# ELECTRONICS and Beyond

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MAPLIN ELECTRONICS

SEPTEMBER 1999 NO. 141 £2.65

The International Space Station & Space Tourism

The Latest PersonalScope from Velleman

Servicing a Revox

## A House for the Future

A look at the technology within

## PROJECTS FOR YOU TO MAKE

Ultrasonic Detector

High Fidelity Class AB1 Valve Power Amplifier

Wind Speed, Direction & Temperature Indicator - Mark II

Measuring Small Temperature Changes


**Britain's most widely circulated magazine for electronics!**

THE MAPLIN MAGAZINE

# ELECTRONICS and Beyond

September 1999 Vol. 18 No. 141

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# ELECTRONICS and Beyond

I recently had the good fortune to visit the Building Research Establishment at Watford, primarily to see the eco-friendly house that featured in the BBC TV series *Dreamhouse*. Although the house appears to be an experimental prototype, it does show us what is possible, and the energy savings that can be made. You can read more about the *Integer House* in my article on page 7.

For those of our readers who remember reel-to-reel audio tape recorders, Martin Pipe has written an interesting article on restoring an old Revox tape deck. It is true to say that Revox produced the best semi-professional tape decks, and were designed to have a very long and reliable life. Such tape decks are still available and Martin gives suggestions as to where to find them.

On-line ordering, via the Internet, is set for rapid growth, and we at Maplin have joined the club. You can now order items from the current catalogue over the Internet. The one big advantage of the Maplin site is that you get confirmation that your selection is in stock.

If you prefer to shop in person then the latest Maplin store has now opened in Dublin, at Units 1-4, The Smyths Building, Jervis Street DUBLIN 1.

## Congratulations..

Go to Nyuk Shiong Ho of Plymouth, Devon and Stephen Stopford of London, who's names were picked out of our hat in our July issue 139 draw, and will be receiving a portable soldering iron from Antex. Well done!


## Britain's Best Magazine for the Electronics Enthusiast

# NEWS REPORT


## Motorola Handset Wins Gold for Industrial Design Excellence

Motorola has been honoured with a gold award in the Business and Industrial Products category of the 1999 Industrial Design Excellence Awards (IDEA) for the i1000 integrated digital handset.

The Motorola i1000 handset combines the capabilities of a digital cellular telephone, two-way radio, text messaging and data capabilities into a single, palm-size handset.

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

Contact: Motorola, Tel: (01293) 404343.

# MIT Researchers Help Create Map Of Mars Terrain


Researchers have known for some time that Mars has a deep dent in its southern hemisphere. But until recent measurements yielded a highly accurate, global map of the red planet's topography, they didn't know that the Hellas basin could swallow Mount Everest, or that the asteroid that caused the crater hurtled debris as far as 2,500 miles across the planet's surface.

"Probably the most unexpected finding was how much the Hellas impact basin dominates the topography of the southern hemisphere," said Maria Zuber, Griswold Professor of Planetary Sciences at the Massachusetts Institute of Technology. Another major finding is the planet's dramatic slope from its south to north pole. This would have significantly affected water transport and cycles on the planet, she said, leading to ponding of water in certain places.

Zuber and three other MIT researchers are part of a team of 20 scientists who created a global grid of Mars based on data from the Mars Orbiter Laser Altimeter (MOLA), an instrument on the Mars Global Surveyor spacecraft. Their work, published in the May 28 issue of the journal Science, is expected to lead to new insights about how Mars evolved over the past 4 billion years.

The map is expected to give scientists the basis for many years' worth of further exploration and definition of the red planet. "The most significant aspect of the data is that it is going to allow us to reconstruct the evolution of the planet," Zuber said. "From the shape of the surface and information on gravity, magnetics and surface composition, we can model the internal structure and the planet's thermal evolution. These models bear closely on the history of climate and water.

"It is going to take some work, but the potential is there to construct and evaluate models of the planet as a global system. This is an extraordinary opportunity to study how the different parts of a planet influence and are affected by other parts," she said.

For further details,
check: **<web.mit.edu>.**
Contact: Stanford University,
Tel: +1 617 253 1000.

# Small is Big for Digital Camera

The Fujifilm MX-2700 Digital is reckoned to be the world's smallest 2.3 million pixel digital camera. The MX-2700 features a 35-mm equivalent lens with macro capability and carries an impressive 1,800 x 1,200 resolution, boasting one of the highest pixel counts available.

Depending on the image compression selected: fine, normal, or basic, the MX-2700 can record 8, 17 and up to 35 images respectively on bundled 8MB SmartMedia card in 1,800 x 1,200 mode, and similarly 47, 90, and up to 142 images in 640 x 480 mode.

For further details,
check: **<www.fujifilm.co.uk>.**
Contact: Fujifilm, Tel: (0171) 586 5900.

# NEWS BYTES

## Terminal Tantrums

Office workers are getting increasingly frustrated with their computers, according to a Compaq-sponsored survey from research firm MORI, and the frustration is leading to high rates of computer abuse.

Among the typical forms of abuse are swearing at PCs, physically hitting or kicking the computer, bullying the IT department, absenteeism, and bad-mouthing at the employer.

Workers said computer or software problems cause more than one interruption in work each day, and many said it often takes more than an hour to fix the problem.

For further details,
check: **<www.compaq.com>.**
Contact: Compaq,
Tel: (0845) 2704222.

## Intel Moves To Bigger Chips

**Intel is refurbishing its production facilities to accommodate a change to 300mm diameter silicon wafers - a move that promises to double production volumes while cutting manufacturing costs by a third. Currently, Intel and other chip makers use 200mm wafers as the base material for integrated circuits. The first facility to use the 300mm technology will be a new £700 million plant in Oregon.**

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

## 3Com Forms Wireless Company

3Com and Aether Technologies have formed a partnership to create a new company called OpenSky that will focus on developing wireless technology to support corporate e-mail, Web use, and company-wide information sharing via a wide variety of mobile devices, such as 3Com's own Palm Pilot handheld personal digital assistants.

For further details,
check: **<www.3com.com>.**
Contact: 3Com,
Tel: (0118) 927 8200.

## Nokia Embraces a Plan to Unify Third Generation Mobile

**Nokia has announced its support for a framework that would bring a harmonised, global standard for third generation communications technology worldwide. The proposals, put forward to the International Telecommunications Union TG8/1 meeting in Beijing, China, would provide a single wideband CDMA standard, harmonising both WCDMA and cdma2000 systems.**

**For further details,**
**check: <www.nokia.com>.**
**Contact: Nokia,**
**Tel: (01480) 434444.**

# NEWS BYTES

## Be and Echo Break Through Audio Performance Barrier

**Be has expanded its audio driver capabilities through a development partnership with audio technology leader Echo. Digital media producers using Echo's Layla, Darla, and Gina multi-channel audio peripherals and BeOS will experience unprecedented levels of performance with their multi-tracking audio software.**

**Each product offers multiple 20-bit analogue input and output; Layla and Gina give users additional flexibility with digital input and output. Echo will bring 24-bit, 96k audio capabilities to their products in Autumn 1999.**

**For further details, check: <www.beos.com>.**
**Contact: Be, Tel: +33 1 55 91 77 30.**

## Tweeter Achieves Improved Performance

Boston Acoustics has received a patent for its new high power tweeter. The high power tweeter design utilises a sub-compact magnet assembly built around a miniature high-energy neodymium magnet, instead of a conventional bulky ferrous magnet. This improves speaker performance by allowing the tweeter to be placed physically right next to the woofer, resulting in superior sound quality.

For further details, check: <www.bostonacoustics.com>.
Contact: Boston Acoustics, Tel: +1 978 538 5000.

## WordPerfect Office 2000 Available

**After nearly two years in development, Corel's flagship package WordPerfect Office 2000 is available to consumers who will have the opportunity to experience the future of office suite productivity. With this latest release Corel has concentrated on delivering greater performance, increased compatibility, and value for money.**

**For further details, check: <www.corel.com>.**
**Contact: Corel, Tel: (0800) 973189.**

## No Phone Jack? No Problem

3Com has introduced the 3Com Megahertz 56k global GSM & cellular modem PC Card. It is a modem that gives laptop users fast and reliable access to corporate networks and the Internet - whether connecting via standard phone lines or the most popular cellular and GSM phones. It also features 3Com's durable XJACK connector for easy, dependable phone connections without additional cables.

For further details, check: <www.3com.com>.
Contact: 3Com, Tel: (0118) 927 8200.

## Sun Shows Ultra First Silicon


Scott McNealy, chairman and CEO of Sun Microsystems has shown the first working sample of Sun's new UltraSPARC III computer processor.

Featuring 64-bit next generation architecture, the high performance UltraSPARC III family of processors will have a clock frequency beginning at 600MHz to be utilised in systems with up to 1000 processors working together in the same server. Volume production is expected by the end of 1999.

For further details, check: <www.sun.co.uk>.
Contact: Sun, Tel: (01276) 451440.


## Java to Drive Palm Pilots

Sun and 3Com have cut a deal that will allow 3Com to use Sun's Java operating system on 3Com's Palm Pilot handheld computers. The alliance will help both companies ward off competition from handheld devices that are based on Microsoft's Windows CE operating system.

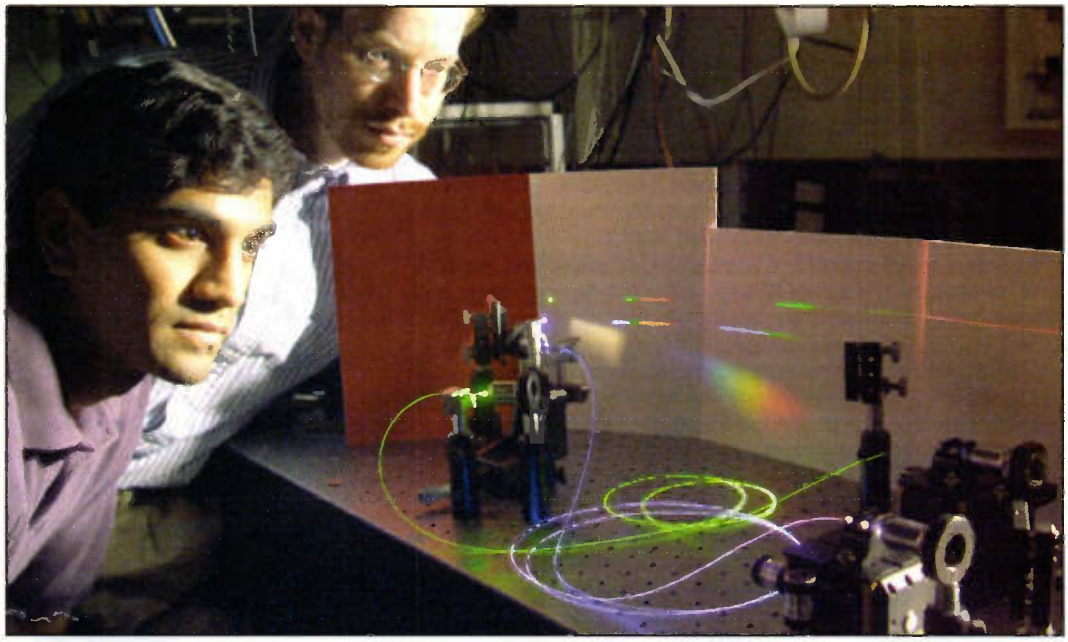
For further details, check: <www.3com.com>.
Contact: 3Com, Tel: (0118) 927 8200.

## HP Unveils New Line of PCs

Hewlett-Packard has announced three HP Pavilion PCs that feature a new design; broadband capabilities; expanded customer service and support; and, on HP Pavilion 8000 PC series, a new one-touch multimedia keyboard.

The HP Pavilion 8570c PC has a smoky translucent panel incorporated into the front of its tower. The new multimedia keyboard is designed to work directly with ISP's services such as AOL and Yahoo.

For further details, check: <www.hp.com>.
Contact: HP, Tel: (0990) 474747.



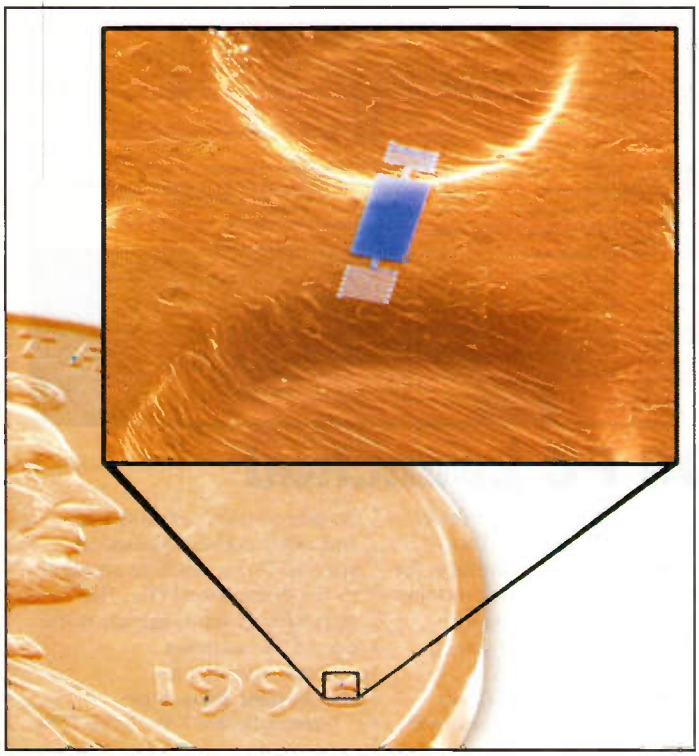
# Advancing Physics by Making Rainbows

Lucent Technologies Bell Labs researchers Jinendra Ranka and Robert Windeler have invented a novel optical fibre that converts a single colour of light into all the colours of the rainbow - from invisible infra-red to red, orange, yellow, green, blue and violet - as it travels through the fibre.

Our photo shows two of the fibres in lab experiments, generating light that is very tightly confined to a narrow beam in each fibre's core. It is surrounded by a glass microstructure with air holes in it that cause unusual dispersion and low loss.

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

Contact: Lucent,
Tel: (01252) 391600.



# Grain of Sand Oscillator

The tiny device shown magnified here is a fully functioning oscillator used to study the effect of magnetic fields on materials. The oscillator, created at Lucent Technologies' Bell Labs, measures about a hair's thickness in length and half that distance in width - or roughly 0.004in. by 0.002in.

The oscillator, which vibrates up to 50,000 times per second, belongs to a new class of devices known as micro-electro mechanical systems (MEMS), which are tiny machines smaller than a grain of sand. Bell Labs is developing MEMS devices as optical switches for communications networks and components for wireless handsets.

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

Contact: Lucent,
Tel: (01252) 391600.

# Will Wireless Win?

A new report entitled 'Will Wireless Win? Prospects for a Wire-Free Future' has been published by telecoms consultancy Analysys.

The report analyses the strengths and weaknesses of wireless technologies, such as cellular, satellite, Bluetooth and DECT, in three key markets voice services over public networks; data services over public networks; and private networks.

It also looks at the potential for wireless services in business and residential markets.

"The ability of wireless, and in particular cellular operators, to substitute wired telecoms services will be an important driver in maintaining high growth rates," says report co-author, David Wilkins. "Success will depend not only on their ability to compete with wired operators on price, quality and coverage but also on the range of Internet services that they can offer."

For further details, check: **<www.analysys.com/publish>.**

Contact: Analysys, Tel: (01223) 341300.

# NEWS BYTES

## MPEG2 Rules the Set-top Box

**MPEG2, a digital video compression technology that shaves transmission bandwidth in TV set-top boxes, satellite set-top boxes, DVD players, camcorders, and PCs, is set to grow at more than 50% annually, says a new report by Insight Research.**

**Global sales of devices that utilise MPEG2 encoders and decoders will reach £14 billion this year and top £75 billion in 2003. According to Insight's report 'The Market for MPEG2 and Video Services', the convergence of communications, information, and entertainment is driving the need for MPEG2.**

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

**Contact: Insight Research, Tel: +1 403 265 8700.**

## Industry Leaders Promote Wireless IP

Nine global leaders in wireless communications have announced the formation of a new focus group to promote an Internet Protocol (IP)-based wireless system for third generation mobile communications technology.

The group, called 3G.IP, consists of BT, AT&T, Rogers Cantel, Ericsson, Lucent Technologies, Nokia, Nortel Networks, Telenor AS, and Telecom Italia Mobile.

Under this initiative, the nine companies will support the development of next-generation wireless services such as enhanced voice, high-speed data and Internet access, imaging and video conferencing on an all IP-based network architecture.

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

Contact: Nokia,
Tel: (01480) 434444.

## Intel, HP Reveal IA-64 Instruction Set Architecture

**Intel and Hewlett-Packard Company has published the details of the IA-64 Instruction Set Architecture (ISA). This disclosure enables software developers to accelerate the development of the next generation of server and workstation applications based on forthcoming IA-64 processors, beginning with the Intel Merced in 2000.**

**The IA-64 architecture represents the most significant advancement in microprocessor architecture since the introduction of the Intel 386 processor in 1985. Published on the Intel and HP Web sites, the IA-64 Application Instruction Set Architecture Guide (AIG) details the application instruction set, architecture features and programming model for IA-64 processors.**

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

**Contact: Intel, Tel: (01793) 403000.**

# NEWS BYTES

## Iridium Slashes Prices

Iridium, the wireless company that created the first global satellite phone network, is cutting prices by as much as 65%. Handsets now priced at £1,400 will be reduced to £600 or less, and the cost of international calls will be reduced from £2.40 to £1.80 a minute.

The company was developed in the late 1980s, before the development of cheaper cellular phones that are now quite common. Plagued by technical, financial, and management problems, the company has signed around 10,000 customers, just 10% of its intended target.

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

Contact: Orange (UK Iridium partner), Tel: (01454) 624600.

## Microchip Has 1K Serial EEPROM

**Microchip has squeezed a 1K serial EEPROM array into a 5-lead SOT-23 package, creating what is claimed to be the smallest 1K serial EEPROM in a standard package.**

**With its substantial space-saving advantages, the 24LC01B is targeted for applications where reduced board size and memory are required, including home and automotive remote-keyless-entry (RKE) systems; rechargeable batteries and rechargers; user presets in TVs, radios, VCRs, and fax machines; and redial number lists on telephones.**

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

**Contact: Microchip, Tel: (0118) 9215869.**

## Motherboard Packs Performance, Multimedia and Protection

Intel has announced the Intel CA810 motherboard, which is home to a Intel Celeron processor and features 3D graphics and on-board audio.

The new motherboard incorporates the recently announced Intel 810 chipset, which integrates Intel 3D graphics with Direct AGP to offer vivid 2D and 3D effects and images.

Combining the 810 chipset with the on-board Creative Labs SoundBlaster PCI audio subsystem, the CA810 motherboard offers a dependable, multimedia feature-rich PC solution for value-minded manufacturers and customers.

In addition, the CA810 supports Intel's Suspend To RAM technology, which enables PCs to enter a power-saving 'sleep state' during idle periods, then quickly 'wake up' on command without the time-consuming shutdown/restart/reboot process.

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

Contact: Intel, Tel: (01793) 403000.

# Sony Launches Four-Legged Entertainment Robot

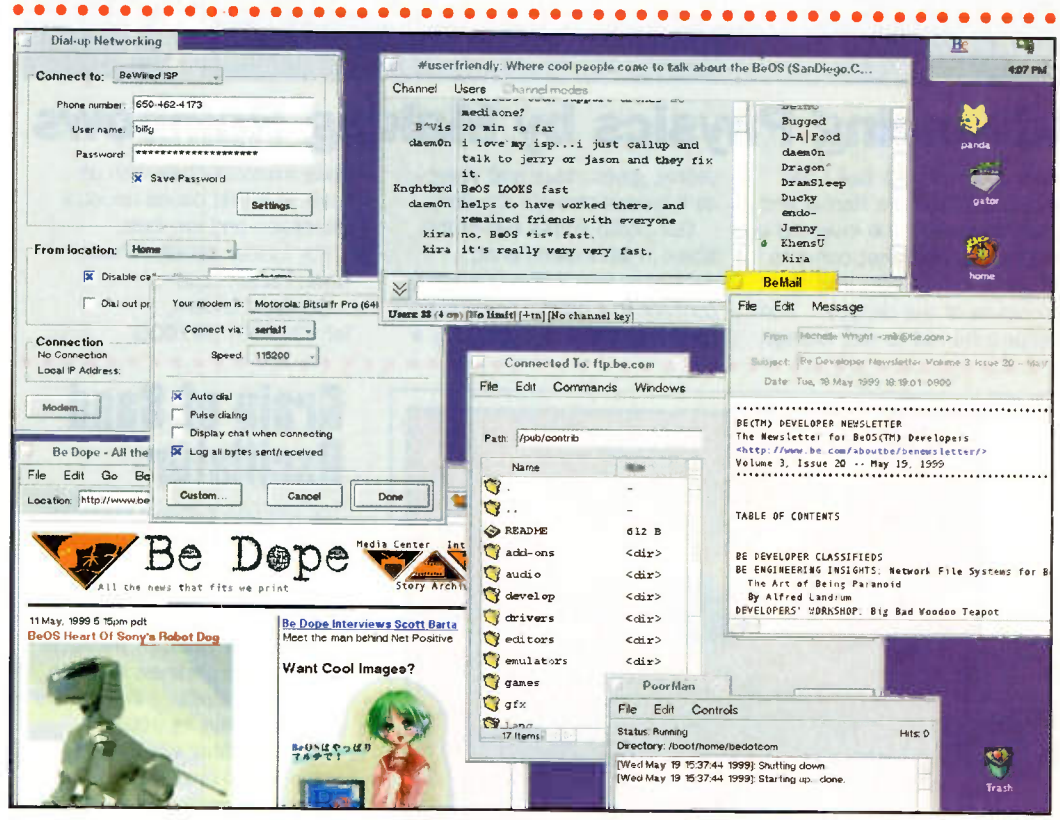
Sony has announced the availability of its four-legged entertainment robot called AIBO, an autonomous robot that acts both in response to external stimuli and according to its own judgement. 'AIBO' pre-announced last year can express various emotions, grow through learning, and communicate with human beings.

Not only is 'AIBO' capable of four-legged locomotion by virtue of the 3° of-freedom in each of its legs, but it can also perform other complex movements using its mouth, tail, and head, which have 1°, 2°, and 3° of freedom, respectively.

'AIBO' incorporates various sensors and autonomous programs that enable it to behave like a living creature, reacting to external stimuli and act on its own judgement. 'AIBO's' capacity for learning and growth is based on state-of-the-art artificial intelligence technology that shapes the robot's behaviour and response as a result of repeated communication with the user and interaction with the external environment.

The robotic dog which is available in limited quantities costs a cool £1,500 and can be purchased from the Sony AIBO Web site.

For further details, check: **<www.world.sony.com/robot>.** Contact: Sony, Tel: (0990) 111 999.




# Low Cost BeOS PC Launched

Be and iDOT.com, the first PC company built for the Web, have announced the first in a series of personal computers with BeOS pre-installed.

The first of iDOT.com's BeOS based PCs will be priced at under £300, including a Cyrix MII 333 processor, floppy drive, 32MB of RAM, a 3.2 gigabyte hard drive, 24X CD-ROM, keyboard and mouse. Monitors are available for around £70 for a 15-inch monitor and £80 for a 17in. monitor.

iDOT.com also announced plans to create a BeOS storefront on the iDOT.com Web site, where customers will be able to purchase software and other add-ons designed specifically for BeOS in addition to BeOS-equipped PCs. The storefront is set to launch at the end of the summer.

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

Contact: Be, Tel: +33 1 55 91 77 30.

# Psion Has First Java-Based Mobile Network Computer

Psion has announced the netBook, the first mobile network computer, incorporating 100% pure Java technology. netBook is the first product in a range of mobile devices aimed at companies seeking enterprise-wide computing solutions. Over time, the range will include a choice of quarter, half and full VGA pen and keyboard driven tablet and clamshell devices.

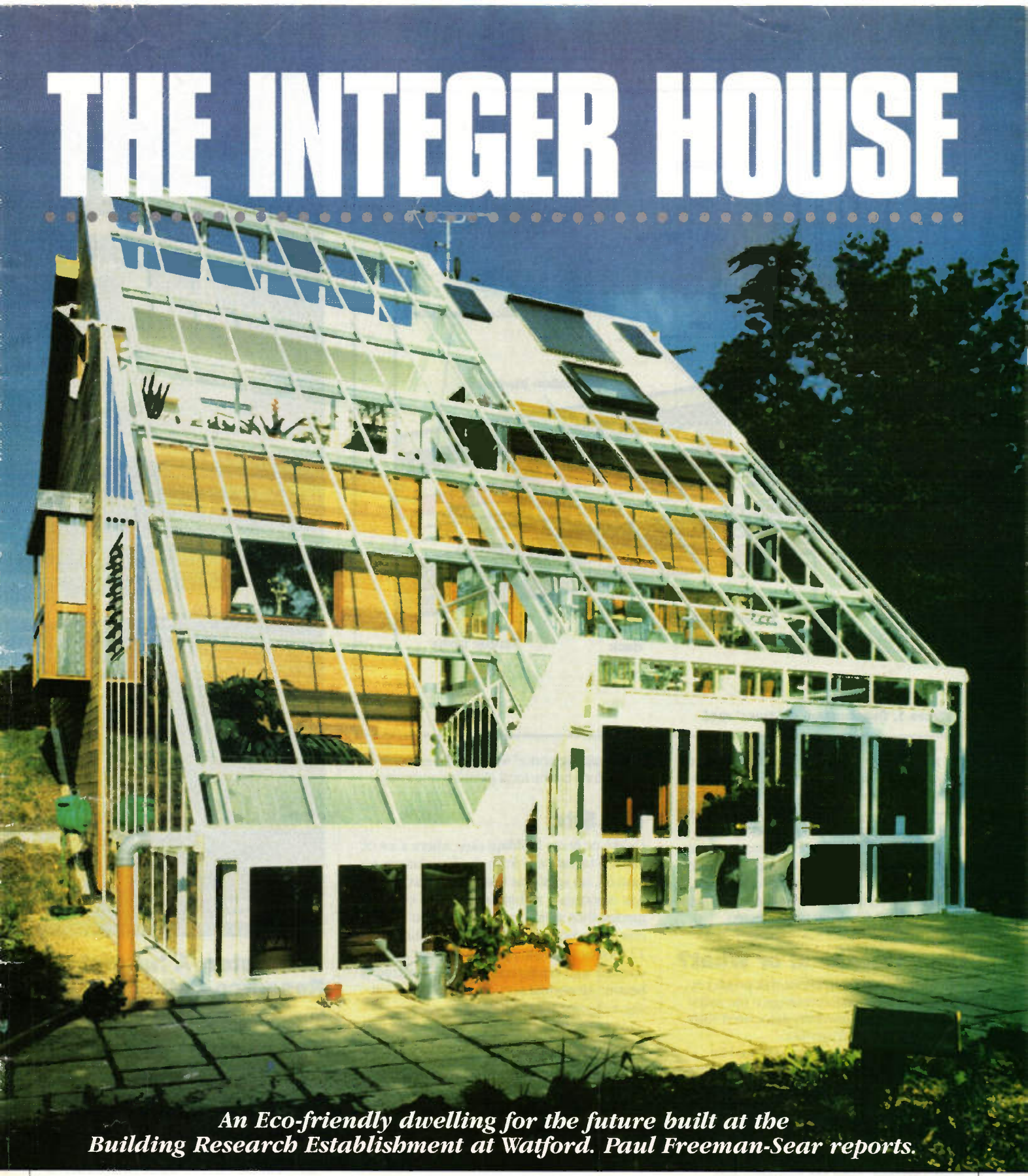
The products will offer easy to use, 'instant-on' portable computing, combined with Sun Microsystem's industry standard Java platform for enterprise application deployment.

netBook features Psion's first implementation of colour on a full VGA high quality screen offering pen-driven navigation and data input and a keyboard with standard Qwerty layout. In addition to a PC card drive, it also has a slot for either a compact flash card or disk drive for large data storage requirements.

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

Contact: Psion, Tel: (0990) 134976.

# THE INTEGER HOUSE



***An Eco-friendly dwelling for the future built at the Building Research Establishment at Watford. Paul Freeman-Sear reports.***

There is nothing like the equivalent of an adrenaline injection when it comes to getting things done. For whatever reason the medium of TV has that effect on people and projects. And so rather like a 'Challenge Anneka' situation, the 'smart' home of the future had to be built within a series of highly co-ordinated time slots, in order to suit the filming deadlines of a BBC TV series called 'Dreamhouse'

The house, on the face of it, appears to be an experimental one, with no costs spared, to show us how an environmentally-friendly home of the future might look and feel. What's different about this house is that a lot of the technology and materials used in its construction combine to give the house a 'green' ticket. Most of this environmental impact comes in the energy saving that the house provides and as a result a much lower 'greenhouse' gas called carbon dioxide being emitted to the atmosphere.

A prototype it may be, but the basic house is currently available as a kit and several lower cost versions of the Integer House using many elements of this first design are now being implemented by Sandwell Metropolitan Borough Council, at Sandwell, West Bromwich, Cherwell in Wiltshire and Harlow in Essex. Average building costs for this new design are about 10% higher than building conventionally.

The Integer House was built and completed in 12 weeks, this being about 20% quicker than traditional build. This is because many parts were prefabricated off site and virtually no standard wet trades like bricklaying and plastering were employed. It contains many new non standard products

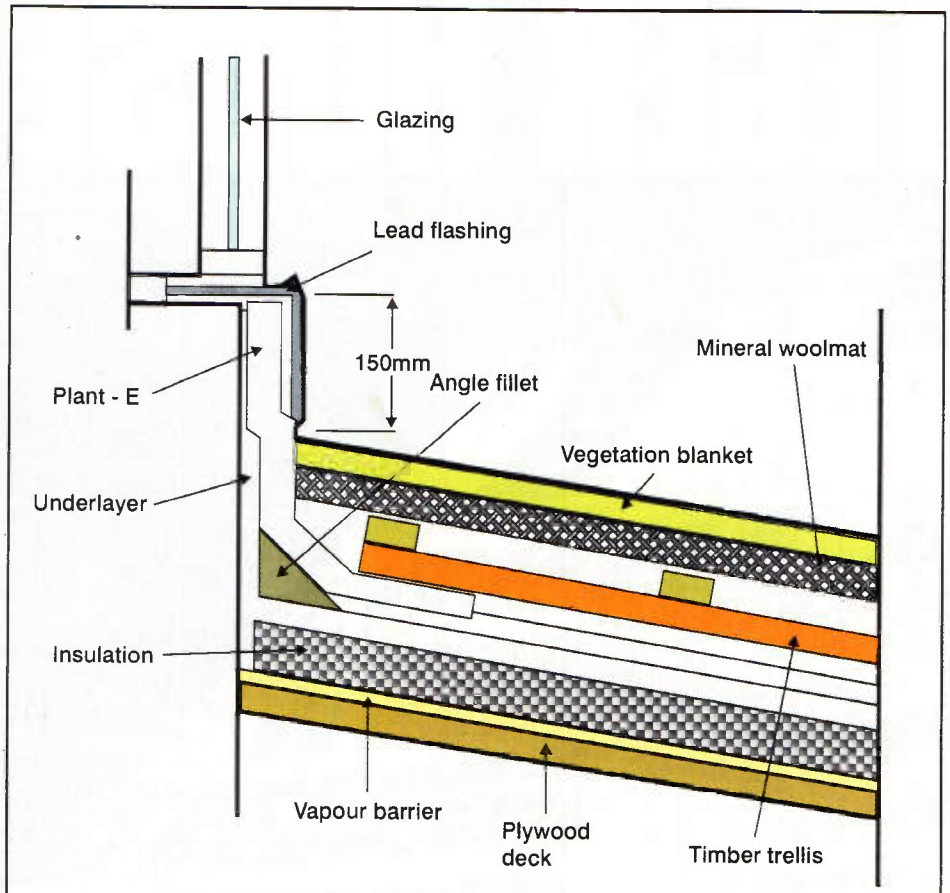



**Figure 1. Construction of 'grass' roof.**

and materials to the building trade. Associated company involvement was high with some 150 leading names replying to the invitation. Here was an opportunity not to be missed. As the whole project was planned around the effect it would have on the environment, apart from the low use of energy in its day to day running, sustainable materials such as wood are used and the natural resources of rainwater and sunshine are collected.

## Unconventional or What?

The remarkable thing about this project is that it seemed to circumnavigate the many traditional routes normally associated with building design and erection.

The central project is co-ordinated by Integer Intelligent and Green Ltd. This name carries a consortium of companies whose aim, in this case, was to create an eco-friendly and auto responsive demonstration house. The building contractor within that group for the demonstration house was Wilcon Homes. They site managed and constructed the main component parts.

A temporary planning application was granted for two years by the local authority to build on a loaned site at the Building Research Establishment at Garston, Watford. This means that after two years either the house is pulled down or an extension to the application can be applied for. No contracts were issued to supply and build in this case and no money changed hands at all for the complete construction and installation. As far as is known, no detailed drawings showing the requirements for building regulations were submitted to the authority, working effectively on a 'building notice' with regular site inspections by the local planning authority.

## The Site

Unlike ordinary building sites where a lot of earth is taken away from the foundations to land fill, no spoil was taken from this site. It was rearranged within the confines of the garden thus saving on transport and land fill costs. The house is built on foundations of 17 tubular steel mini piles and these are crossed with reinforced concrete inverted 'T' beams. All normal services are available on site including mains drainage.

## The Design

The design is of timber frame construction with large pre-fabricated sections built off site to speed up construction. A large conservatory joins the property and faces in a South-westerly direction. The red cedar timber clad exterior hides fibrous newsprint paper insulation. Increasingly waste paper is now being used in a finely shredded form and fire proofed to insulate walls of houses. Like other types of insulation, the paper is pumped in. The roof on the north-easterly side is topped with 'grass' - see Figure 1. Unusually, the bathrooms and their contents were completely assembled off site and craned into position when required. Good insulation combined with placing most windows on a southerly aspect with a large conservatory provides plenty of passive solar gain. As you might expect from such a design, the extra heating requirements are small.

**Photo 2. House under construction.**

## Rainwater- A Natural Resource Collected

Up until now rainwater has only been considered useful for watering the garden. This is certainly still the case at the Integer House. Here the large conservatory roof collects many gallons of rainwater throughout the year and is stored in a large 5000 litre underground plastic tank. An automatic watering system for the garden exists via a series of underground leaky pipes and the system waters the garden at the beginning and at the end of the day in order to reduce evaporation. The exact amount of plant water is controlled by monitoring soil humidity. Another underground tank holds greywater. Now greywater is defined as that water that might typically be discharged from the bath, shower or hand-basins and is used for flushing the toilets. An outside filter bed and a treatment plant supplied by Anglian Water cleans the greywater before being pumped into a header storage tank in the roof space. If the toilet flushing supply from this header tank runs low, then a back up supply will


top up the tank from the mains.

The open ground is covered with a general cover of bark chippings and this provides a garden that requires low maintenance. Overall the house uses about 30% less water than a conventional house. Part of this saving comes about by having aerated taps and dual flushing toilets. The toilets therefore provide the option of using less water.

The roof on the front or northern side is sedum covered. This is an alpine plant that looks like grass and does not need to be cut. It retains up to 95% moisture and need not be watered for up to 10 months. One chief advantage of a grass roof is that it minimises large temperature fluctuations within the roof structure.

## Energy Consumption

In order to consume lower amounts of energy when going about our daily activities, low consumption white goods were installed. Overall the house consumes typically 50% less than the ordinary household.

Plenty of low energy lights exist around the house. The Siemens' Instrabus System provides four different lighting effects in the lounge and dining room. The fridge/freezer in the kitchen only consumes 30W, part of the reason for this low power being that it is vacuum insulated for minimum heat transfer. The dishwasher, washing machine and tumble drier consume around half the normal power of standard machines. The house is so generally well insulated that only a small heat requirement is necessary from the heat pump in the winter. The heating to each room is 'zoned' through a central manifold and so each room is only heated when required. This is also achieved through a fast response system using fuzzy logic to optimise energy consumption. The low thermal lag also means the house never overheats.

## Automation in the Bathroom

Most of us are used to a mechanically operated bathroom to supply water to baths or basins. The facilities available at the Integer House means that just placing ones hands under the mixer tap will turn on the supply and produce the correct predetermined mix of hot and cold water. One little drawback here is that no allowance has been made for 'deadlegs'. This is where there is always a run of cold water initially supplied to the basin in the hot run and is usually run off to waste. The equipment here detects the presence of your hands by passive infra-red. Temperatures for the bathwater can be set and all tapwater control is by push button with automatic bath fill. The toilet also operates by push button.

## Intellikey

The house is secured by a key system with a difference. It's called the Intellikey and each authorised person can be issued with one key. That key will allow the individual to enter permitted areas. This is created in the initial programming sequence. Although the system is battery backed, the key derives its power from the lock assembly when the key

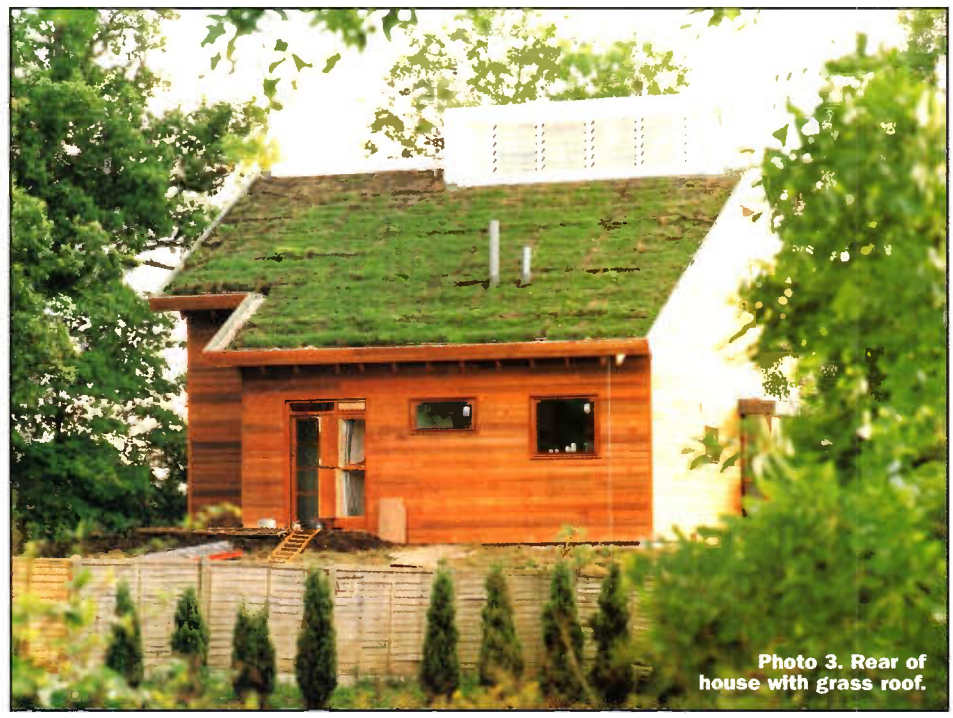


**Photo 3. Rear of house with grass roof.**

Photo 4. Lounge with large screen TV.

is introduced. The other interesting aspect to this is that the keys can be time conscious. So for example one could issue a key to workmen with permitted access times of between 9-5pm, five days of the week, terminating on a given date.

## Wired for Anything

The house is wired for audio, video, telecommunications and the internet. This all centres around the 42in. plasma TV screen in the lounge. Multi-media is available in the kitchen with an on-line terminal to the internet There is also a video display system to help you out with cooking basics in the form of DVD video demos.

The cooking hob from Zanussi will detect the pan when placed on the hob after an

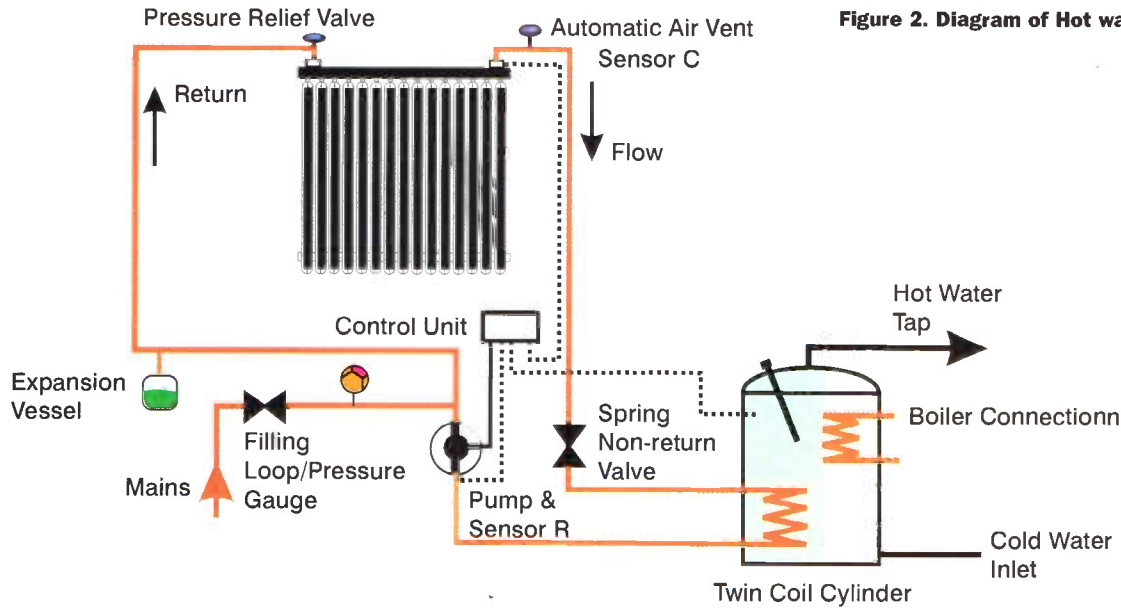



**Figure 2. Diagram of Hot water installation.**

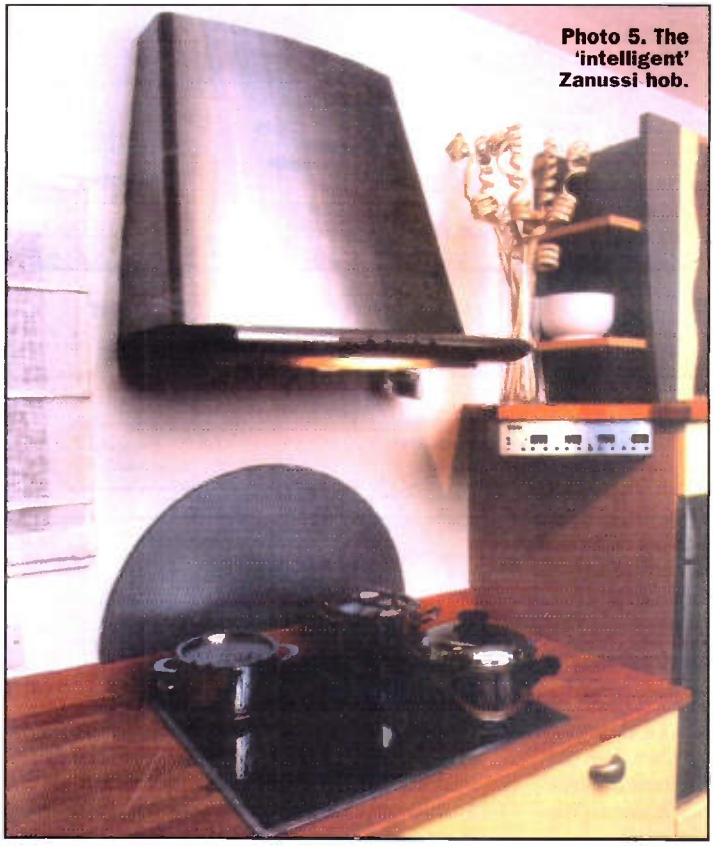


Photo 5. The 'intelligent' Zanussi hob.

Photo 6. Hot water tank.

initial set up procedure to 'calibrate' the pan. The unit measures the magnetic characteristics of the pan in this initial setup procedure, and if the pan is a different one, the appropriate ring on the hob will not turn on. It will also monitor the temperature to ensure any liquid enclosed does not boil over.

The washing machine has an optional delay mechanism and waits for a radio signal via the mains to wash only in the off-peak electricity tariff. These machines have also been engineered to use only half the amount of water and detergent compared to normal machines.

## Heating and Hot water

Undoubtedly there are substantial savings to be made in the area of hot water and heating, and the Integer House provides many relevant solutions. The two principal sources of heat are provided by the 20 Thermomax solar heat exchanger tubes on the roof and a deep water pipe ground loop connected to a heat pump. Top-up heating from this source is delivered around the house by floor level radiators within a duct.

Passive solar heating is achieved by the large south-west facing conservatory and a system of temperature controlled venting ensures that heat is exchanged to the living areas. Internal air circulation passes through ventilation ducts. The air is fan assisted and powered by a battery. This battery is kept trickle charged by photovoltaic panels on the roof and a wind turbine-generator in the garden. Again overheating in the conservatory on the south side is prevented by vents to the open air.. Automatic blinds operate according the brightness of the sun and they provide between 30-85% shading. The conservatory was supplied by a commercial greenhouse manufacturer, Queensbury Structures, and single glazing is used throughout. The angle of pitch is sufficiently steep such that it is self cleaning with any rain that falls.

Figure 2 shows a hot water supply generated from the 20 Thermomax tubes.

## Heat pump and Groundloop

Two 50m bore holes have been drilled on site by a company called GeoScience to extract heat from the ground. At 50m below ground level the temperature remains at about 12 Celsius and so that heat can be collected by water in a sealed groundloop pipe. see Figure 3. A heatpump is really just a fridge in reverse extracting heat from water at 12 Celsius underground and passing it to a heat sink, in this case the hot water tank in the house. In the Integer House the hot water tank is not like any ordinary hot tank. It is a tall highly insulated dual coil tank from a company called Gledhill (See photo 6). It can store the water from the solar tubes at around 77 Celsius.

Conventional heat pumps use standard compressor technology but in terms of heat generation you get typically three units of heat energy out compared to one unit of electrical energy in, to run the compressor. The lower the water temperature that runs into the ground the more energy one can extract from the ground. Heat pumps can also go into reverse and act as an air conditioning unit in summer taking out heat from the building and passing it in to the ground to heat up the ground.

It has to be stressed that drilling boreholes is at present not economically viable. The cost to drill and install a probe at this site was around £35,000. There are other lower cost shallow groundloop alternatives where several coils of pipe are placed at about 2m below ground and could take between 500-900m of pipework provided space is not at a premium.

## Solar Tubes

It is great to see some of the best technologies currently being used to collect solar heat. Many ideas from the very simple to the more sophisticated have been used over the years but this system seems to be

Photo 7. Heat pump.

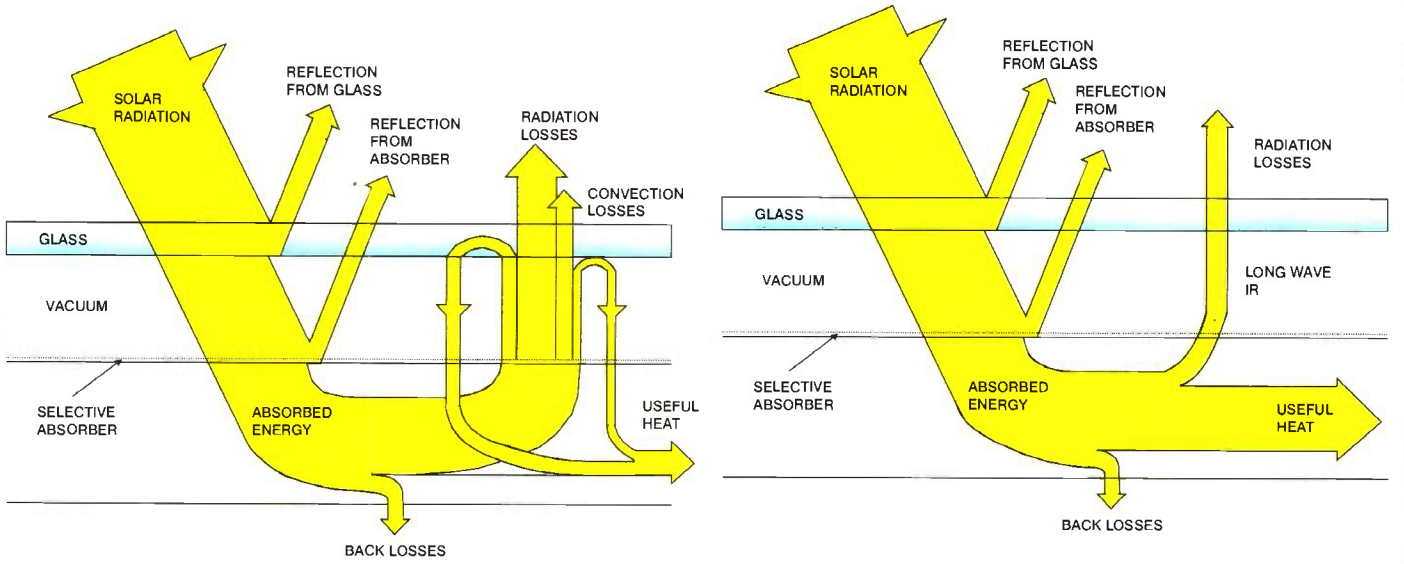



**Figure 4. Energy balance of a flat-plate collector (a), compared to energy balance of a Thermomax collector (b).**

the most effective so far.

All surfaces absorb and re-emit heat to a greater or lesser extent. The trouble is that good absorbers are also good emitters of heat - a matt black surface for example warms up generally far quicker than any other surface. It is also the best radiator surface to emit heat in our homes. (We don't see many matt black radiators though do we!). However, keeping the temperature down by passing a coolant like water through copper pipes to take the heat away attempts to reduce the heat re-emission risk. See Figure 4a and 4b.

A company called Thermomax has supplied 20 solar collecting tubes mounted on the upper part of the conservatory. Some interesting physics and technology has been used here. Within an evacuated glass tube sits a wafer thin solar collector made of copper. It runs the length of the glass tube and is attached to a pipe that runs down the back. This collector plate is coated with a 'wavelength sensitive' combination of Nickel and Chromium to maximise solar heat collection with a minimum of re-emission. Figure 5 shows the system.

Absorbed heat warms up a fluid with a low specific heat capacity. In this case the company uses Methanol. This liquid then vaporises and rises up the tube to the top where it enters the condenser via the valve. Figure 6 shows a Memotron tube construction.

The valve is made of a memory metal and automatically closes off at a specified temperature. In the Thermomax tubes that's 95 Celsius or 130 Celsius, depending

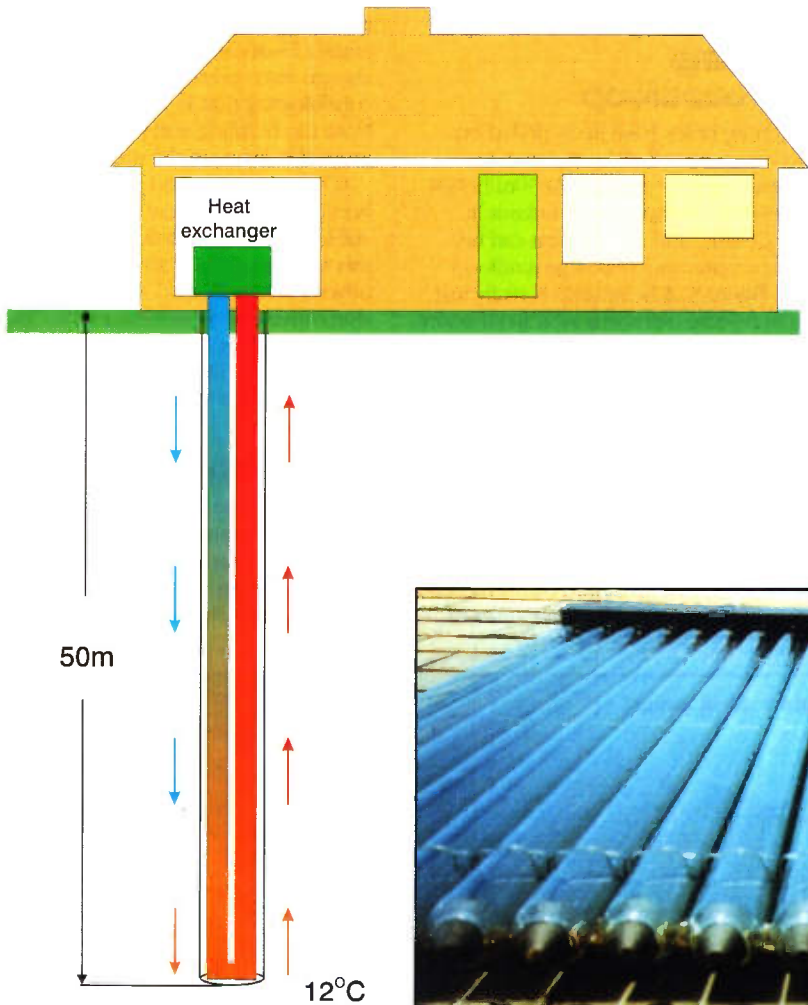



**Figure 3. Typical ground loop.**

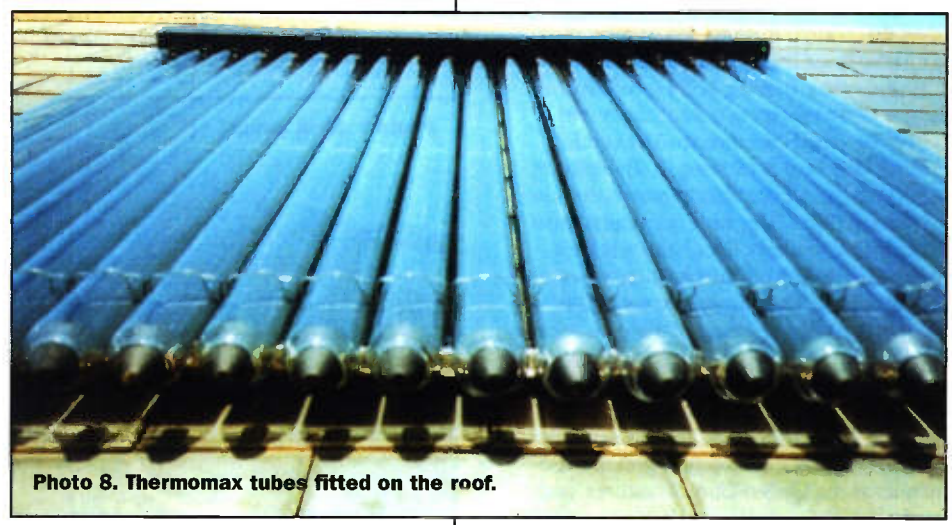


**Photo 8. Thermomax tubes fitted on the roof.**

**Figure 5. Illustration of Themomax system**

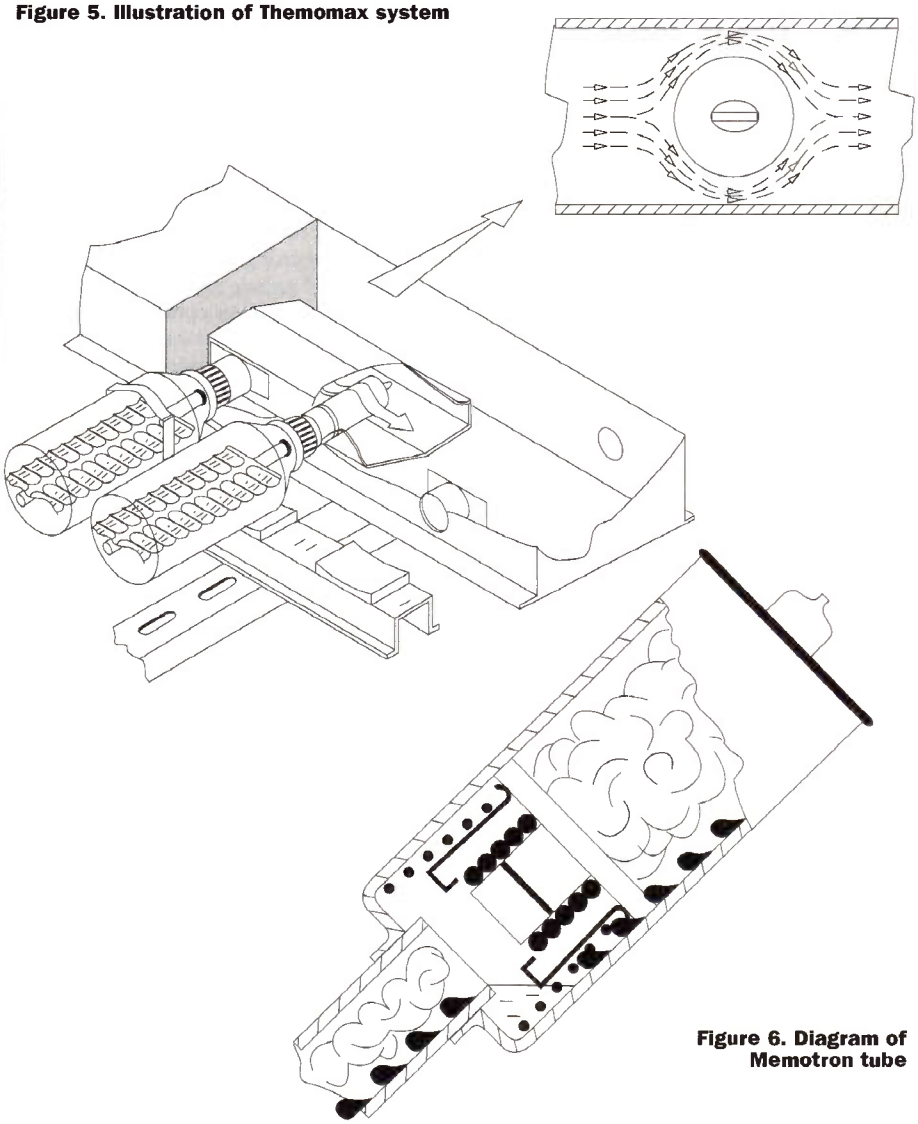
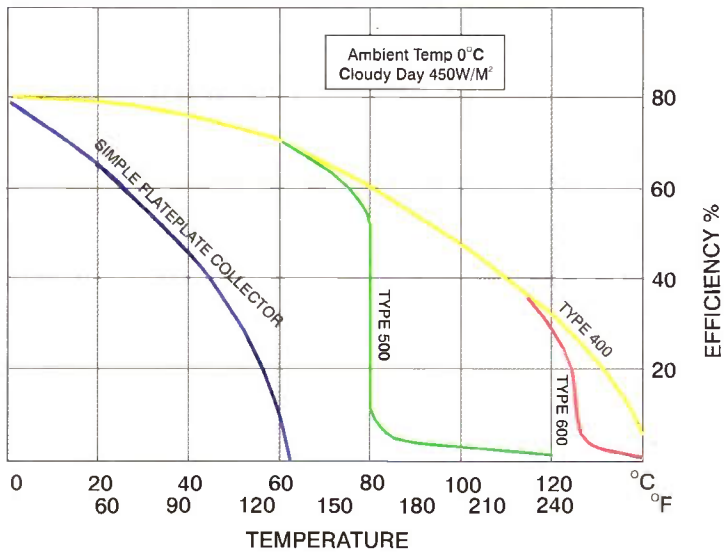


**Figure 6. Diagram of Memotron tube**




TYPE 500: Memotron solar collector tube with controlled maximum temperature of 95°C. Recommended for applications requiring hot water up to 85°C

TYPE 600: High temperature solar collector tubes with no control. Recommended for applications requiring hot water at up to 130°C

Efficiency: $\eta_o = 0.81$

Heat Loss: $\kappa_1 = 1.1 w/m^2K$

$\kappa_2 = 0.01 w/m^2K$

**Figure 7. Graph of response of various collectors.**

on the requirements. The vapour then heats up the water indirectly via the manifold. As the heat is taken out, the vapour then turns back to a liquid releasing its Latent Heat of Vaporisation. Two lengths of manifold are available one for 20 tubes and one for 30 tubes giving a typical absorbing area of $2m^2$ and $3m^2$ respectively. As can be seen from the graph, temperatures of 80-120 Celsius can be achieved. This hot water primary circuit off-loads its heat into the hot water tank in the house. As this tank is highly insulated the hot water supply is typically maintained at 77 Celsius. Figure 7 shows a graph of response curves for different tubes.

