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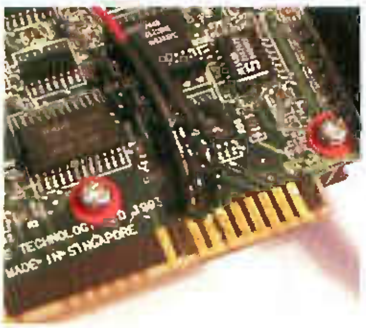
Velleman 250W 12V DC to 230V AC Converter

MP3 Player Update

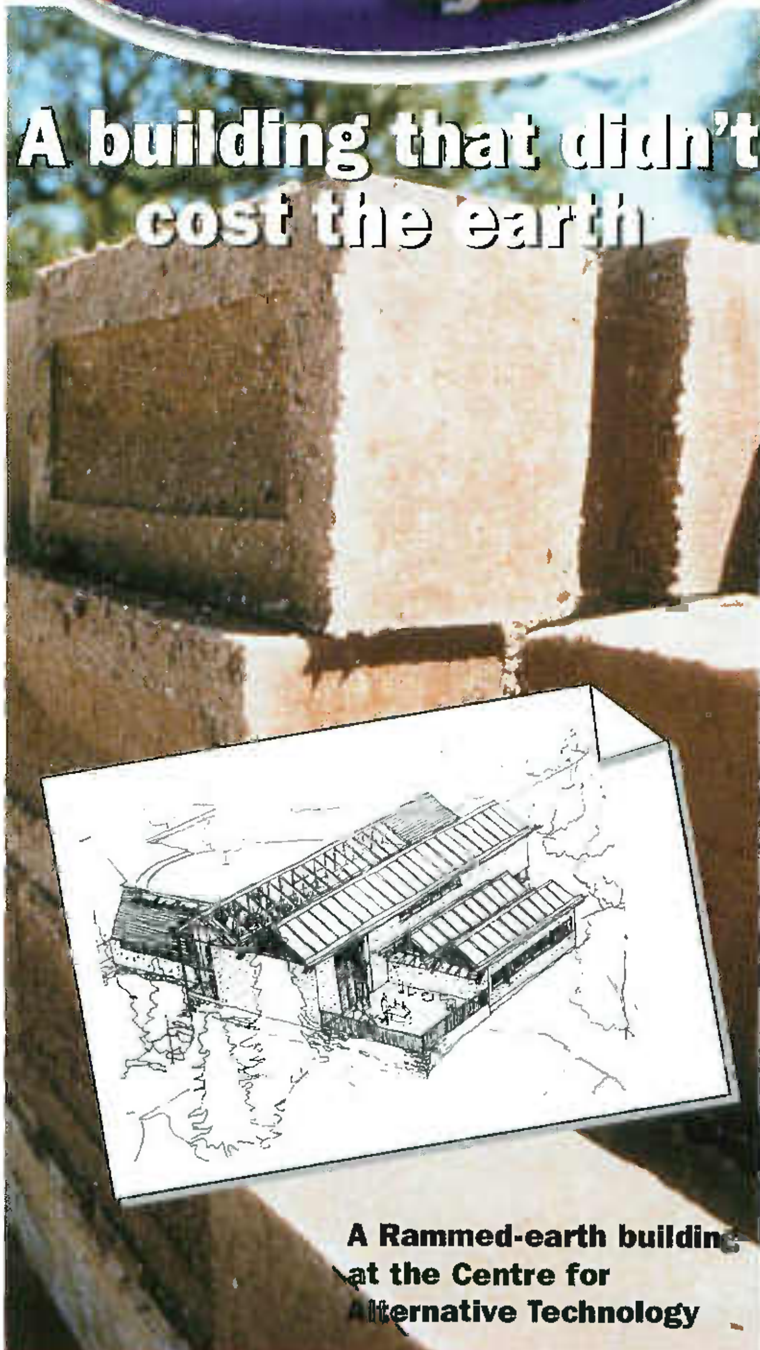


PC-based MP3 player

When Moore's Law Fails

The end of the road for silicon

A building that didn't cost the earth



A Rammed-earth building at the Centre for Alternative Technology

News Report - Pocket PCs from HP

Money from Electronics

From computing to Internet millionaire.

PROJECTS

Velleman 250W Inverter

8031 Computer

FEATURES

Life, Artificial Life and Biomimetrics

Liquid Crystals - A complete analysis

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FEATURES The Quantum World ★ FET Principles & Circuits ★ Valves in the 21st Century	FEATURES The Quantum World ★ FET Principles & Circuits ★ Valves in the 21st Century	FEATURES DVD The Next Generation ★ FET Principles & Circuits ★ Valves in the 21st Century	FEATURES Creating Artificial Retinas ★ Miniture Microsystems ★ Valves in the 21st Century Part 3	FEATURES Fuzzy Logic ★ Very Low Frequency Waves Part 2 ★ Trevor Baylis - The Modern Day Inventor

THE MAPLIN MAGAZINE
ELECTRONICS and Beyond
July 2000 Vol. 19 No. 151

Projects

Features

Regulars

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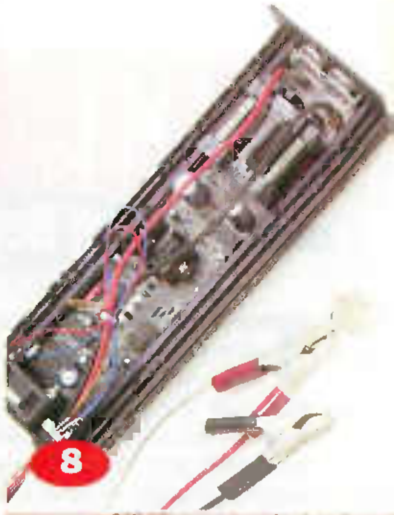
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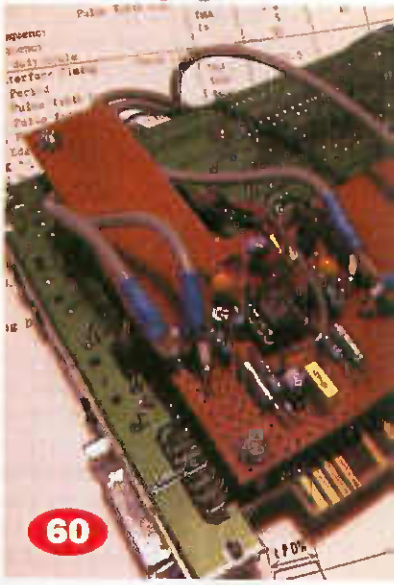
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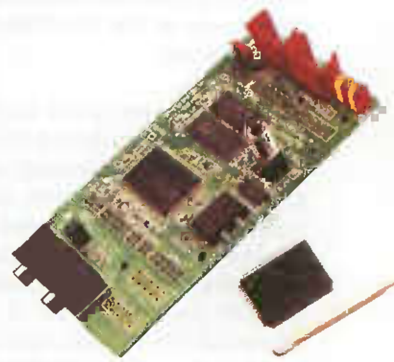
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47

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ELECTRONICS and Beyond

The 'Manchester Baby' was the first ever stored-program computer and was built at Manchester University in June 1948. It operated at a speed of 833 instructions per second had a word length of 32-bits and contained 128 bytes of memory. The valve count was quite modest at about 600, but it still measured 16 x 7 x 3 feet. In the course of 50 years we have moved to desk-top size computers that have 32-bit architecture, a clock speed of 1GHz, can execute instructions at around 1,700 MIPS, address 4Gbytes of memory, and contain over 10 million transistors.
Mike Bedford explains in his article why the microprocessor, as we now it, will soon run out of steam, and how the search is on for a 'replacement technology'.

Speech recognition and processing has come a long way such that it can now be integrated into products without causing endless frustration through misinterpretation of commands. Relatively inexpensive software packages are available for computers that provide dictation and command and control facilities, so almost making the keyboard and mouse redundant. It is likely that consumer products will be the next area to harness this technology, so reducing the need for mechanical interfaces. This month Reg Miles looks at the latest developments in this exciting area.

Ironically, thanks to the Internet, it is almost possible to exist without the need to speak to anyone. Virtually anything can be bought and paid for over the Internet, plus all your financial transactions. If you do have to speak to 'someone' on the phone then you often 'communicate' with an electronic voice or key in numbers via the keypad. In the not too distance future will the 'virtual voice' see the demise of the human response call centre?

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

Interactive Puppy is a Sell Out

Is this the next Pokemon? Poo-Chi, the Interactive Puppy, went on sale at the beginning of April in Japan and sold out of 100,000 in just three hours. Some stores around the country reported lines of 300 people waiting to purchase the pet.

Tiger Electronics will launch Poo-Chi in European launch planned for the summer.

Poo-Chi is a robotic canine that fits in the palm of your hand. He sings, plays games and has an animated head, ears, legs and mouth.

For further details, check: `<www.tigertoys.com>`.
Contact: Tiger Electronics, Tel: +1 847 913 8100.

New Playstation Requires Military Export License

Japan's Trade Ministry says Sony's PlayStation2 will be subject to special export regulations covering devices that can be adapted for military use.

The game consoles are capable of processing high-quality images very quickly - a characteristic of missile-guidance systems.

Officials are concerned that the rich graphics capability could be used by rogue states that have military hardware but lack sophisticated technological components.

For further details, check: `<www.sony.co.uk>`.
Contact: Sony, Tel: (01932) 816000.

Virgin Brands Internet Appliance

Internet Appliance Network (IAN) and the Virgin Entertainment have announced the launch of an online marketing and branding campaign in the US aimed at introducing Virgin-branded Internet Appliances to 10,000 consumers. Once consumer tested in the US, Virgin expects to roll-out the IAN in the UK later this year.

IAN is providing Virgin with Internet appliances, and a comprehensive marketing and branding solution for customer acquisition, retention and customer relationship management. IAN's solution of a branded Internet appliance - the Webplayer by Virginconnect - utilises custom-designed software and a Virgin-branded browser interface for content, applications and services, e-commerce and online advertising partnerships, rich database capabilities, and customer support services.

Using the Webplayer, consumers will be able to directly link to a Virginconnect branded portal, which will serve as the user's entry to the Internet and starting point for their surfing and online shopping, sending and receiving email, and more. Webplayer users will get a continuous Virgin-branded Internet experience, while Virgin customers get a portable alternative to surfing the Internet with a PC.

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

Contact: Virginconnect. Tel: (0500) 558800.

Research in Motion Introduces Palm-Sized Wireless Blackberry

Palm wannabe, Research In Motion Limited has introduced a new, advanced, palm-sized wireless handheld with integrated support for wireless email, Internet, paging and organiser features.

The RIM 957 Wireless Handheld is optimised for mobile users and incorporates a large high-quality screen, 32-bit Intel 386 processor, 5MB Intel flash memory, easy-to-use keyboard, embedded wireless modem, integrated organiser and full support for the award-winning BlackBerry wireless email solution.

BlackBerry is a wireless email solution for mobile professionals. It combines hardware, software and airtime to deliver an end-to-end solution with single-mailbox integration and nationwide wireless service.

For further details, check: **<www.rim.net>**.

Contact: Research in Motion, Tel: +1 519 888 7465.

Nortel Hires Engineering Class of 2000

Nortel has acquired business and academia by offering jobs to each of the 38 Santa Clara University undergraduate engineering students who attended its November recruiting banquet.

Thirty-four students accepted the job offers, which were made following dinner by Nortel Vice President Mario Bruketa.

Each student received a Federal Express packet the next day containing the employment offer letters.

Students who accepted within the first week received a signing bonus and those who accepted during the second week received half of the bonus. Some students are believed to have received stock options as well.

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

Contact: Nortel. Tel: (01491) 682598.

NEWS BYTES

Terabit Networks Round the Corner

Scientists at Lucent's Bell Labs have set a new record for transmitting data over fibre-optic cable by moving 3.28 terabits per second of data over 300km of optical fibre.

At this rate, Lucent's fibre in one second could transmit three times the volume of daily Internet traffic for the whole world. Within years, fibre-optic cable could move tens of thousands of terabits per second of data.

This bandwidth growth will be fuelled by the speed of lasers used to encode data and the number of wavelengths a single fibre can carry at once.

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

Contact: Lucent. Tel: (01895) 852800.

PC Market Posts Double-Digit Growth

The global PC market continued its upward trend in the first quarter of this year, according to reports from IDC. According to the analyst, the market grew at 20%, down slightly from 21% a year ago.

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

Contact: IDC. Tel: (0208) 987 7100.

