intuitive to use sensible names. I chose RLC, Ranges and Calculations for reasons that will soon become obvious. The first of these worksheets, RLC, is the only one that the user needs to see, the other two are for behind-the-scenes purposes. By putting the workings on the second two worksheets, the main user interface isn't cluttered up with irrelevant information. A screenshot of the RLC worksheet is provided so you can see how I've laid it out. I'm not going to describe everything in detail here but I will show you how I created the user interface for the resistance and the circuit configuration. Everything else follows much the same pattern.



First of all you need to display the Forms toolbar which you'll find at View > Toolbars > Forms. A screen shot of this toolbar is reproduced here. Now we need a

	A	B	C	D	E	F	G	H	I	J	K	L
1	Resistor Units		R	1.00E+00		Resistor Values		1		Capacitor Values		1
2			k	1.00E+03				1.2				2.2
3			M	1.00E+06				1.5				3.3
4								1.8				4.7
5	Capacitor Units		pF	1.00E-12				2.2				10
6			nF	1.00E-09				2.7				22
7			uF	1.00E-06				3.3				33
8								3.9				47

combo box for the resistance value so click on Combo Box – this is the 8th icon in the toolbar – and the cursor will change to crosshairs. Move the cursor to where you want the top left corner of the combo box, hold down the left mouse button and drag to the bottom right corner. It doesn't matter if you're not too accurate as you can easily fine tune the position and size later. Now you need to define the list of values which will appear when the user clicks on this control. So, starting in $H$1 of the Ranges worksheet and working down the column, enter the following values: 1, 1.1, 1.5, 1.8, 2.2, 2.7, 3.3, 3.9. 4.7. 5.6, 6.8, 8.2, 10, 11, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, 100, 110, 150, 180, 220, 270, 330, 390, 470. 560, 680, 820. While you're here, you can also enter the permissible values for the resistance units, namely R, k and M, starting in $C$1 and working down the column. And starting in $D$1 and working down the column, enter the corresponding multipliers for these units, i.e. 1E0, 1E3 and 1E6.



Now you're in a position to define the operation of the list box, which you created on the RLC worksheet. So, right click on it and select "Format Control..." from the menu which is displayed. Select the Control tab from the Format Control window which is displayed and enter "Ranges!$H$1:$H$36" into Input range. Now all that's needed is to define the cell into which a value will be deposited when the user selects an entry from the drop down menu. To do this, enter "Calculations!$B$4" into "Cell link". Now you can test this out. Click on the combo box on the RLC worksheet and select a value, say 22. Now take a look at cell $B$4 in the Calculations worksheet and you should find that it contains the value 17 because 22 is the 17th value in the list. What we really need, though, is the value 22 rather than 17. To achieve this we use the Offset function, which determines the value at a row and column offset from a specified cell. Specifically, type "=OFFSET(Ranges!$H$1,B4-1,0)" into cell $C$4 of the Calculations worksheet. The value 22 will now appear in this cell. Now do the same for the resistance units, this time using "Ranges!$C$1:$C$3" as the input range and "Calculations!$D$4" as the link cell. Also enter "=OFFSET(Ranges!$D$1,D4-1,0)" into cell $E$4 of the Calculations worksheet to pick up the multiplier associated with the unit chosen. Finally, enter "C4*E4" into cell $F$4 of the Calculations worksheet to evaluate the actual resistance which corresponds to the value and units selected. Much the same procedure, but with different lists of values and units, is used for the capacitance, inductance and for the lower and upper limits of the frequency range.