## And the Future

All technologies used in the house will be evaluated over twelve months and together with comments via the internet, that knowledge will be considered and in some cases used in real housing projects which are now just starting across the UK. Refurbishment of existing properties will play a key role in the future for Integer for this is where the greatest demand could lie.

The Integer House itself will undergo its first technology upgrade in September 1999 as even 6 months in the lifetime of high technology is now a long time. The house is intended to be a constantly changing exhibit to reflect the 'always achievable' aspect to the way we might wish to live in our houses. The interest shown in the house has in some cases resulted in large orders being placed bringing production costs down on certain low turnover supplier items. In other areas like the 50m bore hole, it could result in others thinking of alternative lower cost ways to achieve the same aim. Which ever way, the Integer House will serve as a constant reminder that there is a serious but cost effective way to reduce our energy consumption within the bounds of our future habitat.

Finally, I am indebted for the help given by Peter Colebrook of i & i Ltd. the IT consultant for the Integer House.

All photographs, with the exception of the Thermomax tubes are by courtesy of BRE Professional Imaging.

### Useful Contacts

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Building Research Establishment (BRE)
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Wilcon Homes Tel:0800 316 4904
**www.wilcon.co.uk**

Foundations by Roger Bullivant Ltd
Tel: 01283 511115

Intellikey Euro Ltd. Tel: 01707 395504

Electrolux/Zanussi/AEG Group Marketing Dept Tel: 01753 872547

Bathroom 'One Touch' controls ECO-Logic (UK) Tel: 0121 6031331

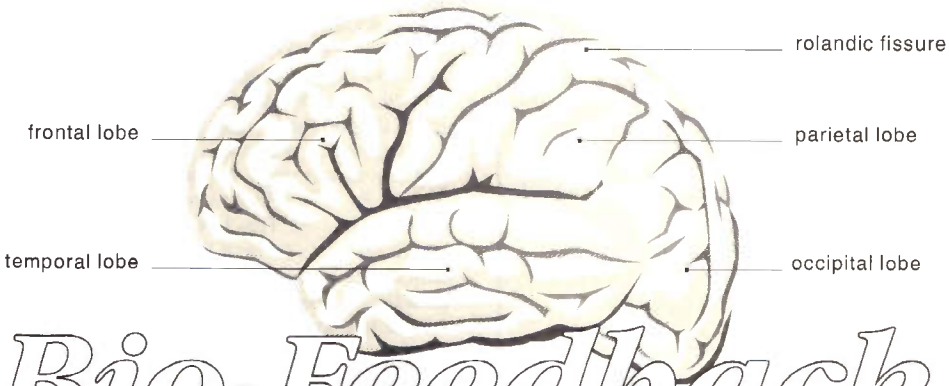
Attrium by Queensbury Structures Ltd.
Tel: 01703 703355

Green Roof by Erisco Bauder Ltd.
Tel: 01473 257671 **www.erisco-bauder.co.uk**

Thermomax solar tubes contact Rayotec Ltd.
Tel: 01344 874747

Borehole and Heat Pump by Earthenergy Geoscience Ltd. Tel: 01326 211070

Hot water Cylinder from Gledhill
Tel:01329 846601




# Bio-Feedback WITH ELECTRONIC ENHANCEMENT

## PART 3

***In the third part of his series, David Clark looks at some of the equipment used.***

## Introduction

This month I am going to be concentrating on the electronic principles involved in equipment used for bio-feedback with electronic enhancement, and apply some of these principles to suggestions for some construction projects to try.

## Equipment

There is a wide variety of equipment available which comes under the category of bio-feedback with electronics enhancement. Not only is there a wide range of differing types of monitor for differing purposes, they also range from small battery powered hand-held monitors with one function for use at home, to computer based equipment monitoring several functions simultaneously for use in clinics by medically trained personnel.

However, as is the case with many apparently complex systems, even the most sophisticated equipment can be broken down into individual functions, and each function broken down to simple component blocks. As has been seen this type of equipment parallels the biological processes that are being 'enhanced', and can be broken down into three basic blocks; a sensor, signal processing, and an output. The following table summarises the most commonly encountered types found for the three categories.

## Sensors

As can be seen the sensor type can be broken down into two categories, those involving electrodes which monitor electrical activity directly, and those that monitor some other parameter and then convert this to an electrical signal. I'll look at these parts separately as they involve some quite different processes.

## Electrode Type Monitoring

Monitoring the electrical activity of the body with electrodes presents some particular problems. Electrically, a body can be considered to be a three dimensional object composed of an external layer of slightly conductive material (the skin) containing various other layers and objects composed of different materials with varying resistivities. This means electrical paths are widely distributed and difficult to define, and any electrical activity is quickly attenuated. Thus the voltages appearing at the surface are usually very small, and we are trying to detect signals having values in the order of a millivolt for heart signals, and microvolts for brainwave and muscle signals. Additionally, the body, like any other conductive material, acts like an aerial for all the electromagnetic radiation in the vicinity which of course passes straight to a highly conductive electrode. Finally, conducting electrical signals down an electrode is not a one way process. As will be seen, electrical currents can pass in the opposite direction to the one required for measurements, i.e. into the body from any electrical equipment it is connected to, and not necessarily just when faulty or mains powered equipment. This safety aspect will be examined in a later part.

**SENSORS**

| Sensor | Monitors |
|---|---|
| wrist electrode | heart electrical activity |
| head electrodes | brain electrical activity ('brain waves') |
| neck & shoulder electrodes | muscle electrical activity |
| finger temperature sensors | temperature |
| finger electrodes | skin resistance |
| air pressure sensor | blood pressure |
| air pressure sensor | breathing |

**SIGNAL PROCESSING**

| Process | Function |
|---|---|
| electrode amplifiers | detect signals<br>isolate 'patient'<br>reject interference |
| transducer amplifiers | amplify transducer signal<br>may include 'excitation' signal |
| filtering | isolates frequencies of interest |

Further possibilities include analogue techniques, digital signal processing, statistical processes and signal averaging.

**OUTPUT**

| Device | Method of Indication |
|---|---|
| meter | needle 'level' |
| LED 'bargraph' | length of display |
| light | brightness |
| computer monitor | graphic display |
| audible tone | variable frequency |
| audible tone | variable volume |

**Table 1. bio-feedback equipment blocks.**

## Amplifying Electrode Signals

Amplifying small signals needs only the application of the usual practices for high gain amplifiers, i.e. careful attention to screening and ground and signal paths to avoid instability and oscillation. Cancelling out signals picked up by the leads from any extraneous radiation can be thought of as being in two parts. Most important perhaps is the use of input amplifiers with good Common Mode Rejection Ratio (CMRR) characteristics. This means that only the difference signal between the input electrodes is amplified, i.e. the required signal, and any unwanted interference signal, which will effectively be the same on each electrode, is cancelled out. The signals of interest for bio-feedback are of low frequency, and so carefully designed low pass filtering will remove any remaining mains interference and any higher frequencies.

## Signal Types

Of the electrode obtained signals, only the heart displays a truly periodic waveform. For muscle activity the voltage picked up at the electrode depends the activity of that muscle and will be effectively random in frequency. For brainwaves the activity can be divided into ranges of frequencies which correspond to various brain activities. The output from electrodes monitoring the heart however gives a true indication of the heart's electrical activity which corresponds to its physical activity. Figure 1 shows the type of signal obtained.

The labels P, Q, R, S, and T in Figure 1 correspond (approximately) to the following stages of a heart 'beat'.

- **P wave**
  the upper chambers (atria) are contracting
- **QRS complex**
  the lower chambers (ventricles) are contracting
- **T wave**
  the atria are relaxing

(Refer to the diagram of heart structure in part 2 of this series.)

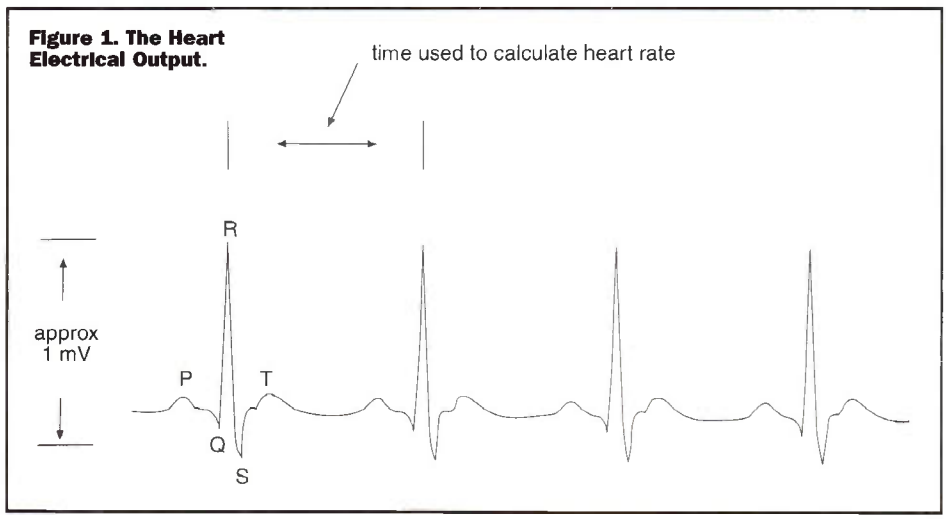



**Figure 1. The Heart Electrical Output.**

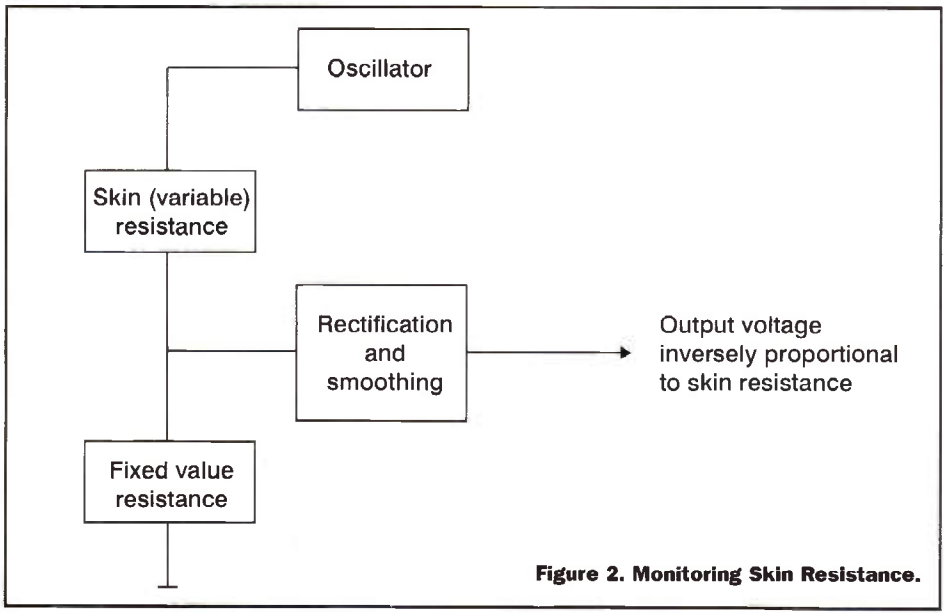



**Figure 2. Monitoring Skin Resistance.**

The electrical signal caused by the relaxation of the atria is normally masked by the electrical signal caused by the ventricles relaxing - both relaxations occur at the same time and the ventricles are normally much larger than the atria.

Analysing these signal types will be examined in the signal processing section.

## Skin Resistance Electrode Function

Skin resistance is of course a function of the skin itself, but in fact this is only a minor contribution. The main influence on skin resistance is the conductivity of sweat on the surface of the skin. This is cause by the presence of chemical 'salts' in sweat, primarily sodium and chlorine.

Monitoring skin resistance is no different in principle to measuring any other form of electrical resistance. However there are some things to be observed - there should be no dc component to the measuring current as this can cause polarisation effects - positive ions move to the negative electrode and vice versa. Even small dc currents passing through the skin (as opposed to the sweat) can cause ulcer effects over time. For this reason a constant current source of 100 or 200μA at around 1kHz is usually employed and the skin resistance determined by the voltage that is generated. See Figure 2.

## Transducer Type Monitoring

Monitoring parameters via a transducer presents no more problems than any other use of such a transducer, in this case an air pressure transducer. The particular requirements are for the type of information which is wanted from the monitoring process; this is looked at under signal processing.

## Respiration Monitoring

The normal method of monitoring respiration is via a sealed lightweight plastic telescopic 'tube' that is fixed around the chest. During respiration the chest expands and contracts and so the volume of the tube changes. Since this is sealed the pressure inside the tube changes, and this is monitored with a pressure transducer. The rate of respiration can be determined from the frequency of change of the pressure peaks and troughs, and the depth of respiration from the amplitude of the changes. See Figure 3.

## Temperature Monitoring

There are two possible monitoring modes for temperature, absolute temperature and difference temperature. As discussed, skin coldness represents a stressed state, and a difference in temperature between the left and right hands represents different activity in both halves of the brain, so two temperature sensors can be used. One type of device used for temperature monitoring in this type of situation is the thermistor. See Figure 4.

## Blood Pressure Monitoring

Devices for automatically monitoring blood pressure are relatively complex, usually requiring software control due to the nature of measuring the blood pressure. As anyone who has had their blood pressure measured by one of the manual mercury sphygmomanometers used in GP surgeries and clinics will know, this is a fairly coarse process involving pressurising a cuff until the blood flow is stopped and then releasing the pressure, the blood pressure being noted from the scale as indicated by listening for the pulse with a stethoscope. This can also be a little uncomfortable in insensitive hands however; using electronic control can be less intrusive and is more suitable to taking intermittent readings to monitor changes over a period of time as required for bio-feedback training. The principle is the same, but the electronic detection of pressure at the points of measurement is less coarse and can cause less discomfort. A further complexity is introduced by the fact that

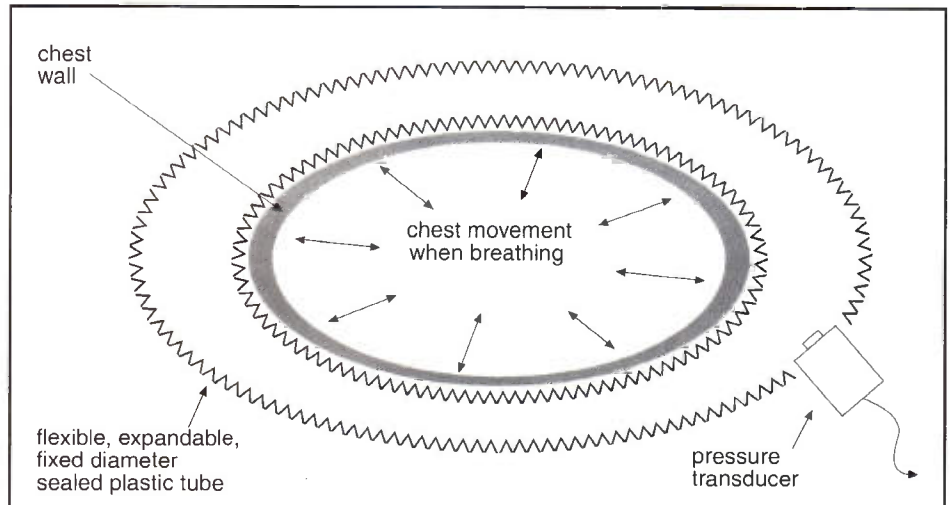



**Figure 3. Respiration Monitoring.**

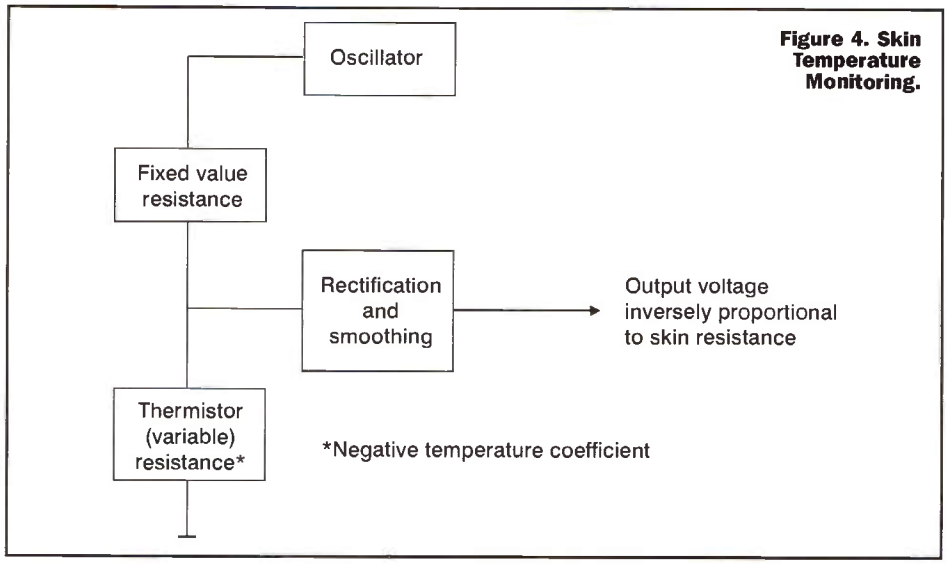



**Figure 4. Skin Temperature Monitoring.**

| Brainwave | Frequency | Activity |
|---|---|---|
| Theta | 4Hz - 7Hz | Appears to correspond to the day-to-day generation of imagery and creative activity - sometimes called the gateway to the unconscious. |
| Alpha | 8Hz - 12Hz | Generally corresponds to relaxed vigilance, or meditation. |
| Beta | 13Hz - 20Hz | Generally corresponds to conscious activity. |
| Gamma | >21Hz | Generally corresponds to conscious activity. |

**Table 2. Brain Wave Frequencies And Activities**

failsafe fault detection is essential to ensure that the cuff cannot overinflate.

Blood pressure measurements are usually reported as 'x' over 'y,' e.g. 180 over 90. The first figure is the systolic pressure, which is the pressure produced by the heart when it contracts, followed by the diastolic pressure, which is the pressure when the heart is between contractions. See Figure 5 and the side text for the automatic procedure for monitoring blood pressure.

## Signal Conditioning

Apart from amplification of signals the requirement is for filtering in order to isolate signals of interest from others. This would normally be achieved using conventional analogue circuitry, but digital signal processing can be employed in computer based systems.

Low pass filtering removes mains and radio-frequency interference as we have seen which is important for all bio-feedback monitoring. Particular requirements are as described in the following sections.

## Muscle Activity

The muscle activity of interest for bio-feedback monitoring purposes is the background tension which causes the symptoms which are the problem. Fine tuning the cut-off frequency of the low-pass filter will isolate this, and then the output is the sum of all the individual actions within the muscles of the area around the electrodes at any particular moment. The amplitude of the voltage is therefore the measure of the activity, and no further processing is necessary.

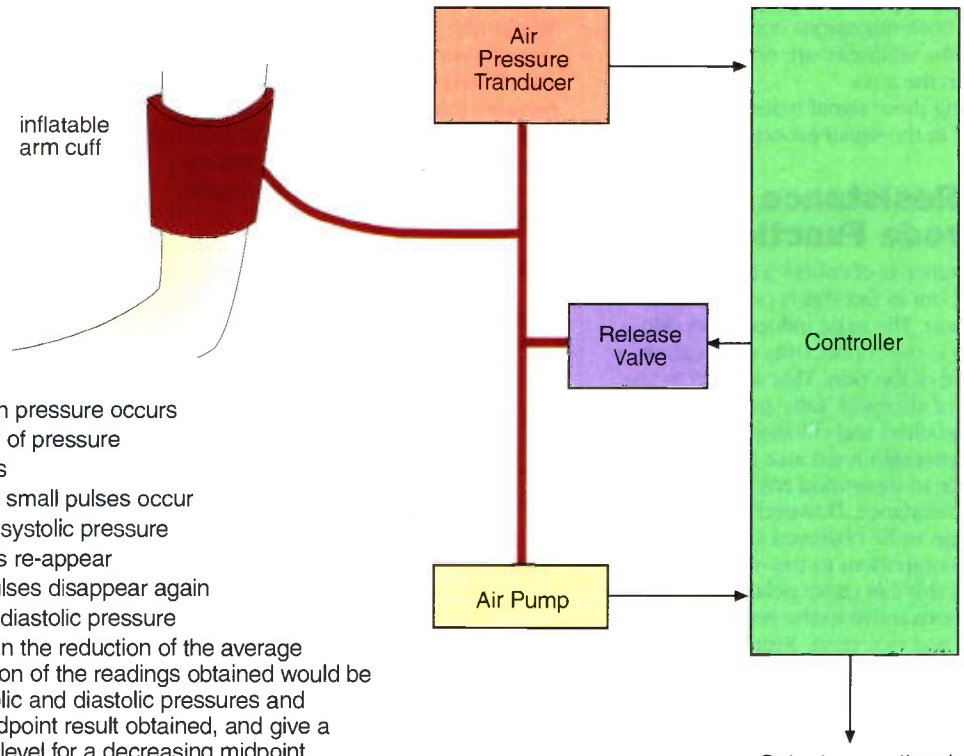
## Brain Activity

For brainwaves the activity is divided into ranges of frequencies, each of which is isolated using a bandpass filter. See table 2 for the frequency ranges and associated brain activity. Within each bandwidth the activity is indicated both by the magnitude of the responses and also how often that activity is occurring, so following separation by filtering an integration type technique which effectively sums the voltages over time for each individual range is the measure of activity required here. See Figure 6.

## Heart Rate

Following isolation by filtering, heart rate is determined by measuring the period of the waveform i.e. the time between the peak of the each QRS complex for example. For bio-feedback an absolute value is not needed, and a voltage inversely proportional to this time is a satisfactory output. Refer back to Figure 1 and also see Figure 7.

**Figure 5. Automatic Blood Pressure Monitoring - Software Controlled.**




- Monitor air pressure
- Pump air until a sharp change in pressure occurs
- count and time the small pulses of pressure
- calculate the pulse rate from this
- increase pressure until no more small pulses occur
- record the pressure - this is the systolic pressure
- release the pressure until pulses re-appear
- release further pressure until pulses disappear again
- record the pressure - this is the diastolic pressure
- For bio-feedback the interest is in the reduction of the average pressure so a typical manipulation of the readings obtained would be to take the midpoint of the systolic and diastolic pressures and compare this to the previous midpoint result obtained, and give a decreasing output frequency or level for a decreasing midpoint pressure and vice versa, a decreasing value being the beneficial effect.

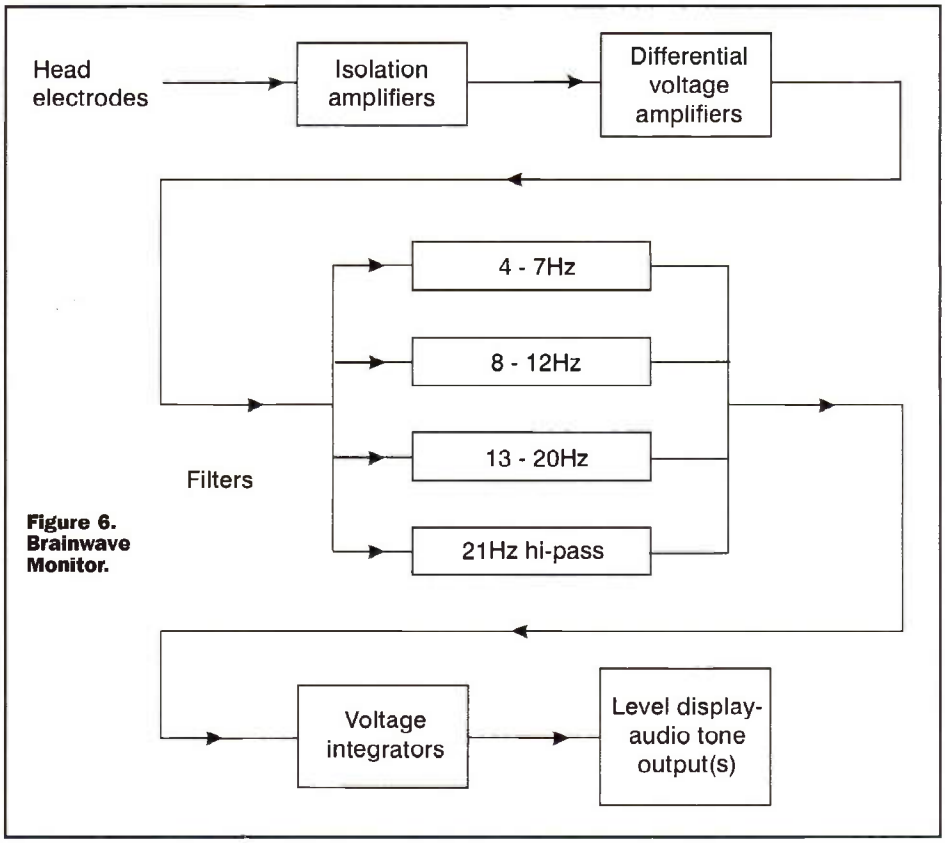



**Figure 6. Brainwave Monitor.**

## Blood Pressure

If measured automatically this will be performed by software controlled equipment, and the form of the output determined by software design. Once again an absolute value is not required, it is how it is changing that is of interest.

## Respiration

The parameters of interest here are the rate and depth of breathing. Like the heart rate, breathing rate can be measured by determining the time between equivalent points e.g. the peak for example on the transducer output waveform, which is cyclic. Depth of breathing is proportional to the peak to trough value of the transducer output waveform.

## Skin Temperature and Resistance

These are slow changing effectively dc voltages and so need no further processing other than gain adjustment.

## Output Displays

**Visual -** The actual values of output are of no real interest for bio-feedback, what is important is the amount of change of activity, with reduction in activity being the required goal. This means output can be quite simple to satisfy the requirements of hand-held or small desktop type equipment, for example a needle meter, or LED bargraph. For computer based equipment with the flexibility afforded by a monitor display, the amount of information displayed and how it is displayed is effectively limited only the imagination of the designer. However, displays of 'virtual' meters or bargraphs are an easy way of displaying the information.

**Audio -** A good way of presenting the output is via an audible signal having a pleasant tone with a pitch, or frequency, which varies with the output of interest. This method encourages the client to relax since there is no need to concentrate on a visual display; in fact having the eyes closed is often the best way to encourage relaxation.

## Practical Considerations

The main concern is the type and positioning of electrodes and sensors. Electrodes can vary, the essential thing being good skin contact which reduces the resistance of the connection. The most modern types are self adhesive and incorporate a conductive gel as part of the electrode, the gel being of a material that is 'gel-like' enough to give a good contact, but firm enough not to be messy to use. However good contact is the main criterion and this can be achieved by holding the electrodes in place on cleaned skin with a headband for electrodes on the head or 'rubber-band' type devices for finger electrodes. Apart from a good electrical contact, the only other important thing is that they should not be too uncomfortable or distracting for the subject. For brain wave monitoring the usual electrode positions are on the forehead (centre and left or right), and on the base of the scalp, to left or right of centre. Heart rate monitoring is usually by electrodes on the wrists.

Positioning of transducer type sensors is determined by the type of device they are part of and can be remote from the chest wall monitoring tube or the blood pressure monitoring cuff if the design requires it.

## Training Techniques

The purpose of bio-feedback with electronic enhancement is to reduce activity, so having had various electrodes and sensors attached, the outputs are acknowledged and then the client taught to relax or achieve whatever is the required state and the change in output noticed. The client is then taught to recognise what they have done in terms of their emotional state etc. and can then use that technique to further reduce output and hence activity. Eventually the client will be able to achieve the desired effect without the help of the electronic enhancement of the bio-feedback, it all occurring internally under the client's control.

## Patient Safety

One very important aspect of the electronics that applies to all medical equipment is the safety of the patient, and this is achieved by effectively isolating the patient from an electrical current. This may not seem to apply to battery powered equipment, but even a small battery can pass enough current to cause skin damage if there is a complete circuit either between two electrodes, or part of a case or switch and an electrode.

The danger from mains powered equipment is more obvious but may present some surprises. For example it might be assumed that if a circuit or electrode is at a low voltage it won't present a hazard. This isn't necessarily the case however, it depends on the current that can flow. To take account of this there are various requirements that medical equipment must comply with, which involve patient isolation, breakdown voltages, leakage currents, earthing requirements, and mains transformers, which are based on various types and classes of equipment. I'll be taking a closer look at this in the final part of the series, as well as taking a look at one or two more specialised bio-feedback processes and some equipment closely related to bio-feedback equipment that are used for some perhaps unexpected therapies.

For the final section of this part I will

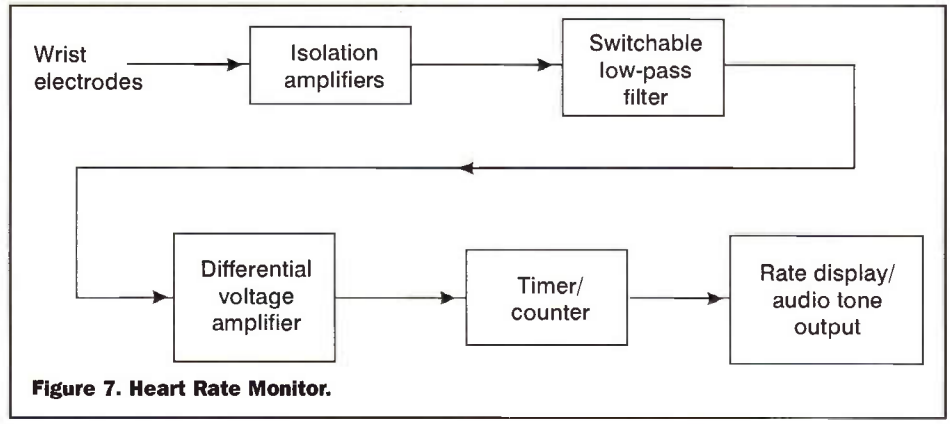



**Figure 7. Heart Rate Monitor.**

make some suggestions for projects that can easily be put together at home which will demonstrate some of the principles of bio-feedback with electronic enhancement, and which will enable some practice at physiological control. The guidance of a trained qualified professional will however give the best results in most cases.

## Projects

For all these projects use a battery powered circuit to ensure there are no mains isolation concerns. Even a professional power supply unit shouldn't be used in medical type applications. As will be seen in the final part of this series there are very specific requirements for medical equipment safety particularly regarding isolation from the mains and each design has to be approved before it can be used commercially.

Restrict the supply voltage to below 10V. A PP3 battery is ideal for these projects.

## The Output Stage

The required output indication for bio-feedback with electronic enhancement is common to all projects and is shown in Figure 8.

The input to this stage, i.e. the output from each particular monitor project therefore needs to be a voltage which falls as the subject achieves more and more of the desired objective.

Specific design considerations for each project follows.

## Skin Resistance Project

There should be no dc component to any current flowing through the skin so for a simple project use dc blocking capacitors between the electrodes and the circuit. Restrict the output current flow to around 100 or 200$\mu$A. This shouldn't be a problem for a skin resistance project with a 9V supply battery since skin resistance values will be in the order of a hundred to several hundreds of kilo ohms. A series resistor could be added if in doubt.

Since dc can not be used an oscillator or pulse generator is obviously required. Frequency isn't critical so something around 1kHz is a convenient value. Radio frequencies definitely should not be used as these can cause burns (and also electromagnetic interference). A square wave astable is probably easier to construct around 1kHz than a sine wave generator.

Probably the easiest detection circuit is to measure the voltage developed across the skin resistance. Although this could simply be observed on a digital multimeter (DMM), it is important for bio-feedback training that the response is quickly and easily observed, so as a minimum requirement an analogue voltmeter with a large display is needed. Preferable though is some form of audio indication as it allows relaxation more easily without having to concentrate on a small indicator. A tone that is 'easy on the ear' is also better to allow relaxation, so a sound waveform closer to a sine wave than a square wave is preferable. For the same reasons sound reproduction on a reasonable quality loudspeaker will give better results than by using a small sounder or even headphones, unless they are lightweight headphones which don't cause distractions. Some form of voltage controlled oscillator would of course be needed to convert the detector voltage to an audible tone; as the original detector output will be a square wave this will need to be smoothed to give a dc control signal.

Since the frequency needs to decrease with relaxation (this is psychologically more natural), which corresponds to increasing skin resistance, the voltage amplifier needs to have an inverting input unless a series resistor has been used in which case the resistor must be in the more 'grounded' half of the voltage divider formed by it and the skin resistance.

The block diagram of Figure 2 is a good starting point for the detection circuit.

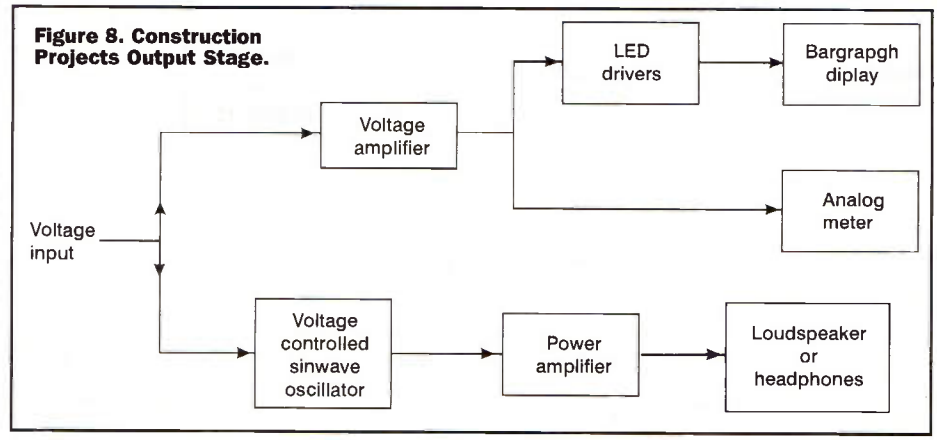



**Figure 8. Construction Projects Output Stage.**

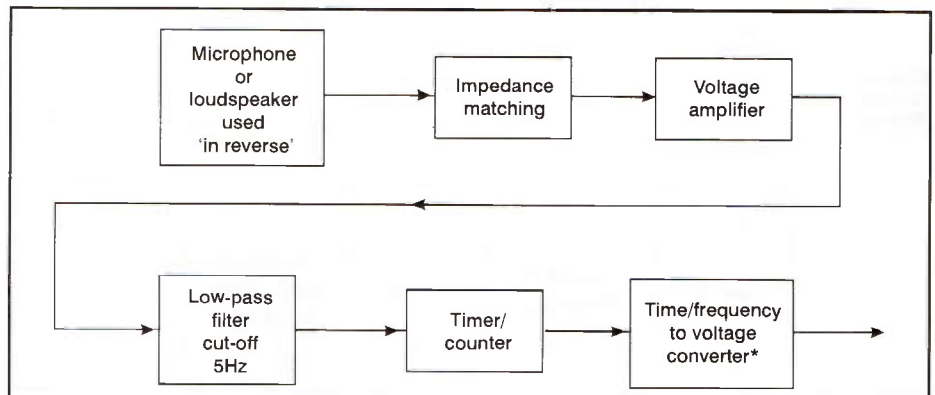



**Figure 9. Phonocardiograph.**

*Output voltage proportional to average time between 'beats'

## Skin Temperature Project

The basis of a skin temperature project is a simple bead thermistor, a device which changes its resistance with temperature and is specifically designed for temperature measurement purposes. The use of a bead thermistor, which is physically smaller than other types of thermistor, is preferable for this purpose as its response time is shorter which is better for bio-feedback purposes.

Any form of resistance measurement circuit can be used here. A suitable method is a simple voltage divider circuit which then connects into a similar circuit to the skin resistance monitor to give an audio or visual indication according to skin temperature. The audio frequency should fall with rising skin temperature.

The block diagram shown in Figure 4 is a good starting point for this monitor circuit. A dc excitation for the voltage divider section could be used instead of the oscillator as there is no direct electrical connection to the skin. This would mean that the rectification and smoothing circuit would not be needed but a dc offset adjust might have to be added in its place.

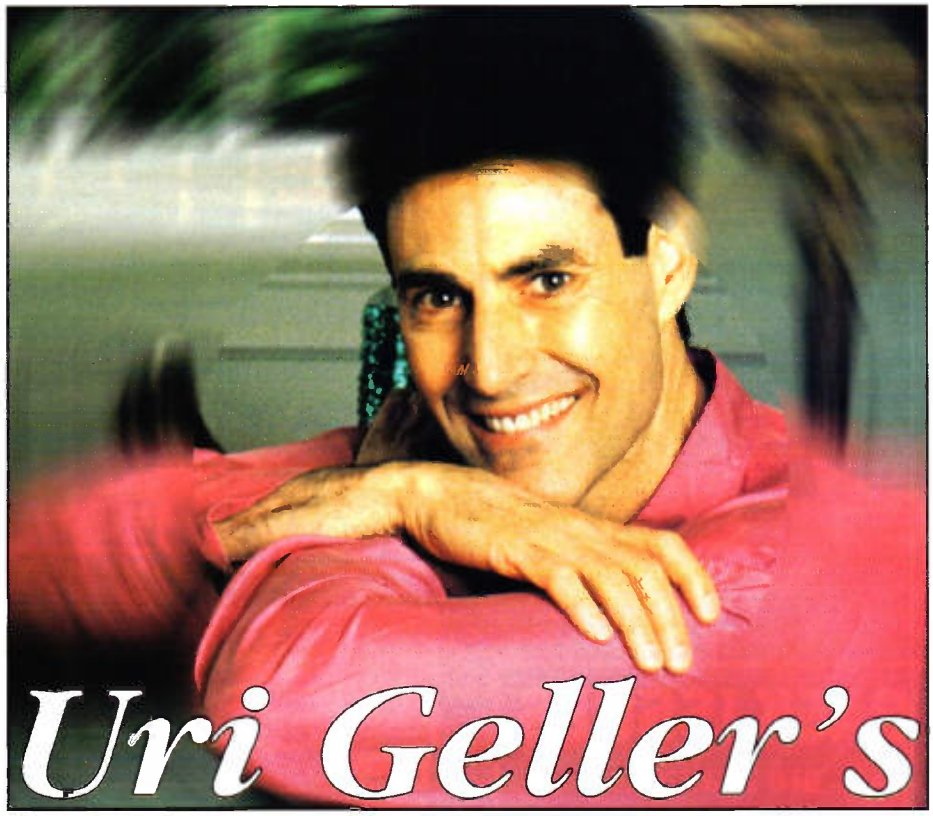
As has been discussed another useful form of bio-feedback uses the difference in temperature between the left and right hands as opposed to absolute temperatures, so a further adaptation of this circuit would be to measure the resistance of two thermistors, one on the same finger of each hand, convert these to voltages and then feed the difference between these to the output stage.

## Phonocardiography Project

This simple project is effectively an electronic stethoscope. By using a sensitive microphone, or even using a small loudspeaker (around two to three inches in diameter) in reverse as a microphone, heart beat can be monitored and by using suitable filtering and signal conditioning this beat converted to pulses. These can be counted and timed to give a voltage proportional to heart rate which can then be fed to the audio or visual display and again used as a basis for bio-feedback monitoring. If a loudspeaker is used as a microphone, account will be need to be taken of the fact that it will have a very low impedance. See Figure 9.

## Next Part

In the next, and final, part of this series I'm going to have a look at one or two of the less common forms of bio-feedback with electronics enhancement, and also have a look at some types of equipment which are closely related to bio-feedback types. Plus I'll also be discussing some of the safety aspects of the use of this type of equipment, particularly in regard to connecting people to electrical equipment especially mains powered equipment.



# Uri Geller's EXTENDED REALITY

## The World's Oldest Mysteries

Some mysteries, it seems, just won't go away even when fairly plausible explanations have been given for them. We are still not absolutely sure who was involved in the murder of President Kennedy, and the conspiracy theorists are never going to let that one go. Nor is the argument about whether Shakespeare really wrote the plays and poems attributed to him showing any sign of ending - a new book has just come out in which author John Michell revives the controversy.

Now I love a good mystery as much as anything, but I like it even better when one of them gets solved convincingly, and it now seems that three of the oldest and greatest mysteries of all time are coming close to solutions. One of them, in fact, may already have been solved.

The oldest of all is probably the one that surrounds the lost continent of Atlantis. There is only one source for this legend, and it comes from one of the most influential writers there has ever been - Plato. He gave a meticulous account of it in two of his Dialogues, including all kinds of dates and measurements, and he described how it was wiped off the face of the earth by a huge flood. He also said more or less where it was - beyond the Pillars of Hercules near what is now Gibraltar. He seems to have had no reason for writing about it in such detail except that he wanted the story to be preserved for posterity.

Some critics have named the site of Atlantis as the Greek Island of Thira, which is about half way between Greece and Turkey. It is one of a group of about twenty islands, the largest being Naxos and Andros, and if there had been a huge flood in this region these islands might well be all that remains of an old continent. Thira is not where Plato said Atlantis was, but it is known to have been destroyed, not by a flood but a colossal volcanic eruption around 1500 B.C. (Plato dated the end of Atlantis at around 10,000 BC, but it seems likely that some copyist misread his figures and multiplied them all by ten).

Other possible sites for the lost continent are in the Atlantic Ocean around the Azores, another group of islands that are prone to earthquakes and volcanic eruptions one of which could have destroyed an ancient civilisation; and as far afield as Bolivia! This may seem a little too far past the Pillars of Hercules, yet I hear that the intrepid explorer Colonel Blashford-Snell is mounting an expedition to the altiplano region around Lake Titicaca. I wish him the best of luck, but I cannot help feeling, with all due respect to Plato (who may simply have been told a tall story by his friend Critias) that you cannot wipe out an entire civilisation overnight without leaving some trace some-where. Atlantis, in fact, may never have existed.

Our second mystery is that old favourite, the Great Pyramid. There is no doubt that this exists, and was built with amazing skill and precision. People have been swarming all over it, and under it, in recent years and we hear exciting accounts of hidden chambers underneath the Sphinx, locked doors at the end of tunnels, and mysterious alignments suggesting that the pyramids were built as an earthly replica of the heavenly constellation of Orion. Mind-boggling stuff, indeed. Yet, I have been told, there is a good chance that new evidence will be found in or under the Great Pyramid and the Sphinx that will strip away some of the mystery of these massive structures. The Egyptians kept meticulous records of just about everything they did, so it would be surprising if there was no record anywhere of them.

Now for the mystery that, many believe, has been very convincingly solved. You have all probably heard of Charles Berlitz, whose best-seller put the Bermuda Triangle on the map. This is the famous stretch of sea where ships and whole squadrons of aircraft vanish without trace. Yet who has heard of Richard McIver? He is a geochemist who came up with a very simple theory to account for the disappearances. It has to do with seaquakes, which emit clouds of gas and generate negative ions on such a scale that the sea temporarily becomes less dense - so much so that ships sink. These clouds have become visible as a kind of fog within which low-flying aircraft have had all their electronics wiped out, sending some of them into the sea.

About five years ago, film maker John Summers decided to put this theory to 'the test. He built a huge tank and placed a model ship in it. Under the tank was an apparatus designed to simulate the effects of a scaled-down seaquake. When the button was pushed, the ship went down like a ton of bricks in a matter of seconds. So the Bermuda Triangle may well be a real syndrome, but its causes are almost certainly normal. I think we can count this one as solved.

The good news for mystery-lovers is that new evidence can always turn up. In music, for example, new 'old masterpieces' are still being found. My friend Byron Janis found a new piece by Chopin, while just a couple of weeks ago another friend of mine went to a recital where a new piece by a fairly well-known French composer from the 17th century (Forqueray) was played - it had been found a few weeks earlier in the Lille public library, in manuscript, and has never been printed.

What next? A deathbed confession from some hoodlum who masterminded the Kennedy assassination? A letter from Shakespeare to Bacon thanking him for that draft of The Tempest? A huge mural in one of the chambers under the Sphinx narrating the history of the known universe?

Anything is possible.

Uri Geller's novel Ella is published by Headline Feature at £5.99, and his Little Book Of MindPower by Robson Books at £2.50, and Jonathon Margolis' Uri Geller Magician or Mystic? by Orion Books at £17,99.

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# Software HINTS & TIPS

**by Mike Bedford**

***If you're writing about software you'll probably want to produce screen shots. Here we investigate how to do that.***

A subject we covered briefly in the early days of this column was how to produce screen shots. This month we give some further details with particular reference to the tools and facilities available in Windows 98. This, of course, is something I do every month as part of my preparation for this article. However, it isn't only computer journalists who need to produce screen shots or screen dumps. If you're writing software documentation of any sort, or simply providing instructions for a friend or colleague, the ability to include screen images is a must.

## The Basics

First of all let's try an experiment. If you're sitting at your PC you may like to try this out. Simply press the Print Screen key which is at the top left of the cursor control pad on your keyboard. You might think that nothing has happened – certainly it won't have caused your printer to burst into action as it would have done in the days of DOS. However, something certainly has happened and to find out what, you need to use the clipboard viewer. If you've never used this tool you'll find it under Start > Programs > Accessories > System Tools > Clipboard Viewer. Here's the sort of thing you'll find.

The clipboard viewer shows that the clipboard contains a picture of what was on the screen when you pressed the Print Screen key. In the case of my example, there was evidently nothing on the screen other than the Windows 98 desktop. Now try a different experiment and in this case make sure that there is at least one Window displayed on the screen. Now hold down the Alt key and once again press the Print Screen key. Start up the clipboard viewer again to see what's in the clipboard and you'll find that this time it contains a picture of the active window rather than the entire screen as it did before.

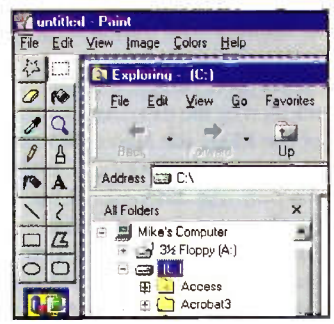
## Saving the Image

So far we've seen how to put an image of either the complete screen or just the active window into the clipboard. However, this alone is of limited value.


Certainly you can use the clipboard viewer to save the clipboard contents but the resultant .clp file isn't particularly useful as it can only be read by the clipboard viewer. To make use of a screen image in a document it first has to be saved in some graphic format such as .bmp or .tif which can be recognised by your word processor or dtp package. A suitable utility for doing this is Microsoft Paint which you'll find at Start > Programs > Accessories > Paint. It's a simple general purpose bitmapped graphics package and it's eminently suitable for converting the clipboard contents into a standard graphics file. Having put a screen or window image into the clipboard using either Print Screen or Alt Print Screen respectively, simply start Microsoft Paint and either press Ctrl V or select Edit > Paste. If the image size currently set in Paint is less than the size of the screen or window image in the clipboard, you'll be asked whether you want the image size to be increased. You should reply that the image size should be increased. If the current image size is greater than the size of the image in the clipboard the clipboard image will simply appear in the top left hand corner of the Paint image. In this case you'd subsequently have to trim the image to size so it's a good practice to ensure that the current image size is always too small. This is simply done using Image > Attributes and selecting some artificially low resolution such as 5 x 5 pixels. Once you've done this, selected Edit > Paste and tell Paint to increase the image size to match the image size in the clipboard you'll end up with something similar to that shown in the screen shot here – the screen or Window image will be displayed by Paint. It's now a simple job to save this in your preferred file format using File > Save.

## Editing the Image

You'll notice that none of the screen shots reproduced in this article are complete screens or complete windows. Instead, I've chosen to reproduce just a portion of the image originally captured in the clipboard. This is a common requirement and is easily done using the editing facilities available in Paint. Having pasted the clipboard image into Paint, use the "select" tool which is the top right box in the tool bar – the one which looks like a dotted rectangle. Now move the cursor to one corner of the rectangle you want to select and drag to the opposite corner. When you release the mouse button you'll find that the selected rectangle is surrounded by a dotted line. It can be tricky to select exactly the right portion of the screen dump but if you get it wrong simply try again – the first rectangle will disappear to be replaced by your new selection. Once you've selected the portion of the screen or windows you're interested in you can transfer this to the clipboard viewer by pressing Ctrl C or selecting Edit > Copy. Now, of course, you're in the same situation as you were when you first pressed Print Screen or Alt Print Screen except that only your selected portion of the screen or window is in the clipboard. So, select File > New and then select Edit > Paste. The cut down image will be pasted into Paint and you can save it in a suitable graphics format as before.




## The Elusive Pointer

So far we've seen how to produce graphics files containing an accurate representation of what was on the screen or in a Window. Actually, though, the image will be lacking one element of what was on screen, namely the mouse pointer. Normally this doesn't matter but occasionally you'll find that it's important to include the pointer. The bad news is that I've found absolutely no way to do this. In other words, it's impossible to produce a screen shot like the one shown.

So how did I produce this supposedly impossible screen shot? I simply cheated, something which Microsoft Paint provides you with the facilities to do. What I mean by cheating is actually drawing in the mouse pointer. It does take a bit of practice, admittedly, but it's not as hard as you might imagine. First of all select View > Zoom > Large Size and the on-screen image will be expanded so that the individual pixels are visible. Now select the Brush tool and select the smallest brush (a single pixel) from the menu of brush sizes and shapes at the bottom of the toolbar. Finally, draw the pointer a pixel at a time selecting the colours of the individual pixels from the colour bar in the bottom left corner of the screen. If you make a mistake you can either select Edit > Undo or overwrite your mistakes in the background colour.

PROJECT

**Photo 1. Finished working monobloc, includes GZ34 rectifier and HT choke in PSU section.**

# High Fidelity CLASS AB1 VALVE POWER AMPLIFIER

***Mike Holmes describes a design based on the famous Williamson valve amp using KT66 Output Valves.***

Judging by the recent additions to the ranges of valves and transformers in the Maplin catalogue, it is plain that valve amplifiers are still generating a good deal of interest. With the inclusion of the KT66 output device to the catalogue range, readers might like to try incorporating this in a power amplifier design as presented here. A finished 'monobloc' made along these lines is illustrated in Photo 1.

The KT66 is a rather strange animal, being described as a 'beam pentode', like a beam tetrode but where the beam forming plates also function like a pentode's suppressor grid (see also *Introducing Valve Technology* Part 4 by Graham Dixey, 'Electronics' issue 70 about beam tetrodes). This came about in order to achieve the large signal swing capability of the beam tetrode, but without the attendant problems.

Developed in 1937 by G.E.C. (who, incidentally, began their valve research in a shed at Osram's lamp making works), the KT66 appeared in time to see much use by allied forces during the Second World War, where it gained a reputation for efficiency and reliability in less than ideal conditions. In other words, it has been well tried!

## Circuit Description

The complete circuit is shown in Figure 1. The output stage is 'cribbed' directly from a 'Williamson' design, initially released by the then manufacturer of the KT66, the Marconi/Osram Valve Co. Ltd. (M.O.V.), in 1947, the only real difference being that here it is 'forced' to use a 6.6kW (Ra/a) Millennium 4-20 output transformer (Order Code DM53H) as T1, instead of the 4.5kW transformer recommended in the data book, but it has no problems with this.

Originally an experimental Williamson triode mode output stage was tried, but this did not have enough gain, being limited to 10 watts. On being 'restored' to the 'ultra-linear' distributed load type, output is approximately 20 watts, which is the same as for the original Maplin Mullard-based Millennium 4-20 design.

There needs to be two special considerations for it, firstly the RC Zobel networks associated with each screen grid resistor of V3 & V4, namely R19 & R23. In each case the addition of C12, R20, and C13, R22 sets the upper frequency limit of T1 to roll off by at least 3dB at some 70kHz - without this there will be a tendency to HF instability and perhaps an overly 'bright' sound.

V3 & V4 could have plain cathode resistors as per the original Williamson of 250Ω each, *provided* that the KT66 valves are a matched pair. In practice, however, differences appeared after some use, even with what started out as a matched pair, to cause some imbalance in the output transformer. Such imbalance may affect LF performance if too severe. Adding a system of manually adjustable bias trimmers was not satisfactory - it needed rebalancing at periodic intervals, a process that required the aid of an AF generator and 'scope in every instance!

## Self-Balancing Valves

Hence a more modern approach was eventually adopted, resulting in the 'self biased' valves of Figure 1. Two constant current generators, comprising TR1 - TR4 and R23 - R26 inclusive, have the effect of maintaining an equal quiescent current of 60mA in each arm of the transformer primary at all times. Since the output stage operates in class A most of the time this is acceptable, C16 & C17 providing the extra for the occasional excursions into class B mode.

As a result, V3 & V4 need not even be a matched pair at all in the first place. One disadvantage of the method is the power dissipation of 2 - 3 W each for TR1 & TR3; these must then share a finned heatsink of at least 2 x 4 inches square, additionally mounted on plastic stand-offs away from the chassis, which itself can get quite warm.

This heatsink incorporates a 2 x 4 inch stripboard 'PCB' to accommodate TR2, TR4 and R23 - 26. Thus the assembly becomes a bolted-on module and connects into circuit via twinned wire leads through the chassis wall.