Microsoft Pocket PC 3.0

Microsoft is introducing Version 3 of its Pocket PC, a handheld computer that includes a Web browser and that can be used for playing music in MP3 audio format, playing video clips, and reading books in Microsoft's new Cleartype software.

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

Contact: Microsoft. Tel: (0345) 002000.

UK Becomes E-UK

To cut costs, save time, and better inform the public, the United Kingdom plans to provide all its services online, creating an e-government restructuring managed by e-envoy Alex Allan, whose scope of activity will include all areas of central and local government.

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

Contact: DTI, Tel: (020) 7215 5000.

NEWS BYTES

Alliance Plans M-Commerce Standards

Nokia, Ericsson and Motorola, which together control more than 50% of the global market for mobile handsets, are forging an alliance to develop technical standards for conducting electronic commerce via mobile phones.

Microsoft is developing an m-commerce standard independently, but may run into difficulties getting its technology accepted, given the market dominance of the three manufacturers.

The Nokia-Ericsson-Motorola standard will be compatible with multiple technologies, such as GSM and CDMA, and will be geared toward making transactions such as e-shopping and online banking via handsets secure.

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

Contact: Nokia, Tel: (020) 7437 4380.

Lucent Tapes Out ARM10

Lucent has fabricated the first silicon of the ARM10 microprocessor core from ARM. This high-performance core for system-on-a-chip (SoC) integrated circuits (ICs) significantly increases the performance of previous ARM cores, enabling the development of next-generation wireless products and broadband infrastructure that support Internet access and transport.

Lucent's ARM10 core-based SoCs have been designed to be at the heart of leading-edge communications applications, including Internet-enabled wireless phones and personal digital assistants, set-top boxes, voice over Internet protocol (VoIP) platforms, wireless and broadband Internet connectivity, Internet routers, high-end gaming and high-speed computer input devices.

The core's small die area and low power consumption are well suited for integration with Lucent's digital signal processors, enabling SoCs that perform real-time audio and video applications at power levels suitable for portable devices, wireless base stations and VoIP gateways.

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

Contact: Lucent, Tel: (01344) 865900.

HP Launches New Range of Pocket PCs

Hewlett-Packard (HP) has unveiled the slim HP Jornada 540 Series Colour Pocket PCs at the Microsoft Pocket PC launch event here at Grand Central Station.

With its sleek design and functionality, the HP Jornada 540 series gives users what they're looking for in a Pocket PC beyond PIM - fast and easy synchronisation to their desktop PCs, access to e-mail and the Internet, expandability for wireless connectivity, and software applications for making free time fun.

The HP Jornada 540 series comes complete with everything users need to get started. Included in-box are a travel charger, USB cradle and a full suite of Microsoft Pocket PC applications, including Outlook, Word, Excel, Money, Internet Explorer, Windows Media Player (supports MP3 and WMA formats), eBook Reader, and a desktop version of Microsoft Outlook 2000.

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

Contact: HP, Tel: (0870) 547 4747.

Intellitech Launches Probe-less Interactive Tool

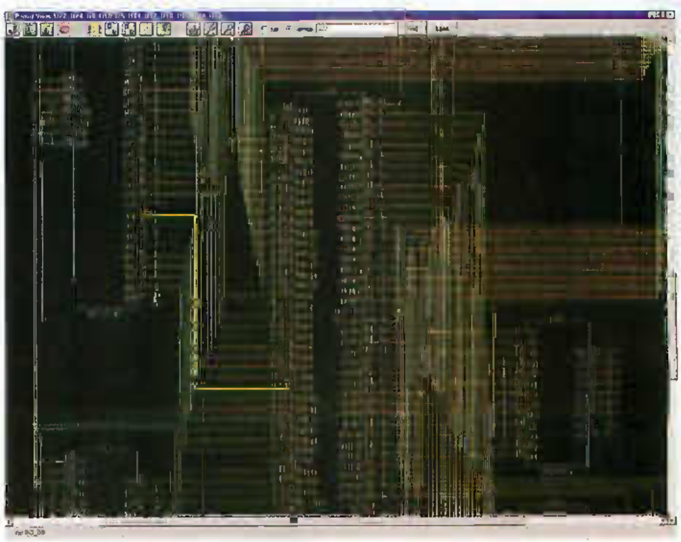
Intellitech has announced the availability of the Schematic Logic Probe (SLP) for probe-less system debug. Schematic Logic Probe is a software version of traditional tools used for debug, such as paper schematics and physical probes.

SLP allows design engineers to control and observe electronic system operation via a software configurable schematic of the system's design and a standard IEEE 1149.1 interface.

A full working 30-day trial version of the application is available for download from the Intellitech's Web site.

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

Contact: Intellitech, Tel: +1 603 868 7116.



Juniper Ships New Filter Chip

Juniper Networks is shipping a new processor called Internet Processor II, a turbo charged version of an earlier filtering technology that scans data flowing through a network to detect suspicious traffic.

The Internet Processor II is capable of filtering 20 million packets of data a second, compared with older security software that could handle only 200,000 data packets per second.

For further details, check: <www.juniper.net>.

Contact: Juniper, Tel: +1 650 526 8000.

AMD Names Processor Family Duron

AMD has selected AMD Duron as the brand name for their new families of processors for value conscious business and home users.

The AMD Duron processor is derived from the AMD Athlon processor core and features full-speed, on-chip L2 cache memory, a 200MHz front side system bus, and enhanced 3DNow! technology. AMD plans to begin shipping AMD Duron processors in June. AMD Duron processors are specifically designed to provide an optimised solution for the most demanding value conscious business and home users, without compromising their budgets.

For further details, check: <www.amd.com>. Contact: AMD, Tel: (01276) 803100.

AMD Duron PROCESSOR

French Military Foils Bluetooth

The French military is currently using part of the radio spectrum that includes the 2.4GHz used by the Bluetooth wireless standard.

The new protocol enables computers, mobile phones and other electronic devices to communicate wirelessly.

France is the only country that has this issue, and unless the current lobbyists efforts are successful, devices that operate using Bluetooth will not be legal in that country.

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

Contact: Visit Bluetooth Web site for contact details of individual member companies of the Bluetooth Special Interest Group (SIG).

Tetris Takes Over Tower Block

Over five months of planning, construction, and installation paid off as the largest fully functional Tetris game in the world appeared on the Brown University Sciences Library, Rhode Island, US.

Containing fourteen custom-built circuit boards, a twelve-story data network, a personal computer running the Linux operating system, and more than 10,000 lights, the artwork, code-named La Bastille, transforms Brown University's fourteen-story Sciences Library into a giant video display which allows people to play a game of Tetris that can be seen for miles.

The original idea to implement Tetris on the Sciences Library was proposed by a Technology House member several years ago.

This year, two members presented the idea to the Brown University Visual Arts Department and received university approval to deploy the project as installation art. Technology House members designed the system, located and purchased materials, built hardware, wrote code, and debugged the system for over three months.

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

Contact: Brown University, Tel: +1 401 863 1000.

Chip Density Breakthrough for IBM

IBM has developed a new method for building microchips that can deliver up to a 30% boost in computing speed and performance.

IBM's new manufacturing technique uses a material known as a 'low-k dielectric' to meticulously shield the millions of individual copper circuits on a chip, reducing the harmful effects of electrical 'crosstalk' between wires that hinders chip performance and wastes power.

The company is putting the technology to work immediately, designing custom chips that meet the high performance and low power consumption demands of next-generation networking equipment and Internet servers. The first chips built with this new process are expected to be available next year.

Today, designers work to improve chips by adding more circuits and packing them closer together on a single piece of silicon. Limits are reached as those closely-packed circuits start to generate interference in one another - just as static can appear on a TV screen when an electrical appliance is turned on nearby.

IBM has developed a recipe for building chips with a 'low-k dielectric'- a material that forms a better seal around the chip's wiring, helping electronic signals move faster.

While IBM's technique is proprietary, the low-k material is a commercially available SiLK semiconductor dielectric produced by Dow Chemical.

In addition, IBM uses mainstream 'spin-on' semiconductor manufacturing equipment to apply the material. The use of both materials and tooling that are generally available help make this the first technically and economically viable low-k process for copper chip fabrication.

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

Contact: IBM, Tel: (0990) 426426.

NEWS BYTES

Smart-Electrics Set to Transform Home Security

BT has announced a new technology dubbed Smart-Electrics, which is set to revolutionise the protection of people and property in home and business settings. It will make stolen TVs, videos and hi-fi equipment useless to burglars and provide an economical platform to monitor homes or workplaces for break-ins, fire, smoke and environmental factors.

The technology, patented by BT, could be available globally in a number of developed commercial forms within two years. It has powerful potential benefits for a number of industries, including all forms of electrical and electronic goods, insurance of property, contents, and health, energy utilities, and residential and commercial property letting and management.

Likely applications include the protection of property against burglary, improved safety against fire and other risks including carbon monoxide poisoning. In the longer term, a cost-effective basis for healthcare monitoring, home automation and utility meter reading services.

The technology is based on a simple intelligent 'home control centre' in the home or workplace to which nearby electrical appliances are registered through an appropriate low bit rate communications protocol. Subsequently any Smart-Electrics-equipped electrical item that is stolen will refuse to operate when plugged into the mains in an unauthorised location, making TVs, videos and hi-fi equipment with the Smart-Electrics circuitry useless to burglars.

In addition to the theft protection application the platform can connect a series of monitored sensors for various factors, ranging from life-threatening conditions such as smoke or high carbon monoxide levels to others such as temperature and humidity.

Communicating at low bit rates via electricity cabling, appliances and sensors can pass information to the home control centre and, where desirable, onwards to central monitoring points which could operate warning systems and/or co-ordinate the necessary actions with emergency services including police and fire authorities.

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

Contact: BT, Tel: (0845) 609 4664.

NEWS BYTES

150 Bright Sparks Required for Interactive TV Incubator

Scotland is set to become a hotbed for both emerging technology and national heritage, thanks to innovation from one of its fastest growing companies.

Graham Technology has launched its biggest ever recruitment campaign to underpin development of new customer service channels, in TV, WAP and Internet environments.

This is the latest stage of the company's long term ambition to turn its newly acquired headquarters, at India Tyre, into Scotland's hi-tech epicentre.

Graham Technology, which works with major blue chip service organisations including GUS and BT, is hiring a specialist team to research and pioneer emerging customer channels and processes. The 150 successful applicants are expected to come from a variety of backgrounds, including project managers, software engineers and high calibre graduates.

The interactive TV research centre will be housed in India Tyre, Glasgow, a Grade A listed building, which is costing Graham £3.5 million to restore. The building is one of the UK's last remaining example of Art Deco architecture and will house up to 300 engineers and project managers working with emerging technologies.

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

Contact: Graham Technology, Tel: (0141) 891 4000.

Quasicrystal Coatings for Non-stick Cooking

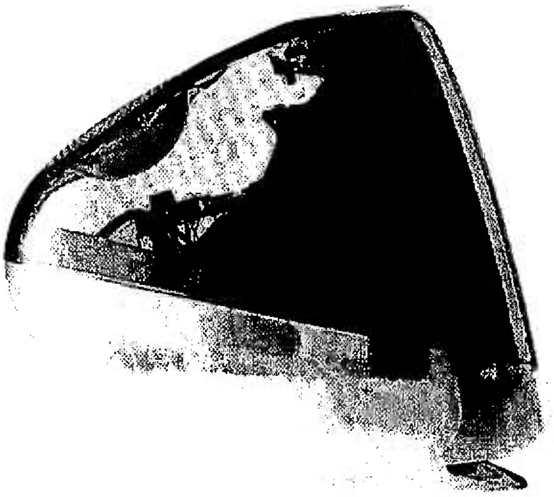
About fifteen years ago, the unusual structure of aluminium quasicrystals was discovered. The structure produces some surprising properties of high resistance to wear, high operational temperatures, low friction and a non-stick surface.

Researchers at the Metallic Materials Science and Engineering Laboratory, CRNS at Nancy in France decided to exploit the hard and non-stick properties of quasicrystal alloys for the coating of cooking utensils. SNMI, a subsidiary company of Saint-Gobain, has succeeded in making the quasicrystals stick to a variety of rough surfaces.

The quasicrystal coating, called Cybemox, is comparable with Teflon regarding its non-stick properties. It is over twice as hard as stainless steel. Heat is distributed evenly across the surface and is retained when taken away from a heat source. Cybernox can withstand temperatures as high as 750°C.

As the temperature increases, the coating initially acts as a thermal barrier. Then, the heat accumulated in the substrate spreads evenly across the whole surface without producing hot spots which occurs with other materials.