The selection of the circuit configuration is rather different – this time we use option buttons. Put four option buttons onto the RLC worksheet – this is the 6th icon in the Forms toolbar. Now drag a group box around them – this is the 3rd icon in the Forms toolbar. Select the group box and then click into its title text and change this to "Circuit Configuration". Similarly edit the text associated with each of the option buttons, this time removing the label completely since the user is going to identify the circuit configuration by a circuit diagram rather than a convoluted textual description. So, create the four circuit diagrams, either using a separate drawing package or Excel's draw facility, and position one next to each of the option buttons. Now right click on any one of the four option buttons and select "Format Control..." from the menu, which is displayed. Select the Control tab from the Format Control window which is displayed and enter "Calculations!$C$10" into Cell link. All being well, if you now try clicking on the option buttons on the RLC worksheet you'll find that either 1, 2, 3 or 4 will appear in cell $C$10 of worksheet Calculations, the number corresponding to which of the buttons had been clicked on. From here on everything should be plain sailing – the screen shot of a portion of the Calculations worksheet should provide some guidance. Oh, and as one final suggestion – since the user won't end up typing anything at all into cells, the grid need not be displayed and the worksheet will look better without it. The 11th icon on the Forms toolbox causes the grid to be toggled on the current worksheet.

You can download this, and all the other Excel workbooks used as examples in this series, from our Website at: **www.electronicsandbeyond.com**.

Silicon Mouse BRAIN COMPETITION

by Reg Miles

A group from the Cavendish Laboratory in Cambridge has won two related competitions set by two researchers in America, John Hopfield of Princeton University and Carlos Brody of New York University. The first was to explain how their simulated mouse brain, 'mus silicium', could recognise ten words with one thousand neurons; the second required entrants to construct their own similar artificial neural network.

Dr David MacKay, who is a Reader in Natural Philosophy, leads the team that solved the brain puzzle. The other members of his group are postdoctoral researcher Dr Sanjoy Mahajan, and graduate students James Miskin, Ed Ratzer, David Ward and Seb Wills. Dr MacKay and Dr Mahajan have PhDs from the California Institute of Technology, where they worked with Hopfield. Although all the members of the inference group have physics degrees, they work on a wide range of topics. These include: the development of human-computer interfaces for disabled users, the development of error correcting codes for communication systems, the search for gene expression patterns in data from cancer patients, and research into effective physics teaching methods.

Dr MacKay and his research group heard about this competition, and they cracked the computational principles underlying 'mus silicium' after a one-hour brainstorming session. 'I knew we had solved it' said Dr MacKay, 'when our tentative explanation started predicting curious details in the recordings from the 'brain'.' The winning entry to the second part of the competition, the search for the best-simulated brain, was developed by Seb Wills using the principles deduced for the first competition.

The runner up in Contest A was Benjamin Rahn, a graduate student at the California Institute of Technology, who deduced the same answer but later. No other entry in Contest B applied the same principles as 'mus silicium'.

The motive for presenting the material in competition form was to pose the question, 'Given the quantity of diverse data now available in neuroscience...to what extent is a deductive approach becoming useful in neurobiology?' by comparison with the more typical 'guesstimating'? The challenge was to deduce the novel principles behind the operation of this network of neurons, from observations of the behaviour of the neurons - the usual problem faced by brain scientists. However, by posing an artificial problem within a well-defined environment and with a known, clear answer, the challenge provided an idealised test case for finding principles underlying the behaviour of neural systems. According to Dr Hopfield the contest was intended to 'provoke neuroscientists into thinking about thinking'. The principles underlying the operation of the system are new. Hopfield and Brody believe they shed light on how the brain recognises auditory and visual patterns, and how it makes decisions.

For Contest A the entrants had to write a 750 word essay describing the principles deduced from the experimental results presented in the Hopfield-Brody paper. For Contest B the entrants had to build an artificial neural network, of approximately the same size, complexity, and biological plausibility as mus silicium. The prizes in both Contest A and B were the same: the winners each received $500 and a Handspring Visor handheld computer signed by Jeff Hawkins, inventor of the Palm Pilot and founder of both Palm Computing and Handspring, the runners up each received $200 and a Visor. Hawkins has long been interested in the brain, and when he learnt about the competition, he volunteered to personally fund the prizes.