Strange to tell, the 'front-end' part of the amplifier, comprising V1 to V2a & b, is directly cribbed from a deflection amplifier for a (now long extinct!) home made oscilloscope. The configuration was, and still is, simple yet very successful, due in large part to the employment of the 6SN7 device, a versatile and flexible double-triode. In fact the circuit may not work reliably using for example the ECC83 type. The low amplification factor of the 6SN7, having a $\mu$ ('mu') of 20, helps to ensure stability of the

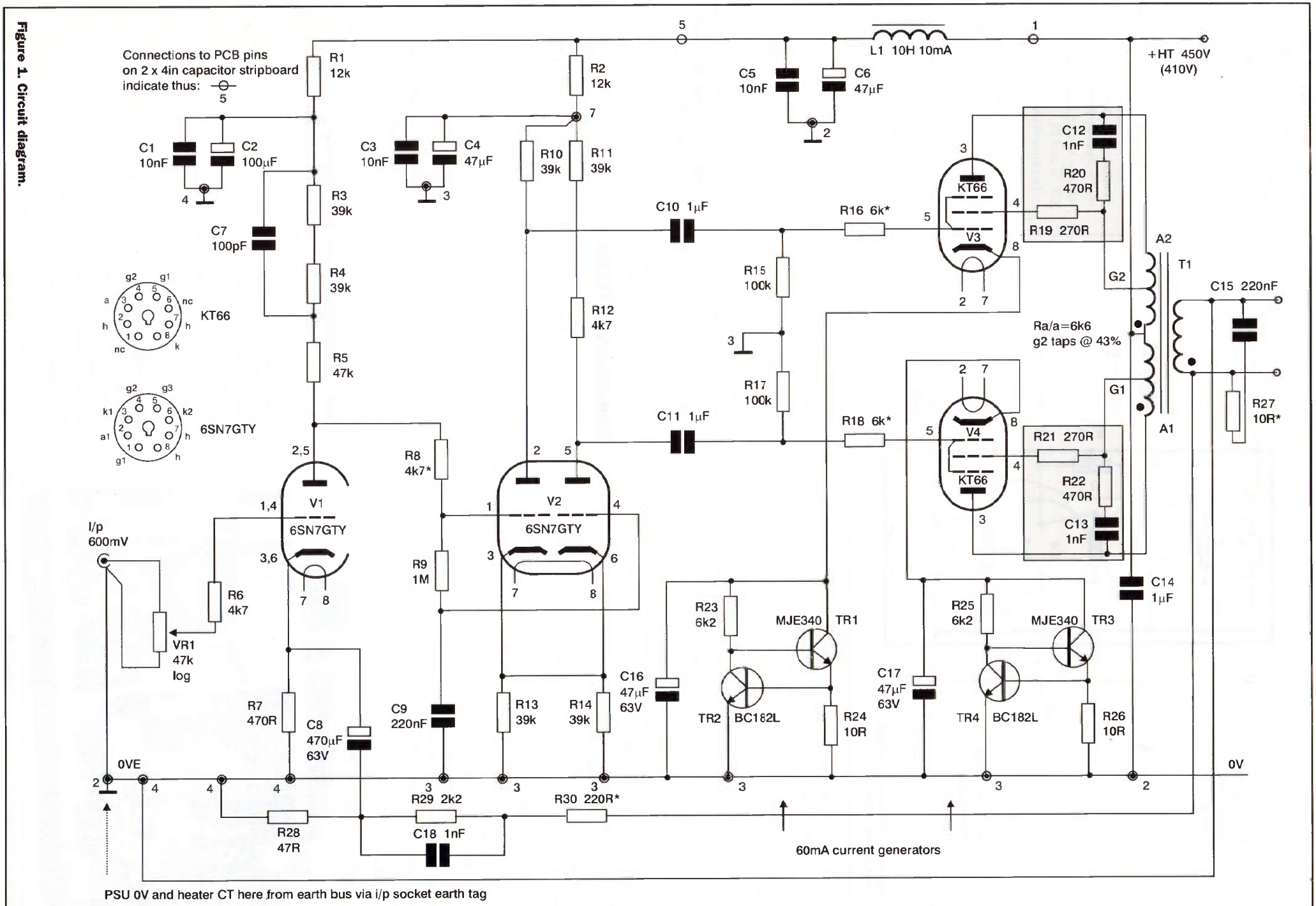



**Figure 1. Circuit diagram.**

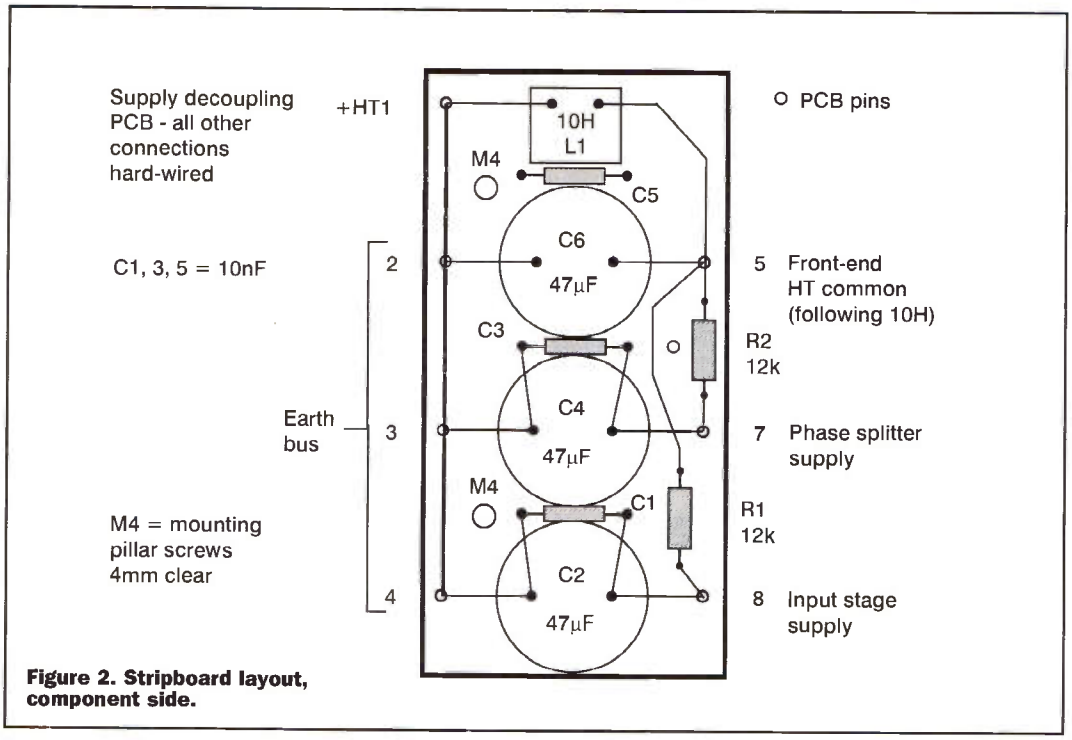



**Figure 2. Stripboard layout, component side.**

circuit. Latterly (comparatively speaking) the octal base 6SN7 acquired the GT suffix, the high quality or 'military spec' type being GTY (can also be marked as the RAF equivalent 'CV1988').

Ideally, V1, a single valve, should be the electrical equivalent, single triode version 6J5, which even comes encased in its own metal screening can, but this seems to be obsolete and in any case was always very expensive. So choose which three pins to use from the 6SN7 as V1, either 1 - 3 or 4 - 6, and ground the three unused pins.

V1 provides direct DC bias to the phase splitter V2a & b, with a comparatively large value anode load chain of resistors R3 & R4, setting the precedent for a series of 39k values throughout that consequently gave the project the early working title of 'the 39-kilohm amplifier...'

HF stability is promoted at this early stage by C7 and R5 providing HF roll-off. V2b receives the same DC bias as V2a, but this is decoupled to ground by R9 and C9; V2b is therefore cathode coupled to V2a from pins 3 to 6 and operates in grounded grid mode, producing equal and opposite phases on the anodes with enough 'headroom' to more than adequately drive the grids of V3 & V4. R12 is added to offset the (very) small loss in V2b incurred by this method.

Note that every valve is given a 'grid-stopper' resistor to further promote HF stability, these are R6, R8, R16 & R18. Similarly a Zobel network, C15 (Mylar type) with R27, is connected across the speaker terminals. These measures were found necessary to help resist RF breakthrough.

The open loop gain overall is actually quite modest - you could arguably operate the amplifier in open loop mode - but for the sake of at least ensuring a flat frequency response some negative feedback is given by the chain R28 - 30 with C18. The tap at R28 is coupled to V1 cathode via C8 where its high value ensures a smooth LF response.

## Construction Notes

All resistors having an appreciable voltage drop need to be 1% 2W metal film types, to handle the power dissipation in combination with the high temperature of their environment; these include R3, R4, R11 - 14, R19 - 22. The remainder can be 1% 0.6W 'Min Res' types. Similarly all non-electrolytic capacitors should be high voltage (500 - 1000V) ceramic types - polystyrene ones find the heat a bit too much. The exceptions are C9 as 500V polypropylene, and C10, C11 and C14 as audio grade 500V polypropylene.

All valve holders are octal type, the layout of these and the position of T1 on the chassis being more or less as per Millennium 4-20 (see 'Electronics' issue 74 or leaflet XU46A). Components and wiring are made directly between the various solder tags, except for C1 - 6 and L1.

Because these are specifically designed for PCB mounting, they are assembled onto a 2 x 4 inch piece of plain stripboard, see Figure 2 (showing the component side). This board doubles as a tag strip providing an 'earth bus' on one side and HT supply points for the V1 & V2 stages on the other. The board is mounted on a pair of M4 threaded pillars between V1 & V2 valve holders (see also Photo 2).

The power supply is exactly as the Millennium PSU ('Electronics' issue 73 or leaflet XU45Y). Complete parts lists can be seen on the web page **http://www.mc-h.demon.co.uk/vpwrparts.htm.** A stereo pair of 'monoblocs' configured as described here have now been operating for at least two years without any problems. Performance is pretty much as for the Millennium 4-20 (see Table 1); with the addition of LF choke ST28F to the HT line (this is not L1 in Figure 1), the output noise is sufficiently minimal to allow headphones to be used - with dummy speaker loads, of course!

Next month Mike Holmes will give details of a GZ34 PSU to use with the amplifier, and to provide an alternative to the 'soft start' PSU.

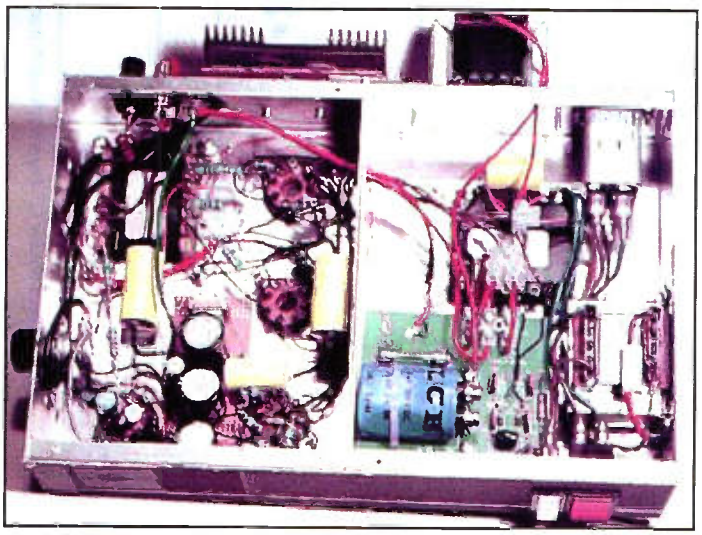


**Photo 2. Internal view of chassis underside.**

**Table 1. Specification for one single monobloc***

| | |
|---|---|
| Type: | Class AB1 push-pull distributed load |
| Input Sensitivity: | 630 mV rms |
| Output Power: | 21 W rms |
| Speaker matching: | 6 - 8W |
| Speaker damping: | >40 |
| Signal to noise ratio: | 70 - 90dB approx. |
| Voltage gain: | 26 dB |
| HF roll-off: | -3 dB @ 70kHz |
| LF roll-off: | -3 dB @ 25Hz full power |
| Distortion: | < 0.1% |
| Valves: | 4 (5 with GZ34 rectifier) |

**Power requirements:**

| | |
|---|---|
| HT supply: | 400 to 450V DC |
| HT current: | 130mA average |
| Heater supply: | 6.3 V AC @ 3.5A |
| Mains input (to PSU): | 115/230V AC 50/60 Hz |
| Power consumption: | 80 - 90VA continuous |
| Working temperature: | 50°C |

*Two 'monoblocs' are required to form a stereo pair

## PROJECT PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS** | | | |
| R1,2 | 12k 0.6W 1% Metal Film | 2 | (M12K) |
| R3,4,11-14 | 39k 2W 1% Metal Film | 6 | (D39K) |
| R5,6,8,12 | 4k7 0.6W 1% Metal Film | 4 | (M4K7) |
| R7,20,22 | 470R 2W 1% Metal Film | 3 | (D470R) |
| R28 | 47R 1W 5% Carbon | 1 | (C47R) |
| R29 | 2k2 2W 1% Metal Film | 1 | (D2K2) |
| R30 | 220R 2W 1% Metal Film | 1 | (D220R) |
| R19,21 | 270R 2W 1% Metal Film | 2 | (D270R) |
| R27 | 10R 1W 5% Carbon | 1 | (C10R) |
| R9 | 1M 0.6W 1% Metal Film | 1 | (M1M) |
| R15,17 | 100k 0.6W 1% Metal Film | 2 | (M100K) |
| R24,26 | 10R 0.6W 1% Metal Film | 2 | (M10R) |
| R16,18,23,25 | 6k2 0.6W 1% Metal Film | 4 | (M6K2) |
| **CAPACITORS** | | | |
| C1,3,5 | 10nF 1000V Ceramic Disc | 3 | (JL04E) |
| C2,4,6 | 47µF 450V PC Electrolytic | 3 | (JL18U) |
| C7 | 100pF 1000V Ceramic Disc | 1 | (BX07H) |
| C8 | 470µF 63V PC Electrolytic | 1 | (VH48C) |
| C9 | 220nF 500V Polypropylene | 1 | (FA22Y) |
| C12,13,18 | 1nF 1000V Ceramic Disc | 3 | (JL03D) |
| C10,11,14 | 1µF 500V Audio Grade Polypropylene | 3 | (KR78K) |
| C16,17 | 47µF 63V PC Electrolytic | 2 | (VH34M) |
| C15 | 220nF 250V Mylar 3 | 1 | (WW83E) |
| **VALVES** | | | |
| V1,2 | 6SN7GTY Double Triode | 2 | |
| 3,4 | KT66 Power Output Beam Pentode | 2 | (LA98G) |
| **SEMICONDUCTORS** | | | |
| TR2,4 | BC182L npn | 2 | (QB55K) |
| TR1,3 | MJE340 npn | 2 | (QH54J) |
| **MISCELLANEOUS** | | | |
| | Chassis AC86 2.5 x 6 x 8in. | 1 | (XB68Y) |
| | Plain Stripboard 2 x 4in. 2 off | 1 pc | (JP53H) |
| L1 | 10H 10mA Choke PCB mount | 1 | (HW27E) |
| | Bell Wire Black | 1 Pkt | (BL85G) |
| | Bell Wire Orange | 1 Pkt | (BL90X) |
| | Hook-Up Wire 3A Brown | 1 Pkt | (FA28F) |
| | Hook-Up Wire 3A Black | 1 Pkt | (FA26D) |
| | 6A Wire Black | 1m | (XR32K) |
| | Single Coax Cable | 1m | (XR16S) |
| TB1 | Gold Twin Terminal Posts 4mm | 1 | (JK24B) |
| | M5 Shakeproof Washer | 1 Pkt | (BF42W) |
| | Std Grommet 9.5mm | 1 Pkt | (JX63T) |
| | M3 x 10mm Bolt | 1 Pkt | (JY22Y) |
| | M3 Nut | 1 Pkt | (JD61R) |
| | M3 Shakeproof Washers | 1 Pkt | (BF44X) |
| | M3 Tag Washer | 1 Pkt | (LR64U) |
| | M4 x 10mm Threaded Spacer | 2 | (FG39N) |
| | M4 x 6mm Bolt | 2 | (JY13P) |
| | M4 Steel Nut | 1 Pkt | (JD60Q) |
| | Heat Resistant Sleeving Red | 1m | (BL70M) |
| | 1mm PCB Pin | 1 Pkt | (FL24B) |
| T1 | 20W Valve O/P Transformer | 1 | (DM53H) |
| VB1-4 | Valve Base Octal | 4 | (CR30H) |
| VR1 | Pot Log 47k | 1 | (FW24B) |
| | Gold Chassis Phono Socket Single (insulated mounting) | 1 | (JZ05F) |
| | Finned Aluminium Heatsink, 4 x 2in. approx. offcut | 1 pc | (FL42V) |
| | M3 x 12mm Threaded Insulated Plastic Pillars 2 off | 1 Pkt | (FS36P) |
| | M3 Clear x 6.3mm Pillars 2 off | 1 Pkt | (FW34M) |
| | 6BA Nylon Washers | 1 Pkt | (BF84F) |
| | Stick-On Feet Square (4) | 1 Pkt | (FD75S) |
| | 25W W/W 8.2R (dummy load) | 1 | (P8R2) |
| | Aerosol Grey Primer Paint | As req.d | - |
| | Aerosol Matt Black Paint | As req.d | - |

# Diary Dates

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

## September 1999

**5 to 7 Sept.** ECTS - Computer & Video Games & Leisure, Earls Court, London. Tel: (0181) 742 2828.

**5 to 8 Sept.** PLASA - Light & Sound Trade Show, Earl Court, London. Tel: (0171) 244 6433.

**10 to 11 Sept.** Computing Careers Exhibition, The Royal Horticultural Halls, London. Tel: (0171) 316 9170.

**14 to 15 Sept.** Broadband Year 99 - ATM & Broadband Communications, Olympia, London. Tel: (0181) 541 5040.

**15 to 16 Sept.** Electronic Components Industries Fair, Olympia, London. Tel: (01799) 528 292.

**15 to 16 Sept.** Onboard - Electronics Assembly Exhibition, Olympia, London. Tel: (01799) 528 292.

**21 to 23 Sept.** Microwave & Communication Technology, Wembley Exhibition, London. Tel: (01322) 660 070.

**24 to 25 Sept.** AM Radio Show, Donington Exhibition Centre, Donnington. Tel: (01604) 790 966.

**28 to 29 Sept.** Business Computer Systems Show, G-MEX Centre, Manchester. Tel: (07000) 464 336.

**28 to 29 Sept.** Call Centre Expo - Telebusiness & Customer Service, National Exhibition Centre, Birmingham. Tel: (0181) 742 2828.

**28 to 30 Sept.** Document & Workflow Management, Olympia, London. Tel: (0181) 742 2828.

## October 1999

**1 to 2 Oct.** TheatreWorld - Theatre Productions & Management, Wembley Exhibition Centre, London. Tel: (01895) 811 986.

**5 to 6 Oct.** FieldComms - Industrial Networking Show, Telford Exhibition Centre, Telford. Tel: (0171) 417 7400.

**6 to 7 Oct.** Softworld in Accounting & Finance, National Exhibition Centre, Birmingham. Tel: (0181) 541 5040.

**6 to 7 Oct.** TEST - Electronic Testing Exhibition, National Exhibition Centre, Birmingham. Tel: (01203) 230 333.

**12 to 14 Oct.** Cards UK - Plastic Card Technology, National Exhibition Centre, Birmingham. Tel: (0121) 767 2665.

**19 to 20 Oct.** Property Computer Show 99, Barbican Centre, London. Tel: (01273) 836 800.

**20 to 21 Oct.** Accounting IT, Business Design Centre, London. Tel: (0171) 221 1155.

**26 to 28 Oct.** City Information Show, Barbican Centre, London. Tel: (01865) 204 947.

**26 to 28 Oct.** Computers & Networks in Manufacturing, National Exhibition Centre, Birmingham. Tel: (0181) 232 1600.

**26 to 28 Oct.** Mobile Data Communications Trade Exhibition, Olympia, London. Tel: (0181) 910 7910.

**26 to 28 Oct.** Windows NT - Computer Trade Exhibition, Olympia, London. Tel: (01256) 384 000.

## November 1999

**2 to 4 Nov.** e-business expo 2, Olympia, London. Tel: (0181) 910 7910.

**8 Nov.** PC@Home+Internet4All, G-MEX Centre, Manchester. Tel: (01895) 630 288.

**10 to 11 Nov.** Data Warehousing, Olympia, London. Tel: (0181) 879 3366.

**16 to 18 Nov.** Digital Media World, Wembley Exhibition Centre, London. Tel: (01244) 378888.

**16 to 18 Nov.** Electronic Information Display, Sandown Exhibition Centre, Sandown. Tel: (01822) 614 671.

**17 to 18 Nov.** JAVA - Computer Software Trade Exhibition & Conference, Olympia, London. Tel: (01256) 384 000.

**17 to 18 Nov.** Softworld in Sales & Marketing, National Exhibition Centre, Birmingham. Tel: (0181) 541 5040.

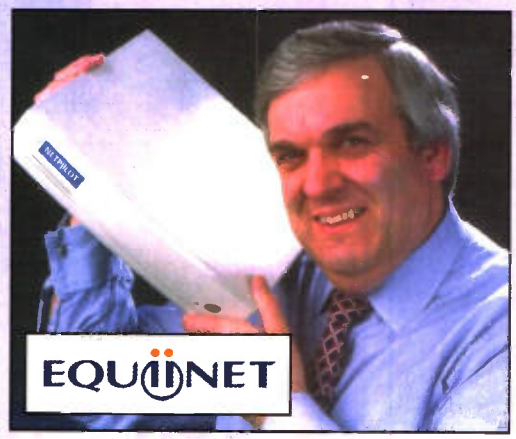
## December 1999

**7 to 8 Dec.** Digital Signal Processing & Data Acquisition, Sandown Exhibition Centre, Sandown. Tel: (0181) 547 3947.

**7 to 9 Dec.** Online Information, Olympia, London. Tel: (01865) 388 000.

**Please send details of events for inclusion in 'Diary Dates' to: News Editor, *Electronics and Beyond*, P.O. Box 777, Rayleigh, Essex SS6 8LU or e-mail to swaddington@cix.compulink.co.uk.**

# What's On?




## Equiinet's Jones Slams BT for High Speed Multimedia Sham

Bob Jones, chairman of Equiinet has critised BT for holding back nationwide high speed multimedia services that would bring voice, video, and Internet capability over BT's existing network to every home and business in the UK.

"BT is attempting to blackmail the country. Company officials are on record as saying that the telecoms operator would be ready to roll out high-speed data access countrywide over existing telephone lines by August 1999," said Jones.

According to a recent report in the Sunday Times, BT has told OFTEL, the industry watchdog and the UK government that it cannot justify proceeding with the high speed network unless demands from BT's rivals for equal access to the network are rejected.

BT would use a technology called ADSL to more than quadruple the bandwidth of conventional telephone lines. This would enable multiple data, voice, high speed Internet or video services to be run over a standard BT telephone line.

"The majority of the network that BT would use to roll out ADSL services was built in the days before deregulation when BT was the state telecom provider. BT owes it to the nation's industry, educational establishments and consumers to make high speed multimedia and Internet access available over its networks," said Jones.

"I have spent the majority of my working life building products and companies that enable information to be brought closer to people. BT is acting against the public interest in holding back a service which is a national resource and is vital in keeping British industry competitive."

For further details, check: **<www.equiinet.com>.**
Contact: Equiinet, Tel: (01793) 603700.

## 3Com President Outlines Key Emerging Network Technologies

Networks will soon become as commonplace as electricity, and as necessary, available, affordable and easy to use as today's telephone network according to 3Com president and COO Bruce Claflin speaking at a keynote address to CAMP Expo '99 in the US in June.

"As networks become more pervasive and accessible, people's quality of life and well-being will be substantially improved," said Claflin.

During his remarks, Claflin stated that achieving a new level and quality of personal access will depend on the deployment of converged networks, or combining the current parallel voice, video and data communications systems on a single network infrastructure,

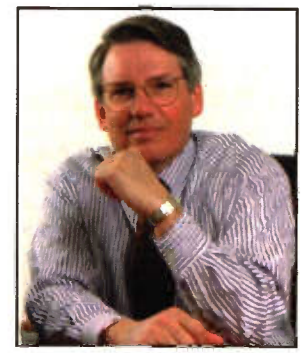
"Converged networks will offer a fundamentally lower total cost of ownership, and the ability to deliver voice, video and data applications, including e-commerce, distance learning, next-generation call centres and telemedicine."

Claflin explained that the new applications supported by converged networks will make it possible for users to collaborate, learn, and transact business in real time across the globe, unlocking significant competitive advantages, and enabling entirely new ways and methods of doing business.

"Converged networks are not only something for the future - they are being deployed in enterprises today to achieve both telecommunications cost savings and competitive advantage," Claflin said.

For further details, check: **<www.3com.com>.**
Contact: 3Com, Tel: (0118) 927 8200.

## Conference Finds Remote Working is Only for the Well-Connected



Small businesses are not adopting technology for remote working. This is the finding of a telephone poll of 150 companies with less than 50 employees conducted by ACC Telecom as part of its campaign to understand the communications needs of small and medium-sized enterprises.

Teleworking, and other issues faced by small businesses, was discussed at the British Chambers of Commerce (BCC) National Conference, Glasgow Conference Centre June 3 and 4, 1999, sponsored by ACC.

88% of companies said that less than one in four of their staff are teleworkers, despite indications that larger companies are fully adopting teleworking. Only 7% expect this number to grow within the next five years. In addition, 59% of companies said that less than a quarter of their staff have e-mail addresses or desktop Internet access.

However, 91% of companies acknowledged the benefits, and importance to their business, of communications technology such as the Internet and mobile telecoms. And most (60%) small businesses have set up their own Web site.

For further details, check: **<www.accuk.co.uk>.**
Contact: ACC Telecom, Tel: (0800) 980 1601.

PROJECT


# Ultrasonic DETECTOR

***Gavin Cheeseman describes a low-cost, wideband ultrasonic detector.***

Sound is transmitted through the air in the form of pressure waves. The human ear will respond to sound waves in the approximate frequency range 20 to 20000 cycles per second (20Hz to 20kHz) although this figure varies considerably between individuals. Sound waves outside this frequency range are also readily propagated through the air but are simply not audible to the human ear. Many other species are capable of producing and detecting sound over different frequency ranges which can vary considerably. For example, it is well known that dogs can usually hear much higher frequencies than their owners and pigeons produce very low frequency sounds. Some species, notably bats, use high frequency 'ultrasonic' bursts to provide positional information, analogous to radar on a boat or aircraft. In addition to natural sources, ultrasonics are also used in a host of technological applications from ultrasonic tape measures to security systems.

In this article we look at a circuit that is capable of detecting and converting high frequency (ultrasonic) waves to an audible frequency. Its uses include testing ultrasonic transducers and listening to the normally inaudible ultrasonic emissions from bats and other creatures.

## Circuit Description

Figure 1 shows a block diagram of the ultrasonic detector circuit. The circuit operates by mixing the signal from a microphone with the output from an oscillator operating in the ultrasonic frequency range. The result is a complex mixture of frequencies including the frequency difference between the incoming signal and the circuit's internal oscillator. The audible components of the output are filtered and amplified. Using this method it is possible to effectively translate part of the ultrasonic frequency range to a much lower audible frequency range. For example if the internal oscillator is tuned to a frequency of 30kHz and the microphone detects an ultrasonic emission at 31kHz, when the signals are mixed the resulting output will include 1kHz (the difference between the two frequencies) which is audible to the human ear. Of course an incoming signal at 29kHz will also produce a 1kHz difference frequency but for many applications this does not present a serious problem.

The circuit diagram of the detector is shown in Figure 2. Power is connected between terminals P1 (+V) and P2 (0V) via switch S1 which is connected externally. Diode D1 is included to avoid damage to the circuit if the power supply is connected with the wrong polarity. Input signals from the microphone or transducer are applied to the circuit on terminal P3. Capacitor C2 blocks DC and also forms part of a simple high pass filter. The signal is fed to the non-inverting input of operational amplifier IC1a. A 1/2 supply voltage reference is provided by resistors R1 and R2 which form a potential divider. C1 helps to ensure that noise on the supply rail does not find its way back to the op-amp input. The maximum gain of IC1a is determined by the feedback network comprising resistors R4 and R5. Capacitor C3 produces a rolloff at low frequencies enhancing the high pass effect and blocking DC.

The output from IC1a is connected to the next stage (IC1b and associated components) via C4. This stage acts as an inverting amplifier. R6, R8 and C5 provide a voltage reference for the op-amp whilst R7, R9 and VR1 set the gain. VR1 allows the user to reduce the gain of the amplifier in the presence of high input levels. Capacitor C6 provides high frequency supply decoupling and is mounted close to IC1.

The output of IC1b is connected to the signal input of IC2, an MC1496 balanced modulator which is configured as a product detector. A second input to the device is taken from the oscillator formed by IC4 and associated components. The two signals are mixed by IC2 producing a series of mixing products at the output on IC2 pin 12. The output is filtered by R19, C11 and C12 to remove high frequency components of the signal whist retaining most of the audio frequency content. C13 provides interstage coupling and VR2 controls the volume of the audio signal.

The filtered signal is applied to the input of IC3, a small power amplifier based around the LM386N-1 IC. This provides enough output to comfortably drive headphones. R20 and C16 help to ensure that the amplifier output is free from high frequency instability. The amplifier output is made available on P5. Resistor R21 is included to limit the output to a suitable level for driving headphones.

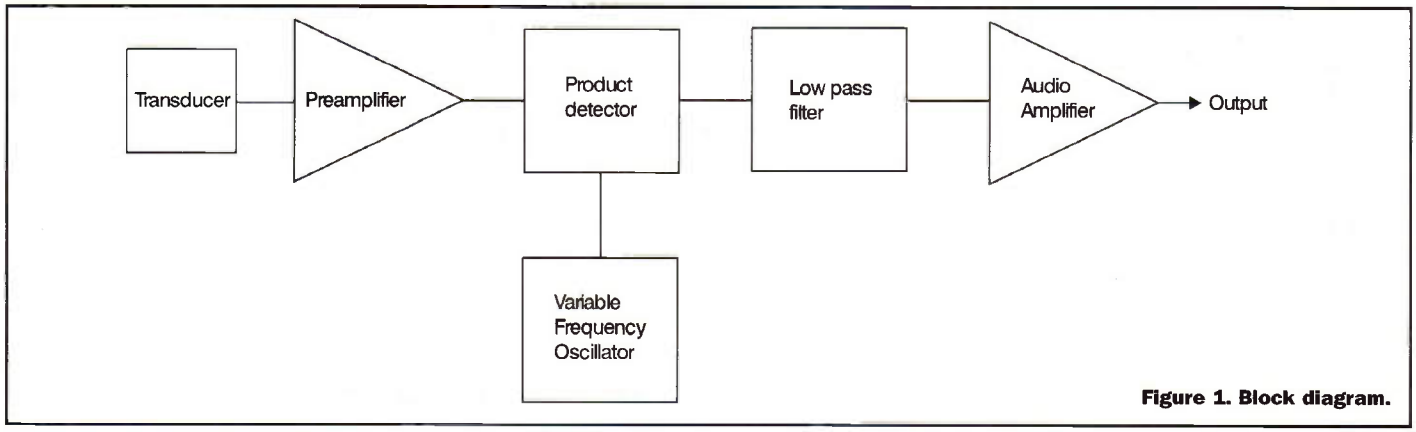



**Figure 1. Block diagram.**

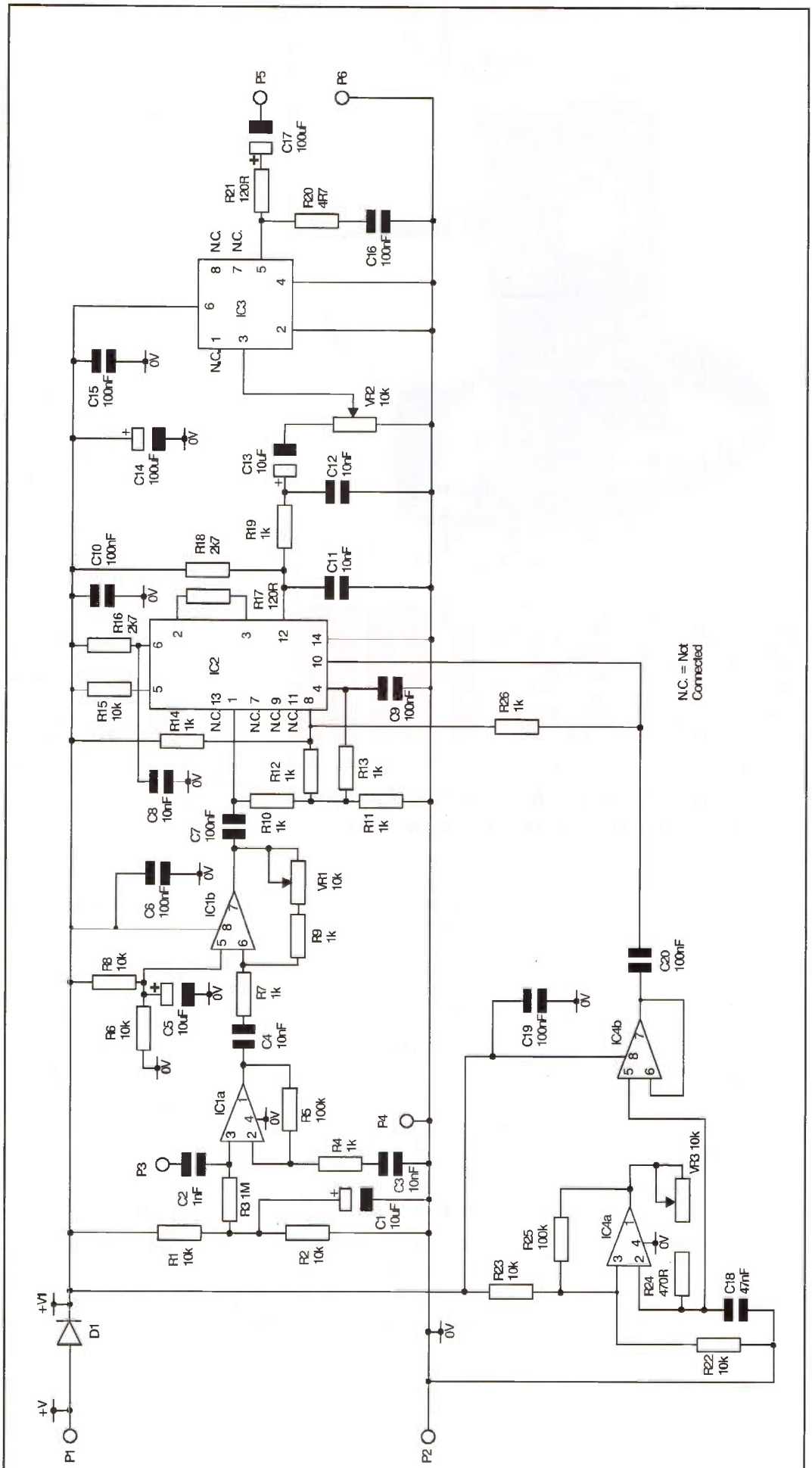



**Figure 2. Circuit diagram.**

## Building the Detector

Most methods of electronic construction are suitable including matrix board and PCB as long as basic layout rules are adhered to. This includes running a separate set of supply rails for the preamp, oscillator, mixer and power amplifier stages joining only at the power supply input pins. Each section should have its own high frequency supply decoupling capacitor, and bulk decoupling capacitor C14 should be positioned close to the power supply input pins. This will help to minimise unwanted noise on the power supply rails and reduce the possibility of instability. Furthermore, it is recommended that the components of each stage are physically grouped together. In particular, power amplifier output wiring should be kept well clear from the microphone input section of the circuit. All leads should be kept as short as possible to avoid picking up unwanted radio frequency signals and to prevent coupling of the internal oscillator into the audio frequency stages.

When constructing the circuit it is probably easiest to start with the low profile components such as resistors and diodes as these can be awkward to fit once the larger components are in place. As usual, it is recommended that DIL sockets are used for the IC's as this helps to prevent the devices being damaged during installation.

Constructors are reminded to take care when fitting polarised components. As well as preventing the circuit from working properly, incorrectly connected components can overheat or explode. Pinout details for the ICs used in the circuit are shown in Figure 3. Electrolytic capacitors are polarised and must be connected correctly. The negative lead of the capacitor is usually indicated by a negative (-) symbol on the side of the component body. The negative lead is also usually the shortest of the two. Diodes are also polarised with the cathode being indicated by a band at one end of the component.

The potentiometers may either be mounted onto the circuit board or be wired off board using short lengths of hook-up wire. In either case, it is important to ensure that the controls are secured properly when the unit is finally assembled. Do not rely on the leads to hold the potentiometers in position

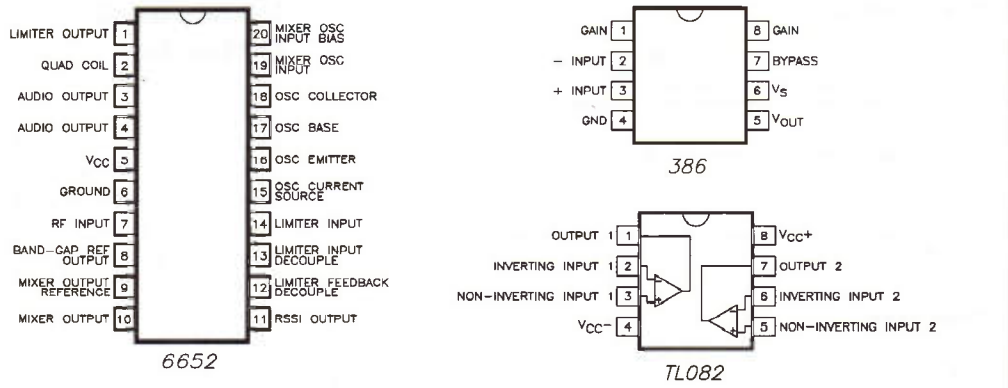



**Figure 3. IC Pinout.**

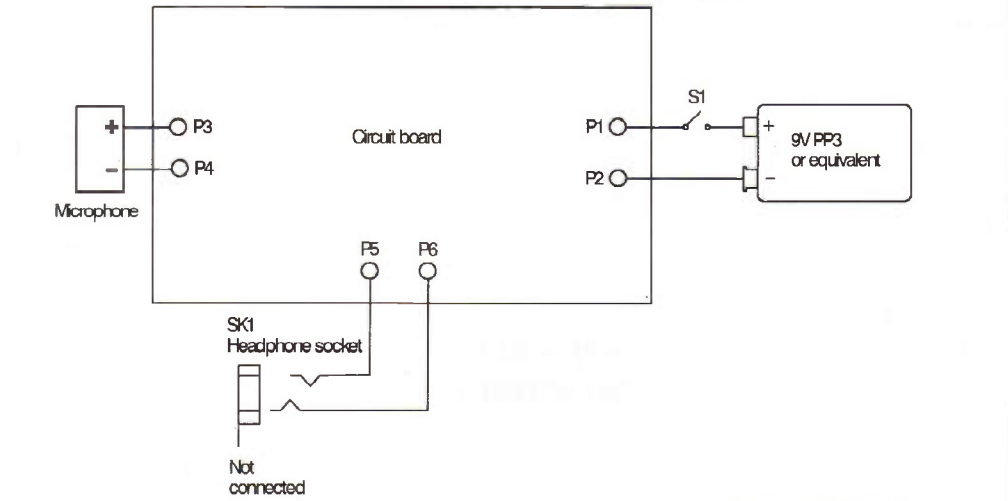



**Figure 4. Wiring diagram.**

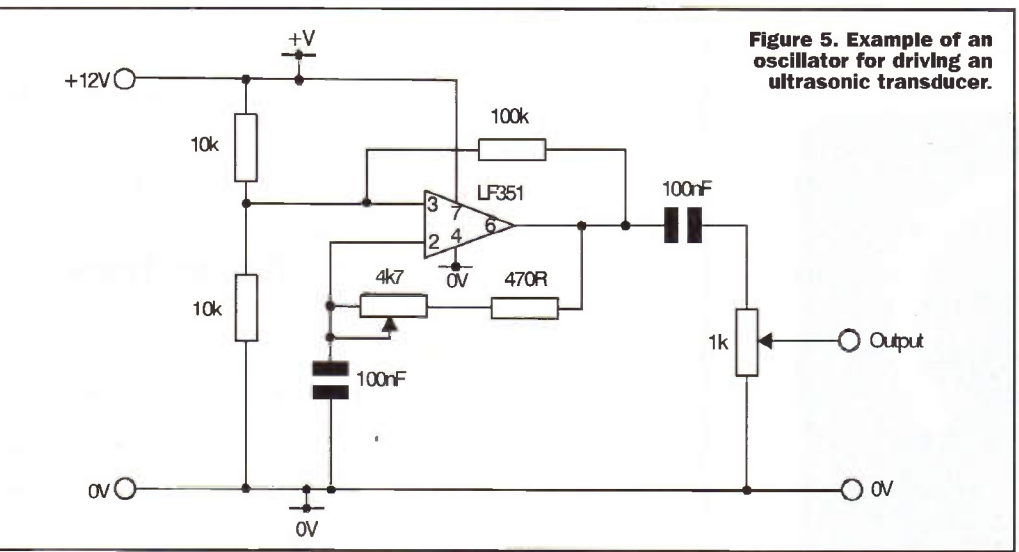



**Figure 5. Example of an oscillator for driving an ultrasonic transducer.**

as these can be easily broken.

The microphone is connected off board using a short length of hook-up wire. Again, try to keep the leads as short as possible. If it is necessary to use leads longer than a few cm, for layout or other reasons, it is recommended that miniature coaxial cable is used to prevent stray pickup. When connecting the microphone make sure that the case (-) terminal of the device is connected to 0V (P4) and that the '+' terminal is connected to P3.

The audio frequency output is connected to a stereo headphone socket. For most purposes it is probably easiest to connect the headphone socket such that the left and right channels of the headphones are in series. This is illustrated in the wiring diagram shown in Figure 4. Parallel connection is also possible with 32Ω headphones but there is little practical advantage in this.

The battery is connected to the circuit using a standard PP3 type battery clip, with the connection made via switch S1. Although the switch is shown separately on the wiring diagram, it actually forms an integral part of switched potentiometer VR2.

## Testing

Before testing the unit, double check the circuit connections to make sure there are no visible errors. Also look over the solder joints. One of the main reasons for the initial failure of constructional projects is poorly soldered connections. Short circuits caused by solder splashes and dry joints where the solder has not flowed properly are common problems.

It is recommended that the completed circuit board is initially tested before final installation into a case. This avoids the need to remove everything from the case if, for whatever reason, the unit does not work first time. The circuit is designed to operate from a 9V PP3 type battery, and an alkaline type is recommended. The +V connection is made to P1 and 0V (battery negative) is connected to P2. If a multimeter is available, this may be connected in series with the +V power supply rail to enable the current consumption to be monitored.

Set the volume control to minimum (ensuring that the on/off switch which forms part of the volume control is in the 'on' position), connect a pair of headphones to the unit and apply power to the circuit. Under normal circumstances, the quiescent current consumption with the volume set to minimum should be considerably less than 100mA. Slowly increase the setting of the volume control until background noise is audible. Adjust the tuning control to the lowest frequency setting. At this setting it should be possible to hear the highest frequency components of speech (pitch shifted) if you speak into the microphone. To test the detector at higher frequencies an ultrasonic source will be required. Shaking a set of keys or a few coins will usually produce sounds rich in ultrasonic components up to at least 30 or 40kHz. This should be detectable a few metres away from the microphone when the unit is correctly tuned. Another useful source of ultrasonics is 40kHz ultrasonic transducers. These can be driven from a suitable signal generator or oscillator as shown in Figure 5 taking care that the maximum input voltage for the transducer is not exceeded. The response of the transducers is centred around one specific frequency and drops off notably either side of this point. Therefore tuning of the signal source can be quite critical if maximum output is to be achieved. When you have a reliable source, check that the sensitivity control adjusts the input sensitivity. If everything appears to be working correctly, the circuit board can be installed into the case.

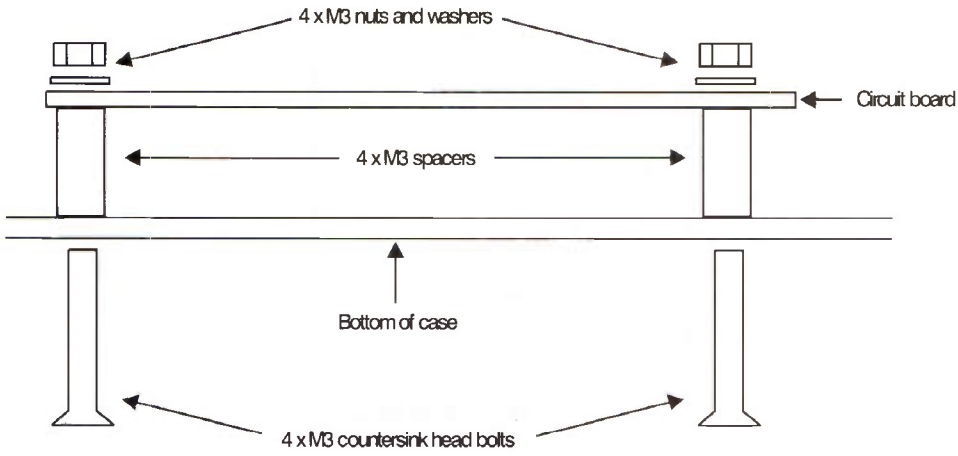



**Figure 6. Mounting the circuit board.**

## Circuit Board Installation

The recommended case is Maplin stock code BZ73Q although other suitable cases may be used as long there is sufficient room for the circuit board and associated components. The circuit board is mounted into the case using four spacers as shown in Figure 6. It is also necessary to drill holes in the case for the microphone, headphone socket and panel mounted components. The front panel label design shown in Figure 7 may be used as an approximate guide to hole positioning.

When positioning the circuit board in the box, please don't forget to allow enough room for the battery. The battery may be fixed in position using a small self adhesive pad or a suitable self adhesive clip. The second option is preferable as it makes the battery easier to change.

The microphone is mounted on the inside of the case as shown in Figure 8. Where possible, it is advantageous to reduce the acoustic coupling between the microphone and the case or circuit board as the circuit is very sensitive and tends to pick up movement in the area of the case. Use of silicone rubber sealant to fix the microphone onto the case reduces this problem although it is always present to some degree. Try to avoid getting any of the sealant over the front of the microphone element as this may impair the performance of the circuit considerably.


**Figure 7. Front panel label.**

## Frequency Calibration

The detector tunes over the approximate frequency range 10kHz to 80kHz although it should be pointed out that the sensitivity of the microphone is considerably reduced towards the top end of the range. A white tuning scale has been included on the label but is not calibrated as there may be some variation in operating frequency due to component tolerances. Also some readers may wish to modify the tuning range (more on this later). If a frequency counter with a high impedance input is available this may be connected to IC4a pin 1 to display the operating frequency. The frequency at various points on the tuning dial may then be marked on the scale.

## Using the Ultrasonic Detector

Just how the detector is used will depend on the application. There are, however, some general points to consider when operating the unit. Firstly the unit is quite directional particularly at high frequencies and is considerably more sensitive to sources in front of the microphone. It is therefore advantageous to slowly rotate the detector if you are unsure of the direction of the ultrasonic source. If you expect the source to be quite weak it is best to start with the sensitivity set to maximum and slowly back off the control if the input level becomes excessive. The sensitivity control is provided so that the gain of the input stage may be reduced if overload occurs. Signs of overload include distortion and clicking at the output on signal peaks. If the sound output from the unit is simply too loud it is best to use the volume control in preference to the sensitivity control.

Because the drive waveform to the product detector is not sinusoidal, some harmonics are present. Although for many general purpose applications this does not present a problem, under some circumstances spurious signals may be detected when the tuning control is set to frequencies where there is in fact no signal present. In many cases the spurious responses are considerably weaker than the true signal and may be ignored.

## Applications

As mentioned the Ultrasonic Detector is designed as a general purpose unit that can be used to detect the output from a number of different ultrasonic sources. A typical use for the

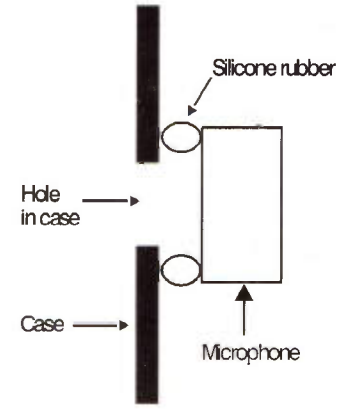



**Figure 8. Mounting the microphone.**

unit is to detect the ultrasonic emissions naturally produced by some animals. Bats are well known for producing such emissions. Different species of bat produce emissions at different frequencies each with a characteristic envelope shape. The ultrasonic detector covers a frequency range which includes a number of UK bat species although it should be noted that some types of bat produce emissions at a frequency in excess of 100kHz and are therefore outside the range of the detector. Most species actually produce sounds over a range of ultrasonic frequencies. Readers requiring further information may wish to consider contacting their local bat group who may be able to provide detailed information regarding the detection of bats and specific frequency characteristics.

**Important Note**

Bats are protected by strict legislation. It is illegal to intentionally disturb bats or their roosts.

Other animals also produce ultrasonic emissions, notably insects. Examples include ants and moths. Some species have specially adapted organs specifically for producing such emissions. The emissions are often in the form of pulses covering a wide frequency range and are thought to form one of a number of methods of communication.

## Applications in Technology

The detector may be used for checking the presence of emissions from ultrasonic remote controls and alarm systems operating at 40kHz. When working correctly, the output from ultrasonic transducers can be considerable, so it may be necessary to initially reduce the sensitivity control. Starting with the volume control at minimum, slowly increase the setting until the background noise is just audible. Adjust the tuning control across its range listening for the whistling sound produced when the ultrasonic emission is detected.

In a similar way the unit can be used to make subjective comparisons of the output level from different ultrasonic transducers. There are also many other potential sources of ultrasonic emission in and around the home. For example televisions and computer monitors often produce quite high levels. It is quite surprising just how noisy the environment can be outside the normal audible frequency range.

## Experimental Modifications

There are a number of modifications that can be made to the ultrasonic detector circuit to improve performance or tailor the response to a specific application.

The crystal microphone specified has a relatively wide frequency response but the sensitivity drops off rapidly as the frequency increases and the response is inevitably poor at the top end of the detector's tuning range. The device was chosen for its low cost and availability and in this respect provides good performance. There are however many alternatives and some readers may like to experiment with different microphone arrangements with a view to improving high frequency performance. For example, if you are interested in detecting emissions on a specific frequency you may wish to consider using an ultrasonic transducer. These have a very sharp response but offer the advantage of providing good sensitivity. A typical example of this type of device is Maplin stock code HY12N). These typically operate in the region of 40kHz and are sold as a matched transmitter/receiver pair. This is a useful frequency since some of the more common species of bat produce emissions in this region as well as many electronic ultrasonic systems. The receive element is very directional and provides good sensitivity. The device may be connected directly in place of the specified crystal microphone without the need for any other changes to the circuit configuration. Due to the sensitivity of the transducer, it may be necessary to reduce the detector's sensitivity control to avoid overload.

The types of transducer used in some camera autofocusing systems are often sensitive over a very wide frequency range often up to more than 100kHz. Also electret microphones have varying degrees of response outside the audible range. The sensitivity tends to tail off rapidly as the frequency is increased but the response curve is generally not smooth. Therefore some useful peaks in response often occur well into the ultrasonic range. Of course electret microphones require biasing and this means that as well as the AF output there is also a standing DC level across the microphone terminals. This does not present a problem and the input of the ultrasonic detector on terminal P3 will happily accept an input signal with a DC offset as long as this does not exceed the supply voltage.

## PROJECT PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS (all 0.6W metal film)** | | | |
| R1, 2, 6, 8, 15, 22, 23 | 10k Min Res | 7 | M10K |
| R3 | 1M Min Res | 1 | M1M |
| R4, 7, 9, 10, 11, 12, 13, 14, 19, 26 | 1k Min Res | 10 | M1K |
| R5, 25 | 100k Min Res | 2 | M100K |
| R16, 18 | 2k7 Min Res | 2 | M2K7 |
| R17, 21 | 120R Min Res | 2 | M120R |
| R20 | 4R7 Min Res | 1 | M4R7 |
| R24 | 470R | 1 | M470R |
| VR1, 3 | Pot Lin 10k | 2 | FW02C |
| VR2 | Sw Pot Log 10k | 1 | FW63T |
| **CAPACITORS** | | | |
| C1, 5, 13 | GenElect 10µF 63V | 3 | AT77J |
| C2 | Ceramic 1000pF | 1 | WX68Y |
| C3, 4, 8, 11, 12 | Ceramic 10000pF | 5 | WX77J |
| C6, 7, 9, 10, 15, 16, 19, 20 | Minidisc 0.1µF 16V | 8 | YR75S |
| C14, 17 | GenElect 100µF 16V | 2 | AT40T |
| C18 | Poly Layer 0.047µF | 1 | WW37S |
| **SEMICONDUCTORS** | | | |
| IC1, 4 | TL072CN | 2 | RA68Y |
| IC2 | MC1496P | 1 | QH47B |
| IC3 | LM386N-1 | 1 | UJ37S |
| D1 | 1N4001 | 1 | QL73Q |
| **MISCELLANEOUS** | | | |
| | DIL Socket 8-Pin | 3 | BL17T |
| | DIL Socket 14-Pin | 1 | BL18U |
| P1-6 | Pin 2145 | 6 Pins | FL24B |
| SK1 | Jack Skt Sto | 1 | HF92A |
| | Crystal Mic In Metal | 1 | HY33L |
| | L/Weight Headphones | 1 | RJ96E |
| | ABS Box 2853 | 1 | BZ73Q |
| | PP3 Clip | 1 | HF28F |
| | Knob K7C | 1 | YX03D |
| | Knob K14B | 2 | FK39N |

## Modifications to the Oscillator

As mentioned the oscillator waveform feeding IC2 is not sinusoidal and as a result spurious responses may sometimes be noticeable. Although not a problem for general purpose use there are some applications where it is advisable to reduce spurious responses to a minimum. Where this is important, the internal oscillator output at IC4b can be disconnected and a low distortion signal generator used to drive the input of IC2. Take care not to overdrive the input; the signal level should be limited to 300mV rms, although in practice a considerably smaller signal level will often be required.

## Changing the Tuning Range

If you wish to modify the tuning range of the detector this may be achieved by changing the value of C18. Reducing the value will shift the tuning range up in frequency and increasing the value will shift the range down. The maximum operating frequency is determined by the characteristics of the operational amplifier.

## Output Level

The audio output level of the detector is limited by R21 so as to reduce the possibility of overdriving the headphones and damaging your hearing if a loud signal is detected. This resistor may be linked out where a higher drive level is required but care must be taken to limit the volume level.

REVIEW

# PersonalScope - A PORTABLE HAND-HELD OSCILLOSCOPE

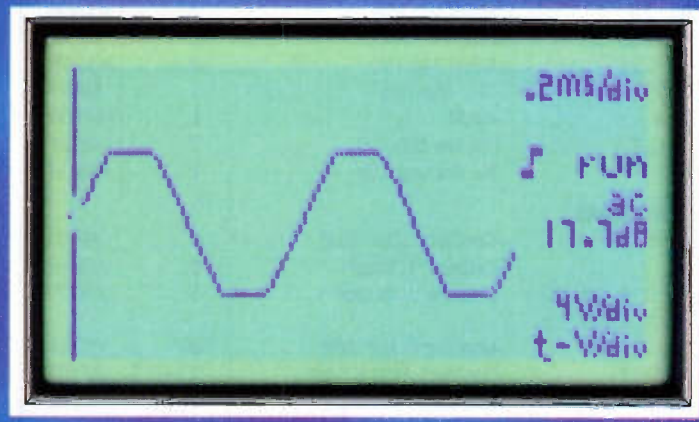

***John Mosely reviews this latest piece of test kit from Velleman.***

The Velleman PersonalScope is not a graphical multimeter but a complete portable oscilloscope that can be held in the hand and all this for the equivalent cost of a good quality multimeter, priced at £124.99 **(order code VT30H)**. Its high sensitivity - down to 5mV/div - and extended 'scope functions make this unit ideal for the hobbyist, service engineer, automotive and development engineers. Also because it does offer excellent value-for-money, the PersonalScope is well suited for educational use in schools and colleges.

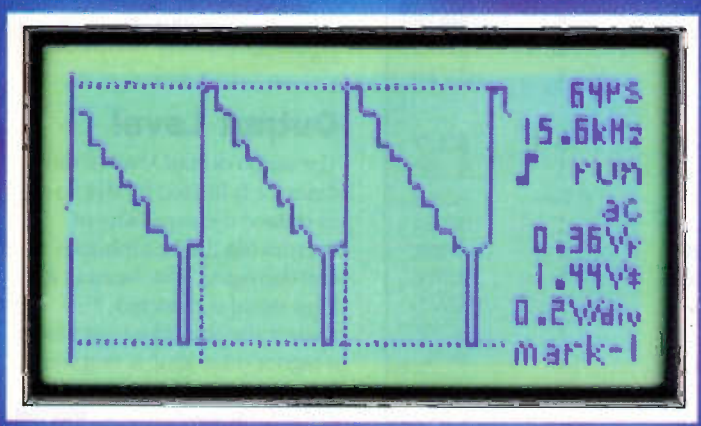
The device is suitable for measurements on audio equipment, mains voltage applications, digital signals, a variety of sensors and signal analysis in automotive applications. It's ultra fast full auto setup function, makes measuring waveforms very easy.