Apple Releases Darwin Source Code



Apple has released Darwin 1.0, the advanced operating system core at the heart of Mac OS X, and the release of an updated Darwin Streaming Server. Darwin's open source model allows the tens of thousands of registered Darwin developers to modify, customise and extend key Apple software, including the modern mach kernel and BSD layers found in Apple's next generation operating system, Mac OS X.

The new Darwin kernel is based on FreeBSD and Mach 3.0 technologies and supports the Kernel Extension Developer Kit for developing drivers and loadable modules. Darwin 1.0 gives developers access to essential Mac OS X source code.

This allows developers to enhance the feature set, performance and quality of Mac OS X products in partnership with Apple engineers. Darwin 1.0 is processor-independent and is built for PowerPC and Intel platforms, enabling Open Source developers to work on Darwin projects on the widest choice of computer systems.

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

Contact: Apple, Tel: (0870) 600 6010.

Engineer-Scientists Link Living With Mechanical

The emerging field of nanobiotechnology could hasten the creation of useful ultra-small devices that mimic living biological systems - if only biologists knew more about nanotechnology and engineers understood more biology.

They soon will. Starting in June 2000, the first 12 PhD candidates will hit the laboratories of Cornell University's new W. M. Keck Program in Nanobiotechnology. The program has been inaugurated with a three-year, $1.2 million grant from the W. M. Keck Foundation of Los Angeles and is expected to receive other sources of support.

Keck Fellows will study with Cornell researchers who are working in the nano scale - as small as a few billionths of a metre - to invent hybrid devices that combine the best of the organic and the inorganic, the living and the engineered. Although this basic research at the interface of engineering and biology does not involve human subjects, the devices that will emerge could someday solve human problems.

For further details, check: <www.nbtc.cornell.edu/organization.htm>.

Contact: University of Cornell, Tel: +1 607 254 4636.

MIT Students Develop Mini Satellites

Picture the Red Arrows flying in formation in an air show. Then imagine miniature satellites doing similar manoeuvres in space.

Introducing MIT's SPHERES project, in which 13 undergraduates in a Massachusetts Institute of Technology course have developed and are testing three satellites the size of volleyballs that they believe will help meet the latter goal. The Synchronised Position Hold Engage Re-orient Experimental Satellites will allow researchers to test a variety of technologies key to formation flying.

Two of the devices, which communicate with each other and a computer, were tested aboard NASA's KC-135 aeroplane last week. The first tests aboard the KC-135, which allows satellites to become essentially weightless for short periods of time, were conducted in late February.

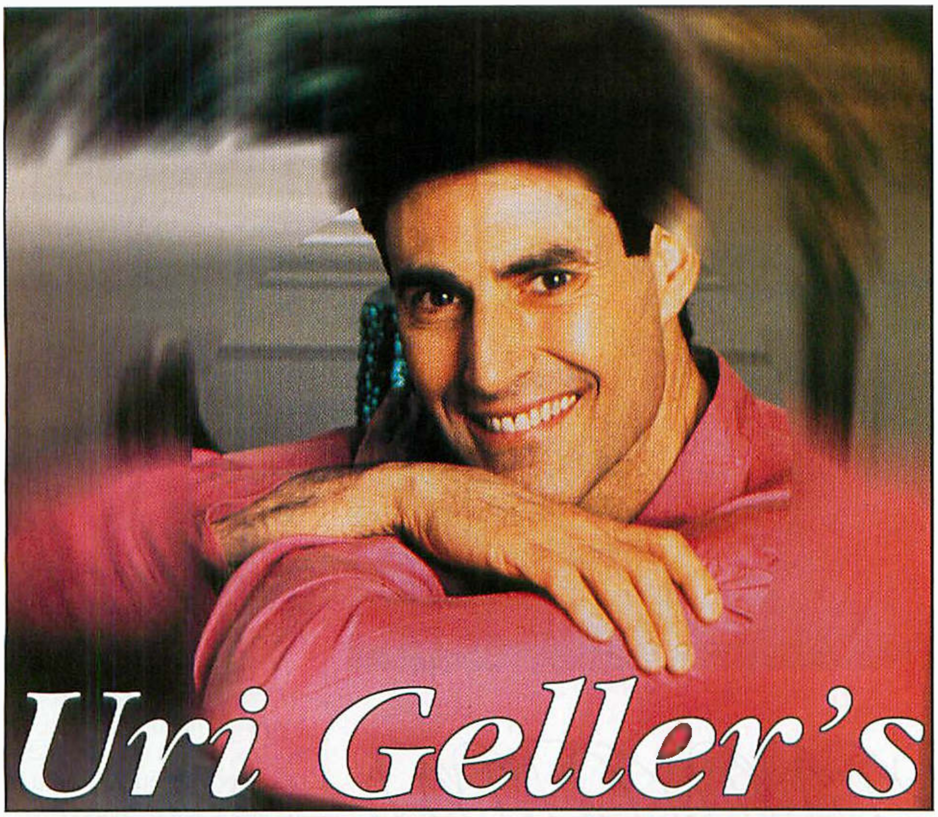
At that time the team successfully operated two SPHERES at the same time inside the plane, and collected data that helped improve the devices for the latest mission.

"Rather than fly one large, expensive satellite, the idea is to network together several small ones, much like how computers progressed from large mainframes to networked PCs," said Associate Professor David W. Miller.

The application of interest to the SPHERES team is a space telescope with a higher resolution than the Hubble, created by stringing across the sky several tiny satellites outfitted with mirrors.

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

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



Uri Geller's EXTENDED REALITY

Alfred Russel Wallace - Part 2

In an earlier column, in the May edition, I pointed out that Charles Darwin and Alfred Russel Wallace, who independently worked out theories of evolution by natural selection and presented them at the same meeting in 1858, were very different in their beliefs. Darwin is seen today by many as the man who did away with God as creator of the universe and introduced a rationalist, materialist view of life. Wallace, who disagreed with his friend over a number of details, had a completely different approach. Let's hear how he came to his own conclusions in his own words:

"During twelve years of tropical wanderings between the years 1848 and 1862, occupied in the study of natural history, I heard of the strange phenomena said to be occurring in America and Europe under the general names of 'table-turning' and 'spiritrapping'; and being aware, from my own knowledge of Mesmerism, that there were mysteries connected with the human mind which modern science ignored because it could not explain [them], I determined to seize the first opportunity on my return home to examine into these matters."

And that is just what he did. His interest in Mesmerism went back to his early days as a schoolmaster, when he had carried out experiments in 'community of sensation'. A mesmerist and subject were able to blend their respective consciousness to the point where, for example, if somebody pinched or stuck a pin into the mesmerist, the subject would feel the pain. Similarly, if the mesmerist took a mouthful of salt or sugar, the subject would also taste the stuff.

Sounds weird? Maybe, but if we accept Wallace's findings as a naturalist, why not accept his opinion that "the sympathy of sensation between my patient and myself was to me the most mysterious phenomenon I had ever encountered"?

He was soon to encounter more. On 22 July 1865 he went to visit a sceptical lawyer friend, and this, according to the notes he wrote immediately afterwards, is what happened:

"Sat with my friend, his wife and two daughters, at a large low table, by daylight. In about half an hour some faint motions were perceived, and some faint taps heard. They gradually increased; the taps became very distinct, and the table moved considerably, obliging us all to shift our chairs. Then a curious vibratory motion of the table commenced, almost like the shivering of a living animal. I could feel it up to my elbows."

This went on for two hours, and afterwards the five of them tried to repeat what they had just witnessed by normal means, but without success. They held about a dozen more sessions, and Wallace then got a group of friends and relatives to sit in his own home, and they were even more successful, being able to produce "tapping, rapping, thumping, slapping, scratching and rubbing" sounds, and eventually to get all four legs of the table a foot from the ground.

Anyone who suspects Wallace made all this up, or had suddenly gone crazy, should bear in mind that several others reported identical results with their tables. These included the eminent French politician and aristocrat Count Agenor de Gasparin and a Swiss astronomer, Professor Marc Thury. Gasparin was convinced that he had discovered a genuine phenomenon, and insisted that "it can neither be explained by the mechanical action of our muscles, nor by the mysterious action of spirits". Thury's own conclusions were:

"Firstly, the will, in a certain state of the human organism, can act at a distance on inert bodies, by a means other than muscular action and secondly, under the same conditions, thought can be communicated directly from one individual to another in an unconscious manner." That was written nearly 150 years ago, long before such words as psychokinesis and telepathy came into the language.

`Wallace did his best to get his fellow scientists interested in his findings, but with little success. The only one prepared to look into this strange new force was a brilliant young man named William Crookes, who had been elected a Fellow of the Royal Society at the age of 31. (He later became its president and received a knighthood.) Wallace attended one of the many experimental sittings Crookes held with the star medium of the day, Daniel Dunglas Home (more about him in a later column) and kept up his interest in psychic matters until his death in 1913, aged 90.

Some of his ideas were well ahead of their time. For instance, writing about ten years before Einstein was born, he noted that "matter is essentially force, and nothing but force" and as it was obvious that some force, at least, originated in the human mind, he argued that:

"If, therefore, we have traced one force, however minute, to an origin in our own will, while we have no knowledge of any other primary cause of force, it does not seem an improbable conclusion that all force may be will-force." Darwin, I am sure, would not have agreed with what he wrote next:

"...and thus, that the whole universe is not merely dependent on, but actually is the will of higher intelligence or of one Supreme Intelligence."

Uri Geller's latest book MindMedicine is published by Element Books at £20.00, and his novel Dead Cold is published by Headline Feature at £5.99.

Visit him at **www.uri-geller.com** and e-mail him at **urigeller@compuserve.com**

PROJECT

Velleman 250W 12V DC TO 230V AC CONVERTER

Camping enthusiasts will find this battery-to-mains converter a very useful accessory - John Mosely describes the construction.

> **FEATURES**
>
> Very compact design with integral heatsink
>
> Light weight - 1.4kg
>
> Automatic shut down if battery voltage drops too low
>
> Short circuit, overload and temperature protection
>
> High efficiency (80% max.)
>
> 0.2A no load current consumption
>
> Protected against battery polarity inversion

This converter kit from Velleman allows mains operated equipment (250W maximum load) to operate from a 12V car battery. This can be very useful in the event of a power cut to maintain lighting, or possibly to drive the central heating. Alternatively, it can provide the basis of a back-up power supply for computer equipment etc. But one of the big advantages can be for the camping and caravan enthusiast where such a converter has many applications.

Circuit

The circuit is shown in Figure 1. The fuse is provided to protect against wrong battery connecting. Diode D17 will conduct and the fuse will obviously blow. Because the diode is not in series with the main 12V DC supply, there is no forward voltage drop so efficiency and energy conservation are maintained. A high efficiency fan is used to help keep the finished unit cool. The choke L1 helps prevent noise generated by the fan motor from effecting VR1 regulator IC. Note that Zener diode ZD4 on the PCB is not used on the 12V DC version, (used on the 24V version) and is replaced by a wire link.

IC4 is the basis of the high voltage conversion circuit and is a dedicated switch mode power supply (SMPS) IC. The two outputs drive MOSFET power devices T7 and 8 which feed into the step-up transformer. ZD2 and 3 offer protection for the MOSFET devices against induced emf produced by the transformer.

The transformer steps-up the high frequency switched input (53kHz approx.) to a high voltage, which is rectified by the diode bridge D19 to 22, and smoothed by capacitor C17. A suitably dropped voltage is applied to the input of the SMPS IC4, to monitor the state of the output high voltage, and by using pulse width modulation (PWM), maintains a constant output voltage regardless of the load. The main output is connected to the H-Bridge driver network formed by T3 to 6 and the output load.

IC1 a 4060 is a 14-stage ripple counter/oscillator, the final output frequency being 8kHz approx., which is fed to IC2, a 4017 decade counter. Outputs Q1 and 2 and outputs Q3 and 4 are ORed together via diodes D1 and 2, and D3 and 4. These then feed the parallel hex inverter 4009 which provides more current drive to the FET output stages.

With lows on inverter inputs N1, 2 and 3, T6 will be switched, and so will be T2, which in turn will switch off T4. When inverter inputs N4, 5 and 6 are low T5 and T1 will be switched on and T3 will be switched off. When either of the outputs Q0 or 3 of IC2 are high, the outputs of inverters N1 to 6 are high, which will turn on T5 and 6 and T1 and 2. This connects the live and neutral of the load to 0V via resistors R43 and R44. The output waveform is a quasi sine-wave. It follows that the combinations of T3 and 4, or T3 and 5, or T4 and 6 cannot be switched on at the same time.