The 'brain' recognises a spoken word by its features, such as sequences of pitch, in their correct order. In operation this is translated into the coincidence of the firing rates of a set of neurons whose firing rates decay linearly over time, at different rates of decay. An early feature will cause a slow decay neuron to fire and a late feature will cause a fast decay neuron to fire). Thus producing firing rates that coincide at the end of the word (no matter that it is spoken more quickly or slowly by comparison with the same word that it was 'trained' to recognise). This transient collective synchronisation, representing `many neurons now agree', is detected by a cell with a small time constant that produces a burst of noise as a recognition signal.

The winning 'brain' used 800 neurons, divided into 400 excitatory (alpha) and 400 inhibitory (beta) neurons. And was further divided into ten 'split brains' to cope with the words from one to ten that it was required to learn and recognise.

According to the organisers, 'We believe that the 'many variables are approximately equal' operation and computation by 'transient synchrony' are powerful additions to the arsenal of neural computational principles. We would not have put forth a competition, encouraging others to spend time on an artificial system, had we not believed so. We hope that all who seriously considered the system will have found some benefit from having done so.'

The winning group are donating the prize money to the campaign to free Sally Clark, the mother who lost two babies to cot death and was then convicted of murdering them, on the grounds that it is highly improbable that two cot deaths should strike a single family. But then justice is inherently irrational, based as it is on the erroneously held belief in free will.

'Orange at Home' house

TECHNOLOGY WATCH

With Martin Pipe

So what will the home of the future be like? Compared to today's dwellings, it will be rather more 'wired' - or should I say 'wire-free', if mobile phone network Orange has its way. Last year, Orange purchased a detached house near an industrial estate in Hatfield, Hertfordshire. A few months - and £2m - have transformed it into a stylish interactive haven. It's all part of an ongoing research programme designed to test, monitor and evaluate new services and products that could make life better - or, at the very least, put you more in control with your surroundings. In conjunction with the Universities of Surrey and Portsmouth (but, funnily enough, not the local Hertfordshire), Orange will establish how consumers will interact with these new technologies, and determine how (if?) they can be marketed. Orange plans to invite families to live in the energy-efficient domestic testbed for six weeks at a time. With the family's consent, cameras dotted around the house will record - Big Brother-style - their reaction to the technology. Orange hope to determine which elements are desirable, which ones are not - and which areas need further development.

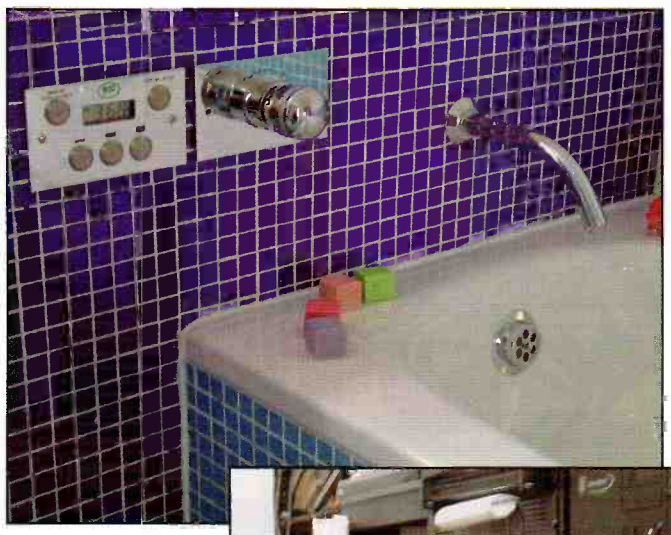
So why exactly is Orange doing this? Building intelligent homes may be fun, but it hasn't anything to do with mobile phones. Or has it? In common with other mobile networks - none of which are, to the best of my knowledge, carrying out experiments of this type - Orange recognises that voice communication is not the only way of making money through your expensively-installed (and expensively-licenced) network. Mobile data and fax have, for some time, been popular among business subscribers. Even the consumer market has taken some non-voice mobile technologies - SMS springs immediately to mind - to its collective heart. The networks have pushed WAP towards subscribers with high-profile marketing, but content limitations and a frustrating user interface have made it less than appealing. GPRS and 3G will improve matters by increasing data rates above the sluggish 9600bps currently offered by GSM data.