## In-Use

The PersonalScope can be powered from batteries, preferably re-chargeable, or from a standard 9V DC mains adaptor. Although the 'scope is designed for hand-held use, I have to say that you need a large hand to cope! But this does not distract from its portability, and hence its versatility. And for simple fault-finding whether on individual pieces of equipment, backplanes or large installations, then the PersonalScope is extremely useful. I would not advocate using the device for




**Clipped Sinewave**




**Video signal**


**Digital Waveform**

**The PersonalScope is suitable for a wide range of servicing applications.**

accurate, detailed analysis, but in auto mode, you can swiftly move round a circuit looking for faults.

The input signal is applied via a single, standard BNC socket which is next to the 9V DC input socket. Tactile switches on the front, with the current operating mode displayed on-screen select all functions. Many of the switches are multi-function and are continuously pressed until the desired function is selected. In auto-mode the 'scope reacts very quickly to the input signal, and adjusts for level and triggering. The marker function allows for measurement of voltage, time and frequency. The contrast 'control' has a very wide operating range which means the 'scope can be used in variable ambient lighting situations - from behind bays to outside. Auto shut-off will help to preserve battery life for if the 'scope is left inactive for a length of time then it will automatically turn off.

| Product | Order Code | Price inc. VAT |
|---|---|---|
| PersonalScope HBS5 | VT30H | £124.999 |

Please note that we do not expect to have the PerosnalScope in stock until September 1999.

In the 'DVM' mode, it will display true rms, dB, peak-to-peak and DC volts. Note that for high voltage measurement a suitable x10 probe will be required. The images give a good indication of the typical waveform displays.

## In Conclusion

The sample we received from Velleman was a prototype, and so came without any accessories and manual, therefore, I can not comment on how good the manual will be in the final retail version. However, for anyone reasonably au-fait with using 'scopes, they will be familiar with the 'feel' and operation of the PersonalScope.

The 'scope performed very well handling a variety of input signals and adjusting itself accordingly. The display being only 4 x 128 pixels limits the practical use of the 'scope - it is not suitable for accurate, detailed measurements. But for simple diagnostic repair work, then the scope comes into its own.

The 'scope will be supplied with a basic probe, that is a test lead type with alligator clips and a soft protective carrying case and manual. Even taking into account the limited display, the PersonalScope at £124.99 offers excellent value for money, and will be a very useful addition to the electronic toolbox.

## SPECIFICATION

| | |
|---|---|
| Maximum sample rate: | 5MHz |
| Input amplifier bandwidth: | 1MHz (-3dB at 1V/div setting) 1MΩ//20pF (standard oscilloscope probe) |
| Vertical resolution: | 8-bit (6-bit on LCD) |
| LCD Graphics: | 4 x 128 pixels |
| dBm measurements: | From -73dB to +40dB (up to 60dB with x10 probe) 0.5dB accuracy |
| True rms AC measurement: | From 0.1mV to 80V (up to 400V rms with suitable x10 probe) 2.5% accuracy |
| Time base: | 20s to 2μs/div |
| Input sensitivity range: | 5mV to 20V/div in 12 steps (up to 200V/div with x10 probe) |
| Supply voltage: | 9V DC min 300mA |
| Battery option: | Alkaline type AA or NiCd/NiMH rechargeable (5 batteries required) |
| Battery life: | Up to 20 hours with Alkaline batteries |
| Safety: | Conforms to IEC1010-1 600V CATII, pollution degree 1 |
| Dimensions: | 105 x 220 x 35mm. |
| Weight: | 395g (14oz.) (excl. batteries) |

# Revox RESTORATION

***Look around, and you may find an analogue tape bargain. Martin Pipe gives us a low-down on the classic Revox A77.***


**Photo 1. The Revox A77 - one of the best 'prosumer' tape decks ever produced.**

We may live in the digital age, but a lot of us have analogue tape recordings that we want to play - or, better still, commit to CD before they deteriorate beyond the point of no return. Fortunately, the price of CD-R hardware has fallen to an affordable level in recent years. Stand-alone CD recorders can be acquired for less than £400, while a trawl around the Internet or your local computer fair will reveal PC-based CD-R writers that start in price from £120. One of these, plus a decent soundcard and the appropriate audio processing/mastering software, will convert your PC into a powerful small-scale CD production system. A series detailing how was published in the issues 121 to 125 of *Electronics and Beyond*. In time, we'll be publishing 'follow-up' articles that will bring this series up to date. In this issue, though, we'll be looking at how tape equipment can be restored.

## Where to Buy

After all, it's fine being able to make your own CDs - but there's little point if you can't replay the media that you want to transcribe! Many readers will indeed have old recordings on quarter-inch tape. In this article, we'll be examining the Swiss-made Revox A77 - a very popular high-end reel-to-reel tape deck of its day. The same basic servicing principles will apply to most, if not all, similar machines though. You'll often see A77s turning up at audio retailers and secondhand music stores - the Music Exchange in London's Notting Hill being a good example. Another excellent place to look is the Internet, since they crop up from time-to-time on private web sites and 'for sale' newsgroups. Very occasionally, you find them at jumble and boot sales - I've come across two Revox machines in this way.

## Versions

The A77 was originally introduced in 1967, and was basically a 'stripped down' version of the studio machines of the day. There were plenty of inputs, the potential to be remotely-controlled and a transport that treated your tapes with the utmost respect! Unusually, the A77 could be switched between IEC (European) and NAB (US) playback equalisation curves. The latter feature adds to the deck's flexibility, particularly as a source deck for CD mastering. The machine was capable of accepting professional 10½in. spools at a time when most machines wouldn't take anything bigger than 7in. As a result, you could record at the faster speed with professional standard-play tape and still have enough running time to capture an hour's concert - something that encouraged high-fidelity recording. The basic A77 has two recording speeds - 3¾ and 7½ inches per second - although there was a high-speed (7½/15 ips) version available for 'ultra-fidelity' and professional applications. In terms of the head block, there were half-track (two tracks) and quarter-track (four-track) options. The quarter-track gave twice the potential recording time from a single spool of tape as the half-track, but at the expense of a slightly worse signal-to-noise ratio and greater risk of drop-out.

Domestic users tended to go for the quarter-track, while professionals opted for the security of half-track recording. There were separate heads optimised for record and playback. Apart from the performance advantage, it was possible to compare the recording with the original source. The three-head configuration also opened up creative possibilities, such as overdubbing and echos. You could buy a A77 with Dolby B noise reduction - it was one of the first tape machines anywhere to have the facility - if frequent slow-speed recording was envisaged. Another interesting option was the built-in 10W power amplifiers, which were available as plug-in modules. Some models even had the speakers built-in, making the machine a true tape recorder (rather than just a tape deck)! The power supply specified for the A77 obviously had to cater for those power amplifiers, even if they weren't fitted. One of the heaviest items in the machine is the massive mains transformer, which feeds the various power supply stages - most of which are stabilised.

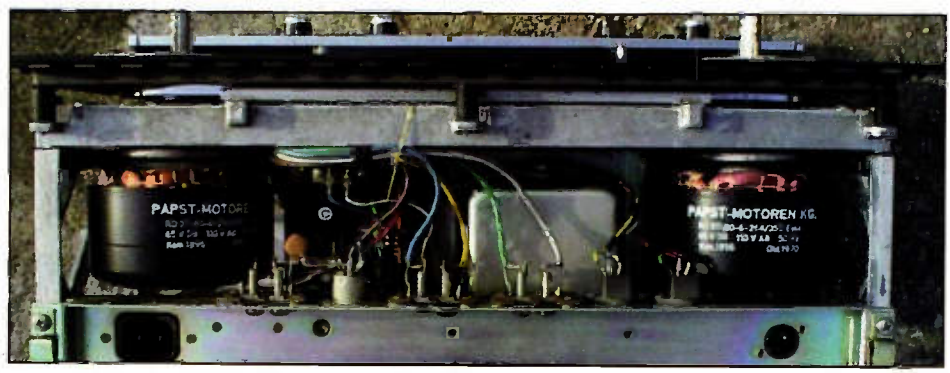
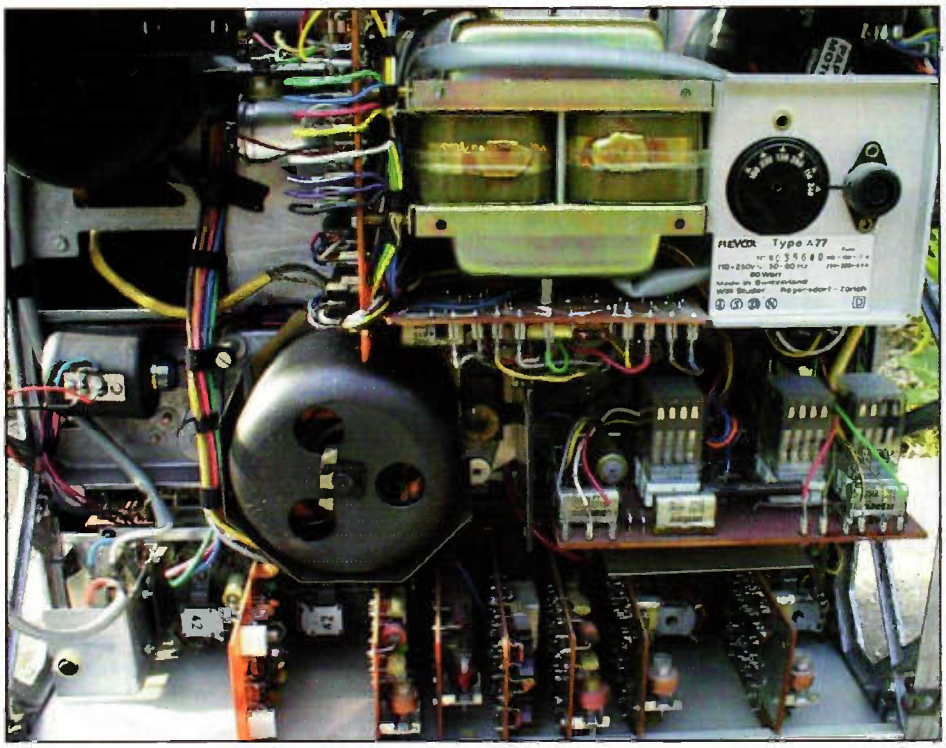



**Photo 2. The top of the A77 sans case, showing the two Papst reel motors. The massive mains transformer can be seen near the centre of the image.**

**Photo 3. An overall view of the A77's rear, showing the neat construction and easily-accessible components - a joy to service!**




The deck's reliability made it very popular in recording studios, radio stations and high-end audio installations. Pretty much every famous musician of the day had an A77 to 'jam' with! There's a very good chance that the A77 you acquire for a few pounds at a junkshop will deliver most of its functionality. The hardware was built like the proverbial tank, with a massive die-cast aluminium chassis that formed the basis of the deck. Designer Willi Studer avoided perishable belts and idlers wherever possible, and this did a lot for their reliability. Indeed the only drive belt in the A77 couples the take-up spool carrier to the tape counter. All transport functions was invoked with relays and solenoids, making possible the aforementioned remote control (if you wanted to, you could control it from a computer if you were to design and build an appropriate interface). Very unusually for the day, the A77 featured electronic servo-regulated speed control of the asynchronous capstan motor.

## Internals

The capstan was directly-driven by the motor, a very heavy outer rotor acting as a 'flywheel' to iron out any servo 'hunting' that could cause audible pitch variation. A series of 120 teeth on the flywheel induces a tone (800Hz at 3¾ips, and 1.6kHz at 7½ips) in an adjacent tape-head like pick-up sensor, and this is used for feedback. At 3¾ips, the capstan rotates at 400 rpm (twice that for the higher speed). Theoretically, you could modify the machine to work at other speeds simply by changing components, but the equalisation circuits may also need to be modified to deliver the correct playback characteristic. As with many audiophile recorders, the reel motors directly-drive the spool carriers. In fast mode (rewind or fast forward), full voltage (105V AC) is applied to the relevant reel motor. The other motor, which works in the opposite direction, is energised with a much lower voltage (21V) to prevent 'looping' and keep the tape sufficiently taut - important if you suddenly hit stop in the middle of a rewind operation!

In playback mode, 55V (10½" reel) or 42V (7" reel or smaller) is applied to the take-up motor, giving just enough torque to catch the tape as it's spat out by the capstan and pinch roller. The feed spool motor is also energised (49V for the larger reel size, 36V for smaller reels). The result is a fair amount of back-tension, which ensures that head-to-tape contact is intimate. The other way of achieving this, found in competing tape recorders of the day, was to employ pressure pads. In playback mode, sprung arms mounted with these small pieces of felt forced the tape against the head. Unfortunately, pressure pads required regular cleaning or they would clog with oxide. In the worst case, they would become hard and accelerate head wear. The A77's superior solution, which was later widely adopted by other recorder manufacturers, is responsible for a long head life.

Indeed, the heads of even some of the earliest examples are in a passable state - provided they were maintained regularly and used with good-quality tape. Some of the ex-studio machines have been thrashed, though, and are hence in a rather poor state. It's worth examining the head block for extensive wear, and - if possible - powering up the machine and checking out the functions with a test tape if you have a chance. Replacement record and playback heads for the A77 (and its eventual replacement, the B77) sell for a ludicrous £144 *each*, and that's before VAT at 17½% is added! If the heads are badly worn, your purchase may not be the bargain you originally thought. Converting between 2-track and 4-track is expensive - three new heads are required, as are changes to the bias oscillator! Make sure that any machine you plan to buy conforms to the track configuration of your old recordings!

'Official' Revox spares are, in this writer's opinion, somewhat overpriced. A VU meter movement (of the type that Maplin might sell for £5) has a £33.45 (+VAT) price tag once it's got that Revox tag slapped on! Expect to pay nearly £20, meanwhile, if you need to replace one of the 'record select' toggle switches on your B77. In other words, do your bank account a favour and use third-party components whenever it is safe or practical to do so! Sometimes, a bit of ingenuity helps. One A77 that came my way had a snapped brake band - basically a steel strip that is wrapped around the spool carrier, via the action of a solenoid, whenever the deck is in 'stop' mode. Fortunately, the break was near the pivot, and a repair was effected by cutting a nick on either side of the strip's end. A piece of copper wire was then looped around the band, and passed through a rivet hole on the pivot. The 'bodge' was then reinforced by applying solder.

## Obtaining a Manual

You might find, however, that one expensive 'official' item is available free of charge. The A77 service manual might be kept at your local library. Many of the bigger facilities (such as Chelmsford in Essex) have a bewilderingly-comprehensive selection of manuals. We were able to get the A77 manual from Chelmsford on this basis. If you can't find what you're looking for locally, most public libraries run an 'interloan' scheme. The librarian should be able to find out whether the manual of interest can be obtained. They might even purchase the publication if it's not in stock anywhere in the county! The well-written A77 manual is an excellent example of the art, with exploded views (including the motors!), circuit diagrams/descriptions, calibration details, parts lists and modification details. It also caters for the Dolby version of the machine, and details the power amp modules and remote control.

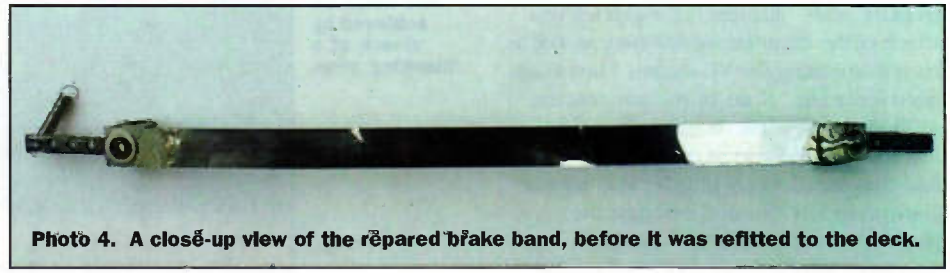


**Photo 4. A close-up view of the repared brake band, before it was refitted to the deck.**

**Photo 5. A close-up view of the A77's all-important record record and play heads. These are quarter-track types that permitted stereo recordings to be made on both sides of the tape. Those who wanted the best performance would have opted for half-track heads, and 'one side-only' recording. Half-track opened up creative possibilities, though - feed the tape in the 'wrong' way and you get 'backwards' playback...**

## Electronics

Low-noise silicon transistors (BC108 et al) were specified in the A77's small-signal circuitry. Generally, the Revox electronics is exceptionally reliable. If something does go wrong, its worth knowing that all of the machine's audio circuits (record/replay amps, bias oscillator, etc.) take the form of plug-in modules for ease of service. When you obtain a machine that's more than 25 years old, it is worth replacing the electrolytic capacitors - particularly those in the power supply section. Over time, they can become rather leaky and the result is an audible hum. Some of the small-value electrolytics in the signal electronics have some non-standard values - 125mF, for example. Still, a 100$\mu$F and 22$\mu$F in parallel comes close... Other components can be replaced by 'off the shelf' Maplin items. The amplifiers and bias oscillator are of conventional design, and hence quite easy to troubleshoot in the event of a fault.

The end-tape sensor takes the form of a light-dependent resistor (LDR) on the head block, which works in conjunction with a filament bulb. The resistor, which falls in value when light is present (i.e. when no tape is obstructing the light path), is connected to a Schmitt-trigger type circuit that triggers a 'stop' relay. Sometimes, the photoresistor will fail and the mechanism will continue to operate when the tape has finished. It will thus need to be replaced - with more modern components. A phototransistor could be specified, but the associated circuitry would require modification. If the end-tape sensor doesn't work, it stands to reason that you should check the lamp too! The A77 pre-dates LEDs by many years - filament bulbs also tell you which of the channels are selected, as well as back-illuminating the VU meters. They might need replacing... Note, by the way, that the A77's VU meters only monitor the input.

If the deck refuses to operate, you might find that the blanking plug for the 'remote control' socket - located amongst the plethora of audio socketry - has been removed. Maplin don't, sadly, sell the 10-pin DIN plug. If you can obtain one of these, short out pins 1 and 2 and insert into the remote control socket. If you're unlikely to need remote control (you could build your own from the circuit diagram given in the service manual), then the relevant pins on the socket could be linked with wire. On which subject, the A77 has a safety interlock that stops you from operating the machine without its case. A mains shorting plug, which is attached to the rear of the case, makes contact with a shrouded socket fitted on the chassis.

To make your life easier during servicing, you could bypass this interlock. While on the subject of mains, the A77 (and other more recent Revox audio products, come to think of it) has a non-standard 2-pin mains connector. It's a bit like an IEC mains connector, but doesn't have an earth pin. What's more, the pitch between the live and neutral pins are different to that of an IEC lead, so you can't improvise! If you don't have the original mains lead, you could replace the Revox mains socket with a standard IEC one. It fits quite nicely into the same space. Note, however, that the original socket is rivetted, rather than bolted, in!

Sometimes, the level controls will 'crackle' when adjusted thanks to oxidisation of the internal contacts. The cure is to apply switch cleaner (e.g., Maplin's JP17T) into the relevant variable resistors - there's normally a convenient aperture into which the substance can be squirted. An extension nozzle supplied with the cleaner helps you direct it to where it's needed. After it's been applied, turn the control back and forth a few times to ensure that the stuff gets evenly spread around! Other elements of the deck will benefit from a clean - often, there's a lot of dust inside these machines. The head block, heads, capstan, pinch roller and tape guides should all be cleaned with isopropyl alcohol. It's also worth demagnetising the record and play heads. Maplin used to sell the perfect device for the job - this focused a strong mains field into a rubber-coated prong that could be brought into contact with the head. Unfortunately, the device is no longer available, at least from Maplin.

Not much restoration work is required to bring the average A77 back into good working order - and that's a practical testimony to the excellence of its design. But then again, it was a very expensive machine (when production of its B77 successor stopped last year, the asking price was two and a half thousand pounds!). The sound quality available from these decks is truly excellent, provided that the recordings were good to start with. I have myself transferred a good few recordings onto CD with an A77 or B77 as a source deck. Maintain it periodically, and a Revox tape deck is probably good for another thirty years. The same cannot be said of most other audio equipment!

**Revox spares can be obtained from:**
Revox Spares, TTL House,
Sheep Tick, Lidlington, BEDS, MK43 05F;
Tel: (01525) 841999

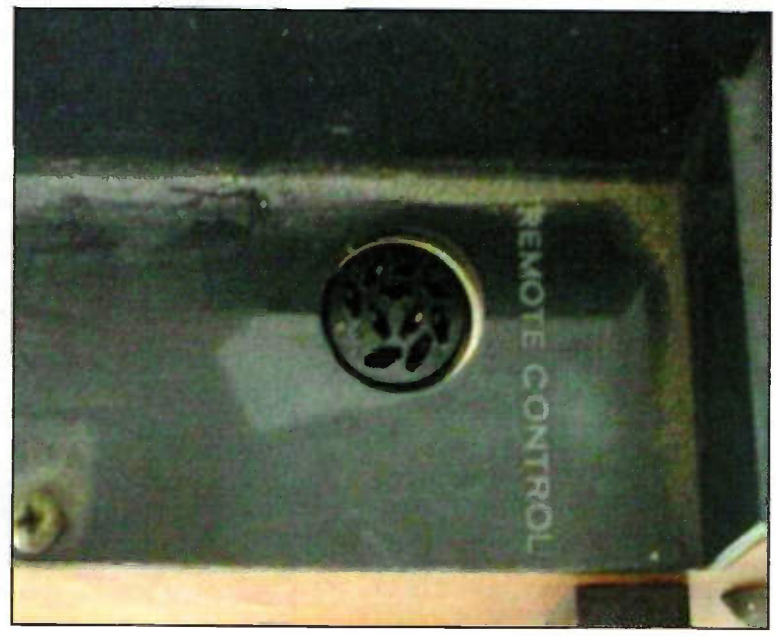


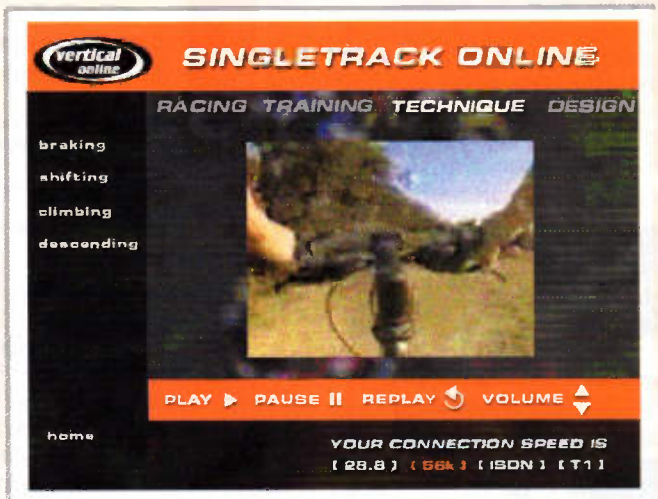

**Photo 6. The A77 remote control socket. Pins 1 and 2 must be shorted in the absence of a remote control. Normally, this would be achieved by means of a 'blanking' plug.**

## QuickTime 4

Last month we reported on the beta version of QuickTime 4 that Apple had posted on its Website. Since then the final version has been released, and it is now available as a free download from: <http://www.apple.com/quicktime>, in both Windows and Macintosh versions. Featuring streaming audio and video clips, QuickTime represents something of the future of multimedia on the Internet, so it's worth downloading for the sheer fun of it. Since its original beta posting just a couple of months ago, there have already been over six million downloads of the software.

QuickTime 4 has a rather neat installation routine, in that to start with, you only need to download the installer itself, which is a comparatively small download (380k in Mac format). Once you run it however, the installer logs you onto the QuickTime site automatically, and allows you to choose what parts of the software you want to be downloaded and installed. A total install is quite a size, but by selecting carefully what you think you'll be likely to need, you can keep online times to a minimum. In a rather clever way after installation, QuickTime will tell you if you're trying to use a QuickTime multimedia file that requires part of the software you haven't yet installed and asks you if you want to download and install it to suit.

Once you've downloaded and installed QuickTime 4, checkout the links from the Apple Website to various media organisations around the world (including the BBC). Mountain bikers might like to try the SingleTrack site at: <http://www.singletrackonline.com> to see some streaming QuickTime clips of mountain biking videos.




## Mapping a Pyramid

Occasionally you hear a news item about the Internet that raises a smile. Here's one that many schools around the world might appreciate. One school - the Mill Cove District School, in Nova Scotia - thought of a great idea to generate some interest in geography with one class of its pupils. The 15 children in the class sent an email to 15 relatives each. Each email message asked the recipient to reply with details of their location, then forward the email message to as many people as possible with the same request to reply with location details and forward on. As the email responses were received, the class were to mark the locations on a world map to see where in the world the email messages they sent actually travelled.

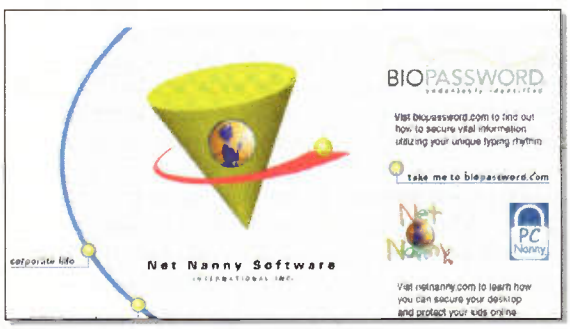
By the end of the first day after sending the initial email messages, the class received over 180 responses. On the following day 250 more rolled in, and by the end of the first week some 200 messages an hour were being received. Then the school's email server groaned and collapsed under the strain, and the project was suspended. In an attempt to stem the flow, the school cancelled its email address, so the email respondents started to send faxes, letters, and even phoned the school. Last we heard, the school was still suffering from an overload of information.

## Cable Modems

If you're a cable telephone or television user and dying to get fast Internet access, you'll be thinking about cable modems. Currently, these are being rolled out across the country in more and more cable telephone areas operated by NTL, and the whole country should be covered by the end of the year.

Cable modems effectively allow maximum data burst transfer rates of some 3Mbps, and should allow average maximum rates of around 500Kbps. Now that is around ten times the maximum rate even a modern modem and computer combination can reach over standard telephone lines, and it's even four times the maximum rates ISDN can deliver! In other words, cable modem access over a cable service is simply unbeatable by any other landline form of Internet communications. While the street price of cable modem service (called HiSpeed Internet, by NTL) isn't cheap at around £40 a month, it is a fixed fee regardless of how long you stay connected to the Internet, so should be a viable proposition for anyone who uses the Internet a lot and will mean that there are no surprise hidden charges when the phone bill arrives on the doorstep.

While other cable modems will be available soon, currently NTL uses only one particular cable modem. It's manufactured by 3Com, and is the USRobotics CMX cable modem. Details of the cable modem can be found at the 3Com Website, at: <http://www.3com.com/products/cablemodem/index.html>. To connect to the cable modem, a computer needs an Ethernet port, so most PCs will need a network interface card fitted, while Macs will plug straight into it. NTL plans to sell the cable modem to cable subscribers, on its own or as a package with a network interface card.




## Net Nanny Introduces PC Nanny

PC Nanny available for download at <www.netnanny.com> is designed for people, who are looking for ways to protect personal, and in some cases, work-related, computer files and functionality on their home computers.

PC Nanny allows users to hide or block access to the following: display and hardware settings, disk, zip and CD-ROM drives, MS DOS, the 'Device Manager' page, the 'Start' menu, the 'Find' key and individual computer files.

Here we look at a number of our favourite

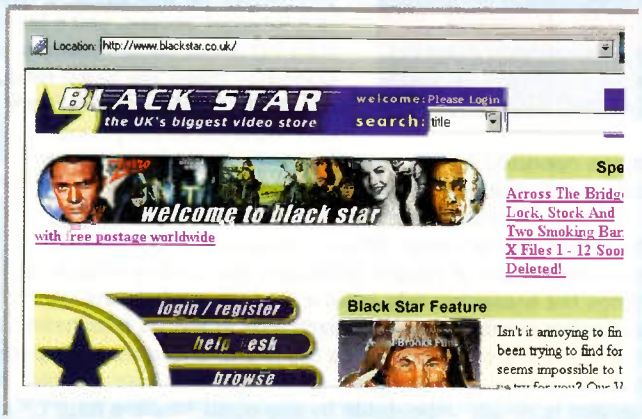
## Amazon ~ Books and Music <www.amazon.co.uk>

Amazon is the UK subsidiary of Amazon.com, the online retailer of books and music. At Amazon.co.uk you'll find more than 1.5 million locally published titles, easy-to-use search and browse features, customised e-mail notification, personalised shopping services, secure Web-based credit or debit card payment and direct delivery.

If you know what you want, go straight to the Amazon search engine where you'll be able to find your book in seconds and check reviews from other users. Ordering at Amazon.co.uk is fast and secure. After you've made your first purchase, your Amazon.co.uk account is automatically created. You can then use single click ordering to buy almost instantaneously.

Amazon charges for the cost of the book, which is typically discounted by up to 50% from the high street price and postage.

## BlackStar Videos and digital video disks (DVDs) <www.blackstar.co.uk>




Black Star is a UK success story. The UK's biggest video store, Black Star brings an innovative, highly customer-driven approach to the emerging market for goods bought on-line. Two factors - customer obsession and continuous innovation – lie behind its drive to become a pioneering global force in e-business.

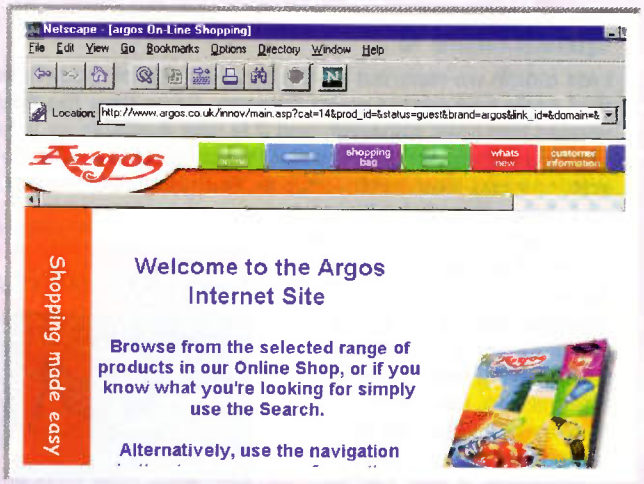
Based in Belfast, the company sells more than 50,000 videotape and DVD titles, including every release currently available in the UK, compared with an average of around 2,500 titles in a traditional High Street outlet. Black Star is on a high growth curve: having been launched early in 1998 they have consistently achieved an average sales growth of 40% month on month.

An extremely high level of customer focus sets Black Star apart from other Web-based businesses selling consumer goods. Customers are given unparalleled personal attention that includes dialogue about their purchases, updates on relevant new releases and products, and a unique Video Hunt Service for tracking down rare and deleted video titles. Customers can also search and browse catalogues online according to a film's director, stars, title, distribution company, year or category.

All items are delivered free within 24 to 48 hours in the UK, and monthly promotions on hundreds of titles, Black Star provides a compelling alternative to High Street video shopping. Purchases are made online using a secure ordering and transaction processing system that accepts all major credit cards, cheques and money orders.

Once despatched all orders are tracked automatically until they reach their final destination – the customer's letterbox. Videos and DVDs are typically discounted and postage is free.

## Argos ~ Catalogue shopping <www.argos.co.uk>




The Argos Web site is a lot like the familiar catalogue. It contains thousands of products to choose from, ranging from DIY and bedroom furniture, to jewellery and gifts.

The site is clear and user friendly with a powerful search engine. Browse through the Internet Shop, adding products to your Shopping Bag. You can view or change the contents at any stage.

If you already know what you want from the catalogue, then you can simply enter the paper version of the catalogue number on the order form next to a product.

You can pay by any Visa or Mastercard credit card, Switch or Delta debit card or by using Argos Personal Account card. Your order details will be encrypted to ensure secure transfer of data. There is a £5.00 delivery charge per order, no matter how many items you order.

Parcelforce is used to deliver most goods within 4 to 6 working days from when you place an order. Some larger items, covered by the Argos free home delivery service take up to 14 days, as specified in the product text.

## Lastminute ~ Holidays and travel arrangement <www.lastminute.com>

This site allows you to make bookings at the last minute for everything including flights, hotel rooms and entertainment tickets at discounted prices. It's a great site with plenty of bargains to choose from.

The site tends to have offers for the next two to three weeks. Offers change daily so it is worth checking the site regularly for the latest availability.

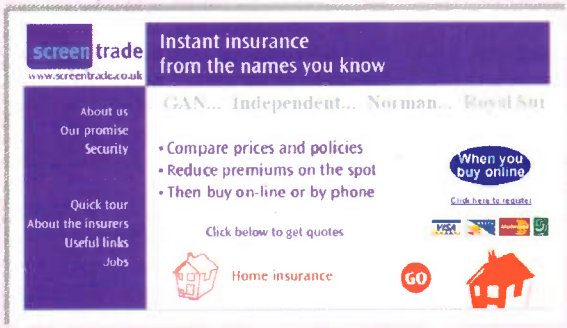
Everything you see on the site is available to buy immediately. It is simple and completely secure. You can use Visa or Mastercard to make your booking. All the prices you see on the site are the real prices – all taxes and VAT is displayed clearly by the product.

When you have ordered from lastminute.com you will receive instant e-mail confirmation of your order. Airline tickets are either delivered by overnight guaranteed delivery for which you will need to sign and pay £3.20, or if you have chosen the ticket on departure option which costs £15, they are issued at the airport.

Entertainment tickets are collected at the Box Office of the theatre – the theatre will debit your card and the tickets will be available at the Box Office upon presentation of your card. Hotel bookings have nothing to collect but the hotel will ask for your credit card and will debit that card when you arrive at the hotel.

# online stores

## Screentrade
## Competitive insurance quotes
## <www.screentrade.co.uk>




Screentrade offers a quick and convenient way of comparing the different insurance policies on offer, displaying the best quotes available from most major UK insurers, with all the key information contained on a single page. Users can compare prices and features, and then go on to buy on line the one that really suits them best, all in about the same time as it takes to call one direct provider.

The site will automatically prepare a number of competitive, personalised quotes for you in just a few minutes. Then you can compare prices and cover, and see just what you're getting for your money - you'll probably be surprised how policy features differ. All you do is key in your details once, and you're in touch with some of the biggest names in the market. And then you can buy online, or over the phone, whichever suits you best.

Users have access to eight products from six of the main home insurance providers: Independent, Zurich, Eagle Star, Commercial Union, Folgate and AXA. The motor insurance service offers a range of 16 products from a panel of seven insurers; Norwich Union, Royal & Sun Alliance, Zurich, Bishopsgate, Folgate, GAN, and ITT London & Edinburgh. Travel is currently available from two providers, Bishopsgate and Norman.

## Maplin Electronics
## Electronics products and components
## <www.maplin.co.uk>

Not wishing to sound too congratulatory, we're featuring our own Web site as a premier online shopping location. After a great deal of behind the scenes work on Maplin's IT systems, the company recently announced an online catalogue system.

The new system is an extension of its paper based and CD-ROM catalogue. The site is hosted on a secure server and offers order authorisation, which is flexible and reliable with personalised reference numbers. The reference number system treats customers as individuals and facilitates product tracing by sending an update e-mail immediately.

The unique attributes to the site, come as a direct result of customer feedback. Maplin talked to its customers and prioritised their key requirements. Thus an online browseable catalogue, comprehensive search option, coupled with technical data and product information the customer has grown to expect.

All of these features had to be built into the system, whilst providing stock availability and secure ordering. Key features of this e-commerce site are that Maplin customers actually create their own orders while online. This provides a number of unique benefits. Primarily reducing time and improving efficiency of the Internet visit.


## Interflora ~ Flowers
## <www.interflora.co.uk>

Since early this century Interflora has delivered flowers worldwide. No one can compete with the company's combination of creativity, experience and guaranteed quality. The organisation consists of 58,000 florists located far and wide from China to Russia delivering flowers to 146 countries.

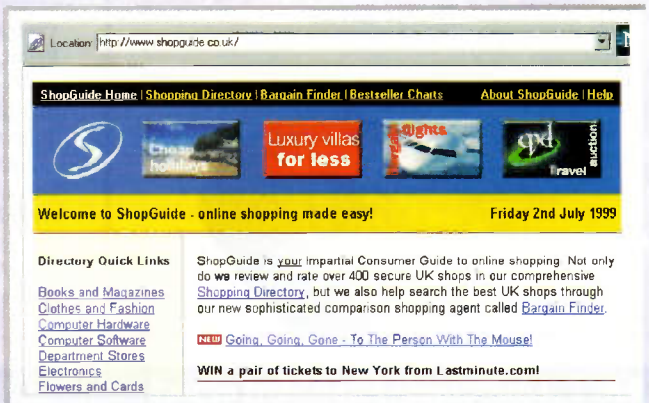
Visitors to the Interflora Web site are given a selection of arrangement types ranging from new birth to birthday and wedding anniversary to sympathy. Once you select a category the Web site offers a selection of arrangements ranging in price from around £10 to £30.

At this point you'll need willpower. The site offers a selection of additional gifts including chocolates, a teddy bear and a balloon to accompany your order. Finally you need to enter credit card details, message details and the name and address of the person to whom you're sending the gift.

Once the order is complete a unique customer reference number is generated. This enables the order to be tracked, not unfortunately via the Web, but by telephone.

Interflora certainly is not the cheapest way of buying flowers, but it is convenient. If you've forgotten a birthday they can despatch a delivery within 24 hours. Expect to pay a £2.99 handling charge in addition to the cost of your flowers.

## ShopGuide
## Online shopping portal
## <www.shopguide.co.uk>




Don't you hate it when you a buy a CD, book, game or video and then see it cheaper somewhere else? Wouldn't you love it if you could find all the best prices for the latest releases without even leaving your home?

With the launch of its new Web site in April, ShopGuide enabled consumers to compare online prices from a variety of Web sites using an online tool called BargainFinder.

Until now this service has only been available in the US but ShopGuide's BargainFinder brings this technology to the UK shopper for the first time. Already top retail names such as Amazon, WHSmith and Entertainment Express have signed up to the service that is already delivering the best deals available on the Internet.

Best seller charts for all the hottest CDs, videos, games and books are another much welcomed addition to the site. All of the titles on the charts are linked into BargainFinder - just click on the item you are interested in buying and up comes a list of all the UK stockists including prices - enabling you to select the best deal out of the top UK retailers.

But ShopGuide is not just about buying books and videos either; the shopping portal lists hundreds of recommended UK Web sites selling thousands of different items. So, whether you are buying a bunch of flowers for your mum, a holiday to the Caribbean or a bottle of vintage champagne - ShopGuide's impartial guide means that you can buy from the Internet quickly and conveniently.

## FTSE 100 Web Sites Are 'Corporate Wallpaper'

Almost half of the UK's leading quoted businesses are using the Web as little more than online wallpaper and are failing to capitalise on its potential as a direct communication medium with customers, investors and other target audiences. Some are even in the precarious position of failing to deliver on promises they make on their sites to customers and investors.

This is the conclusion of a study into the use of the Web by FTSE 100 companies, conducted between 30 March and 12 June 1999 by marketing communications consultancy Rainier Limited.

The study found that 26 of FTSE 100 companies - including BAA, CGU, NatWest and Tesco -failed to respond to a request for basic investor information after a wait of more than 75 days.

A further 16 companies, including BASS, ICI, and Vodafone either did not have a Web site, could not be contacted by e-mail, or e-mail contact details were not easily located on their Web site.

'Having a Web site without a direct feedback mechanism is like having a freephone help line, but no receptionist. Corporate UK is completely failing to recognise the capability the Web and some of those that have invested in it are leaving themselves dangerously exposed to frustrating their customers, partners and investors,' said Steve Earl, director, Rainier Limited.

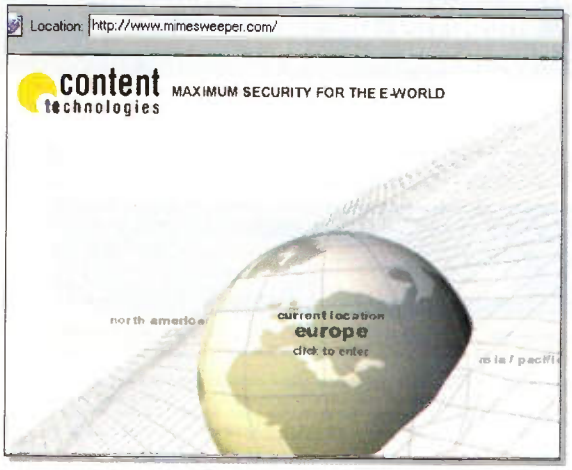
Of the 58% of FTSE 100 companies that responded to an investor query from their Web site, 23 took less than three hours, 21 took between three hours and one day, 10 took between a day and three days and a further 4 took more than three days.

The UK's most responsive companies include Billiton (one min), Allied Zurich (three mins), Smiths Industries (three mins) and Zeneca (eight mins). Amongst the UK's least responsive companies are Severn Trent (six days 20hrs 52 mins), Ladbroke (nine days 44mins), Standard Chartered (20 days) and Boots (30days 21hrs 43mins).

'Under three hours is an acceptable timeframe in which to respond to a Web inquiry, yet less than 25% of FTSE 100 companies met this criterion. Corporate companies are failing to recognise that the Web provides a valuable opportunity for direct communication with customers, investors and partner and should have the back office infrastructure in place to cope with integrating their Web presence with traditional investor and customer communication systems such as telesales and helplines,' said Earl.

The survey found that six of the UK's FTSE 100 companies, including GUS, Land Securities and Prudential, provided no contact information such as address, telephone or fax details of any kind on their Web site, while nine of the FTSE companies provide an address and phone number only.

99 of the 100 FTSE companies have a Web site of varying degrees of sophistication. The study found that British American Tobacco was the only FTSE 100 company without an online presence.




## Don't Let Internet Misuse Impact Business

Content Technologies, the developer of the MIMEsweeper product family at **<www.mimesweeper.com>**, has published a White Paper entitled 'Business Issues Relating to Content Security and Policy Management'.

The paper meets a growing demand among Internet users for information on the financial, cultural and legal risks to a company as a result of accidental and deliberate misuse of the Web and e-mail in Europe.

The third in a series of Content Technologies papers, the document discusses how Internet usage, including internal and external e-mail, can cause breaches of confidentiality and exposure to legal liability. It outlines the similarities and differences between liability and privacy laws in eight European countries.

To obtain a copy of the White Paper, please contact Anna Sutherland at Content Technologies on tel: (0118) 930 1300, or e-mail **anna.sutherland@mimesweeper.com.**

## Dell Launches Free Internet Service In Europe

PC maker Dell at **<www.dell.com>** has rolled out its free DellNet Internet service in the UK at **<dellnet.excite.co.uk>** and plans to expand to Germany and France. The company says it will extend the service to other European countries later this year. Software for the service will come pre-installed on Dell's consumer and small-business computers, and is available for downloading on its Web site.


## Internet Users Deluged by Junk E-Mail


A Gartner survey at **<www.gartner.com>** of 13,000 e-mail users shows that more than 90% receive junk e-mail at least once a week, a probability that increases to 96% for those Internet users who have had an e-mail address for at least four years.

The survey shows that one out of every three Internet users receives six to 20 spam e-mail messages per week. Money making schemes, adult ads, and software offers were the most frequently received bulk e-mail.


## Free Internet Answering Service

Silicon Valley startup Onebox.com at **<www.onebox.com>** is set to offer a free multimedia Internet-based answering service that includes e-mail, voice mail and fax.

The company plans to build its business initially in the US and then worldwide, and then later generate revenue through advertising, sponsorships and add-on services.

Under the basic service, customers will be assigned a telephone number where they can receive all of their messages.

Voice messages will be converted to e-mail format and e-mail messages will be converted to voice format. The messages can then be retrieved either on the Onebox Web site or via telephone.

## Music Downloads More Satisfying Than Sex

It's official. Internet users are looking for downloadable music more frequently than porn. The term MP3 has just surpassed sex as the number one Internet search term. This statistic has been revealed by Iomart at **<www.iomart.com>**, the company behind Madasafish, a unique service aimed at younger and more dynamic Internet users.

Iomart believes users are becoming jaded with the porn available on the Internet and are looking for an alternative means of entertainment. MP3 is a standard technology and format for compressing a sound sequence into a very small file, while preserving the sound quality when it is played. It offers quick, easy access to music direct from the user's computer or any audio CD.


## OrCAD Creates Design Online Centre


OrCAD at **<www.orcad.com>** has unveiled the next phase in the implementation of its Internet business strategy - activeparts.com, an Internet-based design centre for electronics designers.

Using eCapture, a free new online version of OrCAD's market-leading schematic entry tool, activeparts.com is usable by electronics designers worldwide, regardless of whether they are currently OrCAD customers.

OrCAD is the leading supplier of Windows EDA software and services to electronics companies worldwide. Electronics designers who connect to activeparts.com have immediate access to an online parts catalogue of more than 500,000 parts.

The distinguishing attribute of all parts on activeparts.com is that they can be immediately designed-in on the engineer's live schematic - with automatic hot links carried through all documentation produced from the schematic.

## Orange First to Offer Customer Service On Web

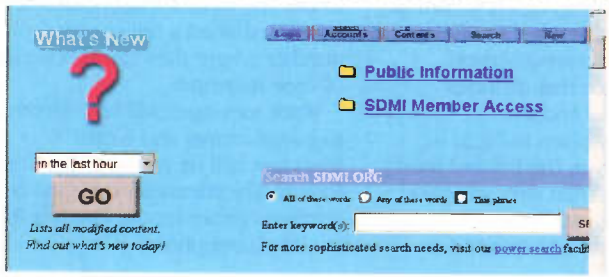
Orange at **<www.orange.co.uk>** is trialing an Internet-based self-service facilities for its customers. The online service will enable its customers to manage their accounts using a package of Internet services, which will be unique within the UK digital mobile phone market.

The first stage of the service is the addition of a new 'how to ...' section on the Orange Web site, which provides an extensive online guide to a wide range of Orange products and services, right down to the instructions for setting diverts on individual handsets. This section of the site has already launched and is available as part of the Orange Web site.

Over the coming months, Orange will introduce the second stage, a 'look and do' section which will allow customers secure access in order to register for Internet access to their Orange account, view and pay their bills, change their service plan, and set Orange Everyphone diverts. The section will also allow customers to send text messages, view account details and even edit their own personal online phone book which can be sent directly to their phone.


In the future, Orange intends to offer customers interactive bill information downloads to standard financial analysis packages, Just Talk voucher recharging facilities, and a wide range of customer service requests, all designed to make using Orange even easier.

## Music Industry Moves Against MP3




A plan to regulate how the personal stereos of the future work have been announced by the Secure Digital Music Initiative at **<www.sdmi.org>**, a music industry working group.

The SDMI plan provides for a two-phase system – Phase I and Phase II. Phase I commences with the adoption of the SDMI Specification and ends when Phase II begins. Phase II begins when a screening technology is available to filter out pirated music. During Phase I, SDMI compliant portable devices may accept music in all current formats, whether protected or unprotected.

In the future when Phase II begins, consumers can upgrade to enjoy new music released in both protected SDMI compliant formats and in existing unprotected formats. For example, when consumers wish to download new music releases that include new SDMI technology, they will be prompted to upgrade their Phase I device to Phase II in order to play or copy that music.

The upgrade will incorporate a screening technology that permits playback of all content except pirated copies of new music releases. In both Phase I and Phase II, consumers will be able to rip songs from their CDs and download unprotected music, just as they do now.

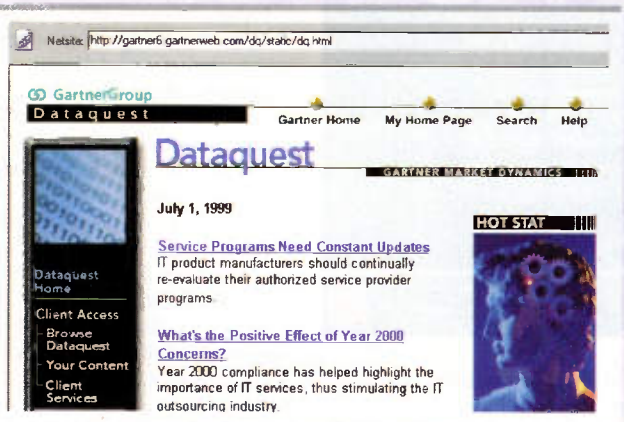
SDMI was set up by a worldwide coalition of record companies and music distributors to try and stem the rise of the MP3 music file format and thus the alleged illegal distribution of sound tracks.

## Europe Doubles Number of Online Households

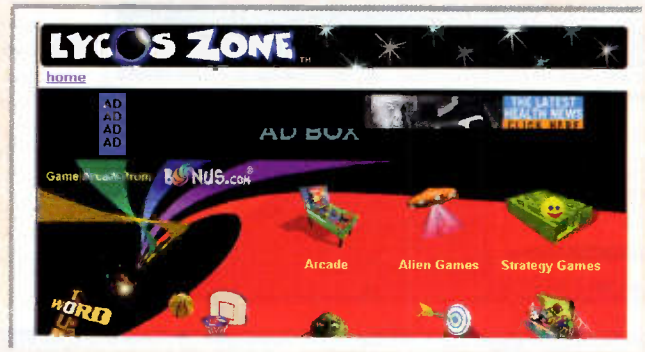
A new Dataquest survey at **<www.dataquest.com>**.shows the number of Western European households and businesses connected to the Internet nearly doubled last year, and the trend is continuing in 1999.

Only 5% of households were online in 1997, rising to 10% last year. Dataquest predicts 17% of all Western European households will be connected by the end of 1999, for a total of 26 million households.

Dataquest predicts that 16% of the European workforce, or 27 million workers, will be online by the end of the year. That's up from 9.5% in 1998 and just 5% in 1997.




## Bonus.com and Lycos Build Online Arcade




Bonus.com at **<www.bonus.com>**, one of the most popular online destinations for children, and Lycos at **<www.lycos.com>**, one of the fastest growing Internet portals, has announced the launch of a co-branded game arcade that provides one of the largest online Java game collections for kids on the Web.

A sampling of the coolest games from Bonus.com will be showcased in Lycos.com's Kids Web Guide to amuse the millions of kids who visit the popular portal each month. The co-branded site at **<bonus.lycos.com>** presents an assortment of action games, brainteasers and interactive board games that are designed to be both fun and family-friendly.

## ezlogin.com Jump Starts the Internet


ezlogin.com has announced the launch of its JumpPage service which it claims dramatically improves users' experiences on the Web.

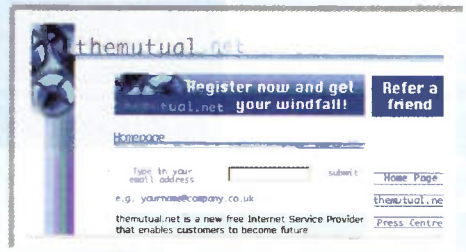
The free service, available on the company's beta site at **<www.ezlogin.com>**, eliminates many of the frustrations that Internet users face on a daily basis, such as the need to remember multiple user names and passwords and the pain of going through repetitive login and registration steps.

For the first time ever, a single click on ezlogin.com's JumpPage takes Internet users directly to all their personal Web sites, registers them to new services, or enables them to surf together with friends and family from multiple locations. The new service automates the usual steps required for access, registration, and sharing of personal Web services.

## Sign Up, Sign Up For Share Option ISP

A free ISP which offers users a share in the business signed up 60,000 people in the first three weeks since announcing its plans.

The Mutual at **<www.themutual.net>** is offering anyone who subscribes to its service a number of credit points, which will vary depending on how quick they are to join up. Should the business ever be sold or purchased, these points will be converted to shares.



## Yahoo! Teams Up with Rough Guides

Yahoo! at **<www.yahoo.co.uk>** has done a deal with Rough Guides at **<www.roughguides.com>**, publishers of more than 100 travel guides, to provide extensive editorial content to Yahoo! Travel at **<travel.yahoo.com>**, Yahoo!'s comprehensive resource for researching, planning and booking recreational and business travel.


Independent-minded travellers searching for information on more than 200 cities in the US and around the globe now have easy access to the insider advice of Rough Guides.

In addition to editorial overviews, Yahoo! Travel is also featuring 'Top Picks' from Rough Guides in the areas of dining, lodging, nightlife and points of interest for individual cities. For example, visitors to San Jose, Costa Rica can go to Yahoo! Travel to access a selection of restaurant suggestions, including the restaurant address, sample menu items, and average price of entrees.


## Explorer Is New Browser Leader


A new study released by Ziff-Davis at **<www.zdnet.com>** research group InfoBeads reckons that Microsoft's Internet Explorer is used by half of the combined household and corporate browser market, surpassing Netscape's Navigator.

The study found that Internet Explorer was installed on 33.8 million PCs by January 1999 - almost double the amount from the previous year - while Navigator is in use on just 32 million computers, or 47% of the market.

## Amazon Steps Into Downloadable Music

Amazon at **<www.amazon.co.uk>** has announced plans to provide free downloadable music from its Web store, and is considering an online toy store to open in the next month.

The company has been offering 30-second, low-quality samples of songs from the CDs it sells, and found that the strategy resulted in higher CD sales. Amazon is hoping that this strategy will avoid upsetting the music industry, which has been concerned by the loss of revenue generated by free downloads.


## 14 Year Old Entrepreneur Secures Forwarding Service


Cheers and Tears Custom Designs at **<www.cheersandtears.com>** has launched a free e-mail forwarding division, MyEZmail.com. MyEZmail forwards all e-mail sent to a user's account to their current e-mail address without the sender's knowledge.

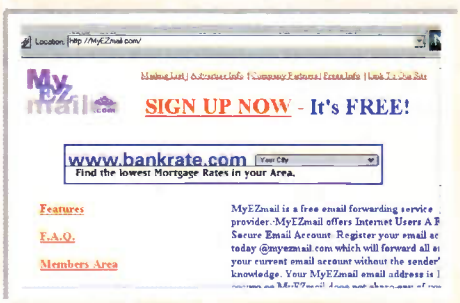
The sender will not know where the e-mail is being forwarded to and they will then be unable to find out personal information, as they would be able to with a regular e-mail address in a search engine.

MyEZmail is a very simple process: first a user visits **<www.myezmail.com>** and signs up for their own free e-mail account.

Once setup, all e-mail sent to yourname@myezmail.com will be forwarded to their current e-mail address. MyEZmail chose to make their e-mail services a forwarding service as this saves the online user from having to visit a Web site and entering their user name and password every time they simply want to check their e-mail.

Cameron Johnson, the owner and developer of MyEZmail is a 14-year-old entrepreneur who has owned and operated several online businesses including a large beanie baby business, which he recently closed to focus on MyEZmail.

MyEZmail is able to offer these free services as MyEZmail is paid for by sponsors. MyEZmail.com is currently offering interested sponsors an amazing £20 monthly ad rate.



# AOL Deal Targets Web Hosting


AOL at **<www.aol.co.uk>** has tied up a deal with Verio, the world's largest domain-based Web-hosting to provide Web-hosting, e-commerce and domain name registration to AOL UK and CompuServe UK online services.

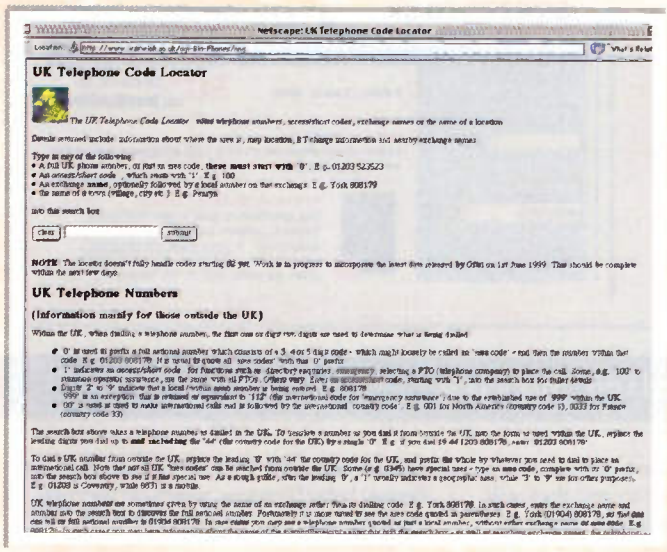
The announcement follows comment by Finance Minister, Barbara Roche, who said last month that UK competitiveness is at risk because small businesses in the UK are close to the bottom of the international league tables in the use of e-commerce.

The online promotion on AOL and CompuServe, consisting of extensive static button and banner advertisements, guarantees Verio millions of impressions over the course of the contract AOL members can access the service at Keyword Verio and CompuServe members at Go: Verio which takes them to the new Verio Web site at **<www.verio.co.uk>.**

According to Barbara Roche, while large businesses in the UK are on par with their US counterparts, small UK businesses are not making the most of new technology. Web-site hosting services enable businesses to quickly and economically establish a global Web presence, publish online information about their products and services, and engage in electronic commerce and other business Internet activities.