Current limiting is provided by current sensing resistors R43 and 44, non-inverting amplifier A2 and Schmitt trigger A3, the output being fed to the overload time out circuit. The overload voltage circuit is also based round a Schmitt circuit A1. Over temperature is provided by a 90°C thermal switch, which is mounted on the same heatsink as T6. If any of these 'fault' conditions exist LD1 will light. A4 is configured as a comparator-trigger and will have a high on its output when a fault condition is present which will disable IC4 via pin 10. This will continue until C14 is discharged which will only happen when the supply is disconnected. Note that some capacitative loads such as computers etc., may cause the thermal trip to operate. If this happens, then the unit should be left on for a few minutes to allow the fan to cool down the unit before it is reset.

Construction

The PCB, when complete, is slid into the slot of one half of the aluminium housing. The two end plates are then secured to the two halves to form a sealed, robust unit. One end plate contains the two power driver FETs, and the other includes the cooling fan, LEDs, cable entry, and on/off switch.

The kit includes wire to form the jumpers, and the jumper at the end where the two driver FETs are mounted is made from three wire links. The other links need to be inserted too. Next mount the small resistors and the 1W types, followed by the IC sockets and the power resistors. Note that R43 and 44 are mounted 15mm and 10mm respectively off the board. The diodes are now mounted and similarly D18 to 21 are mounted 20mm off the board. As mentioned earlier, ZD4 is a link for a 12V power supply. As usual make sure the diodes are inserted the correct way - this is an expensive kit, so do be very careful in its construction to avoid errors. If you have assembled in sequence then you should be left with an inductor (L1) on the supplied bandoleer that looks like a small resistor.

We can now mount the capacitors, and again be careful when inserting the electrolytics. The PCB mounting spade connectors are next followed by the 12V regulator, the small transistors, the 2.4576MHz crystal, PCB pins and the on/off switch.

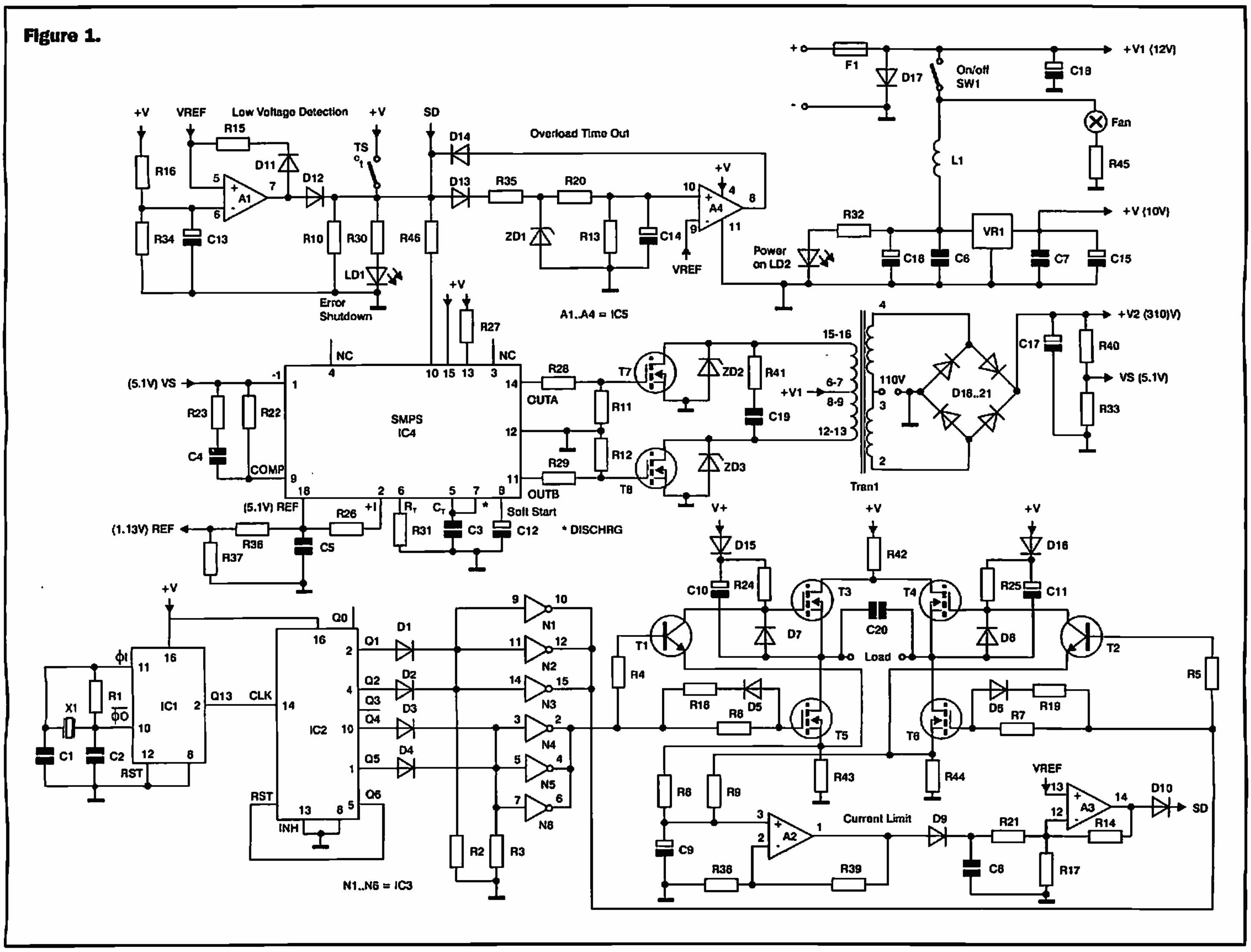
Mount T3 and 4 MOSFET devices by bending the legs through 90° at a suitable place and secure to the board using 12mm M3 screws, lock washers and bolt. T5 is secured to a heatsink using a 12mm screw, lock washer and nut, but do not tighten. The centre tag of the heatsink is removed and the heatsink is aligned onto the board and the device legs are inserted into the corresponding holes. Now solder and tighten the bolt. T6 is secured in a similar fashion but the thermal switch TS is assembled to the other side of the heatsink. Mount the fuseholder and fuse.

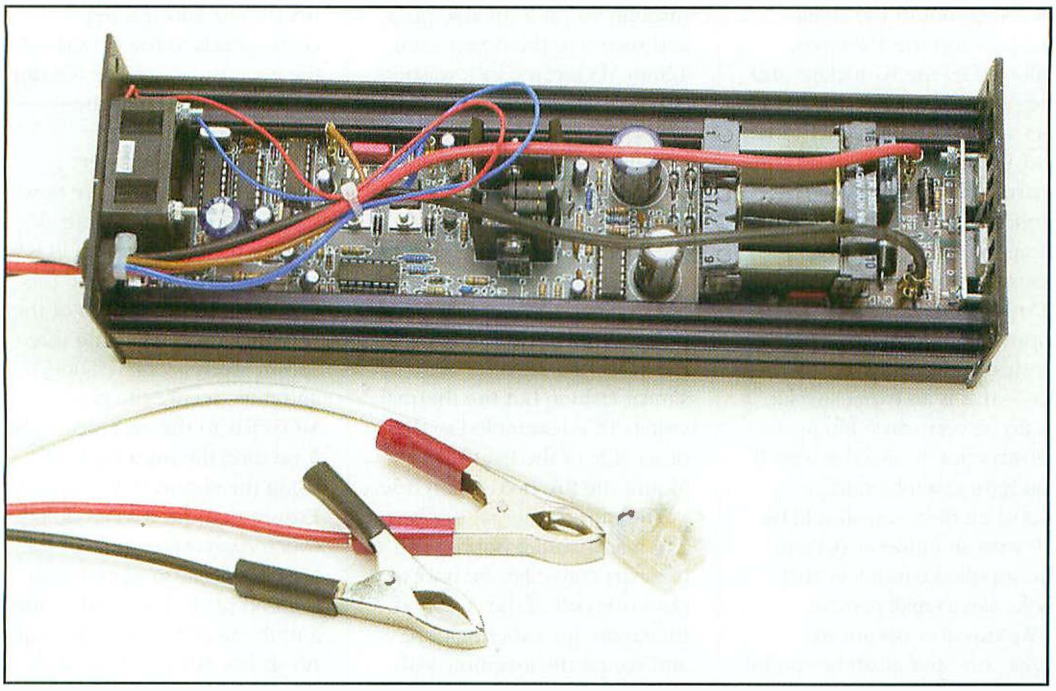
The transformer is supplied as a ready-wound bobbin and a two-part core. Slip the bobbin onto one half of the core and then mate the other half up, and secure the assembly with the two clips supplied. The transformer can only be mounted one way on the board.

The two LEDs are mounted with the encapsulation touching the board with the legs shortened accordingly and soldered to the trackside of the board. The shortest leg corresponds to the flat side of the encapsulation. The ICs can now be inserted into the appropriate sockets.

The two power driver MOSFETs (T7 and 8) are now mounted to the end plate. A tube of thermal compound is supplied with the kit, and this is smeared to both sides of the two mica washers. Using three 15mm screws, lock washers and nuts, secure the two MOSFETs to the end plate - not forgetting the mica washers - using the supplied fixing plate. Ensure that the devices do not touch each other and that they are electrically insulated from the end plate. It is worth using a multimeter to check there are no shorts. Now part assemble the two halves of the aluminium enclosure together using the other end plate, and then slide the PCB into the enclosure, ensuring that the on/off switch and the LEDs align with their corresponding cut outs. Now mount the MOSFET end plate and screw

Figure 1.





in the bolts for about 3mm, and then push the PCB up against the end plate and bend the MOSFET connections back and align with the trackside of the PCB. The board should be touching the end plate. Now solder the connections. Dismantle the enclosure and be careful when handling the board so as not to disturbed the end plate and the MOSFETs.

The track associated with the power MOSFETs needs to be 'reinforced' with wire (1.5m) to increase the current carrying capability of this part of the circuit. What you must not do is use the supplied battery connecting cable. At this stage it is worth thoroughly checking the board.

The fan is fixed to the other end plate by two 30mm M3 screws, washers, lock washers and nuts. There are arrows on the fan to ensure that the fan is mounted correctly i.e. air is blown to the outside of the unit. The fan can now be wired to the PCB, followed by the battery cable and mains out cable (using the supplied 'fast-on' connectors). The cables exit to the outside via a grommet in the end plate. I had problems getting both the battery and mains cable through the hole, so select a suitable size twin flex to use (0.75mm). Wire raps are supplied to tie round the cables on the inside of the enclosure against the grommet to provide strain relief.

Now complete the assembly of the case. It is recommended that some of the thermal compound be smeared on the MOSFET end plate and along the two edges of the enclosure.

Testing

Initially, I connected the completed unit to a bench power supply to monitor the current without a load, and it consumed, approximately, the published figure of 200mA. For a test load I used a mains work lamp (60W), and connected the unit to my car battery, and ran the lamp for some time to monitor the temperature raise, which was not excessive with this load.

You must not connect either of the mains connections to earth or to the battery connections, and never operate the unit in too confined a space or restrict the air flow through the unit. If you use the converter with a television set, then keep it as far as possible from the television to avoid interference - never lengthen the battery leads. Finally, if you use the converter at full load then the car battery will not last very long, so you would be advised to have the car engine running. Do not use the unit outside when it is wet or damp. I had to terminate my test for this very reason. Beware it will get very hot when running at full load.

Conclusion

This is a well engineered, rugged unit that should (if treated correctly) give a long reliable service. But do exercise the usual mains safety requirements when handling and using the converter.