Left: Entry door phone and camera.
Below: User interface via wireless PDA

To take advantage of increased data-friendliness, mobile phones will become more PDA-like and better designed to handle information services. One such phone that has already come onto the market is Motorola's Accompli 008 GPRS handset, which has a large stylus-operated screen, WAP, Internet e-mail support, handwriting recognition and all sorts of other interesting features. I've had the chance to play with one of these for a few days, and see it as the way forward. In time, you could use a device of this sort for composing e-mail or accessing information portals (in the future, these won't be the staid text-only affairs of current WAP offerings, but ones able to carry fancy colour imagery, links to streaming audio and video, and much else besides). But that, if Orange has its way, is just the beginning. Imagine being to access your

home network via an intelligent agent, and monitoring security cameras, scheduling (and indeed playing back) video recordings or retrieving shopping lists and other personal information?

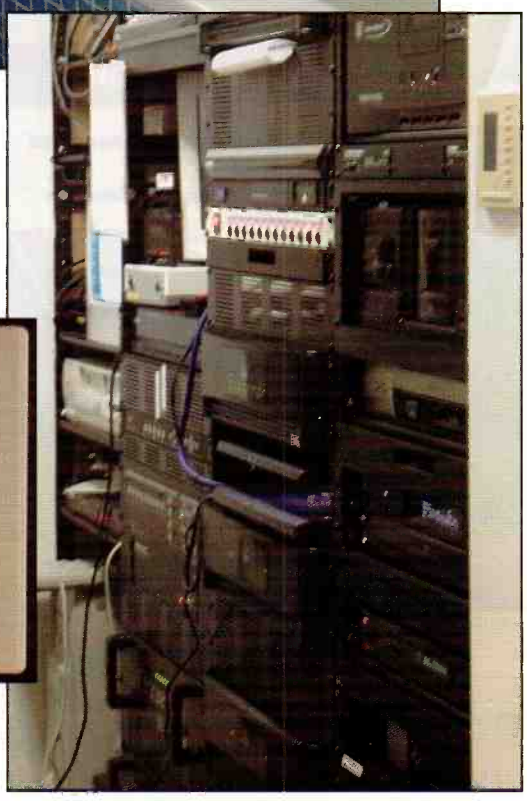
Some of the Orange applications fall within the low-bandwidth capabilities of today's mobile technology. The house has an electromechanical lock, instead of the standard key-operated variety. Householders will be able to use a Bluetooth device, such as a PDA, to open the door by entering a PIN - Orange has also mentioned a purpose-designed electronic keyfob. If these devices have been lost (or their batteries have run out - not a problem, it has to be said, with a boring old key!), a mobile phone could be used to get in by dialling into the house's main computer - which acts as a WAP server - and entering the code. Presumably, Orange has introduced some kind of fail-safe provision. One could imagine all kinds of disasters caused by a power failure or a server crash! But there are advantages. If somebody needs to be let in (a workman or child-minder), then a special one-off entry code could be issued to them. Another common occurance - and one set to become even more so in as e-tailing takes off - is home delivery of goods. Like the 'Screenfridged' Stockholm 'smart-houses' detailed in Electronics and Beyond a couple of issues ago, the Orange dwelling is equipped with a secure delivery unit for storing purchases. The BearBox chosen by Orange is opened by PIN code, records each delivery and informs the householder by means of an SMS message.



Above: Home cinema in the master bedroom.
Left: Eco controls for automatic bath fill at a pre-set temperature.