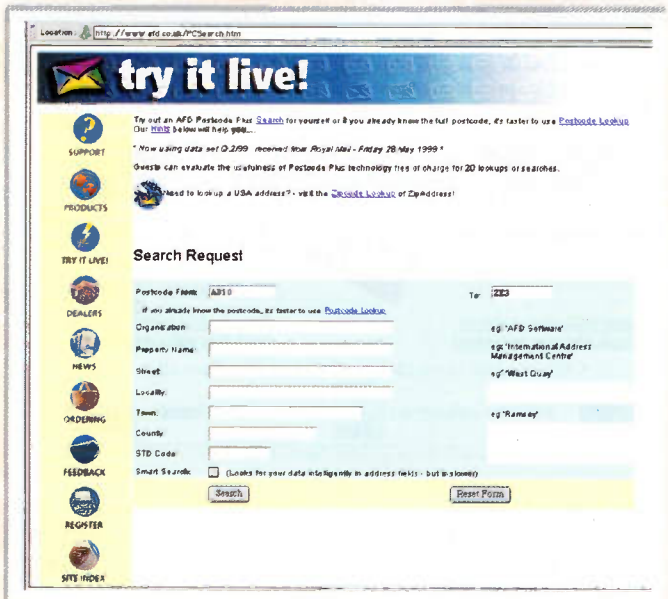
# Site Survey

## The months destinations

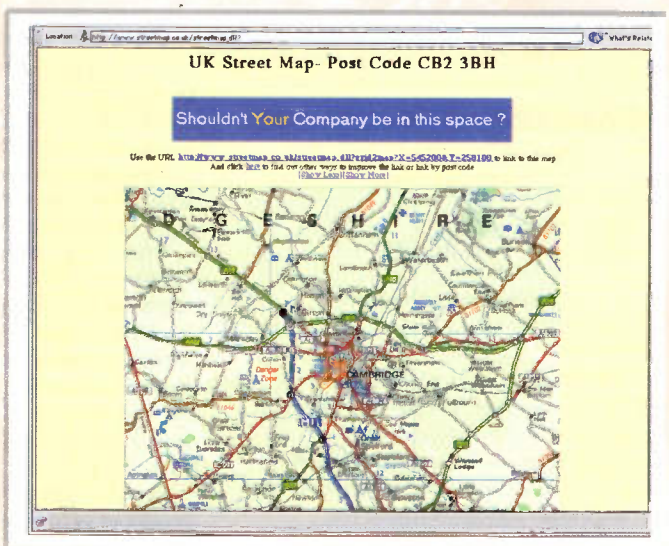



If you're lost, why not locate yourself on the Internet? If you know your telephone dialling code (or anyone else's for that matter) try the UK Telephone Code Locator at Warwick University: **<http://www.warwick.ac.uk/cgi-bin-Phones/nng>**. Just enter the dialling code and you'll get all sorts of information about the code's area.

If you know the postcode, a business name, or even a property name, try the Postcode Search at **<http://195.112.16.2/PCSearch.htm>**. The site is run by AFD Software, and is based on the Royal Mail Postcode Address File so is pretty accurate. Better than this though, AFD has also included data from the Electoral Roll, Business Databases, and the US Postal Service to allow significantly more information than you might expect. While the site is a basic attempt to get interested users to buy AFD Software products, the free use of the Internet service on a one-off basis to locate addresses is a wonderful utility.




If you're still lost on the Internet, try the UK Streetmap site, at: **<http://www.streetmap.co.uk/>**, where from a postcode, an address, or even an OS map reference, you can get a zoomable map showing the exact position of whatever reference you give. Based on Ordnance Survey mapping, this is quite possibly the best way to locate a reference within the UK (although Northern Ireland isn't yet included) you can possibly hope for.



# COMMENT

by Keith Brindley

## One In the Eye for Goliath

Although it's not a battle that's particularly hit the headlines yet, the battle in the music business of late looks set to be the most important battle in the history of entertainment. There's no doubt that the money that's currently being gambled by music companies both large and small will have repercussions for us all over at least the next couple of decades. On one side of the battle Goliath (represented by the big names of the current industry, along with new partners the likes of Microsoft) are preparing their weapons. On the other side David (represented by the independent record companies and the consumer) is already swinging the slingshot.

What's happening is embodied in the spirit of mp3 - the common name for MPEG (that is, Motion Picture Experts Group) Layer 3 multimedia files. Basically, mp3 is a file format that is highly compressed yet easily accessible by computers. It is a controllable quality format, where the user defines how good the quality of reproduction is - from digital CD quality ideal for music, down to rather poor quality perfect for storage of speech and the like. In terms of compression mp3 can store near-CD quality music at something under one-tenth the size of the comparable traditional (that is, audio CD) format. In other words, you could get something like ten or eleven traditional audio CD's-worth of music on a single mp3 CD.

In itself, this is of little importance. Presumably, a future may occur where mp3 CD players could co-exist or even evolve from audio CD players (there actually are a couple in existence already), but then the music business in essence remains the same - with the same big companies making the same big profits. Where mp3 points to a new direction however, is the fact that music files in mp3 format are now small enough to be downloadable over the Internet to individual users' computers. For example, a three minute audio track in traditional audio CD format would be around 30MB in size - clearly no-one in their right mind would want to download such a file. But the same track in mp3 format would be under 3MB in size - which while still large enough to take some time to download over a standard modem link is downloadable nevertheless. As more and more users get ISDN and cable modem links to the Internet, downloading mp3 files becomes even more and more feasible.

It should come of little surprise that downloading of mp3 files over the Internet has already taken off - in no small way. The Internet has already established itself as a medium over which no single organisation or group of organisations has control. It would be going too far to suggest that the Internet's just a means whereby all the pirates of the world can sail their galleons unheeded, but it is never-the-less the modern-day equivalent of the high seas of the past. The very essence of the Internet is that its users can do what they want, when they want, unfettered by the demands placed on them by market forces. Getting back to the earlier analogy, the Goliaths of the world have no control over what happens on the Internet - the Davids of the world are the Internet's users (you and me). Oh yes, the Goliaths *try* and control what's happening, but so far they haven't been at all successful in their attempts and it remains doubtful whether they can do so in the long-term too.

There are already thousands of Internet sites with downloadable mp3 files. Many of these are completely open as anyone can get in and download mp3 files. However, downloading mp3 files in this way is no more than a modern-day piracy. It is, of course, illegal. The people who have created the music have a copyright so are legally right to expect royalties. Many Internet sites however, require that users pay for files before download. Thus artists can expect, and do receive, their royalties as part of a legal business. This, in itself, isn't particularly important, but when you consider that many quite big named artists are getting involved then it's not hard to see what the consequences might be. Also, many independent record companies are viewing this as the way forward. Rather than the expense of creating and maintaining a traditional record and distribution company, they see the Internet as being the ideal medium of the future.

Yet that's not the only concern with mp3. New mp3 players are being developed by many manufacturers. These are totally solid-state, and use flash memory cards as a storage medium - files are downloaded to a memory card from a computer. And you don't need to download mp3 files, you can create your own from your own audio CD collection as there is plenty of software around that allows this. What this all means, is that as these mp3 players become more and more popular, more and more people will start to use mp3 files. As more and more people use mp3, so more and more players will be developed.

At some point, mp3 will reach critical mass and so be unstoppable by all that Goliath can do. So, the question is whether Goliath can prevent mp3's critical mass being reached in the first place. There are moves afoot. Microsoft has developed a system called Windows Media Technology 4.0, which aims to allow distribution of files over the Internet in a restrictable manner, but as yet the music industry is keeping its distance. Also, the Recording Industry Association of America (RIAA) has a Secure Digital Music Initiative (SDMI) which aims to find ways of keeping the situation in check. But as yet, there's nothing that even slows down the mp3 slingshot let alone stop it, and there's nothing yet that looks likely to stop the mp3 stone knocking out Goliath dead.

In the end, it all hinges on who controls the business. If Goliath is in command then the situation remains SNAFU. On the other hand, if David kills Goliath - and there's never been a better opportunity for this to happen - then we are about to witness a dramatic transfer of power. ELECTRONICS

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


# PC SECURITY

## PART 3

***In this last part, Mike Bedford discusses backup.***

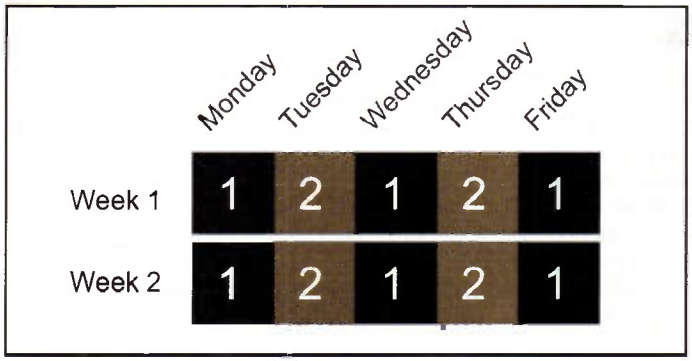
So far in this series we've seen three security risks which threaten your PC. Specifically we've looked at computer theft, at the risks posed by mains spikes and blackouts, and at viruses. Last month we suggested that viruses are one of the most feared security risks since they represent an invisible threat. But there's another reason people tend to fear viruses more than most other computer related security threats and that is that they jeopardises data rather than hardware. Whereas computer hardware can generally be replaced, the same cannot be said of data. Interestingly, though, each of the other risks covered in this series also threaten data. If your PC is stolen then the data which is resident on the hard disk will be lost along with the PC itself. And whereas a mains spike probably won't wipe out your hard disk, if the PC's power supply burns out, it could be quite some time before you can get access to the data on the disk. Please remember that we've only covered the tip of the computer security iceberg. We could also have talked about disasters such as fires, and about unauthorised access to PCs including hacking onto corporate networks and in each case the potential loss of data would have been a common concern. Not that data loss is purely a result of conventional security risks. Software bugs, hardware failure such as disk crashes and just plain carelessness can also result in you loosing your valuable data. However, data loss isn't inevitable in any of these instances. If you have a suitable backup device and if you're conscientious in making use of it on a regular basis, your data can always be retrieved should calamity strike. To complete our computer security series we're going to put data backup under the spotlight. Our coverage of this subject will be in two parts. First of all we'll investigate the bewildering array of backup hardware devices to help you decide which would be the most appropriate for your application. And secondly, we'll take a look at how to use backup devices. This might seem obvious but unless you use a sensible backup strategy the protection provided may be largely illusory.

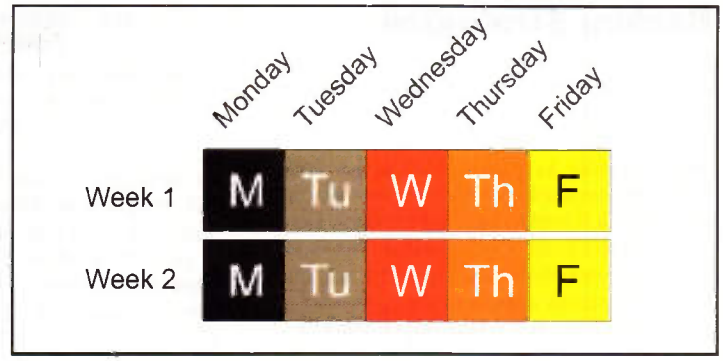
## Backup Devices

A backup device is some form of storage which allows you to make a copy the data on the hard disk for security purposes. Normally a device used for data backup will be one where the storage media can be removed from the PC although this doesn't have to be the case. The difficulty lies in the fact that there are so many competing technologies so coming up with a definitive answer as to which is the most suitable form of backup device is not at all easy. If one device type was a clear leader in all circumstances, then the alternatives would have disappeared from the market. The fact is that all storage devices have their particular niches and deciding which to use involves looking at your particular application. In the following sections we'll look at various devices which could be pressed into service for backup and investigate when they might be useful. Armed with this information you should be in a position to decide whether you need to invest in an additional storage device and if so which would be the most appropriate.

## Diskettes

For many years the majority of PC owners used nothing more than the floppy disk drive to make backups, and in the days when hard disks were just 10Mbytes and files were rarely larger than a few kilobytes, this was a perfectly satisfactory solution. The entire disk could be backed up on eight 1.2Mbyte floppies and, in all probability, you could back up everything you'd worked on during the last week on a single diskette. Now that an entry level PC has a 4.3Gbyte disk yet diskettes have grown only slightly to 1.44Mbytes, so diskettes are no longer an attractive backup option. Almost 3,000 diskettes would be needed to backup the complete disk and it not uncommon to find files that won't fit on a single disk. Furthermore, backing up to diskettes is very slow. About the only sensible use of the diskette for backup purposes is to do a quick backup of individual files you're working on as an interim measure between doing the less frequent full backups. This can be achieved, even if you have files larger than 1.44Mbytes by using the Pkzip compression utility which allows you to span files across multiple diskettes.



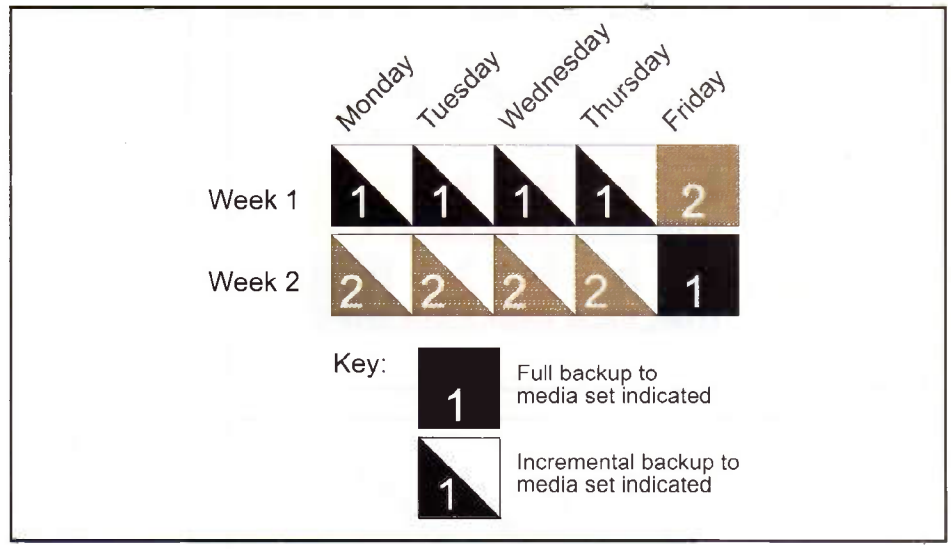

## Hard Disks

The inclusion of a hard disk as a possible backup medium might be somewhat surprising but it does have its uses so long as you recognise the limitations. For example, backing up to a second hard disk in the same PC would provide a quick and easy way of protecting against a disk failure but it would provide no protection against theft, for example. Going one stage further, backing up, over a network onto a hard disk on another PC provides a higher level of protection while still offering a relatively high speed solution. In this case, protection against theft may or may not be provided although a fire could well wipe out all PCs in the one building. Compared to the other methods of data backup, the level of security provided by backing up to a second hard disk isn't that great but, like backing up to floppies, this method might be useful if used in conjunction with some other method.

So far we've only thought of normal fixed hard disks but hard disk drives which take removable disk cartridges are also available. These drives can be fitted either inside a PC or they can be externally interfaced via either the parallel port or a SCSI adapter. Iomega's Jazz drive is an example of this sort of device, taking 2Gbyte cartridges and costing around £240 plus about £65 for cartridges. The price per Mbyte is less than that of many other popular backup devices although it is much more than for a tape streamer. Furthermore, the unit itself is comparatively expensive. On the other side of the coin removable hard disks are one of the fastest forms of removable data storage (so long as they're attached using a fast interface – a parallel port unit would be much slower) and files can be accessed directly just like a fixed hard disk. Taking all this into account it's probably fair to say that you wouldn't choose a removable hard disk if you only needed a backup device. However, if you could also use an additional disk drive then this would be a suitable dual purpose device.

## Tape Streamers

Tape streamers have been one of the primary forms of backup device for many years although other devices are now vying with them for popularity. The tape streamer is simply a magnetic tape drive which backs up onto small tape cartridges of which there are many different types. Sizes up to a few Gbytes are available. Tape streamers are still cheaper than many other forms of removable mass storage but the price differential is now fairly minimal. When we further bear in mind that tape streamers are very slow and, unlike removable hard disks and zip drives, they cannot be used as ordinary disk drives, the reason for their decline in popularity isn't hard to appreciate. About the only major advantage they offer is that the tapes themselves are cheap. Typical media costs are around the 0.5p per Mbyte mark – a tenth of that of the Zip drive and a fifth of a removable hard disk.




## Zip Drives

The decline in popularity of the tape streamer is due in no small part to the Iomega Zip drive and, to a lesser extent, the competing LS-120 disk. Both are super-diskettes or, in other words, high capacity floppy disk drives. The standard Zip drive stores 100Mbyte per disk, the LS-120 stores 120Mbytes whereas the new Zip 250 ups this to 250Mbyte. As with many removable storage devices, a wide range of interface options is available and this will have a very significant effect on the rate of data transfer. Clearly the internal drive is the fastest, followed by the external USB version and with the parallel port variant bringing up the rear. So long as you choose one of the faster interfaces, performance is on a par with most of the other alternatives and very much faster than tape streamers. And like the removable hard disk, Zip and LS-120 drives can be read from and written to in just the same way as a standard diskette or a hard drive. The drives themselves are reasonably priced but the media is expensive giving rise to about the highest cost per Mbyte. A 4.3Mbyte hard disk will require 40 100Mbyte Zip disks or 17 250Mbyte disks. And when we bear in mind that these would cost around £360 or £270 respectively, it's clear that this is not the cheapest way of backing up your disk. However, if your disk is lightly used and if you only need to back up data files this could be a viable solution. The Zip drive is also becoming a de facto standard for exchanging large data files so its acquisition could serve two purposes.

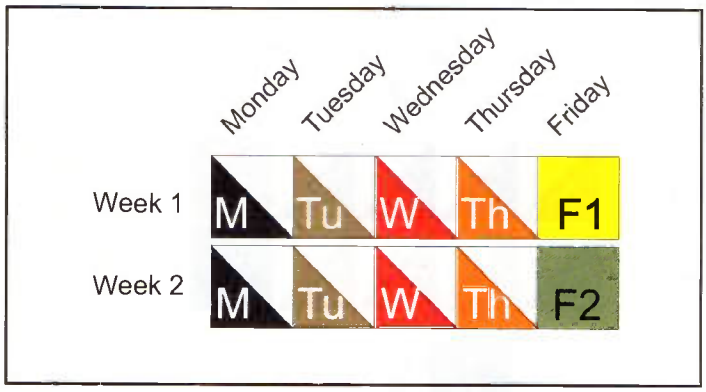
## CD-RW

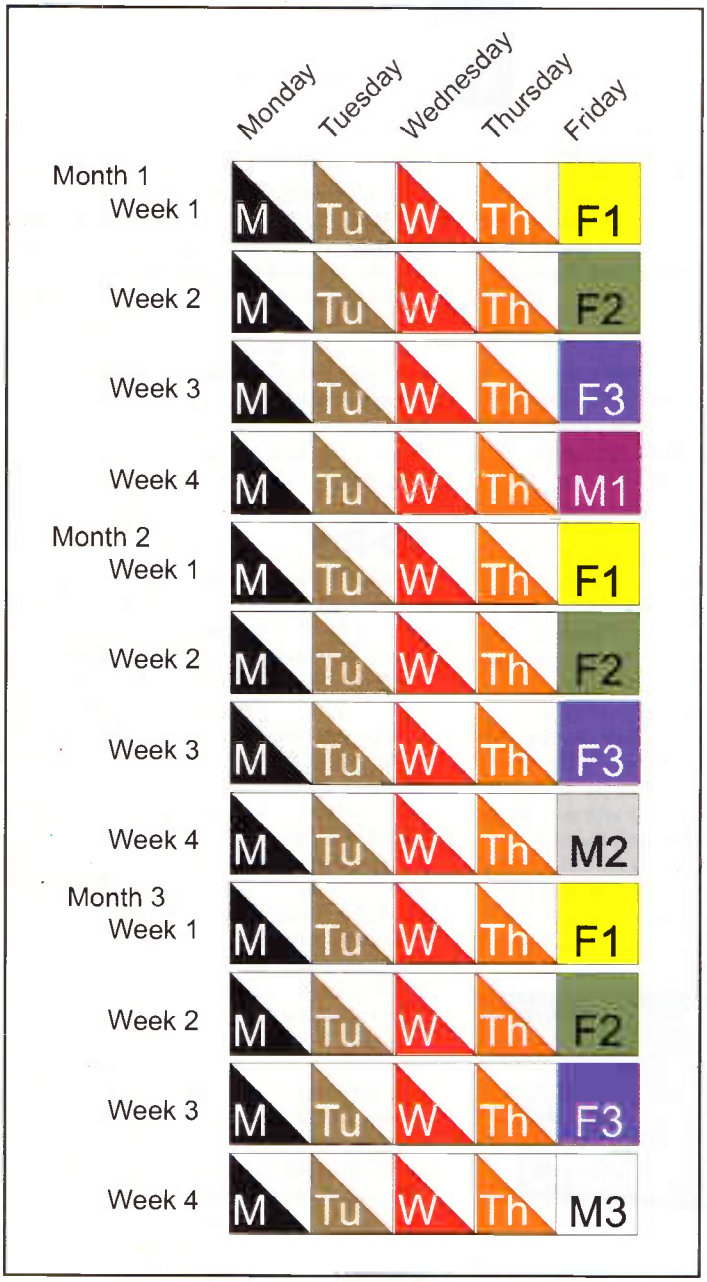
For many years CDs drives were read only devices. Then, for those people who wanted to burn their own read-only CDs, CD-R drives came along at a not insignificant cost. More recently CD-RW (read/write) drives have become available and prices are falling rapidly. You can now buy a CD-RW drive for £200, or less, which will also write CD-R disks and read any type of CD (i.e. CD-Rom, CD-R or CD-RW). CD-R disks and CD-RW disks are priced at about 80p and £5 respectively, giving rise to media costs of around 0.12p and 80p per Mbyte respectively. This makes CD-R the cheapest media of all we've discussed here although we're clearly not comparing like with like. Since a CD-R disk can be written to just the once, it's suitable for archiving but not for normal backup. However, the media cost of the more suitable yet more expensive CD-RW is still very attractive – only tapes are cheaper and not by a great deal. CD-RW drives are also faster than tape streamers even though they are significantly slower than virtually any other alternative. It must be said, however, that doubts over the durability of CDs have been expressed so this may not be the wisest solution for backup purposes.

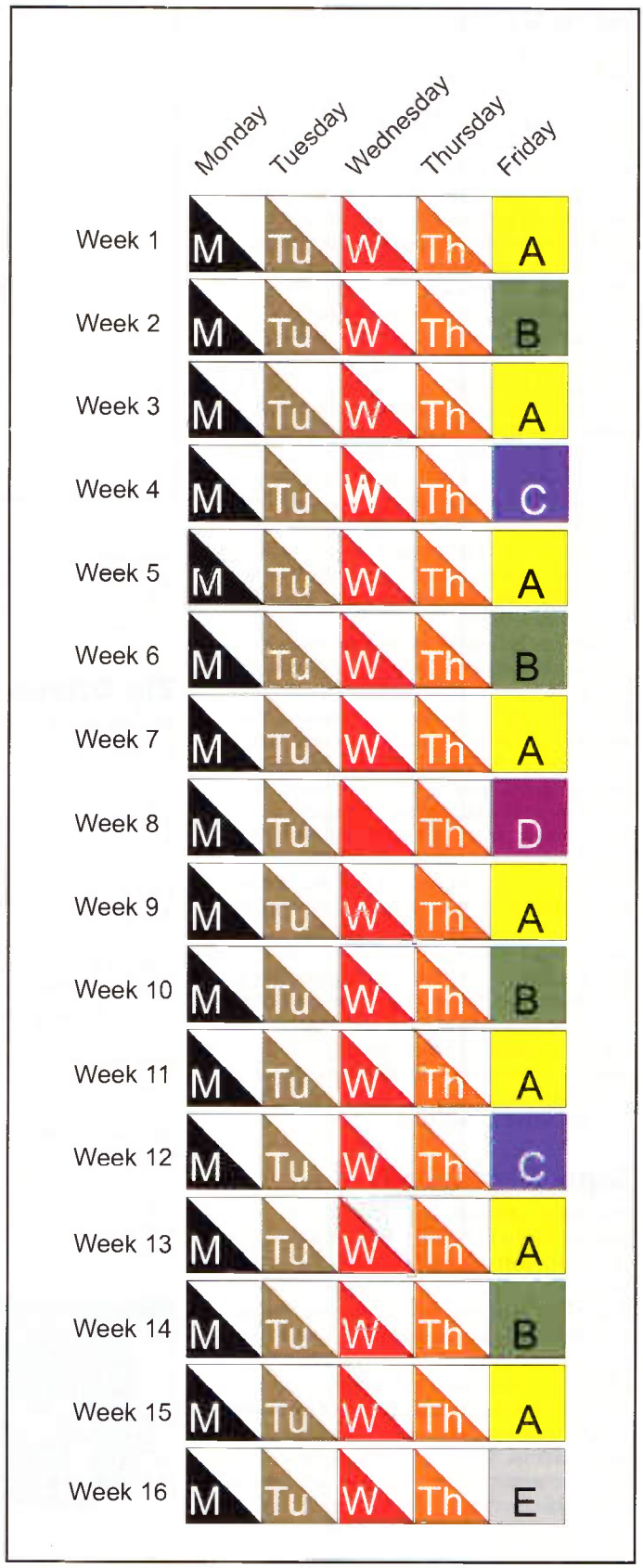
## Backup Strategies

Although we've not provided any definitive guidance on which type of device to use for backup purposes the information provided above should give you the basic facts with which to make a decision. Having decided on a basic technology your decision on exactly which unit to buy will probably be made on the basis of price and on detailed group reviews of specific product categories which frequently appear in the computer monthlies. But even when you've made a decision and bought a unit your data will only be secure if you use that backup device sensibly. And surprisingly, many home users and even some corporate users are totally ignorant of backup strategies. It might seem obvious how to make backups but there's a lot more to this than meets the eye. In the following descriptions I shall use the phrase 'media set.' This means the media necessary to perform a full backup so, depending on what backup device you use and how much data you need to backup, this could be a tape cartridge, a hard disk cartridge, or multiple cartridges of some sort.

First of all you have to decide on a backup frequency. Clearly the more frequently you make backups the more security you achieve but the longer you have to spend making those backups. More than once a day really isn't feasible in most instances and once a week could result in having to redo a lot of work if your PC goes down the day before you're about to do the backup. Daily is a sensible compromise for business use although a home user may well decide to adopt a weekly backup regime instead. In the remainder of this article



I'll assume that backups are being made daily although you can still apply some of the basic principles – suitably modified – even if you decide on weekly backups.

Even when you've decided on a backup frequency there are still decisions to be made. Let me give an example of the sort of problem that can arise if the strategy isn't well thought out. Many people use a single media set for backup purposes. Every day they put that cartridge or cartridges into the drive and make a backup which overwrites the backup made the day before. All seems to be OK until the hard disk suffers a head crash while the backup is being made. Obviously the data on the hard disk is now corrupted but you might think that there's some sort of backup to fall back onto. In fact there isn't. The new backup won't have been completed but the older backup is no longer intact either since it's been partially overwritten. The obvious solution is to use two media sets instead of one, alternating between the two for each backup. Clearly you'll need to label the two sets (with "A" and "B" or "A1", "A2", "B1", B2" etc. if your media sets consist of more than one cartridge) and keep records as to which set you used on a particular date. Now if something goes wrong during a backup, the earlier backup is still available. This is the simplest of all recognised backup strategies but, as we're about to see, it certainly isn't the only strategy.

The problem with using a two-set strategy is that it only gives you a day to discover that a file has been corrupted or accidentally deleted. In the case of theft or a major disk crash this isn't a problem since the loss will be immediately obvious. But what if you accidentally delete a file which you're not going to access for a few days? By the time you discover that the file has been lost neither media set will contain a copy of the deleted file. Since this is a particular concern to organisations which work on particular files on particular days of the week (the payroll on Thursdays, perhaps) an obvious solution is to adopt a five-set strategy instead of a two-set strategy. The media sets are labelled Monday to Friday and used in rotation. Now, of course, losses can be recovered if they're discovered within a week but not if it takes longer than this to discover that a file has been corrupted. If you do your home accounts once a month, therefore, this scheme would not be foolproof. Of course, the obvious extension is to increase the number of media sets to 31 to cover a complete calendar month but this really isn't feasible for cost considerations. This number of Jazz disks would set you back no less than £2000 – there's got to be a better way. In fact, none of the schemes we've already looked on are recommended by backup device manufacturers. A greater level of protection can be achieved at the cost of fewer media sets as we're about to see.

Before we describe any more backup strategies in detail I need to introduce the concept of the incremental backup. So far I've assumed that a backup involves copying every file from the hard disk (or perhaps just from certain directories) to disk. This is a full backup. The alternative method is to only copy to the media set those files which have changed since the last backup. The backup software achieves this by inspecting the archive bit which is stored for each file in the Windows directory structure. This bit is set when a file is backed up and is cleared when that file is edited. The advantage of doing an incremental backup is that it is quicker than doing a full backup. However, it is certainly not as secure so most serious strategies employ a mixture of full and incremental backups. From here on, the textual descriptions get increasingly convoluted. I suggest, therefore, that you follow the diagrams as you read this. The diagrams show which media set is used on which day using different colours to denote different media sets (the colours are in resistor colour code order). A full backup is denoted by a fully coloured square whereas an incremental backup is denoted by a square which is half-coloured along the diagonal. For reference, diagrams are also provided for the simple alternating two-set and the cycling five-set strategies we saw earlier, even though these are not recommended.

Our next strategy provides up to two weeks of protection for the cost of just two media sets. On one day each week, probably Friday, make a full backup to one of the two media sets, alternating between the two sets each week. On the other days, i.e. Monday to Thursday, make an incremental backup to the media set which was used the previous Friday. Obviously these incremental backups don't overwrite the data already on the media set, they just add the incremental data to the end. This scheme could break down if there's a hardware failure while one of the incremental backups is being made but in the unlikely event of such a failure you can fall back onto the other tape. If the possibility of having to restore from a tape which could be almost two weeks old is unacceptable, this strategy can be made more secure by investing in a further four media sets and using two sets for full Friday backups and the other four for incremental Monday to Thursday backups.

## Grandfather, Father, Son

The backup strategy we've just seen embodies the concept of generations, in this case two generations – daily and weekly. This is extended to three generations in the so-called Grandfather, Father, Son rotation strategy. Here ten media sets are used to provide up to three months of protection. At this point, rather than attempt a lengthy description, I'll simply accept that a picture is worth a thousand words and so refer you to the diagram. A similar strategy can be used with just six media sets by performing the Monday – Thursday incremental backups to the same media set as the previous Friday's full backup.

## Tower of Hanoi

The final strategy is called the Tower of Hanoi for reasons which will be obvious if you've come across the game of this name. It might not be obvious exactly why this scheme works but it does conform to a mathematical theory which offers one of the best compromises between the level of protection and the number of media sets. The illustration assumes that separate media sets are used for the Monday to Thursday incremental backups, but as before, you could reduce the number of sets by four by doing the incremental backups to the same media set as the previous Friday's full backup. The media sets for the full backups on Fridays are rotated such that each tape is used half as frequently as the previous one. For example, A is used every two weeks, B every four weeks, C every eight weeks, D every 16 weeks, and so forth. This means that the Tower of Hanoi requires a limitless supply of new media sets, but it's clear that you soon get to the point where a new one is required extremely rarely.

The last two backup strategies we've seen are, admittedly, rather difficult to keep track of. However, deciding which tape to use isn't something you have to do manually. Backup management software is available and this simplifies things to the point whereby you're simply told "perform a full backup to tape 5" or "perform an incremental backup to tape 9".

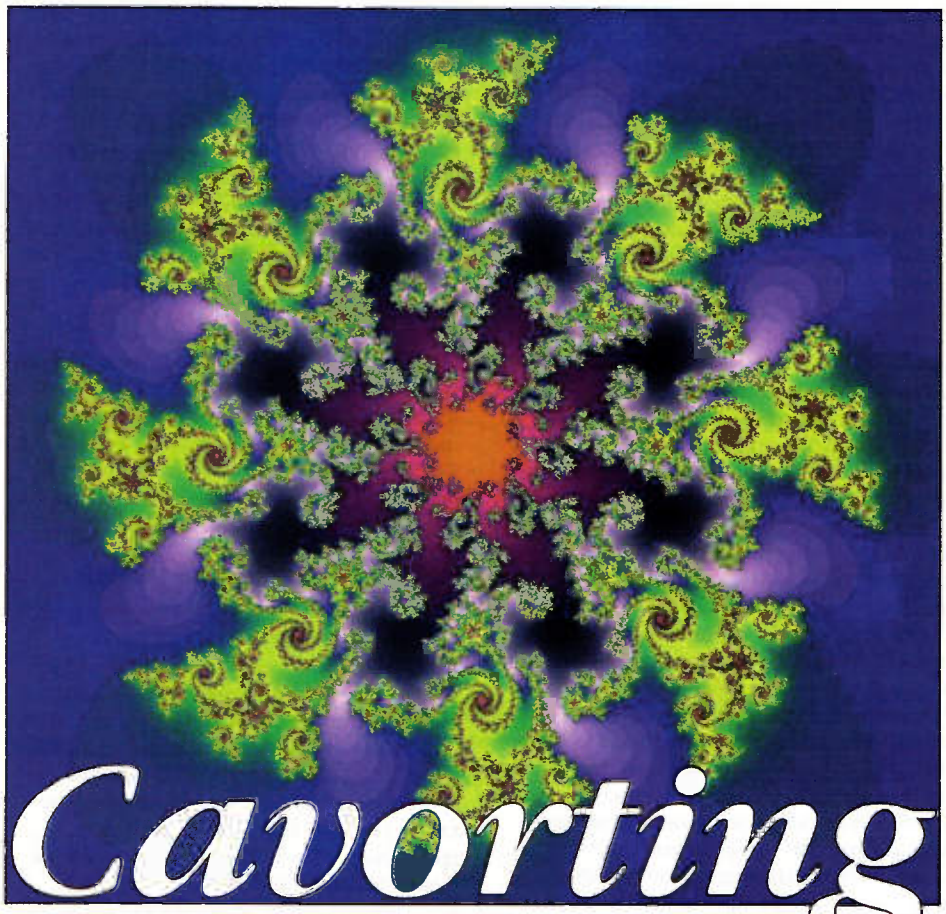
## Further Practical Tips

The following points apply whatever type of backup device you use and whatever backup frequency and strategy you employ. First of all I need to touch on verification. Making a backup can be time consuming so people tend to take shortcuts. One possible shortcut is to fail to perform a verification, something which almost doubles the time taken. Don't be tempted to take this particular shortcut. Tapes can get worn out, heads can become dirty and, as a result, write failures are by no means as rare as you might expect. Unless you do verifications, it could well be that you've been making flawed backups for months. If you do verify, on the other hand, any erroneous data will be re-written until it verifies correctly.

Tip number two concerns what you do with your backup media. Many people keep it on the desk next to the PC or perhaps in a nearby desk drawer. This is a big mistake. Thieves could well decide to pick up any disks or tapes which are in the vicinity of the PC – just in case they contain anything interesting or valuable – and a fire, of course, would destroy the backup along with the PC. So keep your backup media out of sight and as far away from the PC as possible. If your data is especially valuable as it would be in a commercial environment, then it's a good idea to keep backups off-site. If a company's security policy allows it, for example, someone could take backups home. Something else to consider is the acquisition of a fire-proof safe.

## Keep your Head out of the Sand

So that completes our series on computer security and although we've only scratched the surface, I trust that we've caused you to take this topic seriously. At the very best the effect of a security breech is severe inconvenience but it could be much more costly. Many companies which had not taken the right precautions have gone out of business following a major theft of computer equipment or a virus attack. To conclude I'd like to suggest – if you haven't already done so – that you take your head out of the sand. If you take preventative measures now you could minimise the effect of any mishap. If you don't, you could be in for some seriously stormy weather.



# Cavorting WITH CHAOS

PART 2

*Douglas Clarkson continues his exploration into the unknown!*

## Fractally Speaking

So the analysis of the Koch Curve described last month is indicative of a fractal representation. Indeed this analysis has led to speculation of the nature of representation of diverse systems - including living things. In Figure 7, the log of metabolic rate is plotted against log of body mass. This would suggest that various organs of living creatures have a specific characteristic fractal dimension.

It is a sobering thought, that the worlds of pretty images described as 'fractals' represent but a fleeting glimpse of a whole new universe, as it were of mathematical insight. A parallel has been drawn between the universality of Fourier analysis to describe a wide array of physical systems and the field of fractals as a representation of many natural systems, as a tool for describing complex processes and a means for encoding computer data.

The realm of fractals, at the level of proving various complex number set relationships and attributes is mainstream mathematics. The universality of fractals, however, can be visually appreciated by everyone. Our association with them however, is only just beginning and our knowledge of them is far from complete.

As Michael Barnsley described in Fractals Everywhere, "Fractal geometry will make you see everything differently. There is danger in reading further. You risk the loss of your childhood vision of clouds, forests, flowers, galaxies, leaves, feathers, rocks, mountains, torrents of water, carpets, bricks and much else besides. Never again will your interpretation of these things be quite the same."

## The Multiple Reduction Copy Machine (MRCM)

At the core of a large amount of fractal analysis/synthesis is a system known as Multiple Reduction Copy Machine (MRCM). While the general principle can be adapted to evolve highly complex and some surprising forms, a simple implementation is now described.

While computers are masterful at replicating MRCM systems, the humble photocopier should not be overlooked as a means of demonstrating the principle. Draw initially a square say 10 cm by 10 cm on a piece of white A4 paper as in of Figure 8a. Make four or five photocopies of (a) at 100%. Colour in dark the top left hand quarter square of (a) as indicated in (b). Photocopy (b) three times at 50% and cut out each reduced copy. Paste these onto one of the original outline shapes an in (a) to form the pattern (c). Proceed in this way to form pattern (d), (e) and (f). As the process is repeated, a skewed Sierpinski gasket is formed. What ends up as a highly complex geometrical pattern can be represented mathematically as a simple series of multiple transformations. This is therefore a clue about using fractal techniques for image compression. If images can be expressed as such MRCM procedures, then information about the transformation process can code the data in a more effective way.

The concept of the multiple reduction copy machine (MRCM) is a very basic concept in the example previously given. The Sierpinski gasket appears as the 'end game' image. This operator was functioning as a replicator of shape - of similarity. Such a process, however, can yield astonishing results when applied with extra degrees of complexity in the transformation of shape.

## The Sierpinski Clan

The example of the Sierinpski Gasket is essentially one family member of a larger 'clan' of derived MRCM shapes. If rather than simply copying the initial image at reduced scale, we add manipulation of rotation of image and reflection of image about

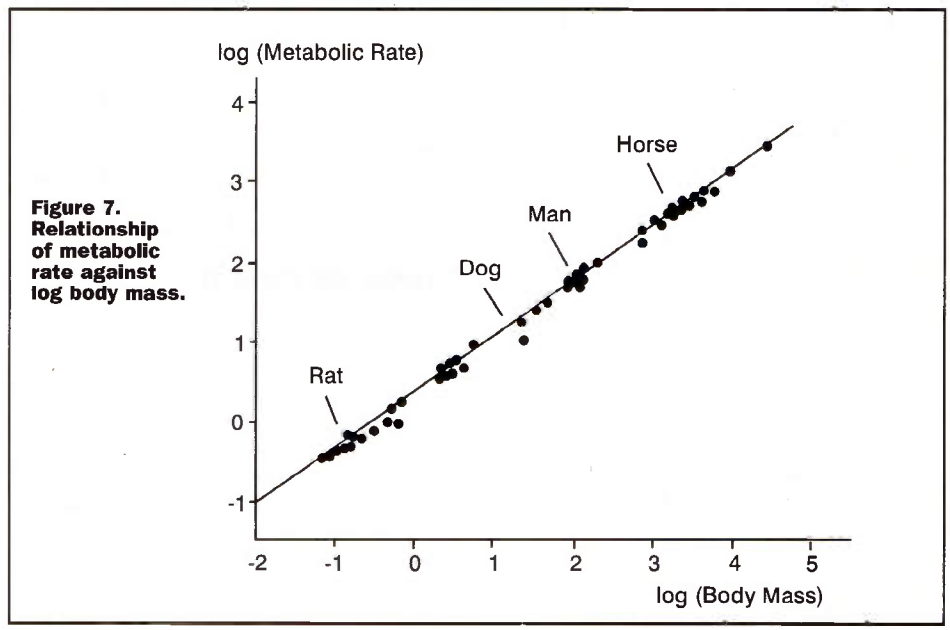



**Figure 7. Relationship of metabolic rate against log body mass.**

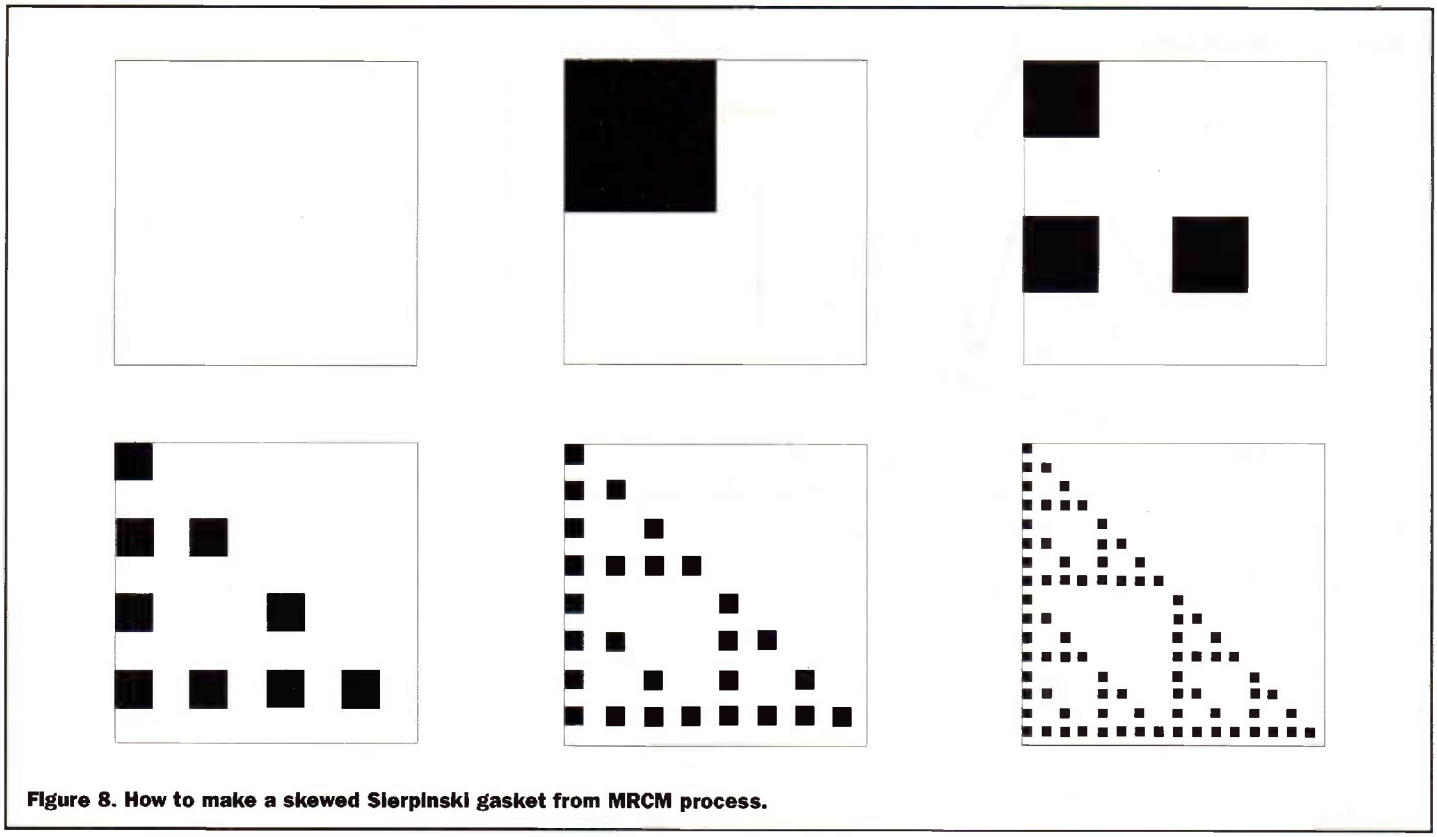


**Figure 8. How to make a skewed Sierpinski gasket from MRCM process.**

diagonals, horizontal and vertical lines, then there are a total of 8 possible variations from each component, giving a total of 8 x 8 x 8 or 512 possibilities in the patterns formed by driving the MRCM 'machine.'

Interesting as these derived patterns are, the do not relate to anything immediately 'interesting'. They still, however, have a relevance in deriving complex image patterns from a relatively simple starting geometry and 'copy' rule.

## Waving Barnsley's Fern

If we break away from the restrictive options of the previously described MRCM and add translation (move left/right/up/down), rotation and scaling for each image copy, then even some very basic MRCM functions can produce some startling images. It was M. Barnsley who by discovering the MRCM of 'Barnsley's fern', was able to demonstrate that some highly complex patterns of nature could be superbly expressed on the basis of such an MRCM rule. This provided an amazing insight into the apparent complexity of nature - whereby astonishingly complex 'natural' patterns can be produced by the application of simple MRCMs.

Figure 9 describes the various manipulations used to produce the elements of Barnsley's fern. Such a system is described as an MRCM 'lens'. It is a speculation that the human brain could employ fractal like encoding of data to recognise images rapidly. On a very direct analogy between Fourier analysis, where a system can be described as an additive sum of individual components of different phase and amplitude, images can be considered as being formed from a series of MRCM lenses.

It is an interesting exercise to try and derive the MRCM 'formula' that will create various observed outlines - in particular those originating from Nature. In the example of a maple leaf, for example, it can be scanned, basic shape parameters identified and then translations tested that would act to generate the initial image based on MRCM operations. The MRCM that gives us the shape of Barnsley's fern is in all respects a simple structure. Also, so called networks of MRCMs can be developed so that more complex variations of patterns and shapes can be derived.

The description of various MRCM systems can be readily described by 'short' programmes in languages such as BASIC. One initial shape can be readily transformed through a specific number of translations merely by referencing the transformation parameters of the MRCM. For the simple Sierpinski gasket, this is a series of three sets of six numbers. The MRCM technique is a very powerful way of creating patterns.

## Chaos: One or Two Surprises

One of the surprises of chaos and apparently random events is the ability to build deterministic shapes as indicated in Figure 10. If we start with a triangle with corners 1, 2 and 3, and a start point Z0 and a dice. In throwing a normal six sided dice, 1,2 and 3 are directly inferred and 6 is equated with 1, 5 with 2 and 4 with 3. If we throw a 2, then we create a new point Z1 mid way between Z0 and point 2. With every throw of the dice, co-ordinates are defined in this way. The surprise in store is that as more and more points are generated, the familiar shape of the Sierpinski gasket is generated. This is one example of an apparently random, chaotic process creating a deterministic fractal.

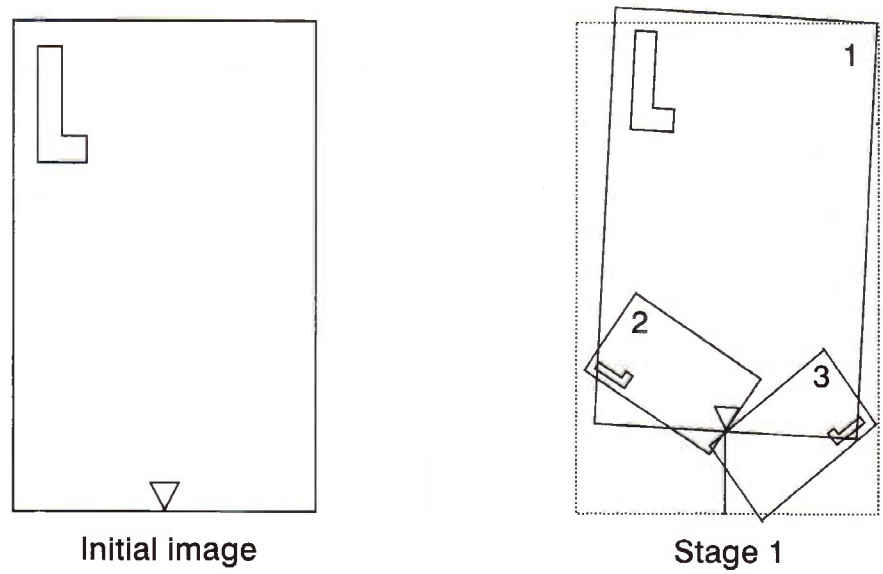
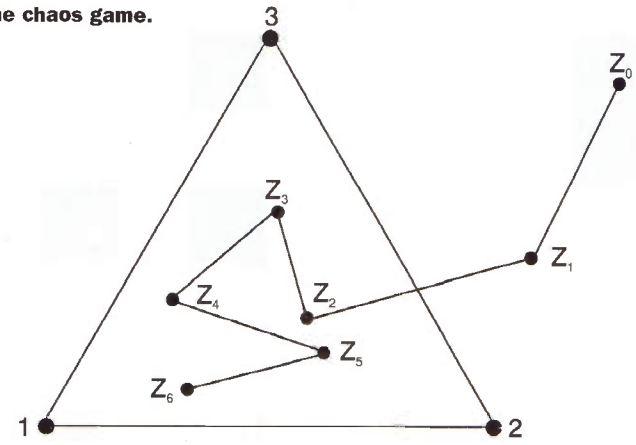



**Figure 9. MRCM lens of Barnsley's fern.**

**Figure 10. The chaos game.**




```
10 REM Example3
50 SCREEN 8
100 REM define co-ordinates of triangle
120 x1 = 300: x2 = 50: x3 = 550
130 y1 = 1: y2 = 200: y3 = 200
      count = 20000
150  x = 300: y = 1
      FOR jj = 1 TO count
160 v1 = RND
170 IF v1 < .3333333333# THEN dice = 1: GOTO 300
      IF v1 > .6666666666# THEN dice = 3: GOTO 300
      dice = 2: GOTO 300
200 REM
      PSET (x, y)
      REM have moved point
      NEXT jj
      END
300 REM form point
310 ON dice GOTO 350, 370, 390
320 END
350 REM dice = 1
      x = (x - x1) / 2 + x1
      y = (y - y1) / 2 + y1
      GOTO 200
370 REM dice=2
      x = x2 + (x - x2) / 2
      y = -(y2 - y) / 2 + y2
      GOTO 200
390 REM dice=3
      x = -(x3 - x) / 2 + x3
      y = -(y3 - y) / 2 + y3
      GOTO 200
```

**Listing 1.**

While we may criticise computers for not really working with the accuracy we would really dream about, they are extremely useful in undertaking many calculations that demonstrate various aspects of 'deterministic chaos' - such as the Sierpinski gasket and the chaos game.

Running programme Example3, where the expression RND is a random number in the range 0 to 1, and forcing this to give the result of a dice with values 1, 2 or 3 with breakpoints at 0.333, 0.6667 etc. produces a uniformly populated Sierpinski gasket. The nature of the distribution can be altered, for example by moving one of the test values for probability from 0.333 to 0.0333. This is associated with throwing a value 1, so this value is less likely to happen and as a result the distribution shows this - points are moving away from corner 1.

Also, if the value used is the cube of the probability, so that values are shifted down significantly in value - 0.5 becomes 0.125 - then more points are generated moving towards corner 1.

Thus starting from a very simple programme, some rather complex characteristics of the Sierpinski gasket and the chaos game can be demonstrated. If we re-arrange the triangle into the form of a square, and repeat the exercise, with breaks in probability at 0.25, 0.5 and 0.75 as we play the game with a dice that can have values 1,2,3 and 4, then a random pattern is at first sight produced. The neat symmetry of the Sierpinski gasket is not seen. This is because we are trying to build patterns in four separate triangles and also from start positions often outside the triangle controlling the game for the value of the dice. However, if the probability of a specific corner is reduced significantly, then the distribution moves towards the Sierpinski gasket of the more dominant triangle.

Also, the relative distribution of points is very sensitive to the 'quality' of the series of random numbers used. This is seen by the pattern being uneven in distribution. The introduction of being able to change the probability of a given operation introduces the concept of the Fortune Wheel Reduction Copy Machine where a specific point is operated on and transferred to smaller, and points are accumulated as in the chaos game in Figure 10 that drew the Sierpinski gasket. In the example, we assume each of the transition is applied with equal weight. For generating the structure of the Barnsley fern, point by point, in this random manner would be inefficient - taking in effect an infinite time to completely produce. But things can be speeded up by making adjustments to the relative frequencies of transitions - allowing the Barnsley fern to be created - dot by dot in a matter of a few tens of seconds as indicated in programme Example4.

It was previously noted that forms such as the Sierpinski gasket are highly sensitive to the true randomness of numbers selected when playing the chaos game as illustrated

```
10 REM chaos game for a fern leaf  Example4
SCREEN 2
20 INPUT "number of iterations (5000):", imax
30 left = 10: w = 400
40 w1 = w + left
50 e1 = .5 * w: e2 = .57 * w: e3 = .408 * w: e4 = .1075 * w
60 f1 = 0 * w: f2 = -.036 * w: f3 = .0893 * w: f4 = .27 * w
70 REM fixed point map 1
100  x = e1
110 y = 0
120 FOR i = 1 TO imax
130 r = RND
140 IF r > .02 GOTO 200
150 xn = 0 * x + 0 * y + e1
      yn = 0 * x + .27 * y + f1
      GOTO 700
      REM map 2 (right leaf)
200 IF r > .17 GOTO 300
xn = -.139 * x + .263 * y + e2
yn = .246 * x + .224 * y + f2
GOTO 700
REM map 3 (left leaf)
300 IF r > .3 GOTO 350
      xn = .17 * x - .215 * y + e3
      yn = .222 * x + .176 * y + f3
      GOTO 700
      REM map 4 (top of fern)
350 xn = .781 * x + .034 * y + e4
   yn = -.032 * x + .739 * y + f4
      REM draw game point
700 PSET (xn + left, w1 - yn)
   x = xn
   y = yn
   NEXT i
   END
```

**Listing 2.**

in Figure 10. While most modern random number generator systems provide an acceptable quality of 'randomness' - various historical methods when translated into the chaos game behave very badly, with only very small areas of the gasket being visited. This is providing sensitivity not to the overall numbers of 1, 2 or 3 which are in fact uniformly selected - on average - but to the history of numbers that are produced - in particular aspects of the sequence of numbers that are generated. Thus the 'chaos game' provides a means of monitoring randomness in processes. This branch of 'visual mathematics' has given new insight into chaos theory.

## Forever Feigenbaum

While computers may not have the ultimate degree of accuracy always expected of them, they serve wonderfully well to bring mathematical insights to life. Returning yet again to the graphical iterator function illustrated in Figure 1, this turns out to contain various important information that relates to systems at one time demonstrating chaos and at others behaving in a predictable manner.

In the expression:

**a x (1 - x)**,

if the value of **a** is changed between 1 and

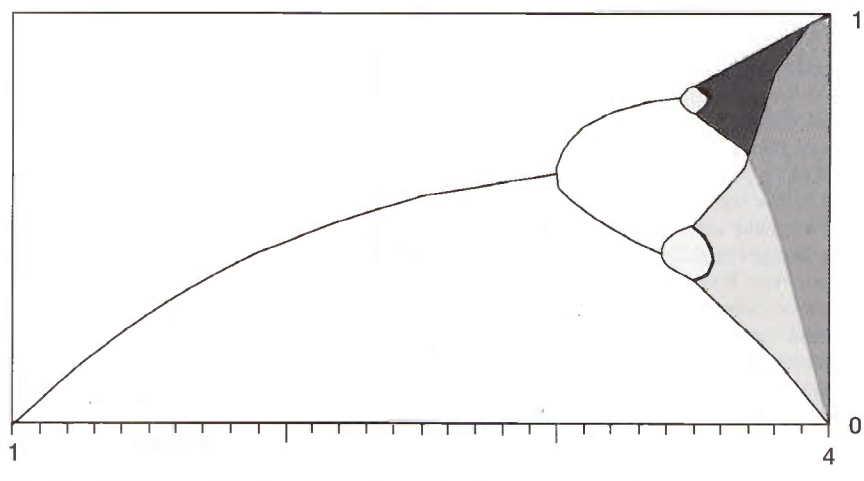



**Figure 11. The so called Feigenbaum diagram of the graphical iterator.**

4 and **a** large number of iterations calculated of the function with arbitrary start value of x, then Figure 11 is obtained. With low values of **a**, the functions always resolves to a single value after a number of iterations. Subsequently as a increases in value, the value of the function oscillates between two values and subsequently it oscillates between four values and so on. So called period doubling is taking place.

The ratio of the length of branches as for example defined by the range of values of **a** for dual branching to the range of values of four component branching is called Feigenbaum's constant and approaches a value of 4.6992... Like pi, it is a universal constant. The mathematical reality of this structure was discovered initially by M. J. Feigenbaum around 1975 by means of a pocket calculator. The movement from order to chaos is characterised by the Feigenbaum point, in this analysis for a value of 3.5699456... This behaviour is characteristic of the transition from well defined values to those of chaos.