Order Code VF35, price £129.99 inc VAT

Specification

Input voltage:	10.5V to 15V DC
Max current:	25A
Output voltage:	230V AC (-10%) for 14V DC i/p
Continuous o/p power:	250W (500W peak)
O/p frequency:	50Hz quartz controlled, modified sine wave
Efficiency:	80% max
Battery protection:	±10%
Temperature protection:	90°C (output devices)
Size:	270 x 60 x 85mm

PROJECT PARTS LIST

RESISTORS: (0.6W min res unless otherwise)

R1	10M
R2..12, 46	10k
R13	1M
R15	4M7
R16,17	47k
R18,19	100(
R20,21	100k
R22	470k
R23,24,25	3k3
R26	1k2
R27,28,29	10Ω
R30	820(
R31	27k
R32	1k5
R33	10k
R34	8k2
R35	1k
R36	56k
R37	16k
R38	2k7
R39	10k
R40	560k
R41,43,44	1Ω8 3W
R42	1Ω 1W

CAPACITORS

C1,2	22pF
C3	1nF
C4..7	10nF
C8	100nF
C9..13	2.2μF Elect
C14	33μF Elect
C15	100μF Elect
C16	1000μF Elect
C17	47μF Elect
C18	2200μF Elect
C19,20	22nF/600V

SEMICONDUCTORS

D1..14	1N4148
D15,16	1N4007
D17	6A6
D18..21	BYT56K
ZD1	3.9V Zener
ZD2,3	62V Zener (1N6290A)
ZD4	Link on board for 12V in
VR1	7812 12V Reg
T1,2	MPSA44
T3..6	IRF740
T7,8	BUZ345
IC1	4060
IC2	4017
IC3	4009
IC4	3525
IC5	LM224
L1	220μH
X1	2.4576MHz
TS	90°C Thermal Fuse
LD1	3mm Red LED
LD2	3mm Green LED

MISCELLANEOUS

Tran1	12V Converter Transformer TR3507
	30A Fuse and Holder
	Min On/off Switch
	PCB Pins
	PCB
	Heatsink Case
	T0220 Type Heatsinks
	Mica Washer x 2
	Thermal Compound
	PCB Spade
	Connectors

Software HINTS & TIPS

by Mike Bedford

Word 97's toolbars make life easier and quicker. This month we look at how to use them and manipulate them.

At one time word processors were controlled purely using key combinations and these are still available in Word 97. Furthermore, if you can remember them all, it's surely quicker to use them than to use the menus. For example, it's much quicker to type Ctrl V while you're typing than it is to move your hand over to the mouse, pull down the Edit menu and click on the Paste entry. However, my point about having to remember them is an important one. Some key combinations are intuitive whereas others - and Ctrl V is a classic example - are not at all what you'd expect.

Menu entries are easier to use since you only have to remember which menu includes the function you're looking for - and often this is obvious - but it is slower. Toolbars are the third option and are a reasonably good compromise. They contain icons that require just a single click. These icons are designed to be self-explanatory, and although it takes longer to click on an icon than to type a key combination, it is quicker than using the menu system. Using these toolbars efficiently is our topic this month.

Selecting Toolbars

An icon occupies a reasonable space on the screen so it's necessary to be selective about how many you display. Unless you've already customised your version of word, the top left corner of your screen will look like this:

If your screen does look like this you've got the default two toolbars enabled - Standard and Formatting. To confirm this, click on Toolbars in the View menu and you'll see ticks against the words Standard and Formatting. However, you'll notice that there are lots of other toolbars you could enable. Why don't you try some of them out now? Try clicking on the Tables and Borders entry, for example and you'll find that a toolbar that includes the following icons appears. Actually it won't look quite like this since some of the icons will be greyed out until you create a table. And don't forget, if you want to know what an icon does, just

move the mouse pointer over it and a pop-up yellow box will tell you. If you use tables and borders frequently, this toolbar will be very useful.

Flexible Toolbars

One other thing you'll have noticed if you played around displaying new toolbars is that they wouldn't all, necessarily, have appeared like the Standard and Formatting toolbars. Some might have displayed as floating boxes. The fact is that there are plenty of options for displaying toolbars and the reason isn't at all hard to appreciated. If you display a lot of toolbars and they're all at the top of the page you'll end up with very little space on screen to display your document. Being able to move the toolbars around, though, allows you to display them in a manner which is appropriate to the document or your way of working. You'll

notice that toolbars, when displayed at the top of the screen, have a couple of lines at the left hand side. You can see these on our first screen shot. Move the mouse pointer over these two lines, click and hold down the left mouse button, and you'll find that you can drag the toolbar to the left, right or bottom edges of the screen. Here's how the top-left corner of the screen would look if you displayed the default Standard and Formatting toolbars down the left hand edge of the screen.

One thing you will notice, though, is that the Style, Font

and Font Size boxes have gone from the Formatting toolbar since these are two wide to fit in a vertical toolbar. A few other icons have appeared by way of compensation. One other thing you could try is to start moving a toolbar but release it somewhere in the middle of the screen. You'll then end up with something like the following which is the Visual Basic toolbar.

This is an example of a floating toolbar. You'll notice that the two lines are missing from floating toolbars so if you want to move this around or return it to the top or another edge of the screen, just click in the blue title bar, hold down the mouse button and drag it to its new location.

And one final thing to point out is that the menu bar also has those two magic lines which means that it too can be attached to a different edge of the screen or made to float.

Customisation

But what we've seen so far is only a start. Not only can you select which toolbars are to be displayed and where they should appear on the screen, you can also decide which options are to appear in each of those toolbars. Let's see how this is done.

From the menu bar select Tools > Customize... > Commands. You'll see a Categories list box at the left and a Commands list box to the right. All the available icons are to be found somewhere by

using these two list boxes. So, choose an entry in the Categories list box and all the icons available for that category will appear in the Commands list box. And once you've found the icon you need, all you have to do is drag it into your chosen toolbar at the required position. Here is a portion of the Standard toolbar into which I've dragged some extra icons that you'll probably not recognise:

Of course you may change your mind about which icons you want displayed on which toolbar so you need to know how to reverse this customisation process. As with adding icons to toolbars, to move them around or to remove them you need to have the Customize... window displayed (from the Tools menu). Now you can drag any icon from any toolbar into a different position in the same toolbar or into a different toolbar. You can also drop an icon into the menu bar if you so desire or you could even drop it into an actual menu as shown in the screen portion below. And to get rid of an icon simply drag it out of a toolbar while the Customize... window is displayed - a cross will appear next to it once you do this - and drop it anywhere other than in a toolbar.

Back to Square One

As always my suggestion is that you try all this out to get a feel for it. And as we've seen, anything can be reversed if you don't like the look and feel of your customised Word 97. However, there's a quicker way of putting everything back to square one than undoing all the changes you've made individually. To put any toolbar back to its original appearance, select it in the Toolbars tab of the Customize... window and click on the Reset button. So long as you confirm this when it asks you to do so, everything will return to the way it was before you started to customise it.

RESEARCH NEWS

by Dr Chris Lavers

21st Century Liquid Crystal Displays Today for the Needs of Tomorrow

In this first part, Dr. Chris Lavers looks at the history and development of LCDs up to the present time

Liquid crystal displays are now available in a wide range of commercial devices from simple digital watches (which currently do not permit e-mail and internet capability but may change in the future!) to mobile phones, lap-top computers and high-resolution flat panel television displays. It seems a timely point to review the incredible pace of development in liquid crystal technology over the last 100 years firstly by looking back to the origins of Liquid Crystal Display (LCD) technology. In the second part we will look into the future of LCD applications and liquid crystal devices for sensing and communications applications.

A brief history of Liquid Crystals

It was only just over a hundred years ago, on 14th March 1888 in fact that the Austrian botanist and chemist Friedrich Reinitzer noted that the organic material cholesteryl benzoate showed very unusual behaviour on melting. Initially, it became a cloudy liquid on heating to 145°C and then completely clear at 178.5°C. Subsequent studies on the part of several eminent scientists of their day - Lehmann, Vorlander and Friedel - established that the intermediate phases of this and several similar compounds represented new states of matter that are distinct from the isotropic phase. Lehmann named them liquid crystals, a term which is certainly more popular than Friedel's 'mesomorphic states'!

As a general rule a substance in this liquid crystal or mesomorphic state is strongly anisotropic (or dissimilar in different directions) in some or all of its properties and yet many still exhibit a significant degree of fluidity comparable to that of an isotropic liquid. The existence of liquid crystal behaviour amongst inorganic substances is uncommon, compared with approximately 1 in 200 of organic compounds. Several thousands of organic compounds are known to exhibit liquid crystalline behaviour with further synthesis adding to this number daily.

For liquid crystal behaviour to occur it is essential that the molecules are highly geometrically anisotropic, usually long rod-like molecules, although the precise form of the geometry need not necessarily be rod-like, in fact doughnut or disk shaped molecules will do! Depending upon the particular molecular geometry the liquid may pass through one or more mesophases on heating before it finally ends up as an isotropic liquid where all properties are the same no matter which direction you look. Transitions to these intermediate states may be brought about by either fairly straightforward thermal (heating processes), or by the influence of solvents. The second of these occurs when the liquid crystal is dissolved in a suitable solvent, most often water, and the liquid crystal phase is formed over a specific range of solvent concentrations. Briefly these so called lyotropic liquid crystals are generally derived from long helical rod type structures or amphiphilic compounds. Viruses are often found as typical long rod shaped molecules, such as the Tobacco Mosaic Virus (TMV), which has large molecular dimensions: 3000 Angstroms long by 200 Angstroms wide. The amphiphilic class are characterised by having a section of the molecule hydrophobic (water hating) and a section hydrophilic (water loving). As the concentration of water solvent is increased the organic molecules form a variety of packing structures from simple layered (lamellar) to a cubic and finally to a hexagonally close packed phase (see Figure 1). These lyotropic liquid crystal phases are of fundamental importance in living biological systems and occur abundantly in nature, including our own bodies. Phospholipids are amphiphilic molecules which form the basis of cell membranes, which mixed with a small amount of water stack into multilayered or smectic liquid crystals. Amphiphilic molecules organise into simple bilayers separated by water so that the head groups lie at the lipid-water interface. A familiar example of such a system is soap (sodium dodecyl sulphate) in water. In the lamellar phase, water is sandwiched between the polar heads of adjacent layers, whilst the hydrocarbon tails are in a non-polar environment. In the cubic phase the layers are bent to form spherical units. In the hexagonal phase the layers are rolled up into cylinders.

Liquid crystals of greatest present benefit to the display industry are the thermotropic family types. Their applications range from temperature sensing (due to selective reflectivity of a cholesteric as its pitch changes with temperature) to flow

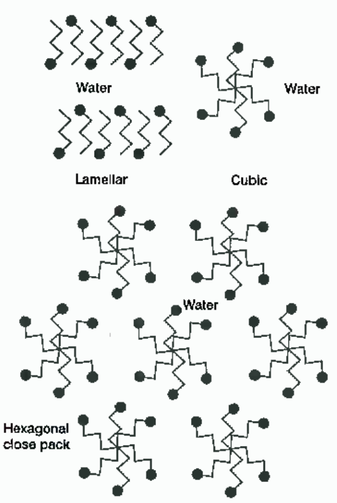


Figure 1. Lyotropic phases of liquid crystals (a) Simple lamellar (b) Cubic (c) Hexagonally close packed.

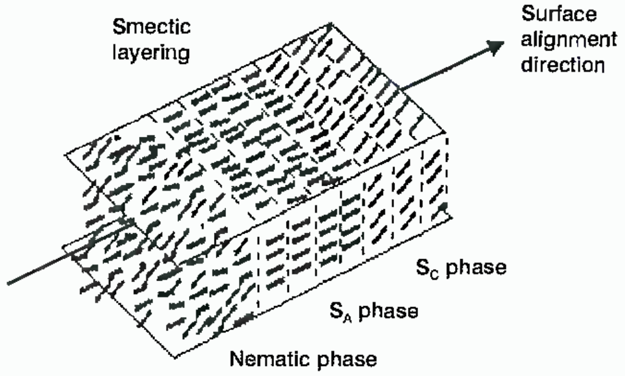


Figure 2. The Nematic phase, the Smectic A phase and the Smectic C phase.

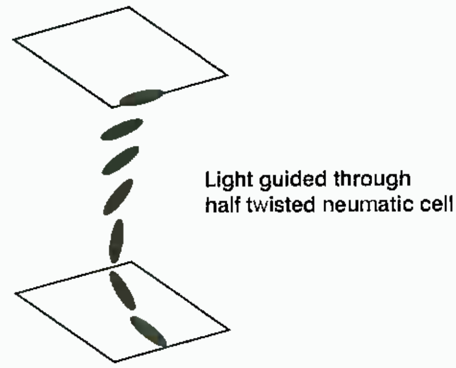


Figure 3. Conventional nematic cell showing molecules before and after an applied electric field perpendicular to the plates.

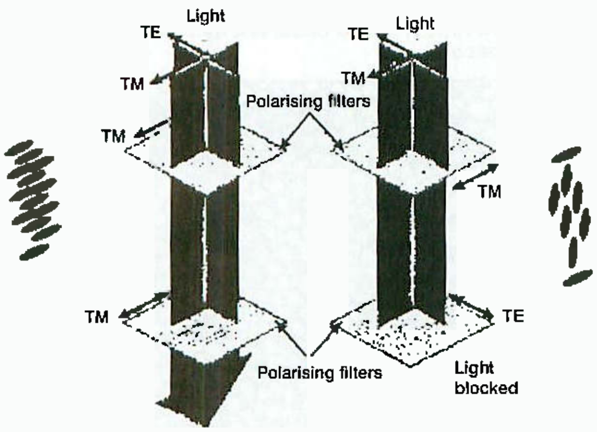


Figure 4. Twisted nematic cell showing successful transmission and blocked transmission.

measurements of thin encapsulated liquid crystal films on turbine blades and aeroplane wings.