Temperature control panel

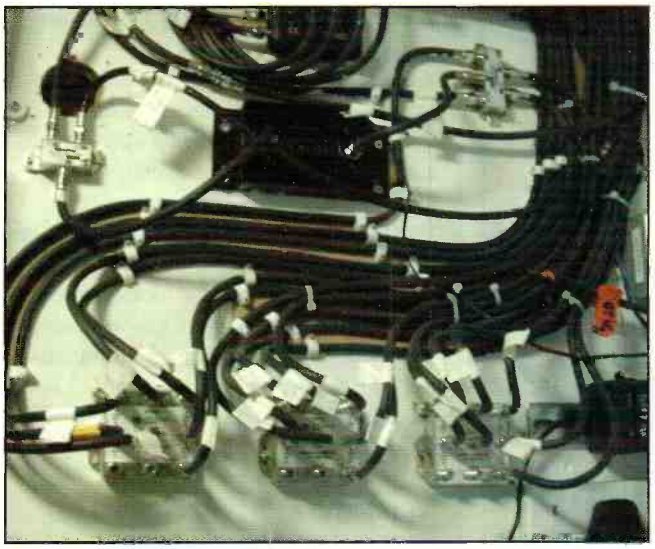
Family members, working or otherwise, will be able to access information and control a number of different home systems and appliances through various wire-free devices – including an Orange WAP phone, wireless touchpad and radio-networked PDAs. Most of these user interfaces were developed using Java. Dotted around the house are other approaches to the house user-interface - wall-mounted touch-panels,



Above: Operations centre

networked PCs, and a voice-recognition system that is presumably based around Orange's 'Wildfire' technology. Unfortunately, the latter proved to be somewhat slow and unresponsive when I paid the house a visit - it took some time for the lights or washing machine to be turned on. Still, it's early days yet; faster computers and further software development should improve matters. Indeed, the house's technology is in a state of flux. Orange plans to update and improve it as seen fit.

50 companies, including Compaq, Intel, Sony and Dyson, have contributed technology that has been adapted (where relevant) and integrated into the Orange house. It's all hooked up by miles of expensively installed wiring - which is ironic seeing that Orange is committed to a wirefree vision! Bluetooth, and other similar technologies, could eventually address this issue. Like many affluent houses, Orange's has four bedrooms, a study, a conservatory and a gym. Unlike most houses, though, every room seems to have some kind of video-monitor in it. Of these, I only saw one 'conventional' cathode-ray tube, in the 'family room' - well, they're old hat, aren't they? A LCD projector serves the master bedroom, while the conservatory benefits from a plasma-screened monitor. In the study and bedrooms, access to TV channels and security cameras is via a 17in. TFT LCD computer monitor equipped with TV tuner and video inputs. Where there are computer monitors there are, of course, computers. All can tap into the home network via a specially developed web site, and can access the Internet for work, education and entertainment. The home network features an intelligent 'agent' developed by Ananova. Each user can set up their own profiles, covering areas that include home banking, news/entertainment delivery and 'e-learning'. Orange sees the



Above: Not quite wireless

Right: Waterproof speaker

Internet as providing a crucial link between home and school. The house is connected permanently to the Internet via a broadband leased-line (cable and ADSL aren't, apparently, available in the Hatfield area yet).

To conserve energy, the house is split into 16 independent 'zones'. This is particularly useful, because each zone may require different heat and light levels according to ambient conditions and each family members' preferences. Each radiator is equipped with an 'intelligent valve actuator', which replaces the time-honoured thermostat. Powered by a motor, this device can be interfaced to electronic control systems. In the case of the Orange system, each zone is equipped with its own control system. A panel set into the wall has a temperature display, and buttons that allow the user to set temperature and occupancy time. Feedback is, in each case, provided by a temperature sensor. Remote or home network control of the heating system is possible - the company that developed the system, SeaChange, has provided a Web/WAP server that allows users to monitor the heating levels and make changes. If you want to come home to a warm house, but want to avoid wastage, you can! If you want to run a bath so it's ready the moment you return home, the Orange house - through the use of electrically-controlled valves - will let you do that too!