The programme Example 5 demonstrates the progression from order into chaos. The actual transition is difficult to show. If we could in some way constantly expand the scale around the transition value, we would for ever witness the branching of the function in this relationship. We have in other words a fractal like structure.

Further analysis of the structure provides a wealth of mathematical observation. There are bands with sparsity of points. There is a degree of self similarity in the structure of the curves. The elements of the Cantor set can be distinguished in the period branching section of the graph. It is through the visibility of such computer simulations that these characteristics come to life. Computers, if anything, should make us more curious about mathematics.

## The Julia Set

The French mathematician Gaston Julia (1893-1998) spent a considerable time investigating a problem described previously by the British mathematician Sir Arthur Cayley. This related to the 'Newton-Fourier Imaginary Problem'. While this work

```
10 REM Example5
   SCREEN 2
20 left = 10: h = 300: w = 1.5 * h: dx = 2
30 iter = 300: hide = 50: astart = 1
40 aend = 4: xbottom = 0: xtop = 1
50 dw = w / (aend - astart)
60 dh = h / (xtop - xbottom)
100 REM draw co-ordinates and tick marks
110 LINE (left, left)-STEP(0, h)
120 LINE -STEP(w, 0)
130 d = INT(LOG(aend - astart) / LOG(10))
140 td = 10 ^ d / 10
150 IF (aend - astart) / td > 50 THEN td = 5 * td
160 IF (aend - astart) / td > 25 THEN td = 2.5 * td
170 ts = td * (INT(astart / td) + 1)
200 FOR i = 0 TO (aend - astart) / td - 1
210 a = i * td + ts
220 LINE (left + dw * (a - astart), left + h)-STEP(0, -10)
230 NEXT i
240 PRINT "from a = ", astart, " to a = ", aend
   PRINT "first tick at "; ts, " ticks delta ", td

250 REM compute iteration and draw final state
260 xn = .01
270 FOR i = 1 TO w / dx
280 a = astart + i * dx / dw
290 FOR k = 1 TO iter
300 xn = a * xn * (1 - xn)
310 IF k < hide GOTO 350
320 IF xn > xtop GOTO 350
330 IF xn < xbottom GOTO 350
340 PSET (left + i * dx, left + (xtop - xn) * dh)
350 NEXT k
360 NEXT i
370 END
```

**Listing 3.**

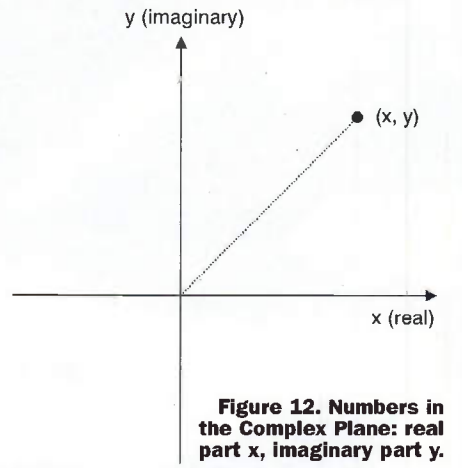



**Figure 12. Numbers in the Complex Plane: real part x, imaginary part y.**

involved complex mathematical relationships within the plane of complex numbers, it was not until computers came to be used in the 1980's to map out the spatial relationships of sets of numbers that the significance of the so called Julia set of numbers came to be appreciated. With numbers being described on the so called complex plane as co-ordinates (x,y) where x the real component and y is the imaginary as indicated in Figure 12. A more frequently investigated Julia set is related to the property of the function:-

$$z_{(n+1)} = z^2_n + c$$
$$n = 0,1,2...$$

where an initial complex number is squared, a constant complex number is added and the resulting value is processed etc. Specific start co-ordinates either 'escape' to infinity (escape set) - their absolute values increase indefinitely or they converge to a stable well defined value after possibly many hundreds of iterations (prisoner set). The associated Julia set is considered to be the set of points which form the boundary between the escape set and the boundary set. Julia sets are not therefore solid structures.

The mathematics to test if specific points are in the escape set or the prisoner set is essentially very simple as indicated in the programme Example6.

Table 1 indicates some values to check out for a value c of -0.5 +i0.5.

```
10 REM   Example6
20 PRINT "enter values of start co-ord,  x,y"
30 INPUT xo, yo

50 PRINT "enter value of constant x,y"
60 INPUT cx, cy

70 FOR jj = 1 TO 600
80 xnew = (xo * xo - yo * yo) + cx
90 ynew = (2 * xo * yo) + cy
100 PRINT jj, xnew, ynew
    IF ABS(xnew) > 1000 OR ABS(ynew) > 1000 THEN PRINT
"? too large": GOTO 150
    IF ABS(xo - xnew) < .001 AND ABS(yo - ynew) < .001
THEN PRINT "? converges": GOTO 150

110 xo = xnew: yo = ynew
120 NEXT jj

150 PRINT "press return for new values": INPUT a$
160 GOTO 20
```

**Listing 4.**

| Start Co-ordinate | Description |
|---|---|
| (1,0) | escape set |
| (0.5,0.25) | escape set |
| (0.0,0.88) | escape set |
| (0.0,0.0) | prisoner set |
| (0.5,-0.25) | prisoner set |
| (-0.25,0.5) | prisoner set |

**Table 1. Identification of status of co-ordinates for value of c of -0.5 + i0.5.**

The Julia set is therefore an infinite array of spatial mappings that satisfy this basic simple relationship. If a specific structure is described, then as we zoom in and constantly expand the magnification there is always fine structure to be observed. In practice there are shortcut ways of generating the features of such Julia sets using techniques such as MRCM methods.

## The Mandelbrot Set

While the Julia set can be described as an infinite series of sets that satisfy the appropriate criteria, the Mandelbrot set is a specific set with a well defined frame of reference. For a starting point $z_o$, if the iterative sequence

$$z_1 = z^2_o + z_o$$
$$z^2 = z^2_1 + z_o$$
$$z^3 = z^2_2 + z_o$$

remains within a distance of two units of the origin, forever, then the point $z_o$ is said to be in the Mandelbrot set. Thus the Mandelbrot set is a series of points of a connected structure, while the a specific Julia set is a set of points describing a boundary condition from 'prisoner' to 'escaping.'

The Mandelbrot set from the time it was first investigated in the mid 1980's has been a constant source of amazement and interest to those probing its secrets. This investigation includes rigorous mathematical probing of the Julia and Mandelbrot sets as well as deriving breathtaking graphical vistas of the derived arrays of points.

In some ways the mathematical concepts behind the Julia and Mandelbrot sets are very basic though when the full rigour of mathematics is applied to them they retreat into a rather confusing complexity. Study of the features of the Mandelbrot set in particular have breathed new life into the understanding of many 'compartments' of mathematics and in particular developed tools for analysis of chaotic systems.

## Summary

The underlying reality of chaos is in mathematics and the best way to catch a glimpse of what is going on is to let a computer do all the hard work of calculation. At the same time this has provided a new perspective on things natural and man made. Once you read a little about chaos theory, you want to know a lot more.

## Further Reading:

*Fractals Everywhere.* M. Barnsley, Academic Press, SanDiego, 1988.

*The Fractal Geometry of Nature,* B.B. Mandelbrot, W.H. Freeman and Co, New York, 1982.

*Chaos and Fractals: New Frontiers of Science,* Heinz-Otto Peitgen, Hartmut Jurgens and Dietmar Saupe, Springer-Verlag, 1992.

*Fractal Geometry,* K. Falconer, Wiley-VCH, 1997

*Techniques in Fractal Geometry,* K. Falconer, Wiley-VCH, 1997

*The New Scientist guide to Chaos,* edited by Nina Hall, Penguin books, London, 1992

### Fractal Web Pages:

A search under 'Chaos theory' and 'Fractal Art' will throw up thousands of web pages. Some 'fractal' sites are extensive galleries while others provide software that can be downloaded to generate images on your PC.


Figure 1. Artist's impression of the X-38 Crew Rescue Vehicle. Courtesy ESA/D. Ducros.

RESEARCH NEWS

# Future Reusable Space Vehicles AND THE INTERNATIONAL SPACE STATION

PART 2

***In this second part, Dr. Chris Lavers continues his look at the latest developments in space launchers, the International Space Station and space tourism.***

## Protection System

Over the last decade, the Manned Spaceflight Programme has resulted in a high level of European technical expertise in experimental facilities and techniques. The ARD was a major achievement for ESA and is the first ESA vehicle to perform a complete re-entry. Throughout re-entry and descent, flight measurements were taken to evaluate heating, transition, reaction control system interaction, ionisation (resulting in communication black out) and parachute deployment. The post-flight analysis will give industry invaluable experience, allowing validation and improvement of existing design tools.

The 2.8tonne ARD will be much less manoeuvrable than the X-38. ESA and NASA's joint project, the Experimental Crew Rescue Vehicle (XCRV), designed as an experimental vehicle for the emergency return of crew from the ISS, is scheduled to have its maiden flight in late 2000. An artist's impression of the X-38 is given in Figure 1. The CRV could replace Russian Soyuz CRVs' at the Space Station by 2002. A scale demonstrator of the X-38 has already been test flown successfully and featured in a recent Research News. Vehicle 132 made a soft landing with a decent rate of only 10.5ft/s and a forward speed of 40ft/s, using landing skids to reduce landing impact. The skids were modified from the original design after a rather abrupt ground slide of only 6ft at the end of the previous drop test. The X-38 must have an operational vehicle on station by 2002, and was originally to have been known as the X-35, but the Joint Strike Fighter had already been designated X-35 when NASA formally requested experimental vehicle status. Since Lockheed Martin pulled in 70% of all competitions it entered, including the JSF, industrial R & D could learn a lot from just observing the process which underpins their success. About 45 people work on the program full time, another 50 part time, the majority are government employees. Some problems still need to be ironed out although recent tests have proved successful. A flight test failure in December 1995 after a C-130 Cargo plane separation problem led to the vehicle being destroyed at a cost of 0.5M$. Centre of Gravity problems have been remedied by shifting ballast forward. The structure will be aluminium with a graphite-cyanate ester epoxy shell. Thermal protection will be afforded by improved shuttle derived blankets and tiles, which can be larger because the composite structure is stiffer and has four control surfaces, body flaps for pitch and roll and rudders that handle yaw. NASA Ames Research Centre in California, has created a new class of ceramics based on the metals Hafnium and Zirconium that can withstand repeated exposures to 2400°C, compared with the shuttle's current protective tiles which begin to burn at 1400°C. New materials should allow leading edges of wings and noses to be built with radii of a few millimetres, allowing future space vehicles to look like supersonic aircraft. German firms will provide the nose cone, leading edge and flaps, flight controls, instrumentation and navigation systems. The Netherlands will furnish the rudder and Sweden will take part in aerodynamic design.

## Manned Spacecraft

The ability to carry astronauts into space and return them safely to Earth is strategic to space exploration and utilisation from a European perspective. At present, there are two transport options; the lifting body XCRV launched from the shuttle's cargo bay, and a second Crew Transport Vehicle (CTV) could be launched from Korou on an Ariane-5. The CTV could carry

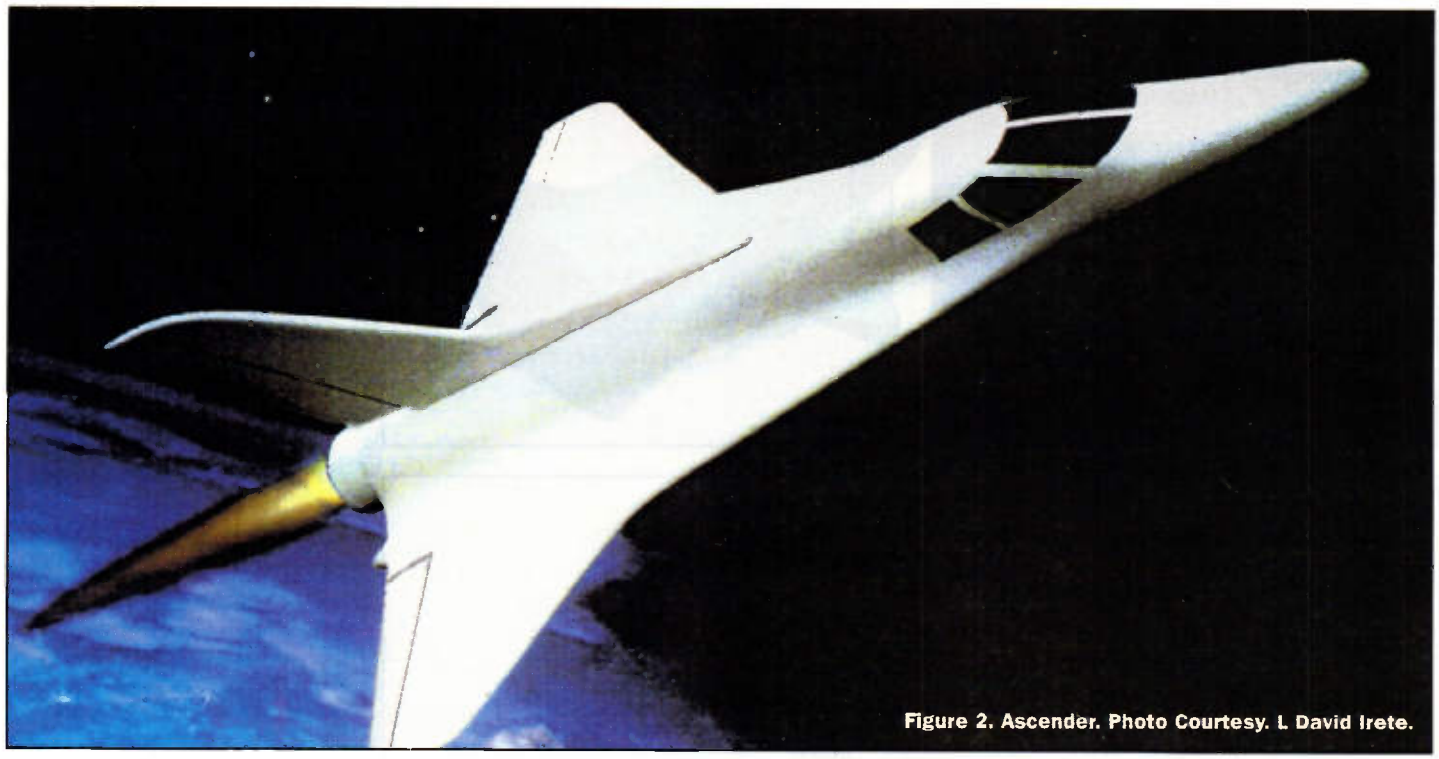


**Figure 2. Ascender. Photo Courtesy. L David Irete.**

from 4 to 6 astronauts and several tonnes of supplies to and from the Station. Such a vehicle would include guidance and propulsion systems resembling those already discussed on the ATV. It could be used as a six person life-boat to return to Earth. ESA is also engaged in an international collaboration with Japan, to study the heating between tiles flown on Japan's Hyflex re-entry vehicle which has now reached the Demonstrator stage.

The development of a space plane by Kelly Space and Technology is for a HTO plane for satellite launches. Kelly Space will use old jet fighters in a 89M$ deal with Motorola, to keep the Iridium satellite network operational into the next century. The company plans to build the Eclipse launcher from adapted F-106 jets. The addition of rockets, extra thermal protection and strengthened landing gear will allow the hybrid vehicle to launch payloads up to 1.5tonnes into LEO at an altitude of 200km. Each launcher will be towed behind a conventional Boeing 747 to a height of 14km. After the vehicle is released, its rocket engine will fire and carry it to an altitude of 125km. The launcher will then eject a final stage which will deliver the satellite to its required orbit. The Eclipse returns to Earth as an unpowered glider. Kelly Space has so far bought two F-106's and claims to be able to reduce small payload delivery costs by half. Bristol Spaceplanes Limited UK, formed in 1991, also have plans to launch a similar looking craft but able to carry passengers on space experience flights for Wild Wings (see Figure 2). The Ascender is designed to be the first aeroplane to carry passengers to space on sub-orbital flights and has been included in a feasibility study for ESA. Dunlop Aviation and Pilkington Aerospace have taken part and the concept was endorsed by an independent review commissioned by the UK Minister for Space. The Ascender will carry a crew of 2 with 2 passengers, taking off from an ordinary airfield. At 8km a rocket fires climbing to 100km and then the Ascender enters a steep dive. Two of the engines are Willliams-Rolls FJ44s and one Pratt and Whitney RL10. The Ascender Flight Path is shown in Figure 3.

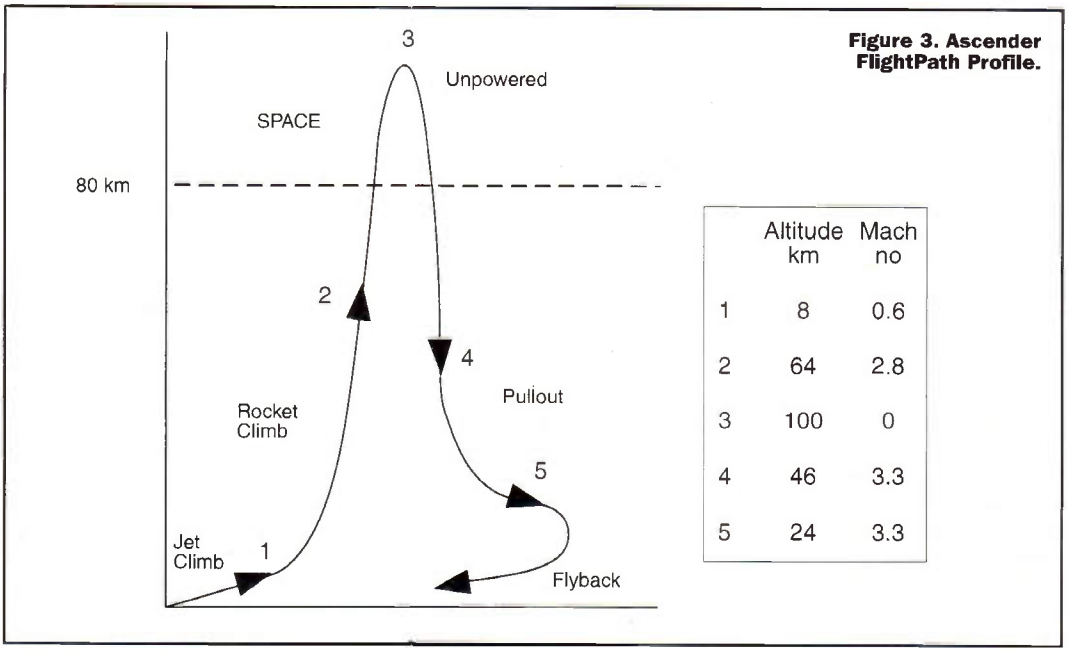



**Figure 3. Ascender FlightPath Profile.**

| | Altitude km | Mach no |
|---|---|---|
| 1 | 8 | 0.6 |
| 2 | 64 | 2.8 |
| 3 | 100 | 0 |
| 4 | 46 | 3.3 |
| 5 | 24 | 3.3 |

## The Rotary Rocket Concept

One of the more bizarre concepts being backed enthusiastically by Bill Gates and more recently by Richard Branson, is the Rotary Rocket or Roton, designed by Gary Hudson, based in Redwood City, California. The Roton will be a crewed rocket, looking uncannily similar to the Delta Clipper, taking off and landing vertically. Oxidizer and fuel are fed into 96 combustors inside a 7m diameter disk spun at 720 rpm before launch. Centrifugal force provides combustion pressure at room temperature, eliminating the need for massive and expensive turbo pumps, and allows the vehicle to act as a true SSTO. The disk periphery will experience an astonishing 1800g as it spins. If successful NASA will buy the Roton's launch services. As Goldin has said "It is going to shake up this aerospace industry that's been too dependent on the Federal government." The Roton descends with the aid of 4 foldaway helicopter blades each 7 metres long, spun by tiny rockets on their tips like a mini Catherine Wheel. Rotary Rocket says it will be able to deliver payloads to LEO with the first orbital flight scheduled for late 2000. The company has already tested individual combustors. Over the next year the craft will make 10 manned flights at

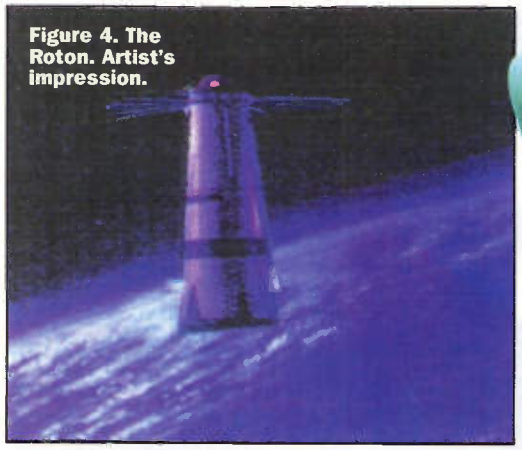


**Figure 4. The Roton. Artist's impression.**

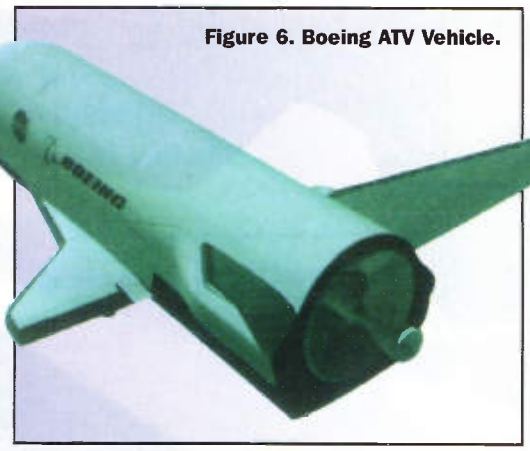


**Figure 6. Boeing ATV Vehicle.**

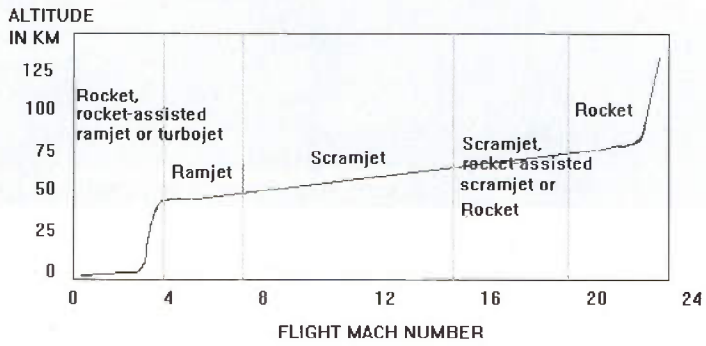



**Figure 5. Scramjet. Speed/Mode Profile.**

Mojave in California. Each rocket produces 350lb of thrust, with the rotors spinning fast enough for the Roton to climb like a helicopter. According to Hudson it is the largest tip-powered helicopter built. After reaching an altitude of 2km thrusters will be switched off, but as the craft descends airflow will keep the rotors spinning, providing enough lift to slow its descent until just before it reaches the ground. Descent should be controllable down to 1m/s, see Figure 4. Firing tip thrusters at this stage will allow the Roton to touch down gently. Hudson has certainly got some convincing arguments, and has even persuaded Tom Clancy, author of Clear and Present Danger to contribute 1M$.

## Scramjets

Looking beyond the X-33 and X-34 NASA is considering a variant of hypersonic jet engines or scramjets to breathe air like a conventional jet but can operate at speeds over Mach 6, bringing the goal of SSTO within reach.. Several unpiloted scramjets, designated X-43, will fly at speeds up to Mach 10 in 2000 from Dryden Flight Research Centre, using a 3.6m long aircraft. The trick is slowing incoming air enough so fuel can be burned in it for thrust without generating excess heat. If things go well flight tests of rocket based combined cycle engines could occur between 2004 and 2006.

A jet engine compresses atmospheric air, combining it with fuel, burning the mixture and expanding the combustion products to provide thrust. Turobojet engines such as those found on commercial aircraft are limited to Mach 4, above which the turbine and blades that compress the air suffer damage from overheating. Fortunately, at such high supersonic speeds a turbine is not required if the engine is designed so that the air is "ram" compressed. Such an engine has an air inlet that has been specially shaped to slow and compress the air when the vehicle is moving rapidly through the atmosphere. Because ramjets cannot work unless the vehicle is travelling at high speeds, they have been integrated in the same engine housing with turbojets. To obtain speeds above Mach 6, supersonic combustion ramjets, or scramjets reduce inlet airflow compression but keep the flow supersonic so the temperature does not increase dramatically as in a ramjet. Fuel is injected into the supersonic airflow, where it mixes and burns within a millisecond. The speed limit of scramjets appears to be above Mach 25, enough for orbital insertion to occur and for smooth transition into a true rocket phase, see Figure 5. High pressure on the underside of the vehicle also provide significant lift.

Rocket engines are not the only possibilities for space propulsion, NASA's Deep Space 1 used an ion engine to successfully place the 152M$ 350kg New Millennium spacecraft en route for a 13km fly-by of the asteroid 1992 KD in July, operating for over 850 hours. Ion engines work by accelerating charged atoms (ions) of a propellant with electrical grids charged to high voltage. As the ions leave the engine they impart thrust. Xenon is the currently favoured propellant, and can produce almost 10 times more thrust per kilogram than chemical rockets. As a result even though ion engines generate only a few grams of force they can in principle operate for years allowing a spacecraft to reach unimaginably high velocities, particularly useful for deep space applications, although solar power may provide some of the answer for orbits between Mars and Jupiter. Future contracts with Spectrum Astro for Deep Space 2,3, and 4 are already planned. Britain's Matra Marconi Space has also carried out successful firing of its own ion thruster in Portsmouth. The 18mN UK-10 Ion thruster is the culmination of 30 years of research in the UK originally at the Royal Aircraft Establishment, but lacked funding. In 1985 renewed interest in Xenon as the electrically ionised expelled propulsion gas grew. Xenon gas is extracted easily from air liquefaction. Once complete the engine will be used in the ESA technology demonstrator Artemis, launched on a new Japanese vehicle. ESA also plan a 200mN engine UK-25 for future ESA interplanetary flight.

## Future-X

NASA has begun a continuous series of flight demonstrators called Future-X under the Advanced Technology Vehicle ATV program, to increase US competitiveness in the world-wide commercial space transportation market and to decrease future government costs for space access from which the European agency could well take note. Boeing have been selected to look at the first Future-X ATV vehicle, 22ft long with a 12ft wingspan, see Figure 6. Clearly these advanced launching programs are set to provide a significant reduction in costs and a big growth of both satellite and 'tourism' applications.

## The International Space Station and Space Tourism

Depending on who you talk to, the International Space Station is either the next step forward in an exciting future of manned space flight, or an incredibly expensive engineering jigsaw puzzle which will hold back space exploration, or a Titanic scale disaster waiting to happen. NASA has just announced its spending for 2000, with a $2.48 billion increase for the ISS, that's 8% up. Administrator Daniel Goldin stated that the changes allow 'necessary resources to meet the current challenges of the ISS'. This will help cover operations and on-orbit research scheduled to begin in 2000, the need for 4-man return-vehicles for 2004, and to cover any difficulty by Russia meeting its ISS commitments. Contingency planning for Russia's participation in the ISS add $1.2 billion to the project cost. Delays in completing the Russian Service Module (RSM) for the ISS add a two year hold up to the programme.

In addition, NASA concedes that the RSM won't be equipped with debris shielding until 2002 at the earliest. If the module is depressurised in a serious debris strike before this, the crew will have to evacuate the station.

The scale of the project is impressive, during the next six years, over 100 separate elements will be spacewalked into place using cordless drills, strong high-strength wrenches and even low-tech crowbars to create the vast structure (see Figure 7). To prevent the proliferation of tools, NASA planners asked contractors to design modules and external accessories with standard bolts having a 7/16" head. Astronauts will primarily use a battery-powered 3/8" pistol grip drill first used on the Hubble maintenance missions, and able to withstand temperatures down to -250°F, made from Beryllium Copper.

## Planning The Station

On 29 January 1998 in Washington representatives of 15 states: the USA, Russia, Japan, Canada and 11 ESA Member states signed an Inter-Governmental Agreement (or IGA) concerning co-operation on the civil International Space Station (ISS). This agreement also formalised Russia's integration into the partnership.

## Usage of the Space Station

The basic principles for use of the Station are laid down in Article 9.1 of the IGA and allow ESA to retain 51% use of its European laboratory and Japan's Co-operation Agency will retain 51% of its Japanese Experiments Module (JEM). On the issue of crews, the complement for the Station will be raised to seven at the start of the exploitation phase, which requires NASA to develop a rescue vehicle able to accommodate four people, in addition to the Russian Soyuz ability to return three people to Earth. Of the seven crew members, Russia will claim three crew to carry out maintenance required on the Russian segment, while the other Partners will share the other four places. ISS co-operation will give a new freedom for European, Japanese and Canadians in their manned space activities. This freedom will have a beneficial impact on all activities such as crew selection, training, and assignment on specific flight missions.

## Operations Planning

As a consequence of the ISS's long expected operational life, the mission planning process is being performed in several distinct steps- Strategic, Tactical and Execution Planning, covering time intervals ranging from several years to a few days. Planning for the ISS, and in particular the Columbus Orbital Facility is based on each partner integrating their respective partner activities.

## The European Contribution - The Microgravity Facilities for Columbus

The European participation in the ISS was formally initiated in January 1997. Ministers approved several elements, including the development of the Columbus Orbital Facility (COF) and a programme to develop facilities for conducting microgravity experiments in the COF, the Microgravity Facilities for Columbus (MFC) Programme. The programme is ESA's main contribution to the ISS and the experiments carried out in its facilities will provide a much needed boost to the European scientific community. Microgravity covers a wide range of activities such as fundamental physics, crystal growth, metallurgy, chemistry, fluid science, biology, biotechnology, human physiology and medicine. The objective of the MFC Programme is to have four disciplines: material and fluid sciences, biology and human physiology, constantly present on the ISS. (Figure 8 Columbus Orbital Facility).

The MFC Programme will continue through the Station's life and is expected to run long-term experiments rather than the short-term experiments typical of earlier Spacelab missions. The first phase of the MFC Programme (1997-2003) includes developing the following launched in the COF: Biolab, a Fluid Science Laboratory (FSC), European Physiology Modules (EPM), and the Material Science Lab (MSL) which will be composed of two facilities, one

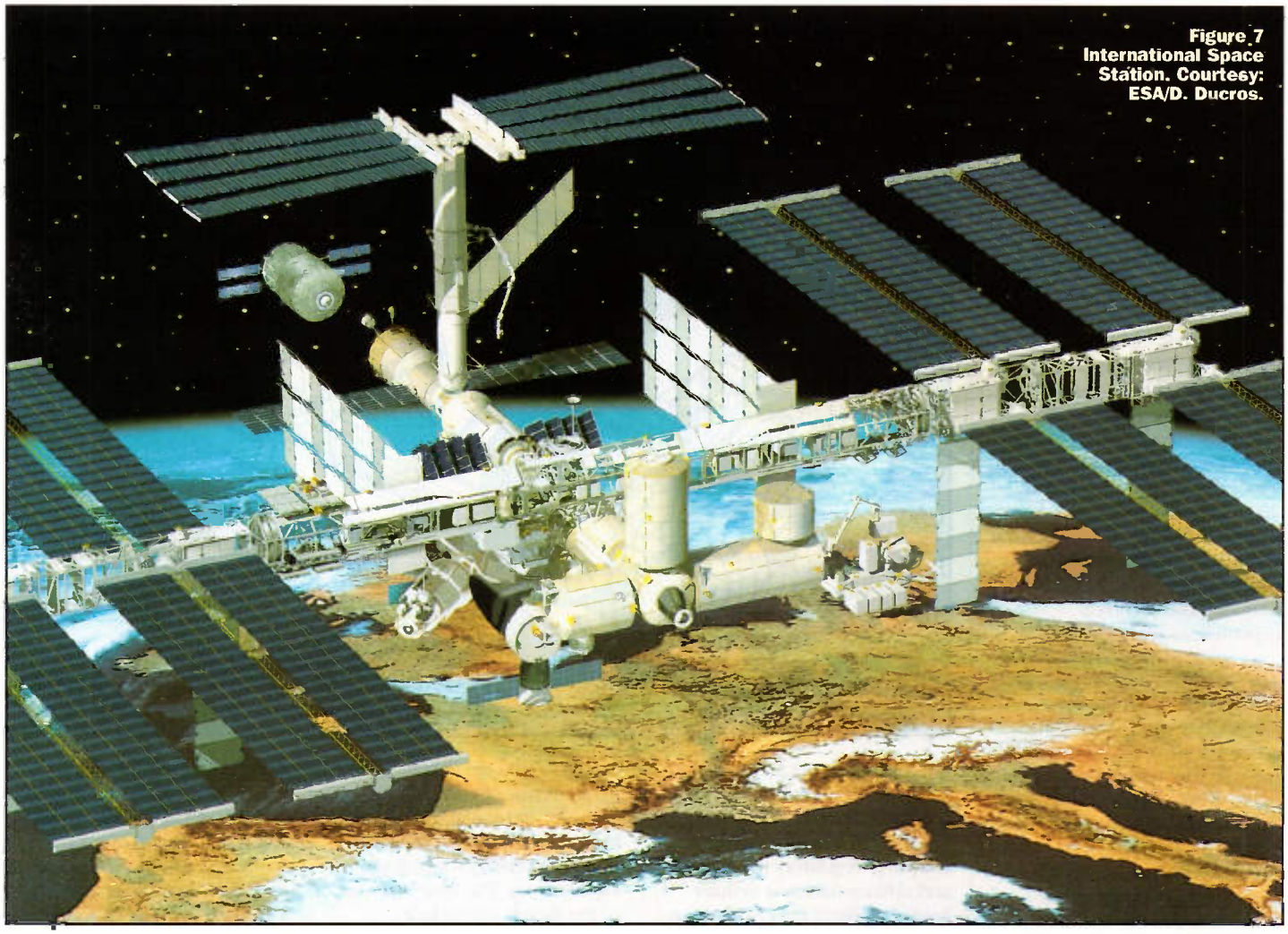


**Figure 7 International Space Station. Courtesy: ESA/D. Ducros.**

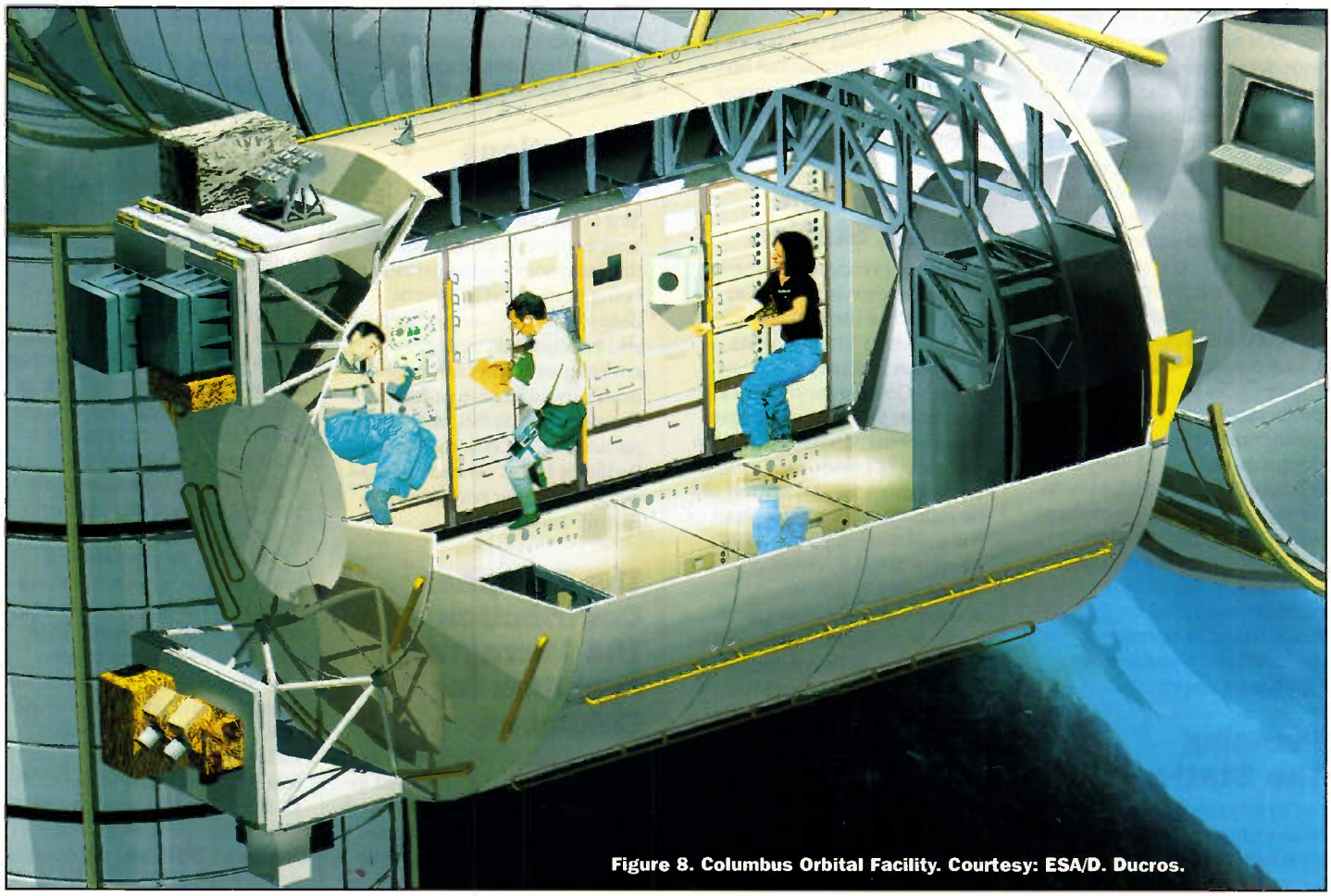


**Figure 8. Columbus Orbital Facility. Courtesy: ESA/D. Ducros.**

accommodated in the US Lab (see Figure 9) and one in the COF. MFC will also develop experiment hardware for these facilities and the preparation of the next generation modules and facilities. The multi-user facilities will be modular in design to allow for upgrades and easy refurbishment/ repair for long term operations.

Each facility is supported by a dedicated team that will follow its development and advise the Agency on its best scientific use. A major challenge of the Programme is to ensure that the scientific performances of the facilities respond to the scientists' needs. Three multi-user labs are planned for launch inside the COF by the end of 2002. Together with these labs there will be allocated stowage and a set of spares for initial maintenance. MFC facilities for scientific and technical experiments are listed in Table 1.

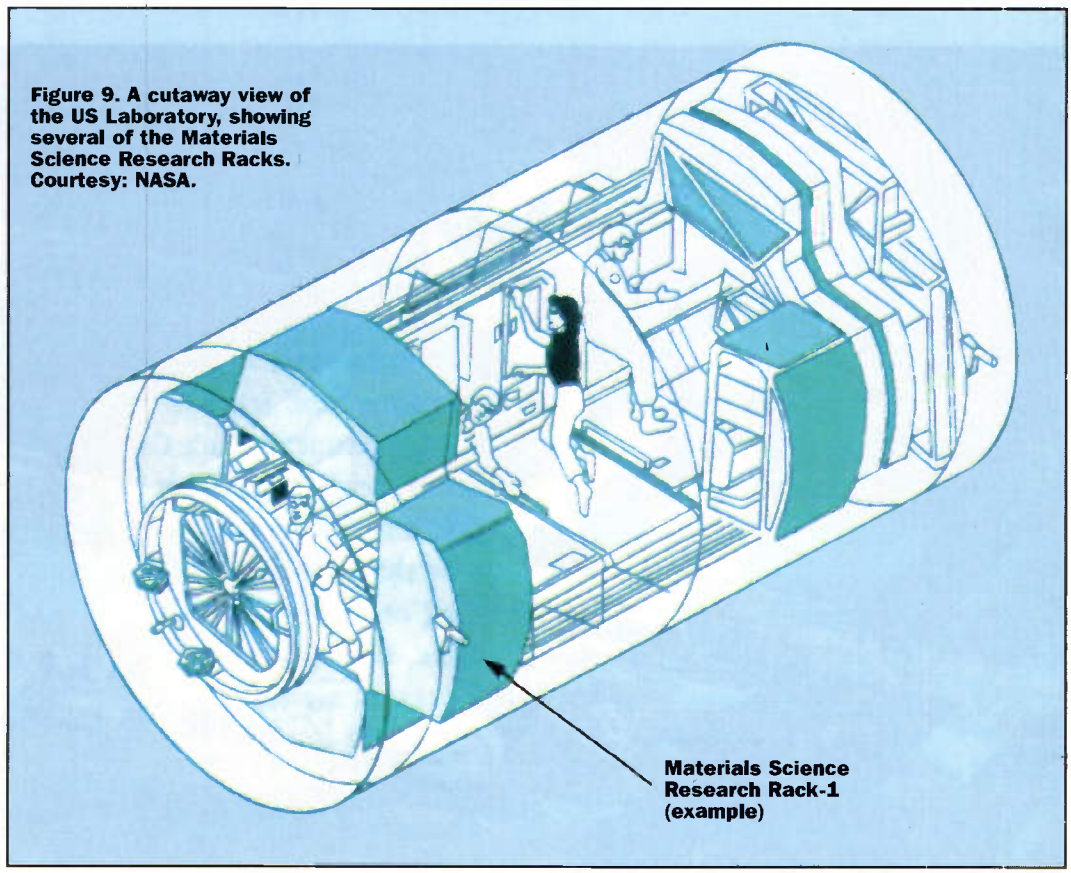



**Figure 9. A cutaway view of the US Laboratory, showing several of the Materials Science Research Racks. Courtesy: NASA.**

## Biolab

Life-science experiments in space are aimed at identifying the role that microgravity plays in life, from single cellular organisms to the more highly developed organisms, e.g. man. The effects of microgravity on man will be investigated by other facilities e.g. the EPMs, but it is important to investigate small biological structures. ESA has recommended life-science research by focusing on the following- regulatory mechanisms and differentiation at cellular level, the role of the cytoskeleton, radiation damage in cells and tissue, repair of cells and tissue damage, and signal transduction in plants. The Biolab will be a multi-user facility for biology experiments. The main features of the Biolab will include: automation, modularity, and telescience. All the automatic features of the Biolab can be controlled from the ground, giving the scientist the possibility to interact actively with their running experiments.

| | BIOLAB | MSL | FSL | EPM |
|---|---|---|---|---|
| **Research Field** | Cell culture<br>Micro-organisms<br>Small plants<br>Small invertebrates<br>Mechanism of radiation damage in cells and tissue | Solidification physics<br>Composite materials<br>Crystal growth<br>Material properties | Bubble formation and growth<br>Thermophysical parameters<br>Directional solidification<br>Condensation | Metabolic functions<br>Cardiovascular<br>Muscular/skeleton systems<br>Neuroscience |
| **Automation** | Complete experiment execution including analysis | Complete experiment execution including analysis | Experiment execution including analysis | When feasible to shorten experiment set-up |
| **Telescience** | All automatic features can be altered from ground | All automatic features can be altered from ground | All automatic features can be altered from ground | Experiment procedures can be modified at any time |
| **Advanced Diagnostics** | Microscope<br>Spectro photometer | Seebeck effect<br>Sample resistance<br>Thermocouples<br>Peltier Marking | Particle image velocimetry<br>Thermographic mapping<br>Interferometric observation | Analysis on-board of blood, urine and saliva |
| **Modularity/Serviceability** | Modular design of the facility<br>Experiments in standard container box | Modular design of the facility<br>Furnace module can be replaced in orbit | Modular design of the facility<br>Experiments in standard container box | Modules can be exchanged and operated in other Space Station locations |

**Table 1. MFC facilities scientific/technical features.**

## The Materials Science Laboratory

Materials science experiments will provide understanding of crystallisation in microgravity, studied with measurements of thermophysical properties, e.g. temperature, resistivity, etc. Research in this field is important to obtain data for ground-based materials production. Cuts in Space Station resources and budget limitations reduced the number of furnaces under study to two, the Solidification and Quenching furnace or SQF and the Low Gradient Furnace or LGF. There is a lot in common between both facilities to minimise costs. The LGF is targeted for Crystal Growth experiments and it is planned to be in the in the US Lab. US scientists are proposing to use the LGF for diffusion experiments on Silicon and Germanium alloys.

The SQF is optimised for metallurgy experiments requiring large thermal gradients and fast sample quenching, and is planned for the MSL in the COF. The maximum operating temperatures of both the LGF and the SQF are set to 1600°C, with stability better than ±0.02K for the LGF heaters, and ±0.2K for the SQF. Both furnaces are designed to achieve high radial uniformity of heating less than ±1K over the circumference. The diameter of the LGF and the SQF heater cavities will be 3cm, and vary in length from 25cm for the SQF to 12cm for the LGF. Diagnostics will be from Seebeck Voltage measurements, Peltier elements and thermocouples. One of the major challenges for the MSL lies in co-operation with NASA, since both NASA and ESA have furnace programmes in progress and their science objectives are similar.

## The Fluid Science Laboratory

Space fluid-science experiments will study dynamic phenomena in the absence of gravity, e.g. diffusion-controlled rather than convective flow dominated heat transfer during crystallisation, resulting in reduced defects. The ability to control such processes requires research to optimise manufacturing processes on Earth. Future science will look at flow and instabilities induced by gradients and thermal forces, adsorption, boiling, crystal growth and directional solidification.

## The European Physiology Modules (EPM's)

Investigations into the effect of microgravity on the human body have been conducted for many years and ESA has successfully flown missions on Spacelab. For the ISS highest priority for research is impaired muscle structure, bone decalcification, blood pressure regulation, fluid balance and kidney function, lung ventilation, and space adaptation syndrome. These fields have important applications on Earth for the treatment of cardiovascular, respiratory and neurological diseases, as well as for the diseases that effect elderly people. The Space Station will offer unique capabilities for $\mu$-gravity experiments including: long flight durations, data-gathering, telescience and automated capabilities which is particularly important given the limited crew time available for carrying out the many planned experiments.

## The Risks

As stated the ISS is set to be completed two years behind schedule and cost US taxpayers an extra $7.3 billion than originally anticipated. The production of a detailed independent report produced in April 1998, now considerably out of date, suggested NASA was being optimistic with this loss. However, the most worrying part of the analysis is that it takes no account of launch vehicle failures, except to state that "there is a high likelihood that one or more failures, including catastrophic failures, will occur." This is a cryptic way of stating that Challenger type explosions can be expected. The shuttle was first conceived to build space stations, but since the Challenger disaster in 1986, doubts over its reliability have failed to fade. Challenger blew up shortly after lift-off, killing all screw crew, and one must never forget that with all the advances in 20th Century technology, the Space Shuttle is still launched on the end of a very big, and very explosive rocket. It was a blow for the Agency, and for millions world wide who watched the event. The shuttle was intended to transport the station's components into orbit, but as time progresses its technology is becoming increasingly antiquated. The shuttle programme has a natural lifespan of another 10-15 years, but could be extended. To highlight one issue, the revolution in computer processors and number crunching ability in the last decade leaves many domestic PCs with more powerful microprocessors than those used to keep the shuttle in orbit. Astronauts often carry their own laptops with them into space!

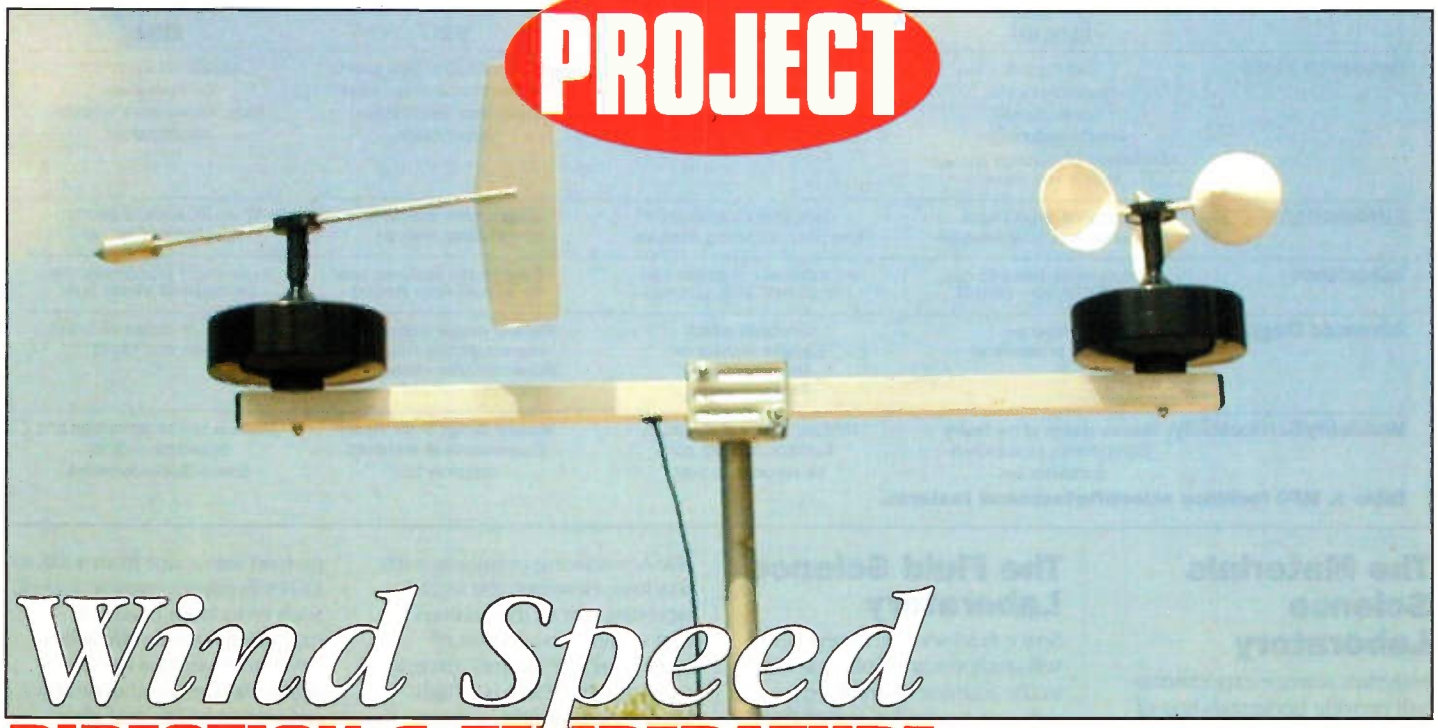
The histories of space shuttle and station are intertwined; both were fronted by NASA in the Apollo era, and an ambitious space station, moon station and manned mission to Mars seemed like the logical next steps in the Cold War Space Race with the Soviet Union. History has revealed a different story, with man only returning to the moon, albeit by remote sensors, with the Clementine and Lunar Prospector in the last few years. Originally, NASA believed it could reduce the cost of launching a pound of payload into space from $10K to $10 by flying one mission a week. Such reductions have not happened because NASA has never achieved this level of flights. At best the shuttle flew eight times a year, and after Challenger there was a long absence of manned US spaceflights.

Safety is a relative concept. Before Challenger, NASA identified 616 'critical' flight systems, but now there are 1,514, all requiring inspection before lift-off. Each shuttle is supposed to fly over 100 missions, however an assessment by the Office of Technology suggested that a shuttle will be lost during every 78 flights! NASA may lose five launches during ISS assembly. If a shuttle is lost during assembly it is unclear what will happen to long-term manned spaceflight. As discussed in the earlier parts of the article the X-33 programme is set to reduce shuttle costs, but streamlining operations may be the best solution for achieving large cost reductions. Fifty six companies cost NASA $3 billion a year, employing 22,500 staff, by handing over flight operations to one contractor substantial savings could be made.

The probability of one launch failure resulting in the loss of cargo is reckoned at over 99%. NASA and the Russian Space Agency (RSA) between them expect to lose largely Russian rockets which are more vulnerable. Most of the 60 Russian launches will carry supplies so their loss would be irritating but involve no loss of life. The probability of losing one of the 33 planned shuttle missions or 12 RSA crucial hardware launches is 73.6%. Daniel Goldin, NASA chief administrator fears their could be a repeat of the Challenger disaster, and is unhappy with present safety levels. He has said "I personally asked our people to assure safety, from engine ignition through main engine cut-off. We do not have it."

**TO BE CONTINUED...**

PROJECT



# Wind Speed

# DIRECTION & TEMPERATURE INDICATOR - MARK II

## PART 2

***Dr. Mike Roberts continues his description of an upgrade to the excellent Maplin Weather Station project - providing both cost reduction and performance improvement.***

## Construction

The mechanical construction is covered in the original articles which are supplied with the hardware.

The printed circuit boards are straightforward. I usually add components in order of height i.e.

- wire links
- resistors
- IC sockets
- small capacitors
- ICs

Please note that the opto-switches OS1 to OS5 must be mounted as high as possible, so their sensing faces are 8mm above the PCB. All other components in the head electronics must be below this height. The ideal sensing range for the opto-switches is 2-3mm.

I used IC sockets for the microcontrollers, the DAC and MAX202 serial conversion IC.

For the base unit PCB connections I used a 2.5mm power socket for the 12V supply, a 3.5mm mono jack socket for the serial output and a 2-pin din socket for the link to the head unit. Make sure polarity is preserved through each of these connectors.

The 16 x 2 display used here has the LED backlight connections reversed compared to the NT57M alternative from Maplin. With the VX24B version used here connect pin 15 on the display to pin 16 on the PCB and vice versa. The NT57M type can be used but in this case connect pins 15-15 and 16-16 and replace R12 with a wire link as the dropper resistor is included on the display.

I originally thought I would get away without using a heatsink on the base unit voltage regulator (IC1). In operation I felt it was a little hot and so added a heatsink to the top of the tab. This was made from a 75mm length of 15 x 15 x1 aluminium angle.

## Base Unit Case

The panel layout is shown in Figure 8. The display looks much better with triangular LEDs and the piercing out of the holes is not as difficult as it might seem - taking an hour or so. If you choose to use round LEDs simply set out the 16 holes on a 2.5in PCD. For triangular LEDs mark out a circle at 59mm PCD for the bases and then drill 2.5mm pilot holes on a 62mm PCD. A 69mm PCD circle can be used to mark where the position for the apex of the triangles. The rest is done with a triangular needle file regularly checking the fit with one of the diodes.

### FEATURES

| | |
|---|---|
| Wind speed: | 0-100 mph, 0-87 knots |
| Direction: | 16 points compass |
| Temperature: | -40°C to +70°C |
| Display: | Analogue, Digital, PC (via serial link) |

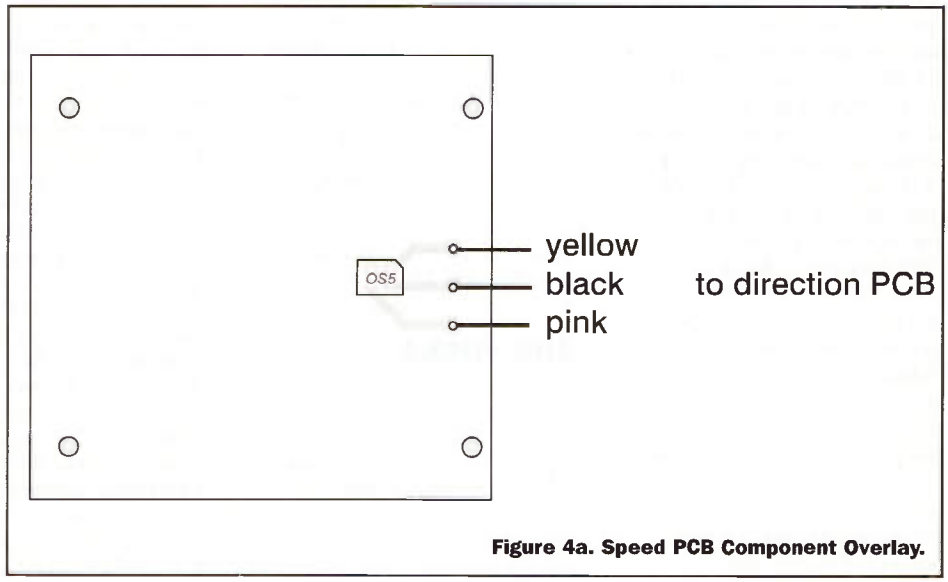
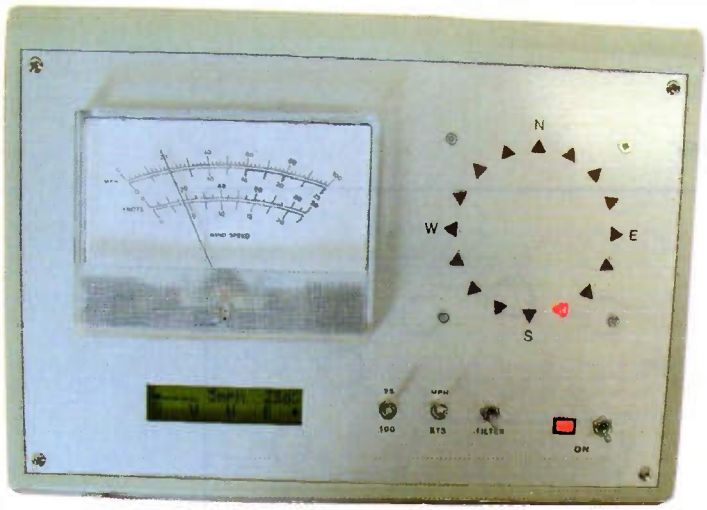



**Figure 4a. Speed PCB Component Overlay.**



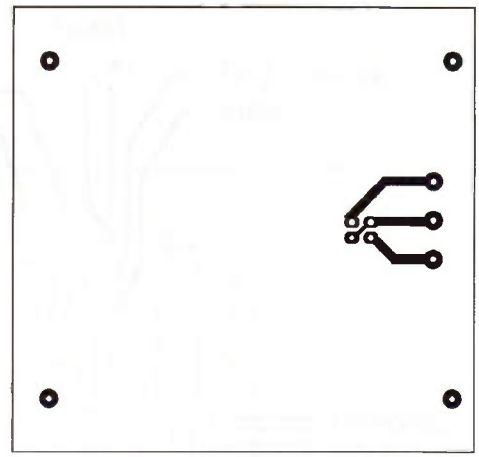



**Figure 4b. Speed PCB Track Layout.**

When marking out the panel note that the corners are not square. It is best to make all measurements from the upper or lower edge.