The phase most commonly used in flat panel, low power display device is the Nematic liquid crystal, which has long range order of the molecular axis (see Figure 2). There was little interest in the commercial application of liquid crystals in the display area until the development of the first liquid crystal electro-optic device utilising the 'dynamic scattering' effect in 1968 by Heilmeier. Competition and progress was then swift leading rapidly to the twisted nematic display device and to the stage that liquid crystal displays have become increasingly widespread in our everyday life.

Schadt and Helfrich described what is commonly known as the twisted nematic effect, where an electric field is applied perpendicular to the plates of a liquid crystal cell and is used to realign in the bulk to a uniform nematic with the long molecular axes lying perpendicular to the plates (homeotropic). In the twisted state if the cell thickness is much greater than the wavelength of the incident light then the twisted structure guides light through the system. Under the application of a DC voltage the uniform homeotropic nematic no longer guides the incident light through the sample, giving high contrast ratios between the light and the dark states (see Figure 3). The simplest practical cell is probably the twisted nematic cell. Light of one polarisation passes through the first polaroid, and then the second polaroid. If the second polaroid is twisted by 90° then it will not transmit polarised light. A cell with a half twist between the two aligning plates will then guide light between crossed polaroids (see Figure 4). Voltages do not need to be very high and in fact are seldom above about 12V as it is the electric field which is responsible for the molecular reorientation (E=V/d where d is the cell thickness). Since typical liquid crystal cells in the nematic phase are of the order of 10-20μm, and in the more ordered smectic phases are less than 5 microns, field strengths are typically of the order of 1MV/m! In fact in my own experience it is possible to successfully generate pretty lightning bolt effects with arcing over between the electrodes of a liquid crystal cell!

Liquid Crystal Phases

Following the original method proposed by Friedel liquid crystals are classified into three types: nematic, cholesteric and smectic.

Nematics

Friedel coined the word 'nematic' from the Greek 'νεμα' meaning a thread and refers to certain thread-like defects (or disclination lines) which are commonly observed. A schematic representation of the order in a nematic phase is shown in Figure 2, and the real optical 'texture' of a typical nematic liquid crystal phase is shown in Figure 5.

In a nematic phase molecules are on average aligned such that their axes are parallel so that a preferred direction is imposed on the system (see Figure 2). The optic axis or director coincides with the defined direction. For most nematics there is rotational symmetry about the long molecular axis so that the phase is identical in all its properties at right angles to its long axes (uniaxial). The absence of long-range positional order determines the fluid character of the nematic phase. In fact a typical nematic such as PAA has a viscosity of 0.1 Poise, about 10 times larger than pure water at room temperature! Flipping the molecules back to front makes no difference. A nematic phase can occur either with molecules that have mirror symmetry, or with an equal mixture or right- and left-handed cholesteric or chiral nematic phases.

Cholesterics

The Cholesteric or Chiral Nematic (N*) phase in addition to long-range orientational order has a gradually twisting spatial variation of the director leading to a helical structure. The cholesteric phase is represented in Figure 6.

If a series of planes perpendicular to the helical axis is considered, orientational order exists in each plane as in the nematic phase. However, the local direction of alignment of the molecules is slightly rotated between adjacent planes. The most striking feature of cholesterics however is their strong optical activity and their selective reflectivity of light. The optical activity and selective reflectivity of light are due to the twisted structure and are inherently related to the twisting pitch. The pitch can be strongly temperature dependent. This effect is utilised in liquid crystal thermography. The encapsulated cholesteric liquid crystal is placed in direct contact with the object to be examined and different colours are selectively reflected (Bragg scattered) from the parallel planes of which the helical structure is composed. This effect has been commercially developed in devices used to sense local temperature changes. In our own work a planar glass waveguide sensor incorporating an encapsulated thermotropic liquid crystal (see Figure 7) has been demonstrated successfully (see Figure 8).

Smectics

Smectics from the Greek 'σμεγμα' meaning soap was coined by Friedel, the two simplest and

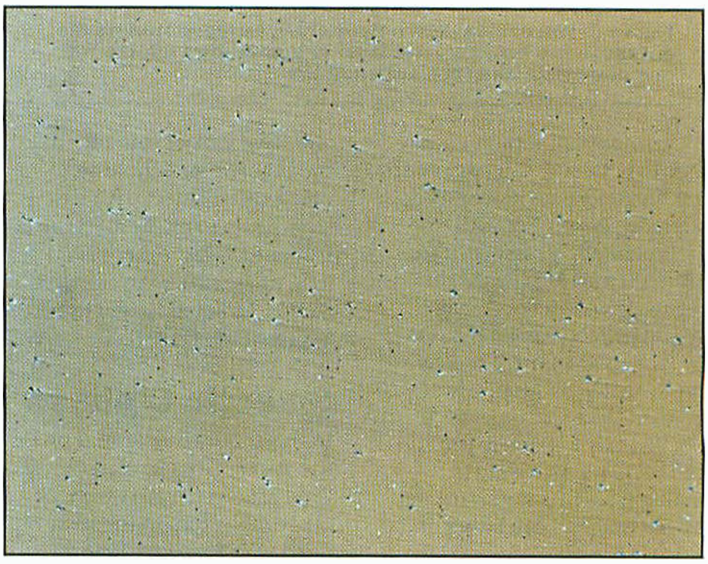


Figure 5. The nematic phase observed by conventional optical polarised microscopy.

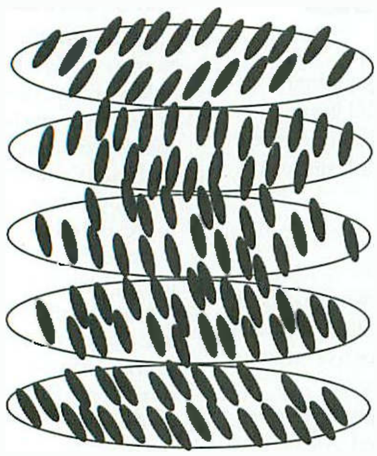


Figure 6. The Cholesteric phase.

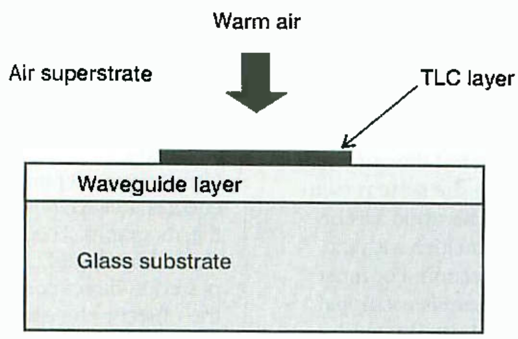


Figure 7. Planar waveguide coated in an encapsulated thermotropic liquid crystal layer.

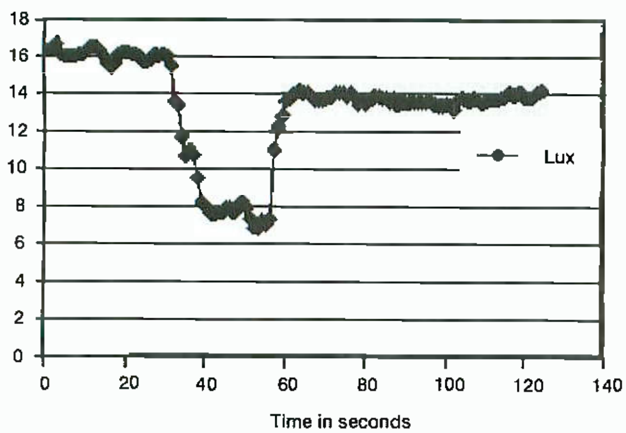


Figure 8. Waveguide light output changes monitored as the air above the liquid crystal layer is heated through the full nematic range and then switched off.

most important (commercially at least) of many smectic phases are the Smectic A and Smectic C phase.

Structurally all smectics are layered structures, with a relatively well-defined layer spacing which can be measured by X-ray diffraction. The first X-ray evidence to support well defined layer spacing was obtained by E. Friedel, the son of G. Friedel, following a tradition set in X-ray scattering by the Braggs, both father and son! G. Friedel discovered the smectic A phase. Smectics are more ordered than nematics and have lower symmetry than the nematic and cholesteric phases. The smectic A phase is shown schematically in Figure 2. Inside each layer there is no long range order. An actual Smectic A liquid crystal texture is shown in Figure 9.

Smectic C phase

In this more complicated phase the average long molecular axis is on average aligned with all other molecules in the layer but tilted with respect to the layer normal by an angle 'θ', as shown again in Figure 2.

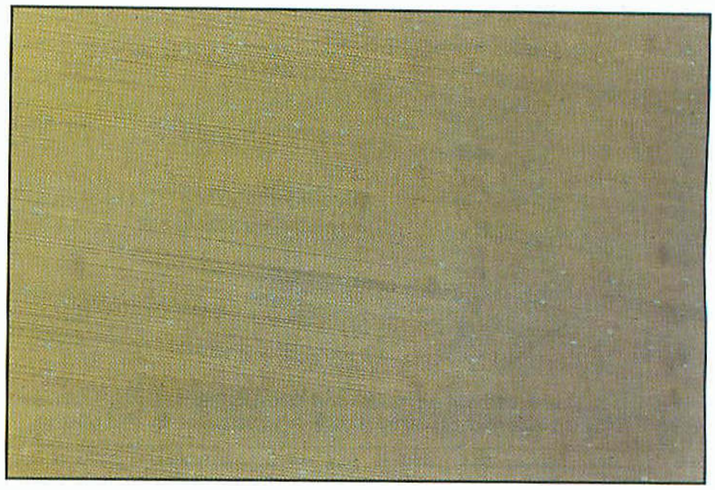


Figure 9. The smectic A phase observed by conventional optical polarised microscopy.

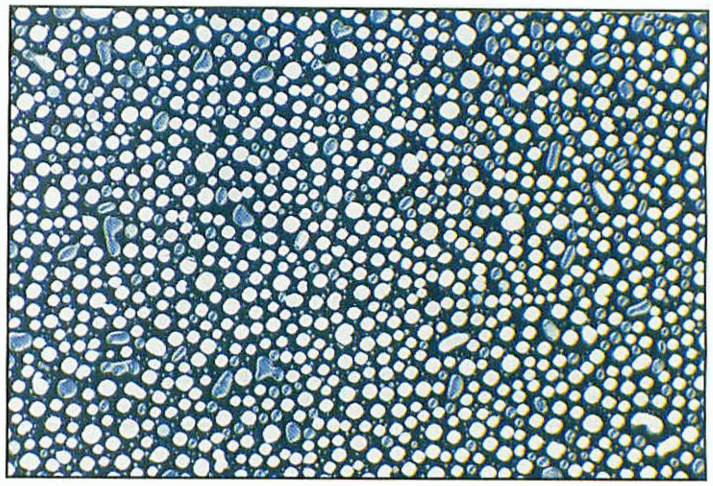


Figure 10. The optical texture of a liquid crystal cell just below the Nematic-Isotropic Transition.

However, the real fun starts with the presence of a permanent molecular dipole attached to a molecule that will make the liquid crystal ferroelectric, which reorients the molecule under an applied electric field, and changes the crystal symmetry. Liquid crystal textures change as the phase changes, for example a liquid crystal just below the Nematic-Isotropic transition is shown in Figure 10, and a typical Smectic A phase is shown just above the ferroelectric transition temperature to the ferroelectric or Smectic C* phase (see Figure 11). Optical changes in a cell continue from just below the Smectic A to C* phase transition observed by conventional optical polarised microscopy (see Figure 12a) well down into the Smectic C* phase (see Figure 12b).

All liquid crystal structures can exist in a variety of textures - that is the optical patterns observed in thin layers with a polarising microscope. These textures are normally complicated by the presence of line defects at which an abrupt change in molecular orientation, a 'disclination' occurs. For device applications it is critical that the liquid crystal phase which forms must be completely uniform over large areas if not all of the display. Once formed liquid crystal defects have a nasty habit of either growing or staying firmly put after several temperature cycles, although controlled temperature cycling will help to 'iron' out some of the defects.

A Chevron in The Layering!