The bath itself will fill to a preset level and provides a readout of water temperature. Its waste 'grey' water is - together with that of the shower and basins - cleaned up, and used to flush the toilet or water the garden. Orange claims that its system can reduce consumption by up to 40%. At a more basic level, the toilets give you a choice of 'full' or 'economy' flush - judicious use of the correct setting can save considerable amounts of water over time. Other resource-saving ideas include a heat exchanger, which is fed with stale air extracted from the bathroom and kitchen - the heat thus recovered is used to warm up fresh air. Solar power also makes an appearance in the Orange house. The conservatory's glass roof is, in fact, a photovoltaic array that occupies 19m^2 of area and generates up to 1.5kW of power. Orange reckons that the solar power could produce up to 1200kWh per year. An adjacent area of the roof is fitted with six square metres of 'solar collectors'. These tube-like devices work in conjunction with the house's Viessmann Vitola boiler to heat water. Orange estimates that 60% of the energy thus required could be derived from the sun. A feature that will appeal to gardeners is its automatic watering system. A series of sensors buried in the earth measure moisture levels; if it's found to be too dry, the sprinklers are automatically powered up.

The AV systems built into the house are also worth a mention. Installed by CEDIA member SMC, the system in the master bedroom is based around a Sony 16:9 LCD projector and motorised screen. Dolby Digital surround sound is relayed through five KEF speakers recessed into the ceiling, and driven by Bryston amplification. The front and centre speakers are mounted on the area of ceiling just in front of the screen, while the rear speakers point down towards the headboard end of the bed! They're motorised, and in use angle towards to the listener. Not as good as conventional speakers dotted around the walls, no doubt, but we can imagine that Orange placed unobtrusiveness and styling over absolute sound quality! Further proof of this compromise situation is that no subwoofer has been installed! The main programme sources – DVD and Sky Digital – are located in a downstairs room packed with equipment. To avoid the obvious problem of having to traipse downstairs for a disc change, a 5-disc Denon DVD changer has been specified – the movie of your choice can be selected via a touch-screen remote control. We hope that Orange replaces the current player with Sony's 200-disc changer at some point, just in case any of the families happen to be movie fans! Note that other AV sources (including radio) can be experienced through the bedroom system, and that all of them can be routed to other rooms in the house at the touch of a remote. Not that music is restricted to the house - there are also speakers in the garden, disguised as rocks. Just the thing for barbeques, or should you just want to escape from all that electronics

Family room

for a short while...

But it's not all play, education and domestic convenience, though - there's work too! To this end, one of the rooms within the house has been set aside as a study, with videoconferencing and fax facilities. Not that you're tethered to the study - the 1.5Mb/sec wireless LAN means that office work could be conducted in the garden on warm sunny days, with some kind of portable computer. Orange has stipulated that the breadwinner of all target families must already work from home - surely that's preaching to the converted? In my opinion, the experiment would be more valid if you took a regular office-worker and isolated him – in all aspects other than the virtual - from his colleagues for six weeks! There are also some odd instances of technology that are nothing more than expensive gimmicks. Take, for instance, Sony's electronic picture frame. This device takes images from a digital camera (Memory Stick, of course) and displays them on a TFT screen. Another rather odd choice is the placement of an 'electronic whiteboard' in one of the kid's rooms. You'll find these £1000-plus (and likely to stay that way!) devices in many boardrooms - any sketches made with a felt marker are simultaneously transmitted, via serial link, to a computer and thereby to a projection display. And how is Orange using this professional equipment?

Nursery with baby monitoring facilities in the pillow

Conservatory at night with PV panels in roof

Room controls

Proving nothing more than the ease through which Junior's infantile doodlings can be e-mailed to Aunt Maud, or whoever... A cheap graphics tablet would do the same job, but that wouldn't be anywhere as impressive - particularly if you're trying to woo potential investors! In some senses, the house could be better integrated. There are too many different protocols - and several boxes could be replaced by one that does everything! As time goes by, a solution may well be found.

Many of the ideas demonstrated by the Orange house is worth experimenting with - a lot of what we saw was clearly very expensive and aimed at society's better-off. You can buy ICs that decode the DTMF tones sent by most telephones whenever a keypad button is pressed - these could be used to drive relays that switched on or off various appliances (such as heating or lights). As a matter of fact, some of the appliances in the Orange house - such as the coffee-maker - are controlled by simply applying or withdrawing power in this way, courtesy of a system known as LonWorks. A simple VCR system that could allow you to change channel, or invoke the OTR timer, via a hacked remote-control handset is another possibility. OK, you must remember to put a blank tape into your machine before you leave the house - but, even with £2m of technology at their disposal, residents of Orange's house must remember to fill the coffee-maker before going to bed! You could even ally a DTMF-based system with spoken confirmation of the desired effect - by means of a voice-synthesiser IC, or audio burnt into EPROMs and feeding a basic R-2R ladder DAC.