I again mounted the display using gluegun glue. First attach four countersunk 2.5mm bolts, with two nuts each, to the display so their heads are parallel to the face of the display. Then mark the back of the panel with the correct location of the bolt heads. With the display a safe distance away from the glue gun apply adhesive to the four spots on the back of the panel. Check that all threads of adhesive are clear of the opening in the panel. Then put the display in place. Final adjustments to position can be made by remelting the glue by applying a soldering iron to the back of the bolt heads.

The meter scale (JL89W) is not in the new Maplin catalogue but was still available at the time of writing. Cut this round the outline. Remove the cover from the meter. Carefully unscrew the original scale and slide it from under the needle. Attach the new scale using adhesive. I used 'Pritt adhesive roller' putting the adhesive around the perimeter of the card.

I put the power and head lead connectors on the back of the case and the serial socket on the front. This is simply a matter of personal preference.

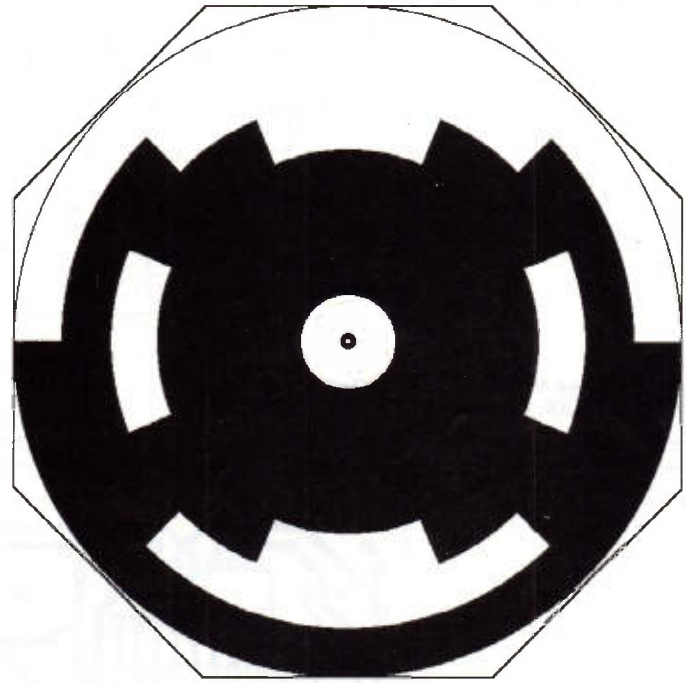


**Figure 5. Direction Code PCB.**

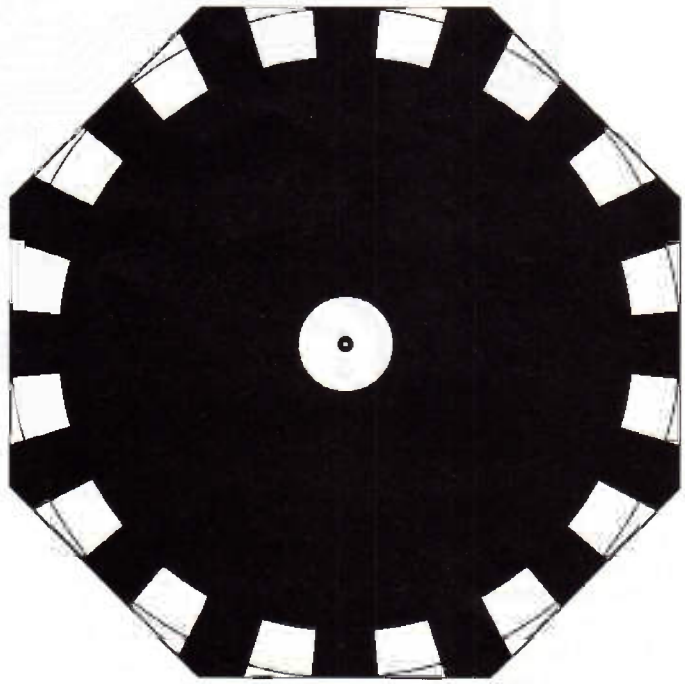


**Figure 6. Speed Code PCB.**

## Serial Cable

Only two wires are required as this is one way transmission with no handshaking. Most PCs now just use 9-pin D connectors for serial. I have included the 25-pin connections if required.

The connections are as follows:

| | 9-pin DIN | 25-pin DIN |
|---|---|---|
| ground / '-' | 5 | 7 |
| data/signal | 2 | 3 |
| connect DTR, DSR | 4,6 | 20,6 |
| connect RTS, CTD | 7,8 | 4,5 |

Data reception by a PC can be checked using Windows 'Terminal' or 'Hyperterminal' using the settings:

| | |
|---|---|
| Baud | 9600 |
| Data Bits | 8 |
| Stop Bit | 1 |
| Parity | None |
| Flow Control | None |
| Connector | COM1 or COM2 |

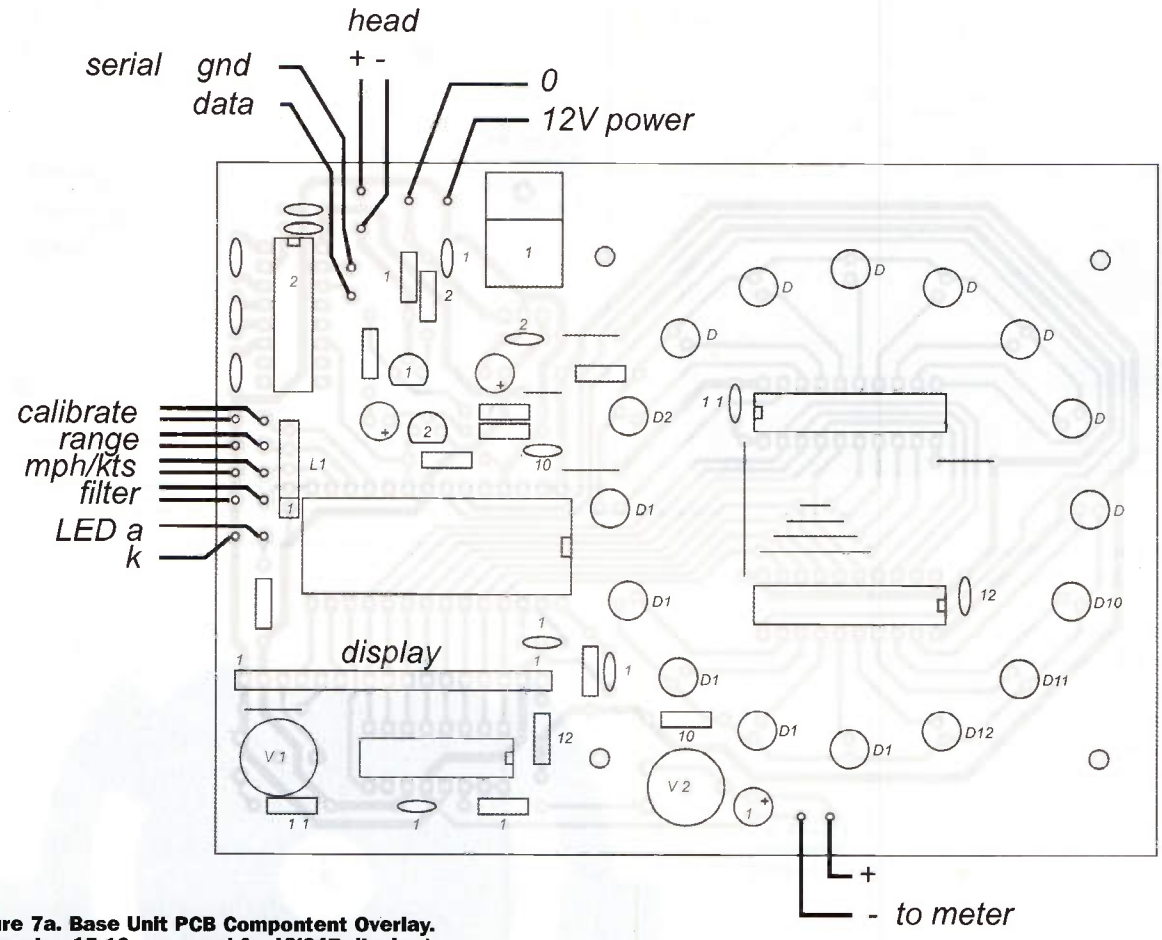



**Figure 7a. Base Unit PCB Compontent Overlay. (Note pins 15,16, reversed for VX24B display.)**

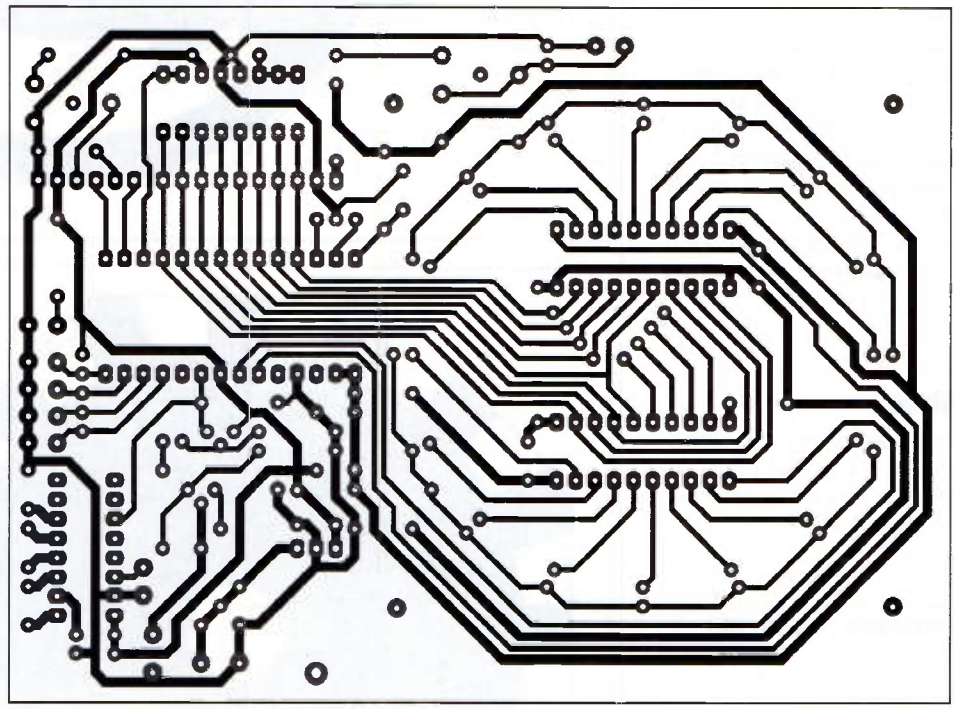


**Figure 7b. Base Unit PCB Track Layout.**

## Set-up

The temperature range has to be set up via VR1 on the head unit. With the electronics complete, add the interconnecting wiring and power up. The current consumption should be 125mA at 12V. The display will show 'Waiting for data' until the first data set is received. All being well this will change to showing the speed, temperature and direction within a second. The temperature can be set by adjusting VR1 until the voltage on pin 2 of IC4 is at 3.84V. Alternatively make up an ice pack with crushed ice in a polythene bag. With this surrounding the sensor adjust VR1 until a reading of 0°C is received.

The only set-up required for the base unit is the scale for the analogue meter (VR2) and the display contrast (VR1). Adjust VR1 to give the best contrast on the display. Then link the pins for SW2 together. The analogue meter should go to approximately full scale. Adjust VR2 so it reads full scale exactly. It is now set up and ready to be installed.

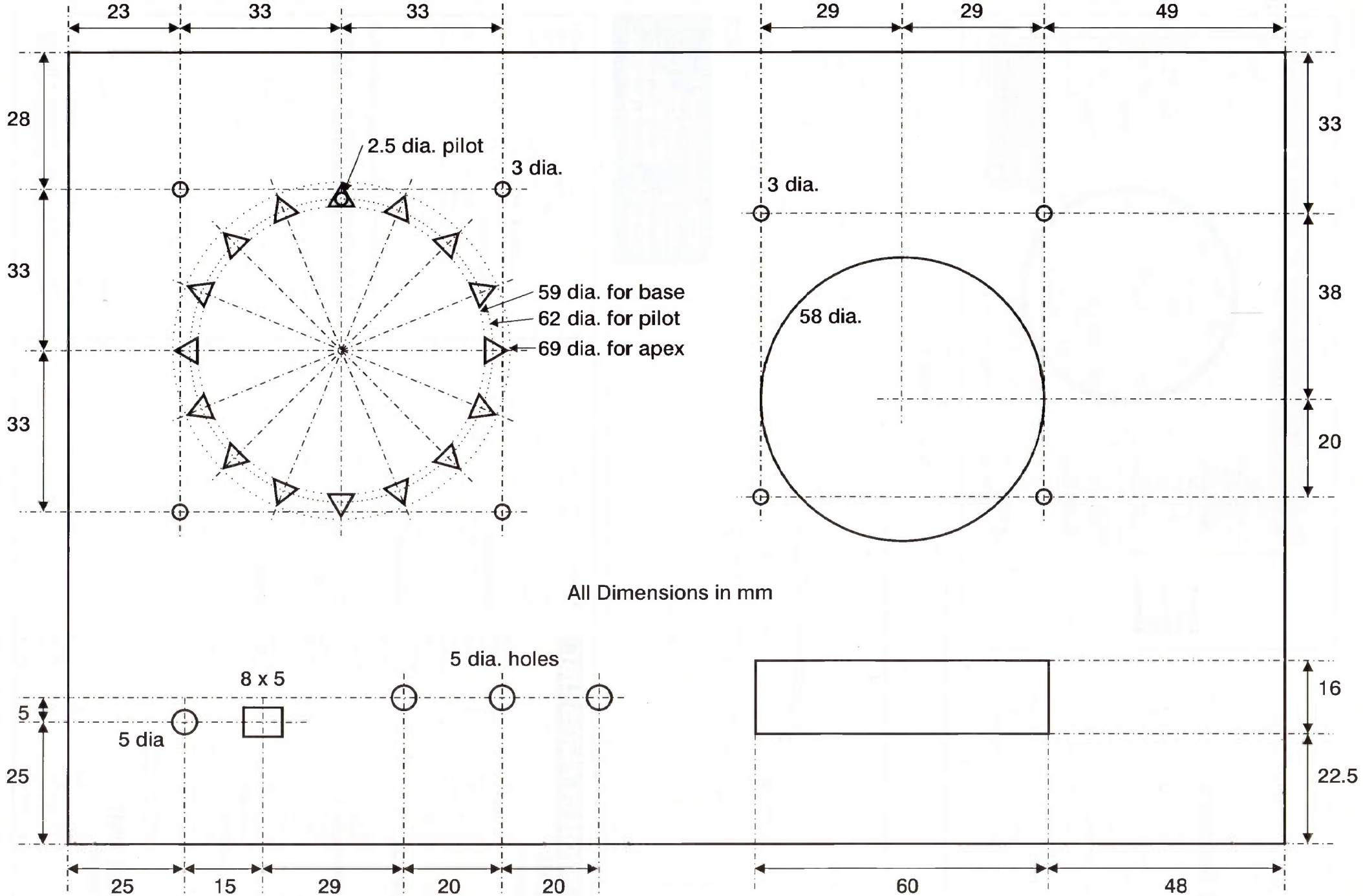





**Figure 8. Front panel detail from rear (shown full size).**

If required the serial data can be checked using an oscilloscope, first at RA4 of IC4 of the head unit and then through R1, R3 and then R6 on the base unit.

## PC Software

Paul Blackmore of *Bearware Computer Consultancy* has updated his MetMachine software to accept the serial data from this new weather station. MetMachine displays the wind speed (current, average and maximum), direction (current and average) and temperature(current, maximum and minimum). The data can be logged, played back and graphs displayed and printed.

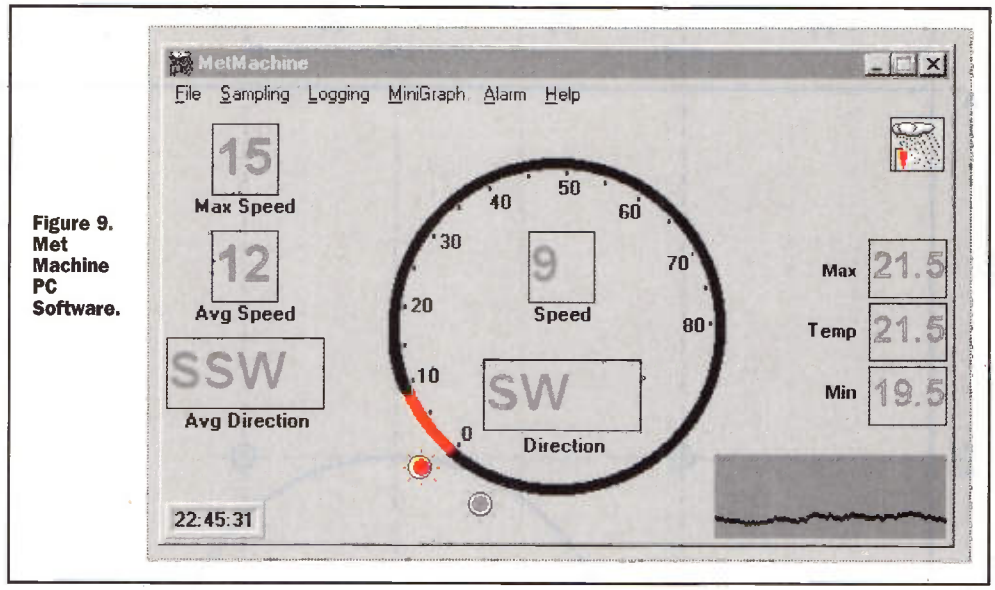



**Figure 9. Met Machine PC Software.**

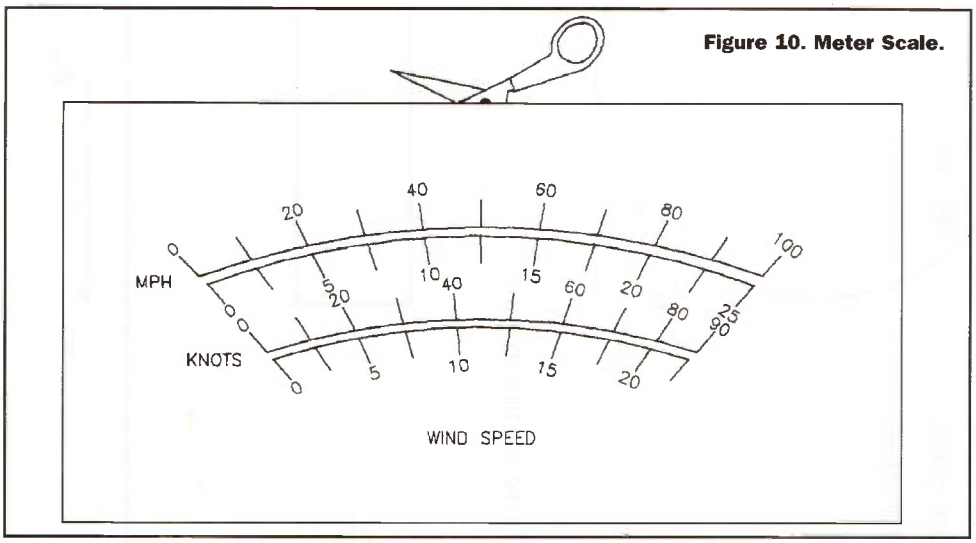



**Figure 10. Meter Scale.**

Details of MetMachine were published in *Electronics and Beyond* issue 70. However, it is very straightforward to use and compatible with MS Windows environments. The initial set-up involves selecting the appropriate communications port, first via 'Sampling', 'Base Address' and then 'Sampling', 'Communications Port'. Then activate via 'File', 'Mode', 'Enable via Comm Port'.

**KEY TO IMAGES IN PART 1**

| | |
|---|---|
| **Image 1** | **Speed PCB** |
| **Image 2** | **Direction PCB** |
| **Image 3** | **Speed Code Disk** |
| **Image 4** | **Direction Code Disk** |

## PROJECT PARTS LIST

### HEAD

**RESISTORS**

| | | | |
|---|---|---|---|
| R1 | 68 Min Res | 1 | M68R |
| R2,7 | 10k Min Res | 2 | M10K |
| R3 | 20k Min Res | 1 | M20K |
| R4 | 4k3 Min Res | 1 | M4K3 |
| R5 | 15k Min Res | 1 | M15K |
| R6 | 470 Min Res | 1 | M470R |
| R8,9 | 100k Min Res | 1 | M100K |
| VR1 | 1k | 1 | WR40T |

**CAPACITORS**

| | | | |
|---|---|---|---|
| C1,2 | 0.1µF 63v | 2 | DT98G |
| C3 | 22µF 16v | 1 | AT99H |
| C4,5 | 12µF | 2 | WX45Y |

**SEMICONDUCTORS**

| | | | |
|---|---|---|---|
| IC1 | LM78L05ACZ | 1 | QL26D |
| IC2 | LM358 | 1 | UJ34M |
| IC3 | TC02VZB | 1 | NU36P |
| IC4 | Pre-programmed PIC | 1 | * |
| IC5 | HCF4024BEY | 1 | QX13P |
| TR1,2 | BC547 | 2 | QQ14Q |
| OS1-5 | OPB608B | 5 | * |

**MISCELLANEOUS**

| | | | |
|---|---|---|---|
| | Wind Hardware Kit | 1 | LM90X |
| X1 | 3.2768MHz crystal | 1 | FY86T |
| | Speed PCB | 1 | * |
| | Direction PCB | 1 | * |
| | Speed code disk | 1 | * |
| | Direction code disk | 1 | * |

### BASE UNIT

**RESISTORS**

| | | | |
|---|---|---|---|
| R1 | 150 Min Res | 1 | M150R |
| R2,4 | 4k7 Min Res | 2 | M4K7 |
| R3,6,8,11 | 10k Min Res | 4 | M10K |
| R5 | 47k Min Res | 1 | M47K |
| R7 | 270 Min Res | 1 | M270 |
| R9,10 | 220 Min Res | 2 | M220R |
| R12 | 18 Min Res | 1 | M18R |
| R13 | 15k Min Res | 1 | M15K |
| VR1 | 1k0 | 1 | UH00A |
| VR2 | 2k2 | 1 | UH01B |
| SIL1 | 10k x 4 | 1 | * |

**CAPACITORS**

| | | | |
|---|---|---|---|
| C1,2,5,6,7,8,9,10,11,12,13,14 | 0.1µF 63v | 7 | DT98G |
| C3 | 22µF 16v | 1 | AT99H |
| C4 | 1µF 63v | 1 | AU09K |
| C15 | 47µF 6v3 | 1 | AT96E |

**SEMICONDUCTORS**

| | | | |
|---|---|---|---|
| IC1 | MC7805CT | 1 | AV08J |
| IC2 | MAX202CPE | 1 | VQ46A |
| IC3 | Pre-programmed PIC | 1 | * |
| IC4,5 | 74HCT574 | 2 | AE30H |
| IC6 | AD557JN | 1 | * |
| TR1,2 | BC557 | 2 | QQ16S |
| D1 - 16 | Triangular LED | 16 | YY54J |
| | alternate round LED | | WL27E |
| D17 | Red Rect. LED | 1 | QW96E |

**MISCELLANEOUS**

| | | | |
|---|---|---|---|
| X1 | 4MHz resonator | 1 | * |
| | Base unit PCB | 1 | * |
| | panel meter | 1 | YJ96E |
| | scale for above | 1 | JL89W |
| | IC socket 28-pin | 1 | BL21X |
| | IC socket 16-pin | 1 | BL19V |
| | switches | 4 | FH98G |
| | rect. LED clip | 1 | YH62S |
| | 16 x 2 Display LED | 1 | VX24B |
| | M2.5 20mm CS bolts | 1 | JC69A |
| | M2.5 nuts | 1 | JD62S |
| | 14mm threaded spacers | 1 | FG38R |
| | 3mm CS screw | 1 | BF36P |
| | 3mm panel screw | 1 | JY21X |
| | heatsink for IC1 | 1 | * |
| | 2.5mm power socket | 1 | JK10L |
| | 3.5mm mono socket | 1 | CX93B |
| | 2-pin socket | 1 | HH31J |
| | 2-pin plug | 1 | JK08J |
| | case | 1 | YN30H |
| | 12V Power supply | 1 | MG81C |

**INTERCONNECTING CABLE**

| | | | |
|---|---|---|---|
| | single coax | as req. | XR16S |

**SERIAL CABLE**

| | | | |
|---|---|---|---|
| | single coax | as req. | XR16S |
| | 3.5mm plug | 1 | HF80B |
| | 9-pin D socket | 1 | RK61R |
| | 9-pin D cover | 1 | FP27E |

* Available from author.

**COMPONENTS NOT AVAILABLE FROM MAPLIN**

***The Programmed PICs, PCBs, and non Maplin components are available from the author:***

**PCBS**

| | |
|---|---|
| Speed code disk | £3.50, |
| Direction code disk | £3.50 |
| Direction PCB | £4.50 |
| Speed PCB | £2.50 |
| Base unit PCB | £7.00 |

**PICS**

| | |
|---|---|
| Head | £12.50 |
| Base unit | £12.50 |

**MISCELLANEOUS**

| | |
|---|---|
| opto-switches OS1-5 | £2.50 each |
| 4MHz resonator | £0.50 |
| SIL1 | £0.30 |
| AD557JN | £7.95 |
| PC software | £5.00 |
| Heatsink | £0.50 |

post + packing £1.50

***Cheque/P.O. to: Dr. M. P. Roberts, 4 Thames Avenue, Guisborough, Cleveland, TS14 8AD***

# PROJECT

# Using Voltage REFERENCE & TEMPERATURE SENSOR ICS

## PART 2

***In this second part, Ray Marston shows how to use various popular 'current source' and 'temperature sensor' ICs.***

Last month's opening episode of this 3-part series dealt exclusively with popular voltage reference ICs. This month's episode begins by describing practical applications of the popular LM334Z adjustable current source IC, and then goes on to present practical application data on three popular temperature sensor ICs manufactured by National Semiconductor.

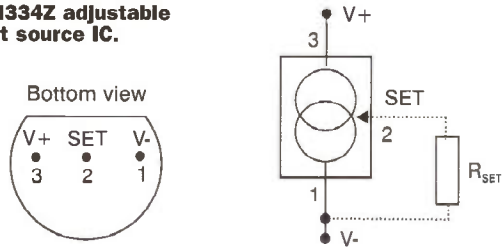
## 'Current Source' ICs

So far, this mini-series has dealt only with 'voltage reference' ICs; the present section moves on from this subject and deals with 'current source' ICs. These devices act as constant-current generators or sinks, and pass a fixed or pre-set operating current that has a value that is virtually independent of variations in the device's operating voltage. Such devices are widely used in precision bias networks and linear ramp generators, etc.

The best known commercial-grade 'current source' IC is the LM334, which is manufactured by National Semiconductor and is available in a variety of sub-types, in various packaging styles; the best known of these is the LM334Z, which is housed in a 3-pin TO-92 plastic package (an almost identical device, the LM334N, is available from SGS Thomson). The LM334Z can be regarded as a high-performance 'floating' constant-current generator that can be used with supplies in the 1V to 30V range and can have its operating current set to any value between 1mA and 10mA via a single external resistor (RSET); Figure 1 shows basic details of the LM334Z.

Note that the LM334Z symbol of Figure 1 perhaps gives a deceptive impression of the device's operation; a more accurate representation of the

**Figure 1. Basic details of the LM334Z adjustable current source IC.**




| | |
|---|---|
| Operating voltage range | =1V to 30V |
| Operating current range | =1µA to 10mA |
| Current regulation accuracy | =0.02%/V (typ.) |
| Current sensitivity | =0.068V/$R_{SET}$ |
| Temperature coefficient | =0.33%/°C |
| $R_{SET}$ value (at 25°C) | =68,000/I(µA) |

Basic specification

**Figure 2. Practical representation of the LM334Z, showing its current distribution.**

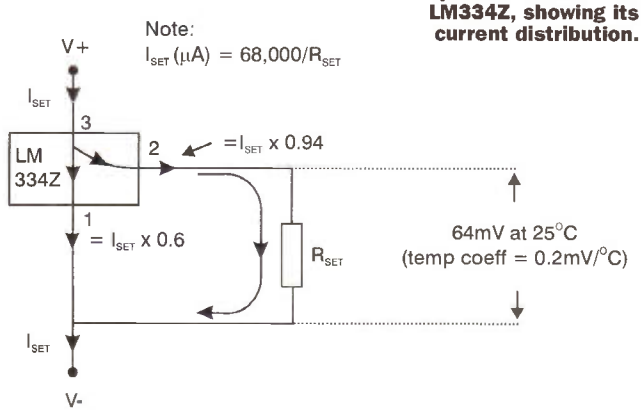
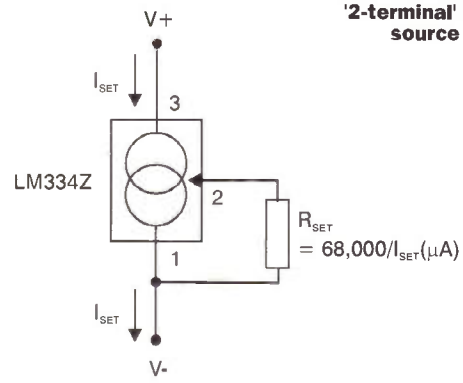



**Figure 3. Basic LM334Z floating or '2-terminal' current source circuit.**



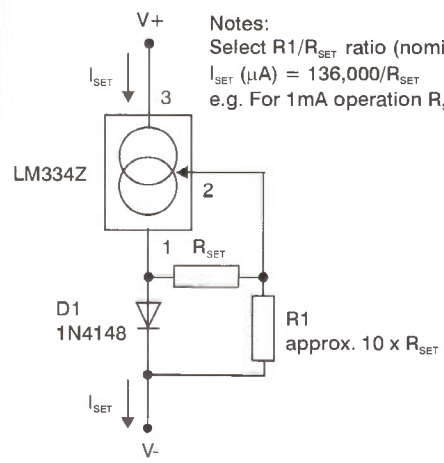




**Figure 4. Zero temperature coefficient current source circuit.**

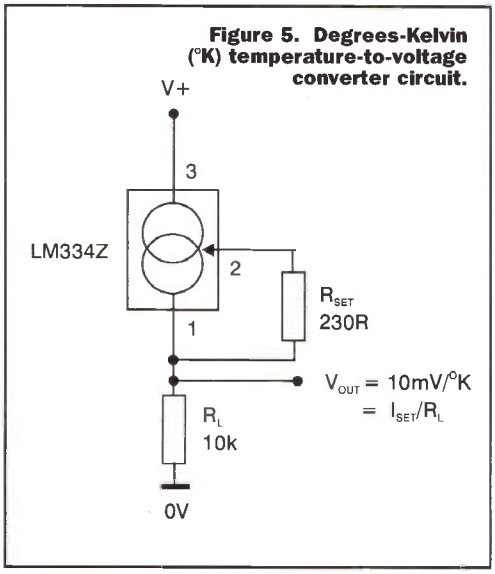



**Figure 5. Degrees-Kelvin (°K) temperature-to-voltage converter circuit.**

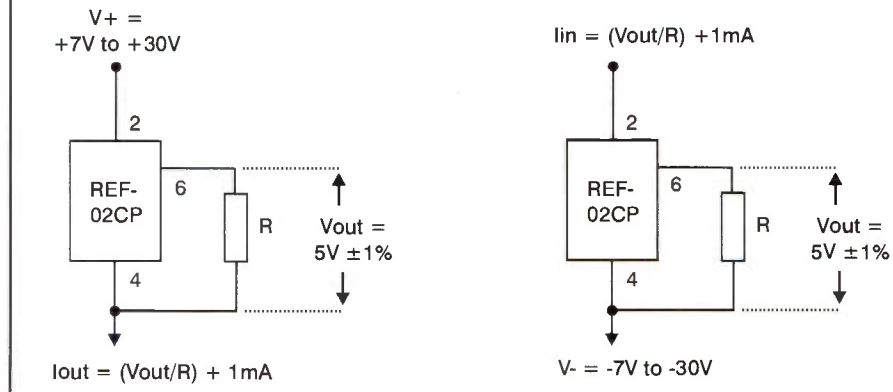



**Figure 6. Ways of using the REF-02CP IC as (a) a constant current source or (b) a constant current sink.**

device action is shown in Figure 2, where the following points should be noted: The ISET current flowing into the LM334Z via pin-3 splits within the device, with only 6% of it flowing to the negative rail (as a 'bias' current) via pin-1, and with the other 94% flowing to the negative rail via pin-2 and RSET: at 25°C a voltage of 64mV is developed across RSET (between pins 2 and 1), and this voltage has a temperature coefficient of +0.2mV/°C. Thus, ISET is temperature-sensitive, and at 25°C has a value (in mA) of 68.000/RSET.

Figure 3 shows the basic way of using the LM334Z as a floating '2-terminal' current source (or current sink). The RSET value determines the IC's operating (ISET) current, using the formula shown in the diagram: spot RSET values are 6k8 at 10mA, 680R at 100mA, 68R at 1mA, and 13R6 at 5mA. Note that, since identical currents flow into the circuit from the positive rail (the 'sink' current) and out of it towards the negative rail (the 'source' current), the circuit can be used as either a constant-current sink or a constant-current source.

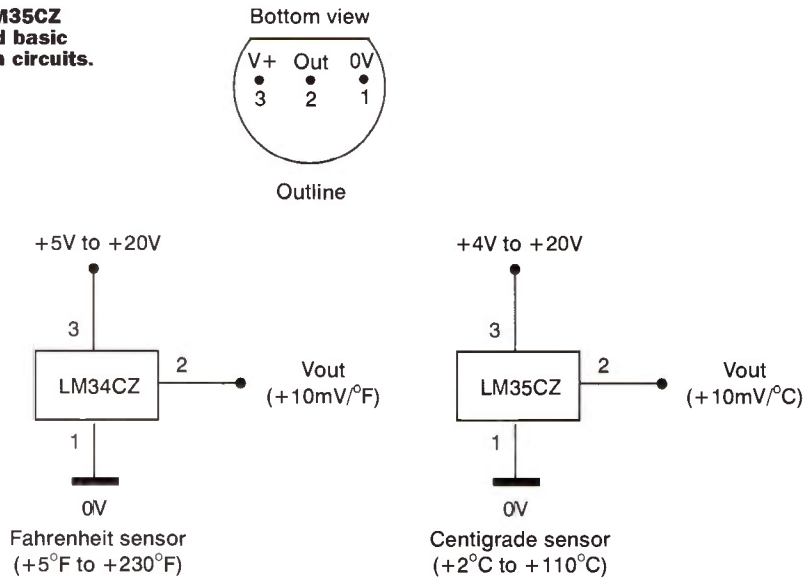
Figure 4 shows how the above circuit can be modified, with the aid of D1 and R1, to eliminate the temperature sensitivity of the current source (D1 must share the thermal environment of the LM334Z). Finally, Figure 5 shows how the LM334Z can be used as a temperature-to-voltage converter that gives an output of +10mV/°K.

Before leaving the subject of 'current source' ICs, note that the REF-02CP voltage reference IC that was described in last

| Parameter | LM34CZ | LM35CZ | LM335Z |
|---|---|---|---|
| Temp range | -400°F to +230°F | -40°C to +110°C | -40°C to +100°C |
| Spot accuracy (typ.) | ±0.80F at +77 OF | ±0.4°C at 25 °C | ±2°C at 25°C |
| Range accuracy (typ.) | ±1/6°F | ±0.8°C | ±4°C |
| Output scale | 10mV/°F | 10mV/°C | 10mV/°K |
| Supply voltage range | 5-30V | 4-30V | N/A |
| Quiescent current | 70µA | 60µA | 0.4-5mA |

**Figure 7. Temperature sensor IC selection chart (National Semiconductor 'commercial grade' devices).**

**Figure 8. LM34CZ/LM35CZ outline and basic application circuits.**



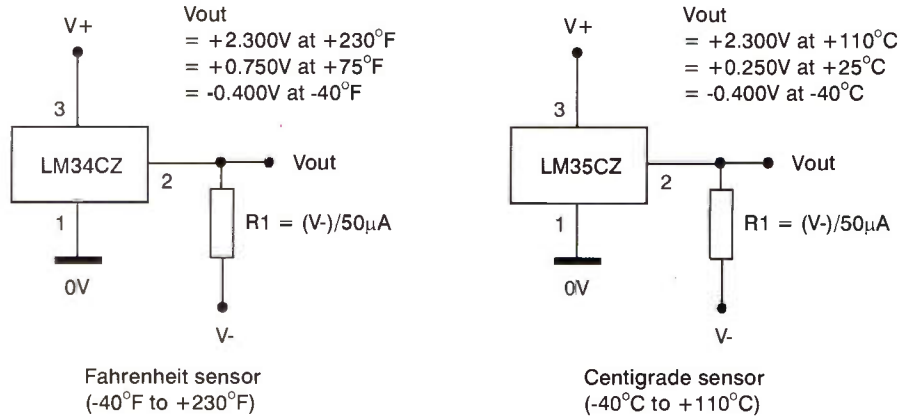




**Figure 9. LM34CZ/LM35CZ full-range temperature sensor circuits.**

month's opening episode of this mini-series (and also the REF-01 and REF-03 types, also described last month) can be used as a precision current source or current sink by using it in the basic ways shown in Figure 6.

## Temperature Sensor IC Basics

Temperature Sensor ICs are simple devices that convert temperature directly into voltage. National Semiconductor are a leading producer of ICs of this type, and Figure 7 shows basic details of the three most popular low-cost 'commercial grade' devices in their range. Here, the LM34CZ and LM35CZ are precision 'micropower' devices that give outputs proportional to °F and °C respectively, and the LM335Z is a simple trimmable device that gives an output proportional to °K. The rest of this month's article gives practical application details of these three ICs.

## LM34CZ/LM35CZ Circuits

The LM34CZ and LM35CZ are housed in 3-pin TO-92 packages, and are designed to consume quiescent currents of only a few dozen microamps, to minimise internal heating effects; both ICs can, however, produce output drive current of up to 10mA. Figure 8 shows the outline and basic application circuits of these ICs; note that these simple single-supply circuits give minimum temperature readings of +5°F or +2°C.

The LM34CZ and LM35CZ ICs can be made to give full-range outputs (i.e., to give temperatures readings down to -40°F or -40°C) by using the two-supply connection shown in Figure 9, or the simulated two-supply connection of Figure 10 (in which a bias voltage of about 1.2V is generated across the two series-wired IN4148 silicon diodes and is applied to pin-1 of the IC).

Note that (like most micropower ICs) the LM34CZ and LM35CZ tend to become unstable if their outputs are directly loaded by capacitive loads greater than a few picofarads (pFs). This problem can easily be overcome by feeding such loads in either of the ways shown in Figure 11, using either a series resistor (2k2 or greater) in the output line, or a simple Zobel-type load across the output.

Finally, note that these ICs can be used as an analogue thermometer by connecting their outputs to a reasonable sensitive moving-coil meter via a suitable 'ranging' resistor, as shown in the basic circuit of Figure 12, in which the IC is shown driving a 100mA moving coil meter.

## LM334Z Circuits

The LM334Z acts like a temperature-sensitive trimmable zener diode that gives an output of +10mV/°K (e.g., 2.732V at 0°C, or 2.982V at +25°C). Figure 13 shows the IC's outline and simple ways of using the device in either the basic or the 'trimmable' (precision) mode; note in these circuits that the R1 value is chosen to set the IC's current at about 1mA. Figure 14 shows how the basic circuit can be modified for 1mA operation (via the LM334Z constant-current generator) when using a wide-range supply.

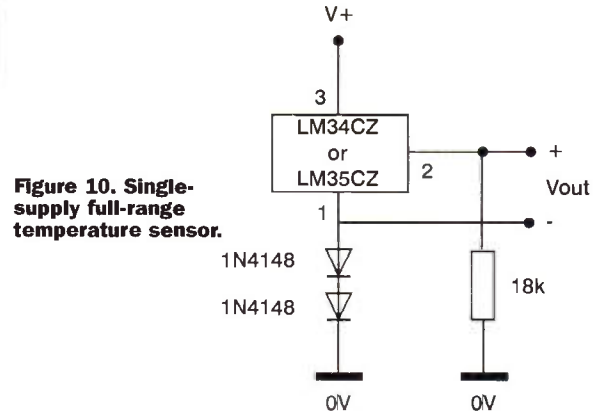



**Figure 10. Single-supply full-range temperature sensor.**

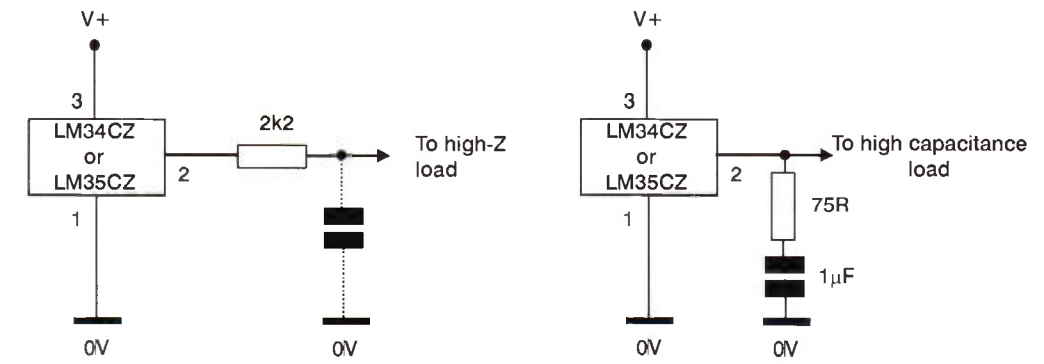



**Figure 11. Methods of driving high-capacitance loads.**

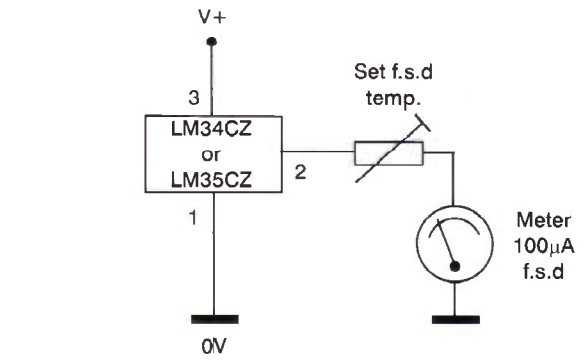



**Figure 12. Analogue °F or °C meter.**

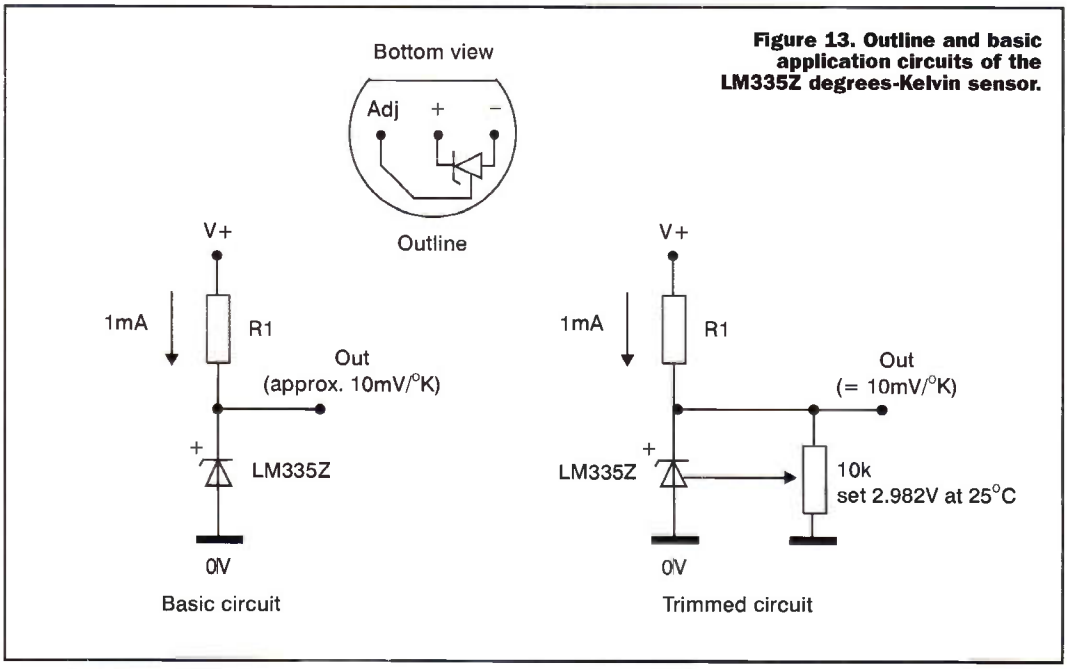



**Figure 13. Outline and basic application circuits of the LM335Z degrees-Kelvin sensor.**

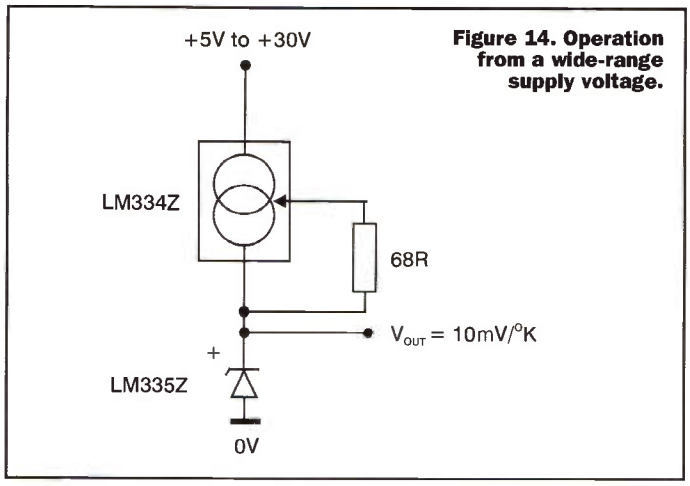



**Figure 14. Operation from a wide-range supply voltage.**

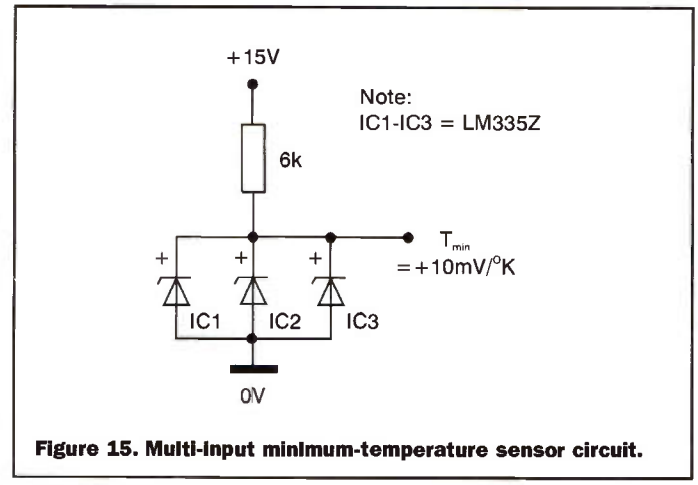



**Figure 15. Multi-input minimum-temperature sensor circuit.**

Figure 15 shows three LM334Zs used in a circuit that gives an output proportional to the lowest of three sensed temperatures, and Figure 16 shows a circuit that gives an output proportional to the average of three independent readings. Finally, Figure 17 shows how two sensor ICs can be used to make a differential temperature analogue meter; the meter should be a centre-reading (50mA-0-50mA) 100mA type; the CAL control is initially set to give zero reading when both ICs are at the same temperature, and R1 is chosen to set the desired full-scale differential reading.

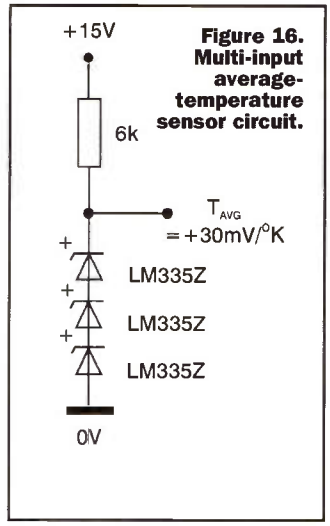



**Figure 16. Multi-input average-temperature sensor circuit.**

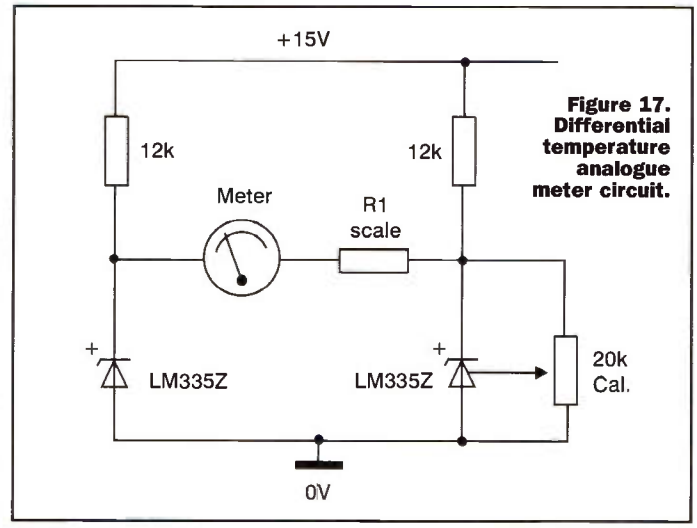



**Figure 17. Differential temperature analogue meter circuit.**

# Easy Web Page CREATION

## PART 2

***In part 2 Mike Holmes discusses enhanced layout design, 'Anchors' and index pages.***

HTML hypertext links, also called 'anchors' for reasons that will become clear in a minute, were only hinted at in Part 1. This is because it is a fairly involved subject, hypertext links and URLs being integral to a Web browser's most basic functionality. As a result, the total number of different applications for hyperlinks have become manifold and confusing, so we will try to restrict ourselves to the most common (read 'most useful'!).

## URLs

The Uniform Resource Locator (URL) is one of the most important features of HTML - it allows HTML documents to function as hypertext documents. A URL is a text string describing the address of a file (and, optionally, a specific location within that file).

It follows a format that a Web server understands, and which a browser can use to access the file via the Web. The URL can be typed into the browser's 'Address' or 'Location' input area (near the top of its window), or supplied by a clickable hypertext link on a page.

In essence, a URL has three parts:

1. A communication scheme or 'protocol'
   Of which the commonest are:
   * http - HyperText Transfer Protocol
   * file - a local file
   * mailto - invokes an E-mailing method
2. A server address or 'domain name'
3. The file's name with optional sub-path if any.

The scheme part is always followed by a colon ':', then two obliques '//' if 'http', else three if 'file'. The server address is made up from a series of words separated by full stops and hyphens where appropriate, and must be ended with a further oblique separator before the file name. These parts and their subdivisions are better illustrated in Figure 1.

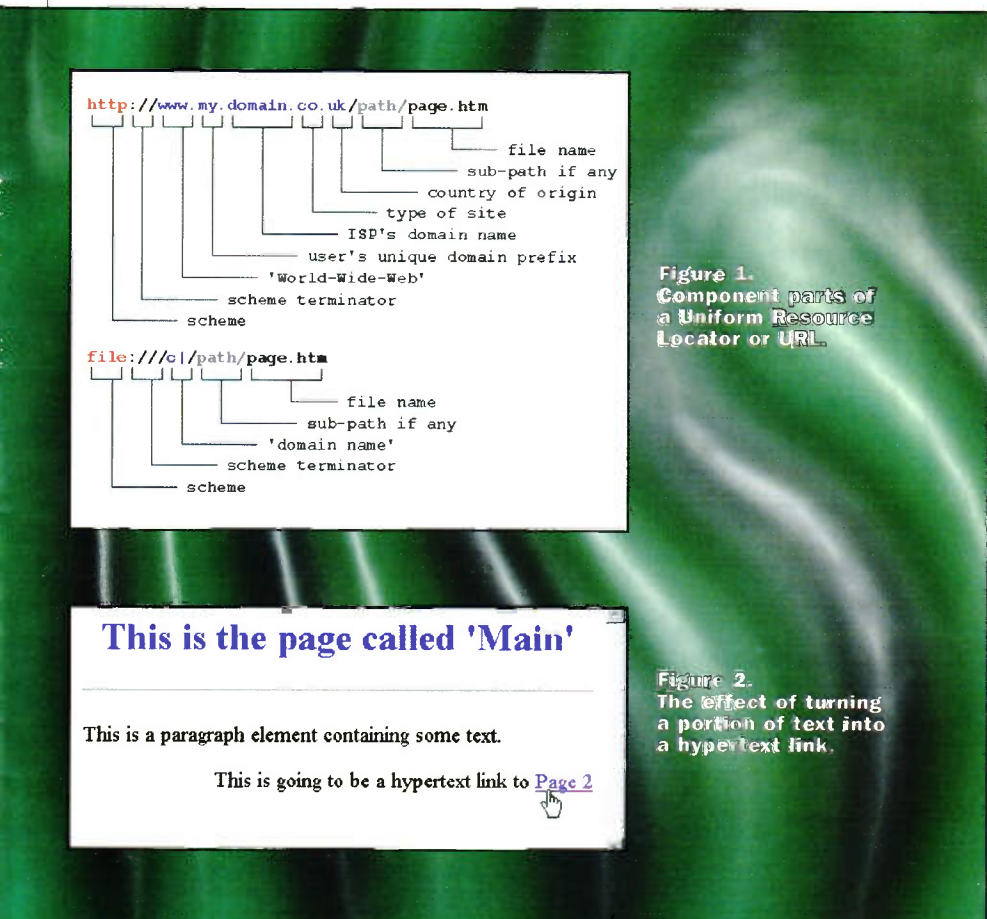



**Figure 1.** Component parts of a Uniform Resource Locator or URL.

**Figure 2.** The effect of turning a portion of text into a hypertext link.

The exception is 'mailto', where merely an E-mail address follows the colon as in: 'mailto:me@my.domain.co.uk'.

There are a couple of details regarding an 'http' domain name that are worth noting at this point. Firstly, many of them may begin with 'www' meaning 'World-Wide-Web', although I've noticed this being increasingly dropped since merely 'http' has come to imply the World-Wide-Web anyway.

Of more usefulness, however, are the suffixes. Commonest are for example 'ed' or 'edu', an abbreviation for 'educational', meaning that the Web server is owned and maintained by an educational facility, typically a university.

Such facilities, by the way, can be readily described as the 'founding fathers' of the Web as we know it today; its 'World-Wide' coverage being initiated in the first place by the CERN particle acceleration laboratory at Geneva, Switzerland, so that universities involved in this sort of research could quickly communicate details of such experiments and their results.

The other common one is 'co' or 'com', meaning 'commercial' and which strictly speaking is confined to business usage. However, albeit you may be a 'private' user, your ISP's domain is still most likely a 'com' type since you are after all a paying customer, it being their business to provide this service.

This may be followed by a further suffix defining the country of origin for the Web server, and, hence, the ISP. Thereby you get a clue as to where in the World the Web site is based, and by implication, the most likely nationality of the webmaster of the site. These are typically two-letter abbreviations such as: 'uk' for United Kingdom; 'us', United States, 'au', Australia; 'nz', New Zealand; 'nl', Netherlands; 'dk', Denmark; 'pl', Poland, and so on.

The URL syntax requires that sub-folder names in the path part of the URL be separated by forward slashes or obliques '/'. This is different from the IBM PC's Windows and DOS convention, which uses back slashes, '\'. There are actually several URL formats, but fortunately most of the ones you'll have to deal with are either 'http' or 'file'.

In the case of the 'file' scheme, the drive name takes the position of the 'domain' in the URL (lower illustration in Figure 1). But instead of using the normal Windows/DOS 'c:' to describe it, you must replace the colon ':' with a vertical bar (keyboard shift + '\'), so it appears as 'c|'. This is because ':' is a scheme terminator in the URL syntax.