As the temperature reduces from the Smectic A to the Smectic C* phase, the layers will start to shrink. Since the layers are firmly anchored at the aligning surface, in order to maintain the fixed spacing of the smectic A phase (often referred to as the density wave layer spacing), the Smectic C* layers have to tilt as a response to the 'shrinking' which occurs. Something similar can be seen when you take a stiff piece of upright card and try to bend it by pushing inwards from both ends. Initially it bows or 'bananas' out slightly and then suddenly and dramatically kinks

Figure 11. The optical texture of a liquid crystal cell just above the ferroelectric Smectic-A Smectic C* transition.

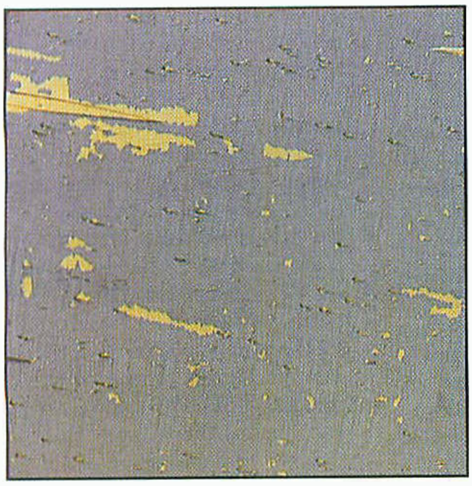
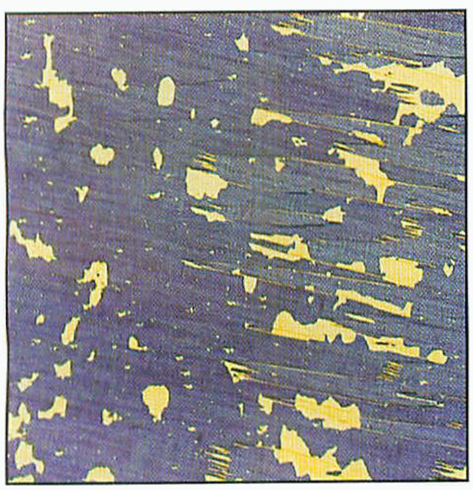


Figure 12. (a) The optical texture of a liquid crystal cell just above the ferroelectric Smectic A- Smectic C* transition. (b) The optical texture of a liquid crystal cell well below the ferroelectric Smectic A-Smectic C* transition.



near the middle of the piece of card. The stiffer the material the greater the energy required to deform the card. Similarly in the liquid crystal layering, when sufficient energy is supplied the layer suddenly kinks over. The kink deformation which then forms, just as in the piece of card, is 'locked' into the cell leaving a 'memory' if you like, even after future temperature cycling. This shrinking and tilting of the liquid crystal layers forms a clear 'Chevron' in the layers (see Figure 13), which was verified experimentally by both X-ray scattering in the late 1980's and by laser based optical probing techniques. Various frustrated liquid crystal modellers have come up with a variety of both fruitless and fruitful models to correctly explain what was going on. This included the so called 'banana' model which for a number of years seemed a much more plausible model than the idea of a single 'kink' forming somewhere near the middle of a very thin liquid crystal cell. To further confuse things the Chevron in the layers caused the molecules to give a large fixed optical 'twist' out over most of the cell, irrespective of the anchoring of the liquid crystal molecules at the surface which led to the 'fast' banana model.

Switching Speeds

But why all the interest in ferroelectric liquid crystal displays anyway? Two reasons initially, speed and memory or bistability. For the various effects which liquid crystal devices may employ the switch on (t_{on}) and switch off (t_{off}) times are often important, usually times are quoted for 90% and 10% saturated response respectively. High-speed devices rely on the movement of electrons only, thermal and molecular processes are unfortunately much slower, but how slow. Liquid crystal devices are in the slower category because the process involves the realignment of molecules. In the ferroelectric phase this realignment process is given by the coupling of the ferroelectric dipole Ps to the Electric field E such that $1/\tau$ the switching time is proportional to Ps.E as shown by Meyer. Unfortunately, this wasn't the end of the story, as although scientists ran off and started to synthesise new Smectic C* liquid crystals afterwards it was shown that fast potential switching speeds were actually offset by the presence of a dielectric term $-\epsilon E^2$ giving rise to a minimum in the switching time. However, switching times typical of milliseconds rather than hoped for microseconds still offers many potential applications, although unsuitable in current form for fast digital data rate communications applications.

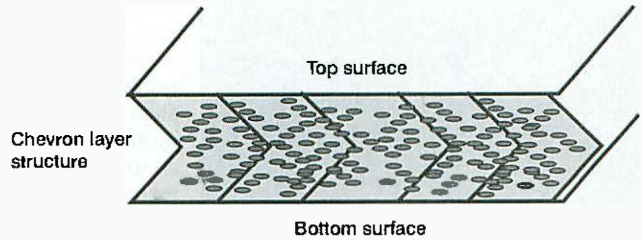


Figure 13. Chevron in the Smectic C* layering

The second point involves a cell which would sit in one of two optical states, optically equivalent to a digital 'on' or 'off' until the application of an applied voltage of the opposite polarity. This potentially would reduce the problems being encountered by large area nematic liquid crystal displays where the time between pulsing a voltage across an individual display element or 'pixel' was becoming so large due to the physical display size. Instead of a clear dark/light contrast only partial reorientation of the molecules was taking place, so that most of the time elements gave an average 'grey' intensity as the molecules 'relaxed' back to their resting state.

Figure 14a shows a ferroelectric cell switched one way on the application of a small DC voltage. Figure 15b shows the same ferroelectric cell switched in the opposite field direction. Upon the application of a DC bias voltage the equal likelihood (or degenerate bistability) of these two energetically favourable states is broken and the dipoles in both regions try to align pointing in the same direction parallel to the applied Electric field. Reversing the polarity of the applied electric field causes both regions to switch into the other possible uniform state. With a slow ramped voltage it is possible to take pictures of the switching process as different regions of the favoured optical state nucleate and grow across the cell. Figure 15 shows the formation of one of the states with a positive applied electric field in the middle of switching. Two types of defect are commonly observed in display cells, designated lightning (see Figure 16a) and hairpin (see Figure 16b) defects for obvious reasons. These defects are also often referred to as 'Zig-Zag' defects and are due to regions of different oriented layering coming together in a disordered pile-up. In both types the colour changes from a bright to dark or vice-versa whenever the disclination makes a turn. These defects or disclinations occur between regions of oppositely directed chevron layering, with uniform UP and DOWN domains either side of the defect but on one side of the defect both UP and DOWN domains will have the same direction in the smectic layering. Zig-zag defects present a considerable technical hurdle to the implementation of large area ferroelectric liquid crystal cells. The second hurdle is that cells which should be bistable, are rarely so, often relaxing back across large regions of the display to the preferred original direction rather than staying in the intended switched state. Yes a memory effect, but of the original domain cell orientation!

Liquid Crystal Alignment

In order to make decent large area single molecular orientation (domain) of well aligned liquid crystals, two limiting cases are important.
1.Homeotropic layers, in which the molecular axis or director is everywhere perpendicular to the walls of the cell, and
2.Homogeneous alignment,

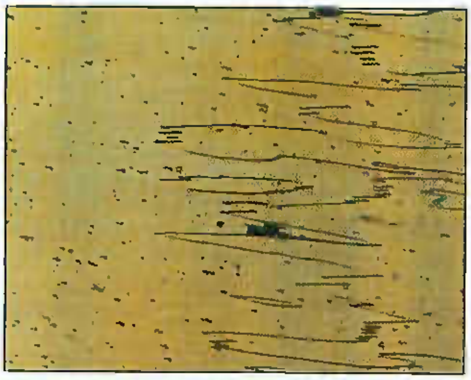
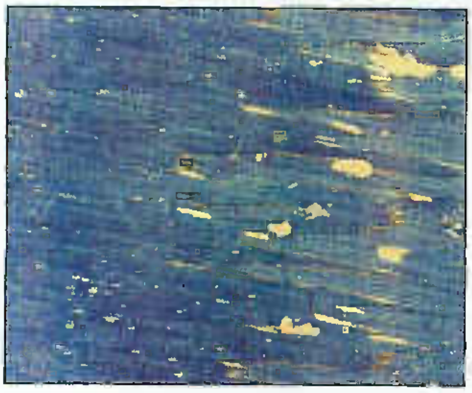


Figure 14. (a) A cell switched one way under an applied electric field. (b) The previous cell switched with the opposite polarity electric field.



xFigure 15. Nucleation of domains during switching.

where the director is in the plane of the substrate. In homeotropic alignment the more reliable and controlled techniques involve the use of surfactants, such as lecithin found on the lining of the human lung.

The first preparation of planar or homogeneous samples currently used in displays involved the directional rubbing of a glass substrate with paper. Understanding the mechanism or mechanisms by which alignment is achieved was very poor, and is still not ideal, being regarded somewhat as a 'black-art'! Alignment can occur in a combination of ways: including microscopic surface grooving, deposition of rubbing material and charging of the surface.

Another well-used technique involves the vacuum deposition of thin films under oblique incidence, SiOx, now a commonly used commercial anisotropic alignment layer. It is believed that corrugations are formed from columnar growth of the SiOx layer. A rubbed polymer alignment technique achieves parallel low surface tilt alignment, where a monomer is spun onto the substrate, unidirectionally rubbed and then polymerised giving alignment of the liquid crystal. A monomer is firstly spun onto a conductive glass substrate, usually coated with Indium Tin Oxide. The 50nm thick polymer layer is heated to remove solvent, rubbed mechanically in a chosen direction several times by hand or machine, achieving low surface tilt, and then polymerised at several hundred degrees Centigrade. Examining a typical rubbed polymer layer with a Scanning Electron Microscope (see Figure 17) it is seen that the surface is covered with a background of fine lines parallel to the rubbing direction and large 'strips' of different material parallel to the rubbing direction. It is believed from this that as the large 'strips' are on the scale of microns they cannot possibly be responsible for alignment and are probably due to deposition of rubbing cloth material, the fine scale lines may be microscopic grooving on the surface causing the alignment.

Alignment in the Smectic A and nematic phases is relatively well understood. Molecular alignment will propagate out from the aligning cell surfaces up to 100μm. On average the long molecular axis will lie along the preferred axis created by polymer rubbing. Differences in polymer curing or differing evaporation angles of silicon oxide can create significant surface tilt of the order of tens of degrees, leaving the mechanical director tilting away from the rubbing direction, the so called 'high-tilt' regime. In general, Smectic A layering forms perpendicular to the bounding walls.

The alignment in the SC* phase is not well understood. For alignment to succeed in the Smectic C* phase it is necessary for the cells to be much thinner, of the order of a few microns. The smectic layering is modified to accommodate the shrinkage of the layering with the formation of the previously mentioned chevron layer structure. In a thick cell, greater than say 5μm, the twisted state is likely to occur, involving a half twist of the alignment axis through the sample. For thin sample cells methods utilising shearing, rubbing and silicon oxide, and oblique evaporation are used.

So liquid crystals have had an interesting history so far including bananas, chevrons and half twists! In the next part we shall spend some time looking at real devices, applications and future applications.

Figure 16a. Lightning defect
<<<*>>>

Figure 16b. Hairpin defect
>>>*<<<

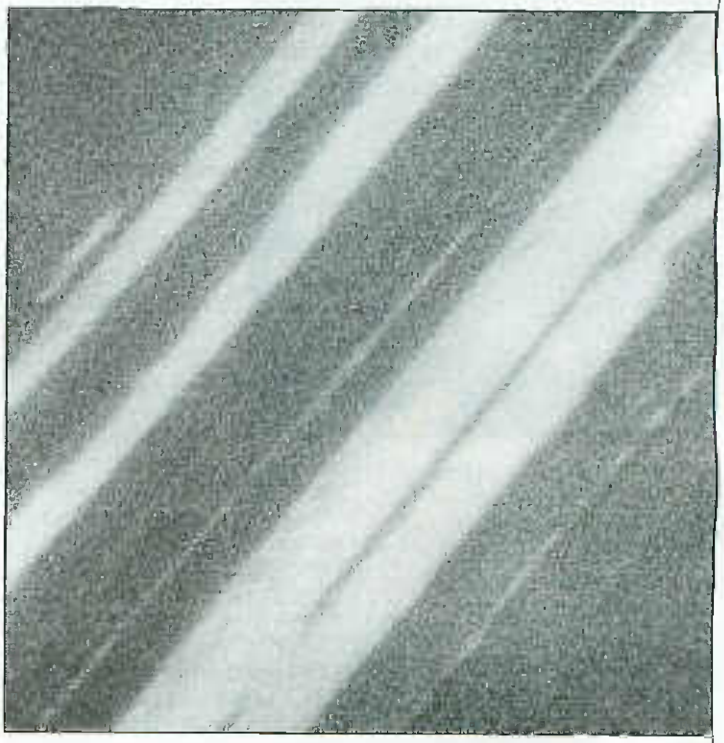


Figure 17. SEM of a typical polymer alignment layer.