A telephone answering machine could form the basis of such experimentation - these would provide the line interface and automatic-answering capabilities for very little cost. If you're scared of modifying BABT-approved equipment, a microphone placed over the answering machine's speaker could decode the tones as the 'call' is answered and recorded. Unfortunately, there would be no way of confirming that the intended action had been carried out. Electrically-operated solenoid valves can be acquired cheaply (salvaged from redundant washing machines from your local rubbish tip, perhaps) are useful items - and essential if you wanted to design equipment that automatically quenched your garden's thirst during those hot summer days. They could also form the basis of a system that filled your bath. A temperature sensor, plus valves fitted to both hot and cold supplies, would ensure the water was comfortable. It shouldn't be too difficult to build in a water-level sensor to prevent over-filling (some kind of ball-cock lash-up, perhaps?).

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

PV Solar panels and solar water collectors

This bulk pack offers fantastic savings over individually cased CDR's, ideal for your music, MP3's, digital pictures and backups. Each individual disc for under 30p. Exclusively available from Maplin Electronics!

100 Pack CDR Media

- 100 CDR Shrinkwrapped
- 8x rated media
- Exceptional value
- 650MB or 74 minute capacity

Order Code: ZW49D

SAVE £5
WAS £29.99
£24.99
100 PACK
CDR MEDIA

MAPLIN
ELECTRONICS

Order yours today! call
0870 264 6000

quoting ref AD078. Also available from Maplin stores and from our web site at www.maplin.co.uk. We accept the following cards for telephone orders

Seriously Easy Tools

ST7 Starter Kit - 42/56 pin

£109

- ST7 Flash, OTP & EPROM development environment.
- Supports 42/56 pin devices.
- Programming IDE, Professional Assembler, Full function editor
- In-circuit Simulation, Application Builder

STK200+

£39

- Simple In Circuit Emulation, single step and run to breakpoint.
- Supports ALL AVR products including 8-pin, 20-pin, & 40-pin devices except MEGA range

The STK200+ is an ideal design platform for taking your AVR design from conception to realisation.

AVR ISP Super

£99

- The Perfect Production Programmer for AVR Flash devices.
- Super Fast ISP via your USB port.
- Connect up to 127 programmers from one PC.
- Autodetection of new devices DLLs for embedding into your own software

Palm Eraser

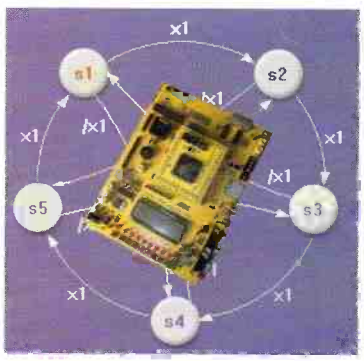
£40

The Palm-Erase is the perfect Solution for the tech on the go. Erase EPROMs from24 to 40 pins in 5 minutes or less.
Dimensions: 2" by 4" by 2"
UV elements: one,

FPGA Training System

£465

- Interactive VHDL Tutorial on CD-ROM
- Onboard hardware peripherals
- Expansion socket for extra user
- Programming Software
- "Get going with FPGA" book on CD-ROM
- Including latest generation FPGA (AT40K20)



Shooter III

£199

- Portable, battery powered.
- Hand-held Programmer/Copier
- Small, fast, easy to use and economical
- Optional PC connection
- High voltage programming (Vpp)

Kanda Systems Ltd. Units 17/18, Glanyrafon Enterprise Park, Aberystwyth, UK. SY23 3JQ. Tel: +44(0) 1970 621 030, Fax: +44(0) 1970 621 040, Email: Sales@Kanda.com, Internet: www.kanda.com