## Implementing URLs In Hyperlinks

Enough of this. Let us put this into practice and try making a hyperlink jump to a URL.

Run your word processor and create a new HTML document by loading the template template.htm (see Part 1), and resave it as page2.htm.

In page2.htm, have it display some text ('wrapped' in a <P> </P> element, remember) saying for example 'This is Page 2.'

```
<!DOCTYPE HTML PUBLIC "-//SQ//DTD HTML
2.0 + all extensions//EN">
<HTML>
<HEAD>
<TITLE>Page 2</TITLE></HEAD>
<BODY>
<P><A NAME="top"></A><FONT FACE="Times
New Roman, Helvetica, Univers" SIZE="+1"
COLOR="black">This is Page 2.</FONT></P>
<HR>
<BR><BR><BR><BR><BR><BR><BR><BR><BR>
<BR><BR><BR><BR><BR><BR><BR><BR><BR>
<P><A NAME="anchor"></A><FONT
FACE="Times New Roman, Helvetica,
Univers" SIZE="+1" COLOR="black">Named
anchor for Page 2.</FONT></P>
<P><FONT FACE="Times New Roman,
Helvetica, Univers" SIZE="+1"
COLOR="black"><A HREF="#top">Go To Top
of Page</A></FONT></P>
<HR>
</BODY></HTML>
```

**Figure 3. Modifications required to Page 2 to demonstrate named anchors.**


**Figure 4. The effect of jumping to the lower of two named anchors on Page 2 from another page.**

Save this then load main.htm. Following from Part 1, somewhere near the bottom of main.htm is the <P> block:

<P><FONT FACE="Times New Roman, Helvetica, Univers" SIZE="+1" COLOR="black">This is going to be a hypertext link to Page 2</FONT></P>

Modify the text part by introducing an 'anchor' element as follows:

This is going to be a hypertext link to <A HREF="file:///c|webpages/page2.htm">Page 2</A>

HREF is the most used attribute of the <A> or 'anchor' element and specifies a hyperlink jump using the URL between double quotes (" ... "). When this page is saved then loaded in the browser, the part 'Page 2' has changed colour, is underlined, and causes the mousepointer to change to a pointing hand icon when passed over it, as in Figure 2. When clicked on, the browser displays page2.htm.

## Anchors

Okay, but this is a hyperlink - where does the name 'anchor' come from? Because, the other way in which the <A> element can be used is to identify a specific place in a document. In page2.htm, modify its text as shown in Figure 3 by adding the copy indicated in red. Each <A> element having a NAME attribute is an 'anchor', that is, a target for a hyperlink jump. The multiple <BR> elements should cause the second line to disappear off the bottom of the browser window, a vertical scrollbar appearing at the right hand edge.

Save this, then re-edit main.htm, changing the contents of its hyperlink to read:

<A HREF="file:///c|webpages/page2.htm#anchor">Page 2</A>

'Anchor' here being the named target in the new page2.htm. The value of the NAME attribute is an identifier for the anchor. Identifiers are arbitrary strings, but must be unique within the same HTML document. Another document can then make a reference explicitly to this anchor by putting the identifier after the page address, separated by a hash (#) sign.

Try this in the browser. Click 'Back' to return to the 'main' page and click 'Refresh' (or equivalent) to force it to be reloaded. Now when you click on 'Page 2', you should see the effect shown in Figure 4. On loading page2.htm, the browser scrolls directly to the bottom, because that is where the named target 'anchor' is positioned.

Now click on 'Go To Top of Page'. Hey presto, the browser jumps to the top of the page. Note also that this becomes a new item in the 'history' even though it is actually the same page - if you click the browser's 'Back' button you are back where you were, at the bottom. Note also that in the HREF statement for the 'Go To Top of Page' anchor, the leading URL part is actually completely missing, thus it is implied that the named target 'top' is on the same page.

Obviously these are very simple examples, but I hope from this that you can begin to see how you can not only jump to another page, but precisely locate a particular part of that page. The only thing you have to remember is that, where making a reference to a named target in HREF, to precede it with '#' following the URL (if any).

The commonest use of named targets is the case where you have a single large (that is, has lots of text) page, and include an index or contents list of topics at the top. Each list item is a hyperlink jump to the relevant topic below, the actual point where the topic text starts beginning with a named target anchor.

Moreover, you are not restricted to only one target for each single HREF hyperlink either, you can have several links jumping to

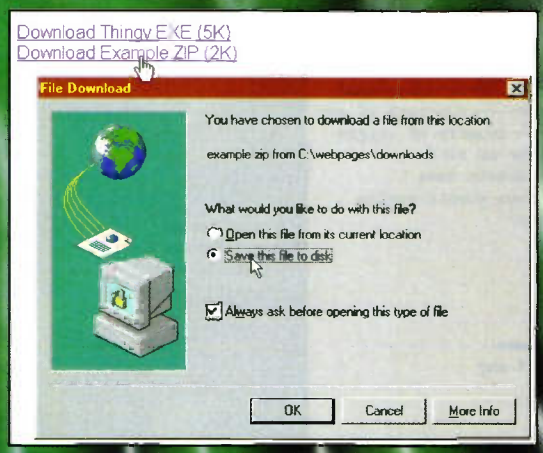



**Figure 5. Microsoft's Internet Explorer's response to clicking on a hyperlink to something that is not a recognised HTML document.**

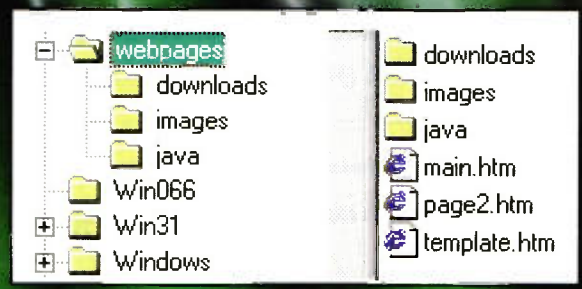



**Figure 6. A Web site 'mirror' as maintained on local hard disk (here shown by Microsoft Windows 95TM Explorer).**

the same place, even from completely different pages (provided a URL is also given), as in 'See also Such-and-Such'. The glossary pages **http://www.mc-h.demon.co.uk/maplin/glossary.htm** and **http://www.mc-h.demon.co.uk/maplin/terms.htm** (associated with this series) use this technique extensively.

## Making Links To Other File Types

What happens if you make a hyperlink to something that is not another HTML document? Suppose page2.htm was further modified to include two extra lines:

<P><A HREF="file:///c|/webpages/downloads/thingy.exe">Download Thingy.EXE (5K)</A><BR>
<A HREF="file:///c|/webpages/downloads/example.zip">Download Example.ZIP (2K)</A></P>

When displayed in the browser, it appears as Figure 5. Clicking on 'Download Example.ZIP (2K)' has the effect of generating a dialogue window (courtesy of Microsoft Internet ExplorerTM, in this instance) asking what you want to do with the file. (In the case of 'Thingy.EXE' the first option becomes 'Run this program from its current location'.)

It is, of course, how you provide free downloads and similar 'gifts' to readers of your Web pages. If you've written a program, for example, 'thingy.exe' could represent a working demo of it, or a 'freebie'. Note that it is also a good idea to indicate the size of such files (as in '(2K)'), as this gives the user some indication of its size and probable download time.

More often than not, though, it is more practical to pack a group of associated files into a compressed ZIP, which of course can contain anything. Apart from which, as we shall see in Part 3 about images, resorting to file compression wherever possible is the cornerstone for speeding Internet traffic and conserving storage space on servers. Obviously this is not possible for HTML documents, but it can be done for almost everything else.

## Don't Do As I Have

As they stand at the moment, these pages have URLs of the 'file' scheme, because the browser is loading them from a local disk. Unfortunately, for the actual Web, where you create a link to another HTML document or file, you'll have to specify a file on a Web server.

In that case, the URLs must be rearranged to the 'http' order shown in Figure 1. This means that before you can upload pages that were created and tried out on local disk using the 'file' scheme, you will have to translate all the URLs to the 'http' scheme before uploading!

Thus for the foregoing examples, the hyperlink in main.htm for Page 2, currently '<A HREF="file:///c|webpages/page2.htm#anchor">Page 2</A>' to work from local disk, needs to be changed to '<A HREF="http://www.my.domain.co.uk/page2.htm#anchor">Page 2</A>' before uploading. Apart from being a real drag to do if you have lots of hyperlinks, it results in hyperlinks on pages that formerly worked okay when browsed from local disk, ceasing to work thereafter.

This makes testing edits and updates to existing uploaded pages very difficult. So now I am going to tell you not to write URLs in full at all, but instead use relative URLs.

## Relative URLs

URLs can be divided into two groups: complete URLs and relative URLs. Figure 1, and all examples thus far, show complete URLs. A relative URL, on the other hand, will be missing some of this information, and the browser obtains the missing information from the base URL of the document that contains the relative URL.

Thus, the hyperlink on 'main' becomes simply: '<A HREF="page2.htm#anchor">Page 2</A>'. The browser already knows that the base URL for main.htm is: 'file:///c|webpages/', so you don't need to reiterate!

This works equally whether pages are browsed from local disk or from the Web. Therefore, you will be certain that hyperlinks that work properly on your local hard disk will also work properly on the Internet.

The only variation is where you reference something in a sub-folder. Thus the ZIP download example becomes '<A HREF="downloads/example.zip">Download Example.ZIP (2K)</A>', where 'downloads' is a sub-folder below the current base URL level.

It follows that the only reason for having to specify a complete URL is where you make a reference to a page on someone else's Web site. In this case the URL will always be the 'http' scheme, and which won't affect the behaviour of pages stored on local disk.

## Creating Your Web Site

To actually get access to your 'free web space', you will need to approach your ISP as to the procedure. While you may have an account with them for E-mail and Usenet, and while free Web space may be part of the deal, the actual space itself is unlikely to physically exist on any server. This is not unreasonable; the ISP is not going to maintain empty server disk storage of X megabytes each for every customer just in case they might want to suddenly begin making use of their web space!

The procedures are varied, but usually requires at least an initial 'index' page to be uploaded to the server. This is done using FTP (File Transfer Protocol). Your ISP should have or be able to provide you with the necessary FTP software for the purpose. While it appears that you are sending your initial page to your domain (it has your unique prefix), it actually goes into a part of the server that 'alerts' the system that you want to begin using your Web space, so this must now be physically created.

For example, the procedure required by Demon Internet Ltd. is that you upload an index page to your domain. It must only be a single page. You then have to wait 24 hours by which time the machinery should have allocated real storage space on the 'homepages' server. After this period you can re-attempt to list its contents with FTP and voila, it exists!

## The 'Index' Page

The path/filename can often be omitted in the URL of a site's 'home page', that is, the page that forms the top level or first point of entry to all the other pages on the site, which may under a range of various topics. The server will generally return a file – usually 'index.html' – by default.

For example, **'http://www.my.domain.co.uk/'** is the URL for your 'home page'. In the absence of a file name, the browser assumes 'index.htm' (or 'html'). If no such page actually exists, the server returns a pseudo-generated 'page' that does not look very unlike the effect of typing 'DIR' in MS-DOS, that is, a list of sub-directories and files with date stamps and file sizes.

For example, next time you're online with the browser try typing **'http://www.mc-h. demon.co.uk/maplin/'** in the 'Address' or 'Location' text input area. This location does not have an index.htm file, so the server returns a listing instead. The actual 'index page' in this location is mapindex.htm.

But you don't want visitors to your Web site to be presented with a mere listing. Hence you create an entry-level page, or 'home page', named index.htm. This is returned by the server in lieu of a listing in the absence of a specifically named page in the URL.

Some templates for making 'index' or 'home' pages can be accessed from **http://www.mc-h.demon.co.uk/maplin/mapindex.htm**, under the sub-title 'HomePage Templates'.

## Mirroring Your Web Site

This is my recommended working method: create and maintain an exact mirror copy of your Web site layout on local hard disk. Such a 'mirror' is exampled in Figure 6. Here you will be able to create and try out your new pages and other files, stored in a directory structure that should exactly duplicate that of the Web site. If you confine your URLs to the relative form, hyperlinks should function exactly the same at both locations. This saves a lot of time, otherwise you will be online often to your own site trying to find out where you made a mistake!

From this you can not only upload additions and updates with FTP, but also back up the mirror copy as a complete set.

## Next Time

In Part 3 we shall begin by discussing the inclusion of pictures in HTML pages - a minefield for the unwary!

# TECHNOLOGY WATCH

with Martin Pipe

## 20th Anniversary WALKMAN

July 1st of this year marked the 20th anniversary of a product we all know and love - the Sony Walkman. Since its Tokyo launch in 1979, over 150 million of the wee beasties have been sold. Sony reckon that if all the product sold was to be stood end-to-end, the line thus created would be a not-unimpressive 22,000 kilometres long! The Walkman is a prime example of how markets can be created, and an example of what can be achieved if you have an unshakable faith in your ideas. The Walkman concept was originally born when Sony co-founder Masaru Ibuka arrived at the office of fellow co-founder Akio Morita for a meeting some time in 1978. He carried with him one of Sonys portable stereo cassette decks - at that time popular for in-the-field recording - and a regular pair of hi-fi headphones. Ibuka told his colleague that he was far from happy with the equipments bulk and weight. He was prepared to put up with it, though, because he liked to enjoy his music on the move without forcing others to listen to his personal tastes. Others around the world obtained their fix of portable music from bulky cassette/radio units, using headphones if personal listening was required. You could have stereo in the car, stereo at home - but why did stereo on-the-go have to be so impractical?

At the time, Sony had among its product range a small mono cassette recorder - complete with built-in microphone - that was aimed primarily at reporters and journalists. This TCM-100 Pressman, which was powered by four AA cells, was small enough to be pocketable, although its niche customer base meant it was quite expensive. Morito had a brainwave - why not modify the Pressman, and turn it into a personal stereo cassette player? His idea was to strip out the recording circuitry, and replace it with a stereo tape-head preamp, and a two-channel power amp capable of driving miniature headphones. The tape head would be a stereo one, rather than the Pressmans mono item. And the player would not need the little permanent erasure magnet that the Pressman brought into contact with the tape during recording. Although the mechanism, stereo playback head, electronics and casing would be components already manufactured by Sony, the lightweight headphones would have to be designed specially. They would have to be extremely efficient, so that decent sound levels could be obtained from small battery-powered amplifiers.

Initial response from Sony engineers was less than enthusiastic. They did not think that the product would sell without recording capability. In his defence, Morito cited the case of the in-car cassette deck, which did not have a record facility. People would make tapes for the car on their home stereo. Why should the situation be any different for a personal cassette player? Moritos faith in his idea remained unchanged, and he commissioned a prototype. When it arrived, he was amazed with the sound quality. He took the device home and was happily listening to it when he noticed his wife in the room. She obviously felt shut out, and so the next day he instructed his engineers to add another headphone socket, together with a button-activated microphone that would allow the listeners to talk to each other. He passed the modified prototype to his marketing department, but they did not share his


**First Walkman TPS12 in 1979.**

**UM6dc Professional Walkman 1984.**


**d50 First Diskman 1984.**

enthusiasm. In February of 1979, Morito decided to take personal responsibility for the project, which was nicknamed Walkman by some of the younger Sony employees.

A mere six months later, the first Walkman - the TPS-L2 - went on sale. In the US, it was sold as Soundabout, and over here you could buy it as the Stowaway. In Tokyo, Sony generated interest in the Walkman by hiring young couples to walk around Tokyos Ginza pedestrians paradise on Sundays, proudly showing off their tape players and headphones. In another promotional drive, the first hundred Walkmen were handed to members of the Berlin Philharmonic amongst others. The rest, as they say, is history - Moritos gamble paid off big-time. Within three months, 30,000 units had been sold. Indeed, Sony had to build new production facilities to satisfy demand for the TPS-L2. Eventually, the Walkman moniker proved to be so popular that the other two names were dropped. The Walkman became an Eighties fashion icon, and was seen to represent identity and individuality, particularly among younger people. You could now take along your own sound when going out into the world! The original TPS-L2, which weighed 390 grams and was powered by two AA cells, had the two headphone sockets (labelled, somewhat cheesily, guys and dolls) and the talkback mike. Interestingly these features, which were copied by many third-party imitators, were subsequently dropped on later models. After all, everyone wanted their own Walkman - something that Sony was clear to encourage!

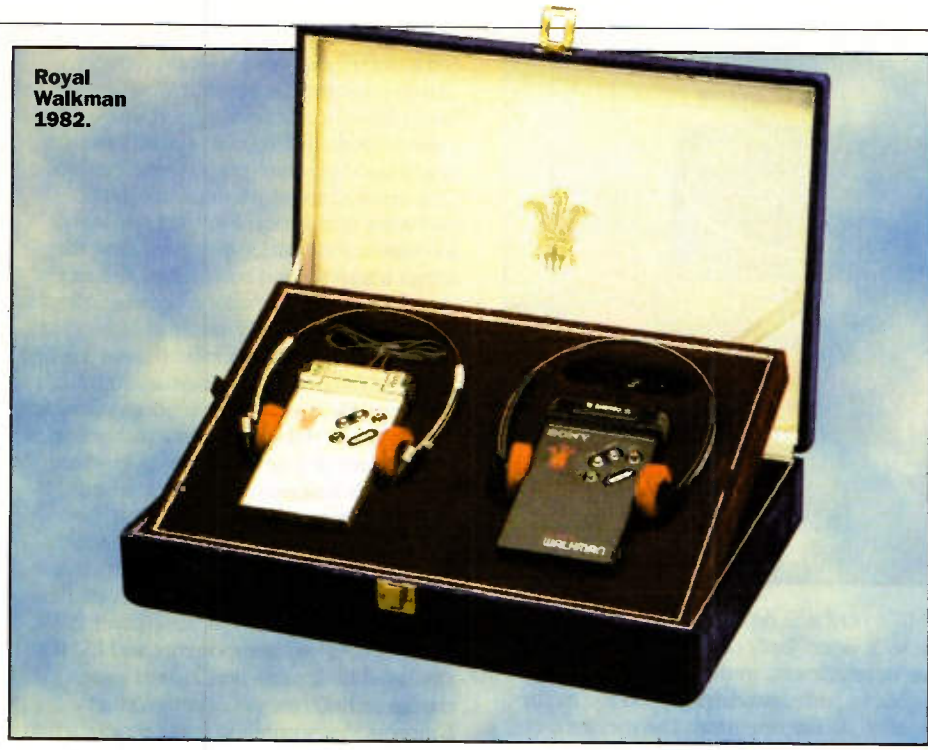
Since then, the trend has been to make them smaller and lighter, to improve sound quality and to lengthen battery life. The next Walkman - the WM-2 - was launched in 1981. It was a good deal smaller and lighter (250g) than its predecessor. The WM-2, like its predecessor, had a switchable HF-cut filter so that metal and chrome tapes did not sound excessively bright. The next step in the drive for better sound quality took place in 1982. That year saw the introduction of a Walkman with Dolby noise reduction. The trend-setting (and expensive) WM-7 also had a logic-controlled transport, and was the first Walkman with auto-reverse. This feature, made popular by car cassette players, meant you did not have to fumble around swapping the cassette over. The WM-7's playback head could read all four tracks at once. Only one pair of heads - that were relevant to the direction of playback - were switched in, and fed to the pre-amp, at any one time. The mechanism was a dual capstan/pinch roller type. Both flywheel-mounted capstans were driven by a single motor, but revolved in different directions courtesy of the way the drive belt was laced. The pinch roller related to the required direction of travel was brought into contact with the relevant capstan. Interestingly, the WM-7 allowed to select the tape direction by means of a remote control unit built into the headphone lead.

Also in Sonys 1982 product range was the WM-F2 - the first Walkman with in-built radio. These days, the vast majority of personal cassette players have such a facility - using the headphone cable as an aerial lead. The WM-F2 also went against Moritas original vision by including a recording facility! You could plug in a mike and record from that, or tape off the radio. The sound quality of recordings was not up to the standard of a hi-fi cassette deck - recording level control was automatic, and there was no Dolby. This all changed in 1984 with the introduction of the WM-D6C. Although it was slightly bigger than a regular Walkman, the D6C Professional was a record/playback machine equipped with Dolby B/C, manual recording level (complete with peak-reading LED meter) and a quartz-locked direct-driven capstan that brought wow-and-flutter levels down to those of a good home cassette deck. Indeed, the specification was just as good in other respects too. The WM-D6C enjoyed a long production run and become a firm favourite among musicians, journalists and bootleggers. Even now, they attract a high second-hand value. The recent popularisation of portable recordable Minidisc has, however, probably sealed its fate.

1984 also saw the introduction of the first portable CD player, or Discman. Although its battery life was poor by modern standards, the D-50 was rightly seen as a technological masterpiece at a time when regular-sized CD players had only started becoming popular amongst audiophiles. Plus, here was a unit that had a footprint not much larger than a regular CD! Indeed, todays personal CD players are not much smaller than the 15 year-old D50. Multi-layer PCBs, surface-mounted components and LSI ICs all played their part - and indeed were crucial technologies in other product concepts that were new at the time, such as camcorders and cellular phones. To get around the problem of the short battery life, you could buy a rechargeable cradle as an accessory. This contained high-capacity NiCd batteries, which could be charged by a mains unit. Unfortunately, the cradle added to the D-50's bulk! Sony recognised that domestic CD penetration was rather low back in 1984, and encouraged its home hi-fi potential. To this end, the D-50 had a line output that could feed an existing hi-fi system - running it off the mains helped save on expensive batteries. These days, CD equipment is now so inexpensive that many people have a personal CD player, a hi-fi system with CD, and an in-car CD player too!

In 1986, Walkman appeared in the Oxford English Dictionary for the first time - by now, it had become a household name. Fast forward to the early 1990s, and Sony was trying to promote its MiniDisc digital audio recording format. At that time, it was competing heavily with the Philips DCC (Digital Compact Cassette) system, which many experts believed to sound better. Unfortunately, DCC failed due to poor marketing - leaving the market open to MiniDisc as a successor to the analogue


**First md walkman M31 1992.**




**Royal Walkman 1982.**

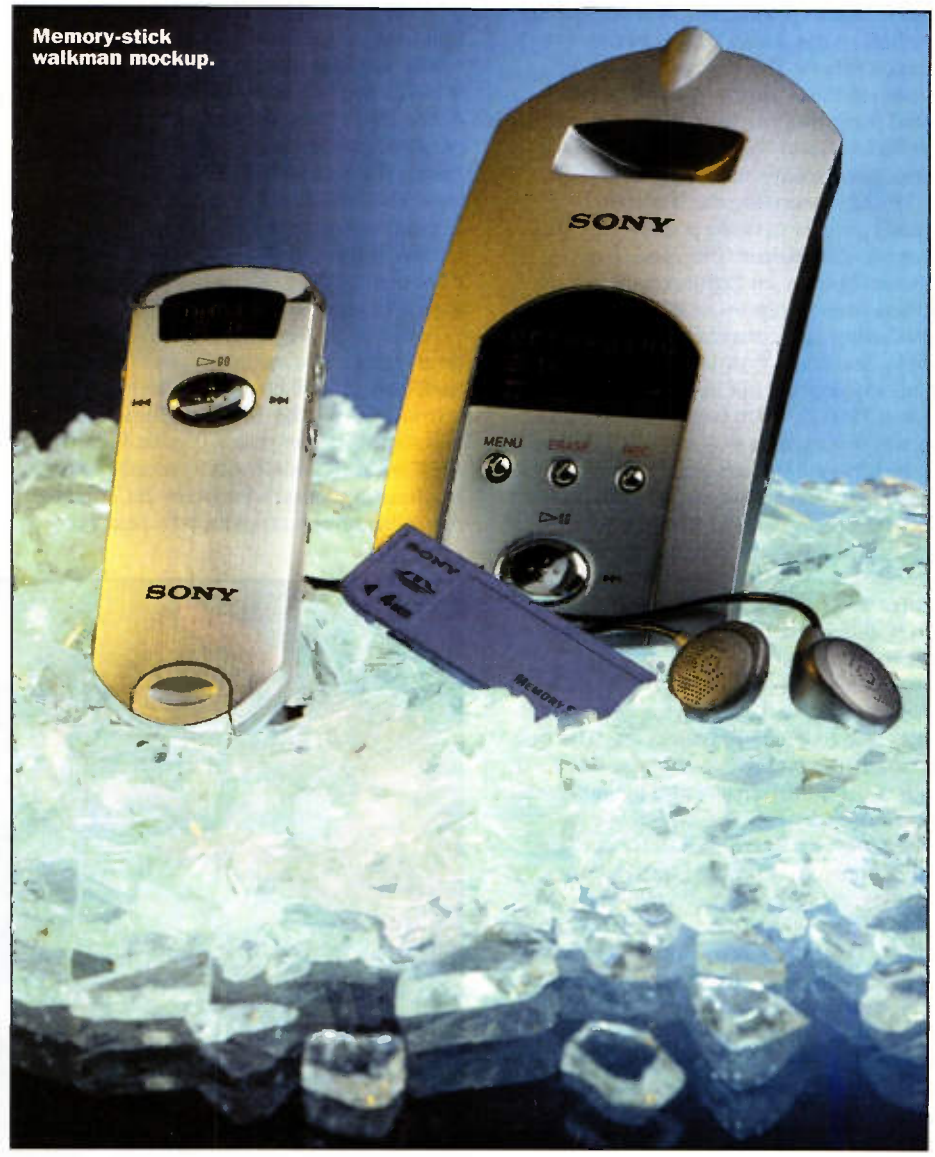
cassette. Since then, Sony has improved the sound quality of MiniDisc, and it is beginning to take off in a big way. You can even buy pre-recorded MiniDiscs, which are ludricrously overpriced (you are better off buying the CD and a blank MiniDisc to record it onto). The small size of MiniDisc media lends the format very well to personal audio applications, and the first deck available - back in 1992 - was the ground-breaking MZ-1 MD Walkman recorder/player. This was the bootleggers dream - near CD-quality recording in your pocket! Playback-only decks not much bigger than the discs themselves are now available - these are, like the digital version of Moritos original cassette Walkman, intended to play media that has been recorded elsewhere.

Over the last 20 years, we have seen all manner of variations on the Walkman theme - including a solar powered version, and even a waterproof model with built in stopwatch! The Prince and Princess of Wales were presented with exclusive gold-crested 'his' and 'her' Walkmen when they visited the Bridgend Sony plant back in 1982. An innovative accessory was a pistol-like battery charger that derived its energy from its user! Grip and release the handle a few times, and your battery would (eventually) be charged. In all, there have been over 300 different Walkmen, making this one of the greatest consumer success stories. So what are Sony doing now? They recognise, through products like the Diamond Rio MP3 player, that solid-state is the way to go - unlike conventional disc and tape players, there is no skipping or wow on the move! Modern personal CD and MiniDisc players include a sizeable amount of buffer memory, but a jog around the block will put this to the limits! Solid-state storage of audio information means no moving parts - in addition to the audio benefits, you get a healthier battery life. The Rio, for example, claims ten hours of playback from a single AA battery! No cassette player can beat that!

The Rio has 32Mb of non-volatile flash memory. This is only enough for around 40 minutes of not-quite CD quality sound, but its possible to increase the memory by plugging in external SmartMedia cards. SmartMedia, and its competitor SanDisk (Compact Flash), are perhaps more commonly encountered by anybody who has a digital stills camera. Into this busy arena - perhaps a little too late - comes Sony, with its Memory Stick. Like SmartMedia and CompactFlash, Memory Stick is being initially aimed at the digital camera market, and indeed the latest Sony models employ the new technology. You can currently get 4Mb and 8Mb versions, but 16Mb and 32Mb versions are imminent and a 256Mb variant is currently under development. Perhaps hardly surprisingly, Sony reckons that a Memory Stick Walkman is not out of the question. Indeed, it has already presented a mock-up to the press. By the sound of it, the Memory Stick Walkman will not use the MP3 audio compression system - which is fast becoming an industry standard. Sony's press information says that it will instead rely on new copyright protection and sound compression technology being developed internally. Hmmm...

Next months Technology Watch will also have a personal audio flavour. We will (hopefully) bring you an in-depth comparison between personal MP3 players from Diamond and LG.

Martin Pipe welcomes comments and ideas.
E-mail him as: whatnet@cix.compulink.co.uk
Or look out for him online! His ICQ ID is: 15482544




**Memory-stick walkman mockup.**

PROJECT


# Measuring Small TEMPERATURE CHANGES

## PART 1

***Dr. Pei An describes a computer-based temperature measurement system, which is specially designed to measure a minute temperature change in the order of 0.0001°C in an ambient temperature range from 15°C to 35°C!***

The system consists of two units - the data logger unit and the sensor unit. The former is connected to a computer via the Centronic port, and is powered either by an on-board 9V PP3 battery or an external 5.5 to 9V DC supply. The resolution of the A/D conversion is 10$\mu$V and the input voltage range is –2V to +2V. The conversion rate is 2.5 conversions per second. A software written in Turbo Pascal 6 was developed for the logger which displays temperature on the screen. Figure 1 shows the complete system connected to a laptop computer.

The sensor unit houses the temperature sensor, and is connected to the logger unit by a screened cable.

## The Circuit

The block diagram of the logger is given in Figure 2. The temperature logger consists of five blocks: NTC sensor, bridge and amplification, A/D conversion, PC interfacing and power supply.

The NTC sensor is to measure temperature. The NTC has a reference resistance of 100kΩ at 25°C. Its β value is 4143K ±0.3%. The thermistor is placed in a thermal insulation material and is mounted in an ABS box. Connection to the data logger

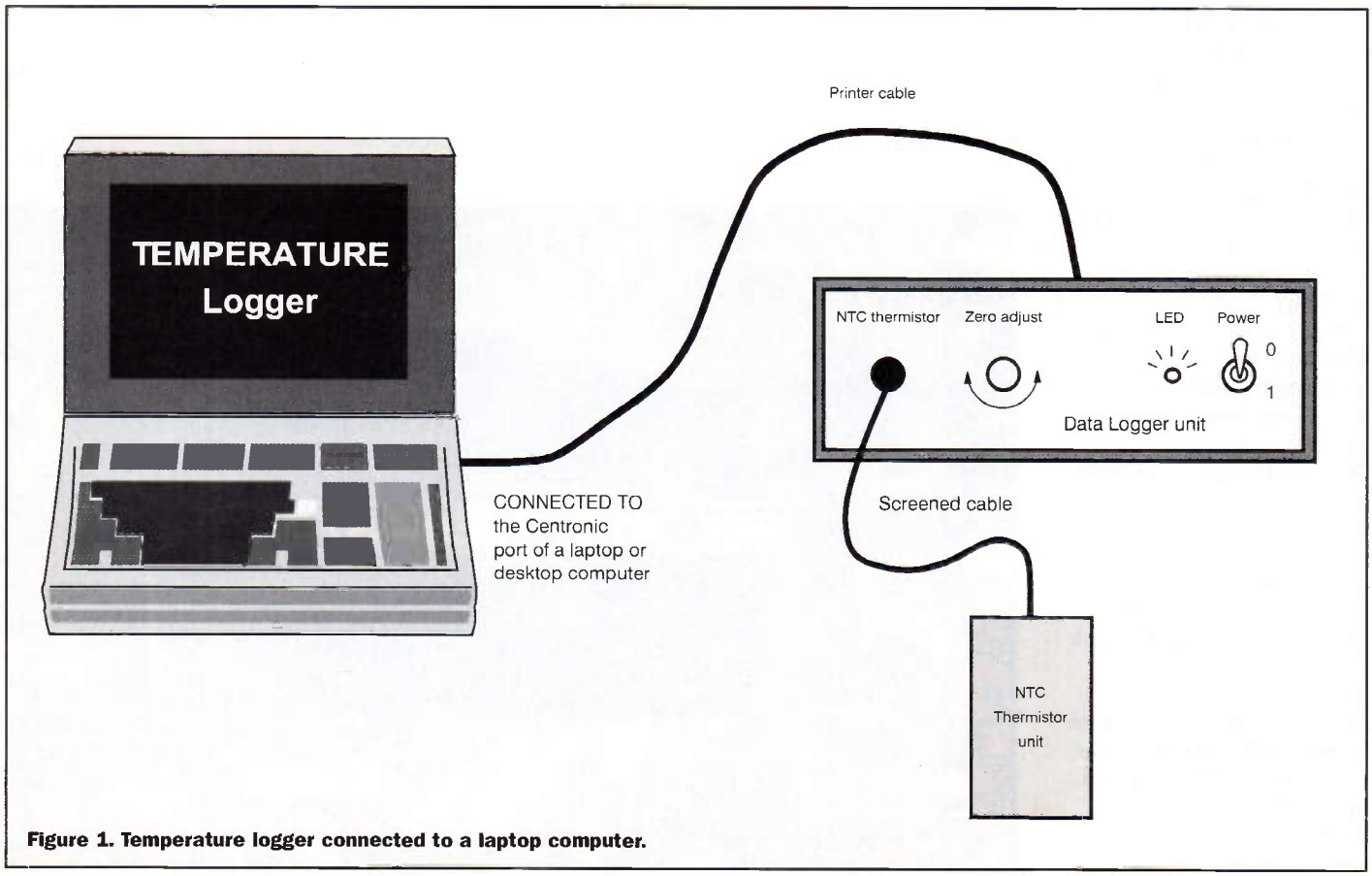



**Figure 1. Temperature logger connected to a laptop computer.**

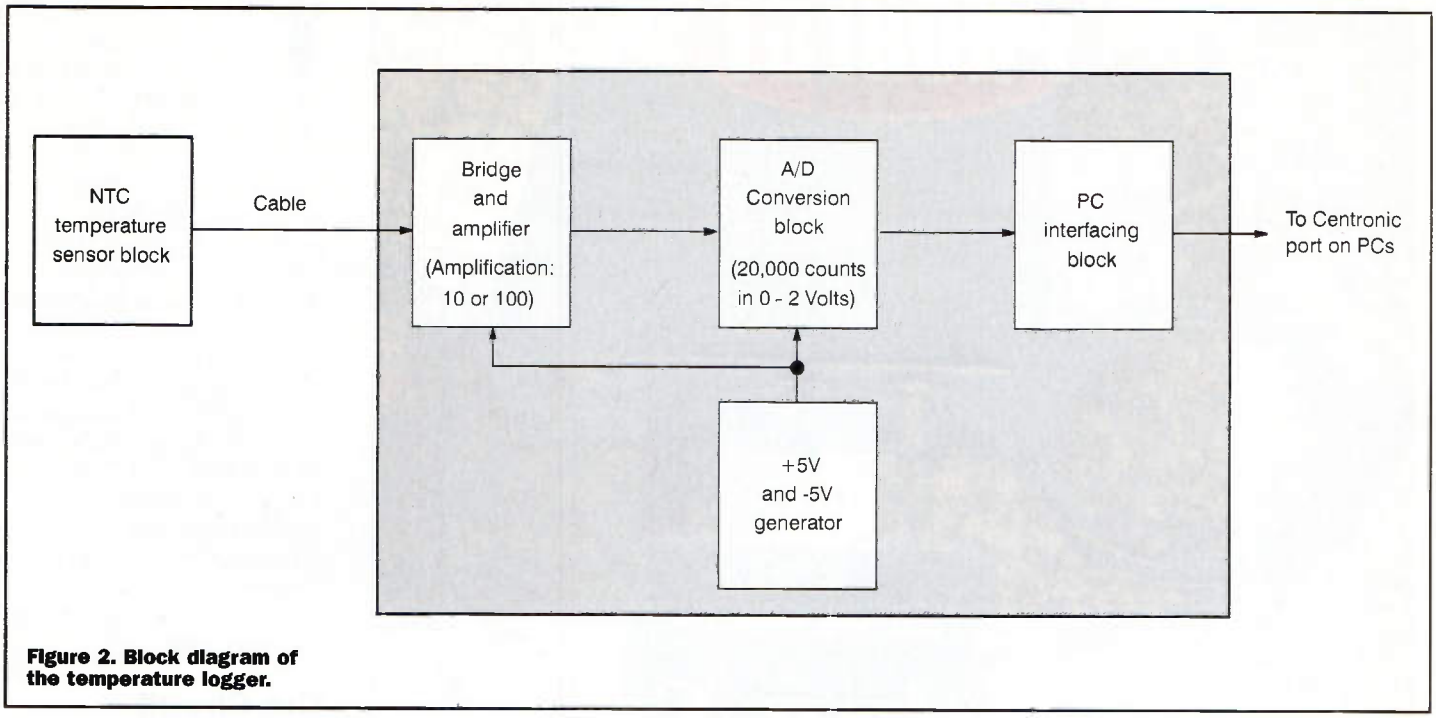



**Figure 2. Block diagram of the temperature logger.**

is via a screened cable. The thermistor can be connected to the data logger via various means to suit specific applications.

The bridge and amplification unit contains a Wheatstone bridge and an instrumentation amplifier (INA118), see Figure 4. The NTC sensor forms one arm of the bridge. The bridge is balanced by adjusting a 10-turn wirewound variable resistor connected to another arm. The drive voltage to the bridge is generated by a 2.50V voltage reference IC, TLE2425. The voltage output from the bridge is amplified by the INA118 amplifier, the amplification of which can be set to 10 or 100 using a 2-way switch. The resistors which form the Wheatstone bridge are all 0.1% precision resistors and of a typical temperature coefficient of 15 PPM.

The output from the amplifier is fed into the A/D converter block which is based on an ICL7135 dual-slope integration A/D converter (see Figure 3). The converter gives 0 to 20000 counts for an input voltage from 0 to 2V. Every count corresponds to a 10$\mu$V increment. The 1.000V reference voltage is produced by an ICL8069 1.2V reference and a variable resistor. The clock input to the A/D converter is generated by a 7555 CMOS timer and is adjusted to 100.0kHz to reject 50Hz and 60Hz mains interference. At this clock rate, the conversion rate is 2.5Hz. Polypropylene capacitors are used in the circuit to achieve high temperature stability.

Combining with the amplifier, a bridge voltage output as small as 1$\mu$V or 0.1$\mu$V can be measured by the A/D converter with the amplification set at 10 or 100.

The digital outputs of the 7135 A/D converter pass to a PC interfacing block, which enables the PC to read the conversion result from the converter through a Centronic port. The circuit is built around a 74LS241 buffer. Data transfer from the A/D converter to the computer is accomplished by using the control and status ports of the Centronic port, see Figure 3.

The A/D converter and the amplifier require +5V and –5V power supplies. The +5V supply is produced by a low-current and low drop-out +5V voltage regulator (TC55RP5002EZB). The –5V supply is generated by a voltage inverter, TC7660 (see Figure 3).

## NTC Temperature Sensors

A negative temperature coefficient (NTC) temperature sensor (thermistor) is a thermally sensitivity resistor that consists of a sintered mixture of sulphides, selenides, or oxides of nickel, manganese, cobalt, copper, iron or uranium.

The property of the mixture is that its resistivity decreases as its temperature increases. The relation between temperature and resistivity is described by the following non-linear equation.

$$R_t = R_{ref} \times \exp(-\beta \times (1/T - 1/T_{ref}))$$

Rt is the resistance in ohms at a given temperature T (in Kelvin). $R_{ref}$ is the resistance at given reference temperature $T_{ref}$ (normally $T_{ref}$ = 298K, 25°C). The constant β depends on the material from which the thermistor is made. It has a unit of Kelvin.

To give an example, the thermistor used in the present project has the following parameters.

| | |
|---|---|
| Resistance at 25°C: | 100.000 Ohm |
| β (0-50°C): | 4143 ±0.30% |
| Tolerance (0-70°C): | ±0.2°C |
| Temperature range: | -55°C to 150°C |

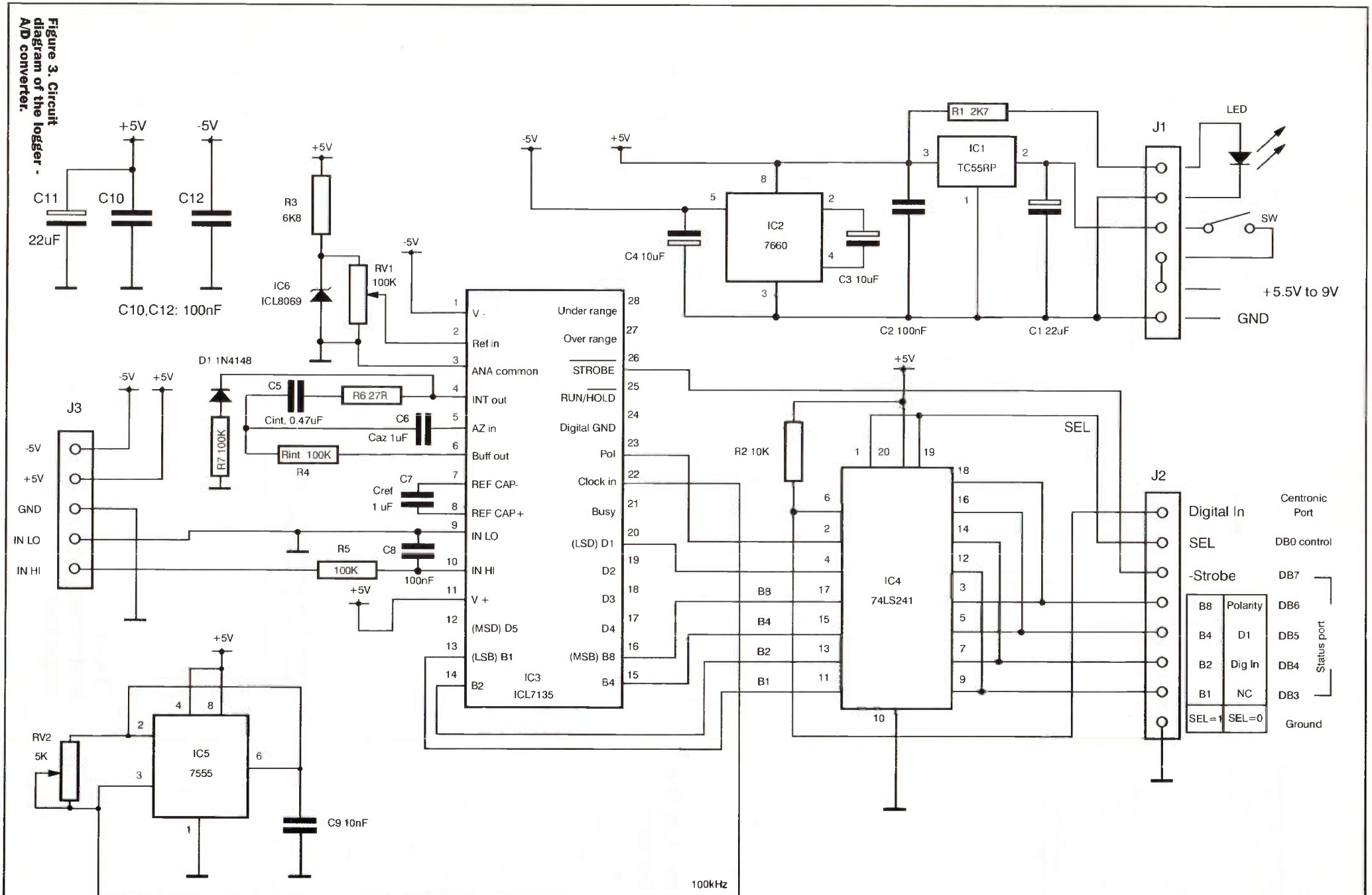



**Figure 3. Circuit diagram of the logger - A/D converter.**

The resistance verses temperature for the thermistor is tabulated in Table 1.

| Temperature [C] | Resistance [Ohm] |
|---|---|
| 20 | 78902.41 |
| 21 | 82785.08 |
| 22 | 86830.55 |
| 23 | 91044.36 |
| 24 | 95432.23 |
| 25 | 100000 |
| 26 | 104753.7 |
| 27 | 109699.3 |
| 28 | 114843.3 |
| 29 | 120192.1 |
| 30 | 125752.1 |

**Table 1. Resistance verses temperature.**

The sintered material can be made in to the shape of a rod, a disc or a bead and may be bare or sealed in a glass or plastic/metal capsule. Thermistors operate over the temperature range –50°C to 300°C, and can be made very small with very small thermal capacity and rapid response time.

One problem with using a thermistor is that it is necessary to pass a current through it in order to generate a voltage across it. The current heats up the thermistor and alters its resistance.

## How to Use the NTC Sensors

To measure temperature using NTC thermistors, we must be able to measure its electrical resistance. There are three ways of doing this.

The first one involves a resistor network as shown in Figure 5a. If Vin, Vout, and the resistance R0 are all known, resistance of the thermistor can be calculated. From the calculated resistance, the temperature can be found.

The second method involves a constant current source and a thermistor. Knowing the current flowing through the thermistor and the voltage across it, we can find the resistance of the thermistor, see Figure 5b.

For measuring very small temperature changes, the third method, which involves a Wheatstone bridge, is used. The method is illustrated in Figure 5c. It consists of four branches (or arms), each containing a resistance. A voltage ($V_{in}$) is applied across the bridge at points A and C, causing currents to flow along the routes ABC and ADC. $V_{out}$ (voltage between B and D) is measured. The relation between $V_{out}$ and $V_{in}$ is expressed by the equation shown in Figure 5c. In order to measure a very small change in resistance, $V_{out}$ should be amplified further using instrumentation amplifiers.

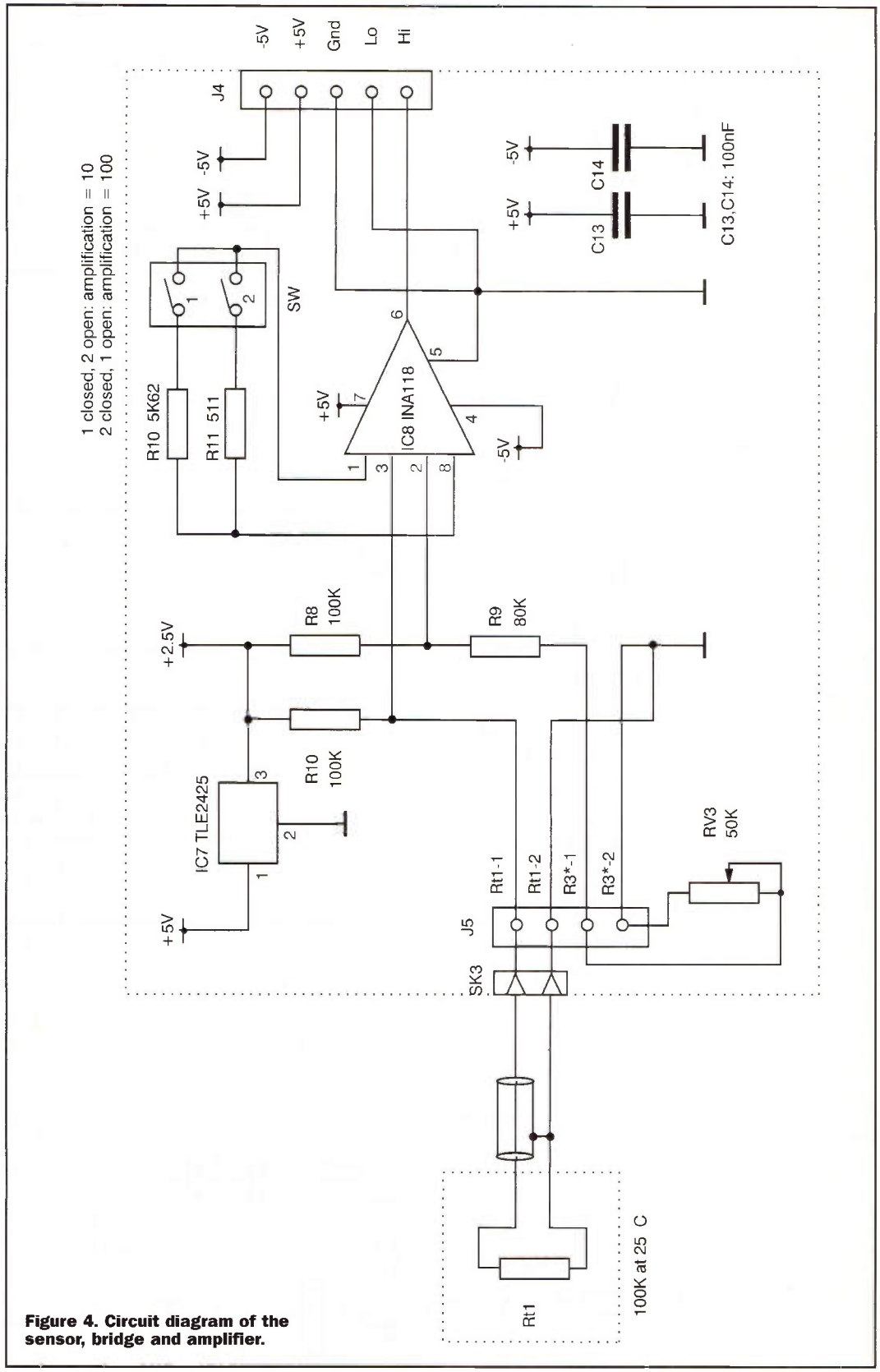



**Figure 4. Circuit diagram of the sensor, bridge and amplifier.**

## INA118 Instrumentation Amplifier

The INA118 is a low power, general-purpose instrumentation amplifier that offers excellent accuracy and stability. It accepts a wide supply range from ±1.35V to ±18V. The quiescent current is only 350μA. It is a laser-trimmed device for very low offset voltage (50μV) and low drift (0.5μV per °C).

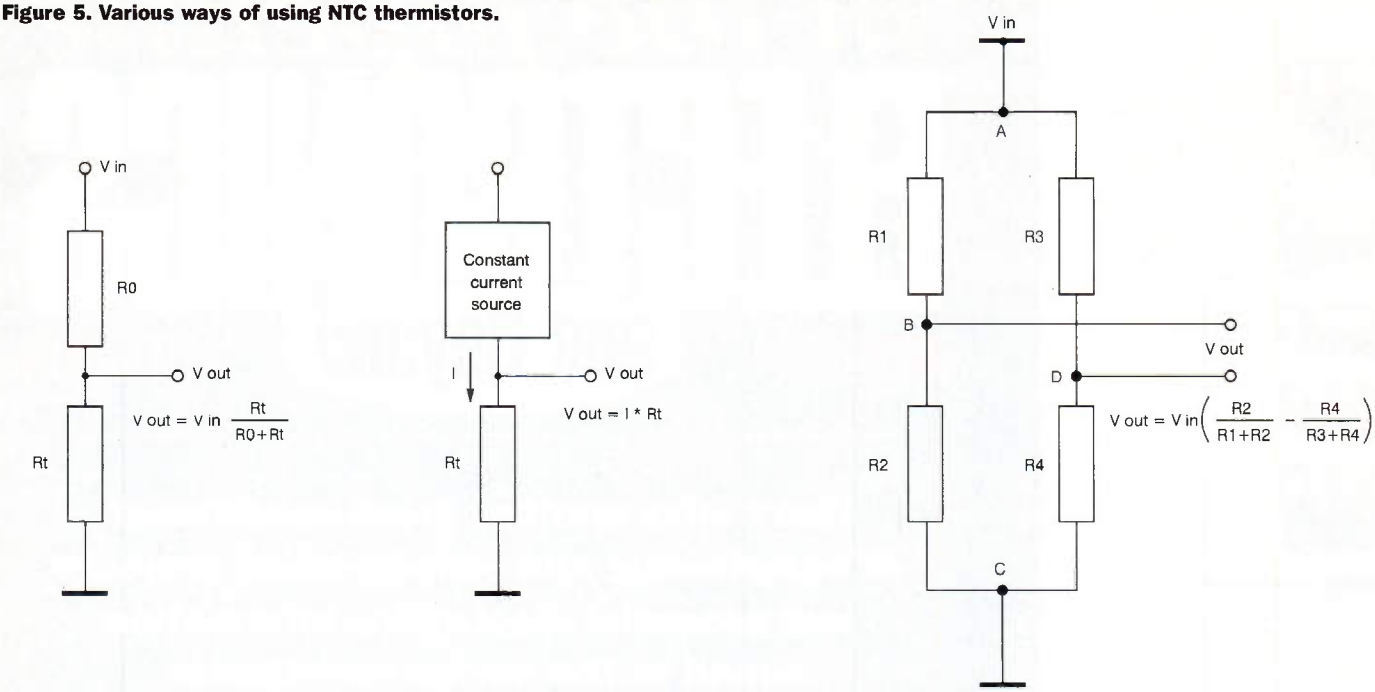
The pin layout and internal block diagram of the INA118 is shown in Figure 6. A single external resistor sets any gain from 1 up to 10,000. The relationship between the gain (G) and the resistance ($R_G$ in kΩ) has the following form:

$$G = 1 + 50 / R_G$$

The following table shows the required $R_G$ for some gains. The nearest resistance values available (0.1% precision resistors) are shown in the third column and the actual amplifications are shown in the last column.

The device also features an internal input signal protection

**Figure 5. Various ways of using NTC thermistors.**




(a) Resistor network (b) Constant current source (c) Wheatstone bridge

circuit which can withstand voltages up to ±40V. The input common-mode range is 0.6V below the positive power supply to 1V above the negative supply. The two inputs must be in that voltage range for proper operation.

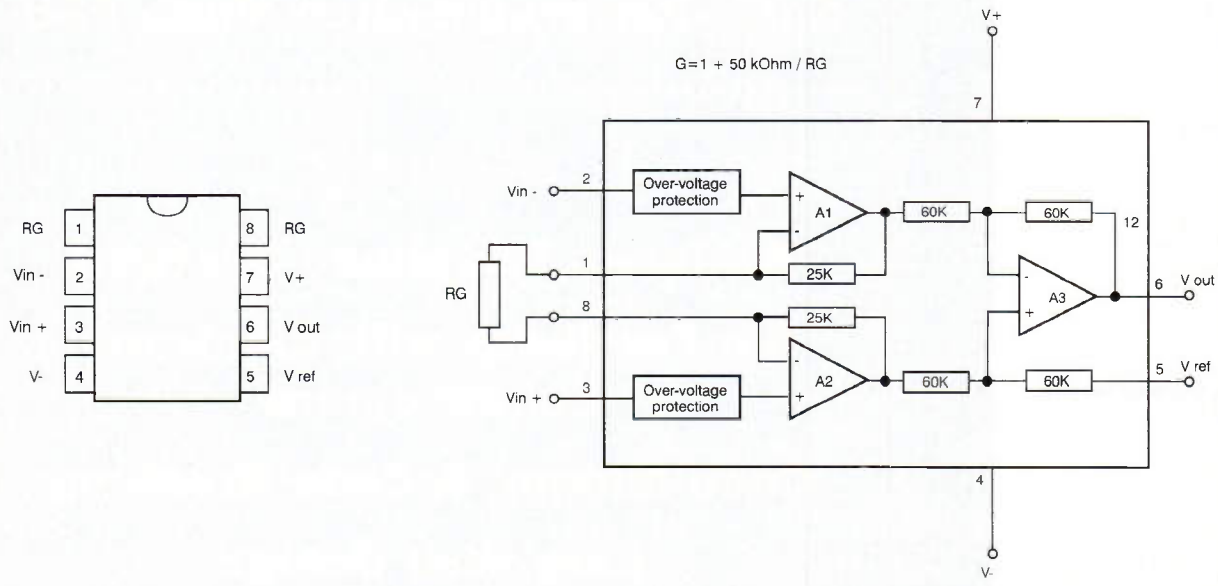
The input impedance of the INA118 is extremely high ($10^{10}$ Ω). Input bias current return paths should be provided for both inputs. The input current is approximately ±5nA. The paths are needed for proper operation.

| Amplification | Required resistance (kΩ) | Nearest resistance (kΩ) | Actual amplification |
|---|---|---|---|
| 1 | NC | NC | 1 |
| 2 | 50000 | 49900 | 2.002004 |
| 5 | 12500 | 12400 | 5.032258 |
| 10 | 5555.556 | 5620 | 9.896797 |
| 20 | 2631.579 | 2610 | 20.15709 |
| 50 | 1020.408 | 1020 | 50.01961 |
| 100 | 505.0505 | 511 | 98.84736 |
| 200 | 251.2563 | 249 | 201.8032 |
| 500 | 100.2004 | 100 | 501 |
| 1000 | 50.05005 | 50 | 1001 |
| 2000 | 25.01251 | 25 | 2001 |
| 5000 | 10.002 | 10 | 5001 |
| 10000 | 5.0005 | 5 | 10001 |

Without the bias current paths, the input will float to a potential which exceeds the common mode range of the INA118 and the amplifier will saturate. If the differential source resistance is low (such as a thermocouple), the bias current return path can be connected to one input. With higher source impedance (such as a microphone), two equal resistors are used.

**TO BE CONTINUED...**

**Figure 6. 1NA118 instrumentation amplifier.**




(a) Pin-out (b) Internal block diagram

## Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:


Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering, side cutters, pliers, wire strippers, and screwdriver). Test gear not required and no setting-up needed.


Easy to build, but not suitable for absolute beginners. Some test gear (e.g. multimeter) may be required, and may also need setting-up or testing.


Average. Some skill in construction or more extensive setting-up required.


Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.


Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

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