Speech PROCESSING

Reg Miles looks at the latest developments in speech processing

Speech processing has been developed to the point where it can be integrated into products without causing endless frustration through frequent misinterpretation of commands. Software packages are available for computers that provide command and control facilities, dictation and, possibly, a read-back facility, thus rendering the keyboard and mouse largely obsolete. Mobile phones are appearing that can be 'dialled' by voice commands. And other consumer products are seen as ripe to receive spoken commands - cooker, microwave, washing machine, TV, even switching lights on and off. Some will also be given the power to reply: you might ask the TV whether a particular programme is on any one of the multitude of digital channels that evening?

These 'man-machine interactions' also extend to forms of user verification and identification in public, with speech being just a part of the wider field known as biometrics: the automatic identification of a person based on physiological or behavioural characteristics - the most popular at present being face recognition and fingerprint matching. But all of them are essentially nothing more than pattern recognition systems. In the case of speech the pattern being the unique characteristics of the speakers' words extracted from the acoustic signal.

Phonation

These characteristics are caused by the vocal tract (shaded area in Figure 1); the organ that produces speech by modifying the spectral content of acoustic waves as they pass through it. The waves are produced when air from the lungs is carried by the trachea through the vocal cords (folds of the lining membrane of the larynx). Depending on how and where the air flows within the tract it gives rise to phonation. This is when the airflow is modulated by the vibrating edges of the vocal cords), frication (produced by constrictions in the vocal tract), and other forms of excitation known as compression, vibration and whispering, or combinations thereof.

Sound produced by phonation is called voiced, that produced by phonation together with frication is called mixed voice, and that produced by other forms of excitation is called unvoiced. Voiced sound has component frequencies that are exact multiples of a fundamental frequency which is determined by the tension of the larynx muscles; unvoiced sound has no harmonic frequencies but consists of a wide frequency band. The larynx regulates the pitch and intensity of the former and the intensity of the latter; their spectral content is then modified by the mouth and nasal cavities that form double or triple Helmholtz resonators. The result is speech

Automatic Speech Recognition

It is the minor variations in these characteristics that colour speech and make it unique to each individual. Unfortunately, this makes it more difficult for Automatic Speech Recognition (ASR) systems to recognise individual words. That and the fact that words are not normally pronounced individually but flow into each other at a rate that again depends on the individual speaker.

After digital sampling, the ASR attempts to remove the individual characteristics of the speaker from the acoustic signal by pre-processing. It will also attempt to remove all other characteristics that colour the signal: the medium - microphone, telephone; and the environment - the level and types of noise.

The wanted signal is then generally processed to produce a spectrographic representation in which the energy of the utterances in fixed segments of time is measured as a function of frequency, with the object of reducing the bandwidth required. Analysis techniques used include Fourier transformation, power spectral density analysis, extraction of linear predictive coding (LPC) and cepstral coefficients (the cepstrum being defined as the inverse Fourier transform of the logarithm of the magnitude spectrum), and digital filtering.

The sequence of patterns generated by the pre-processing is then compared to acoustic models - patterns stored or learned by the system. Again there are a number of processes to achieve these comparisons: dynamic time warping, hidden Markov modelling, neural networks, expert systems, and various combinations of techniques. These acoustic models will consist of words if only limited recognition is required, or phonemes if recognition of more than about 100 words is required. It is worth noting that AT&T has been developing very large vocabulary ASRs, such as a 500,000-word dictation system. Surprisingly, experimental results have shown that increases in vocabulary size improve recognition performance.

Phonemes

Phonemes are the basic sounds that go to form words; so all words can be formed from the thirty to fifty phonemes that every language uses (English has about forty; and these are spoken at an average rate of about ten per second). The accuracy with which phonemes can be identified is improved if it is done within context - placing each in relation to preceding and succeeding phonemes. Sequences of likely phonemes are then compared against the words and patterns of words that are specified by the active grammars. That is the words that are permissible and the sequence in which they can be used is constrained by either the limited processing capability of the speech recogniser or the natural grammar of the

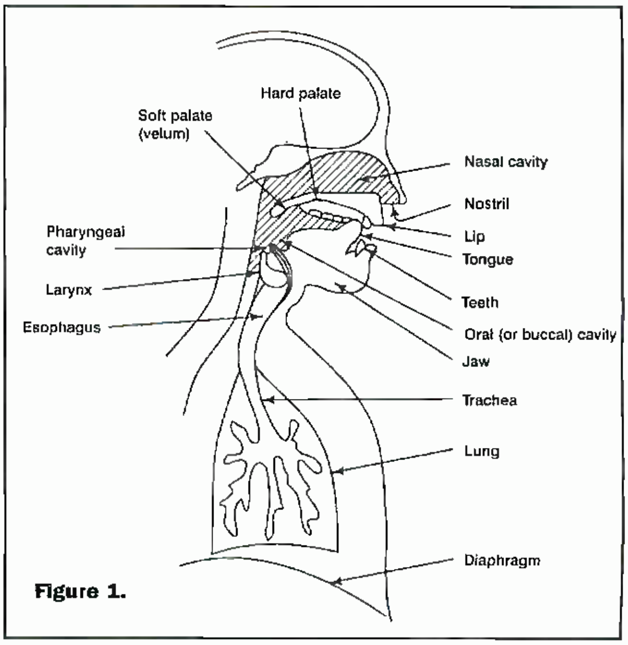


Figure 1.

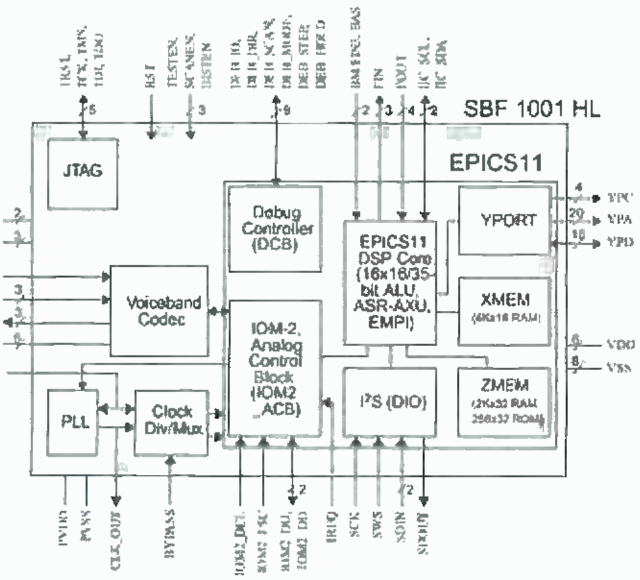
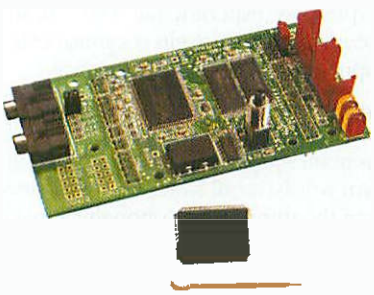


Figure 2b.

Figure 2a.



spoken language. The result is then presented as the best guess of the user's utterance.

Recognition

There are also three categories of recognition: speaker dependent, speaker independent and speaker adaptive. The speaker dependent system is trained by the individual who will be using it so that it learns the words exactly as they will be pronounced. Usually this only requires a single utterance for each word. The advantages are that the accuracy rate is higher, particularly if the speaker has a strong accent, an unusual voice or a slight impediment, and it does not have to be designed for any particular language. The disadvantages are that it takes time to enter the voice samples - which limits the possible vocabulary, and that it will only respond accurately to that individual. A speaker independent system will, as the name implies, respond to any average user. To this end it is pre-trained with multiple samples of the words to cope with a wide variety of speakers. The advantages of this approach are that the system is immediately usable, and anyone (theoretically) can use it. The disadvantages are that the accuracy is somewhat less - particularly in the aforementioned cases of atypical voices, and it is language specific. A speaker adaptive system is a combination of the previous two: it has a stored vocabulary; but this will be modified with use to improve recognition.

Different types of ASR require different styles of speaking. Isolated systems are designed to handle words delivered separately, with a pause between each one. Thus the recogniser has only got to analyse and identify bursts of sounds, not cope with a more or less continuous stream of sound. A connected system allows the user to speak multiple words. While a continuous system allows continuous speech: the type used for computer dictation; and, until recently, virtually impossible to achieve with accuracy.

A Philips speech recogniser IC is shown in Figure 2a, and the block diagram in Figure 2b. This is used for building into consumer products: or it can be used as a hardware accelerator for dictation systems.

Accuracy

The question of accuracy, of all types of ASR, depends on a number of factors. Clarity of speaking is obviously important, particularly for a speaker independent system using continuous speech. The accuracy will be improved if the background noise is low, and the microphone is of good quality - which rules out the token microphones generally fitted in computers. Not only are they likely to be of poor quality, but they will pick up all the computer noises, too. Microphones specifically designed for speech recognition are available that have good directional characteristics, or make use of noise cancellation or reduction techniques. Philips has produced an unusual variation on a dedicated microphone in the form of the SpeechMike (see Figure 3), which combines microphone, speaker and trackball into a hand-sized unit.

However, ASRs still make mistakes, more than do people in the same situations. Just how irritating this is will depend on what needs to be done to correct it, and how potentially damaging the error may be. Fortunately, many of the latest systems are designed to improve their accuracy with use. Dictation systems may also have a limited contextual ability, so that like-sounding words such as sail and sale are correctly spelt in the text and not always queried.

One additional problem that can arise with dictation systems is that dictating for two to three hours can cause a sore throat. However, that can probably be overcome by taking regular breaks and having something to drink.

Speech synthesis, conversely, should cause no health problems. This is exactly the opposite of speech recognition in that it converts digitised text into speech - hence the alternative name of text-to-speech (TTS).

As with speech recognition, TTS has improved considerably over the last few years with the latest and best offerings no longer sounding robotic. However, it would be an exaggeration to say that they sounded quite natural. The variations in prosody and intonation, and the variations in the pronunciations of words (even the same words) according to context that combine in everyday conversations to give speech its natural quality still largely elude even the best examples. Additionally, it has to make sense of a word like 'row' to be able to pronounce it either to denote a row of objects or an altercation (at present it will probably either mispronounce it or seek help from the user).

XML

To begin with the input text is converted into a markup language, usually eXtensible Markup Language (XML) or some related variant, that provides structural information about paragraphs and sentences, how the words should be pronounced, and prosodic information, by using tags like those in HTML (eg, <emp> for emphasise). Incidentally, there is a new mark-up language - VoiceXML - intended to

make Internet content and information accessible via voice and phone. The text can then be converted into speech.

This begins with text-to-phoneme conversion, in which each word in the text is converted into its sequence of phonemes. Then comes prosody analysis: the processing of the sentences, words and phonemes to achieve natural sounding pitch, timing, pausing and delivery rate. And it is from these that the speech is synthesised.

There are two basic types of synthesiser in use: formant and concatenative. The formant attempts to model the main features of real speech by using a source/filter model. The filter is described by a small set of formants (a formant being the envelope of the frequency pattern arising in the vocal cords) and represents articulation in speech, while the source represents phonation. Both are controlled by a set of phonetic rules. The concatenative synthesiser relies on a database of sampled speech, with the words broken down into coded segments. These can be syllables, phonemes or diphones. The first two have the problem of a lack of fluency at the transitions when joined to produce words, but diphones, conversely, are segmented in the middle of phonemes, thus leaving the transitions intact. Whatever is used the synthesiser then concatenates the segments, smoothes their transitions, and produces the speech signal.

TTS can be used on its own, for applications such as announcements that require more variation than can be dealt with by recorded speech, or for getting a computer to read files over a phone.

It is also increasingly being used in conjunction with speech recognition to communicate directly with people (see Figure 4). Depending on the system its recognition and responses may be limited to stock phrases or it may be able to recognise and respond to natural speech. In this natural dialogue case the system will query anything it cannot assess. And, to be able to cope properly, it should have the facility to allow 'barge-in' - its output being interrupted by the speaker. Which is not as straightforward as it sounds as the system has to recognise that it is being interrupted, it then has to pause, recognise what is being said, and modify its response accordingly. Another thing that all speech recognition systems need to cope with, but do not necessarily do so, is the 'out of vocabulary' sounds such as coughs and sneezes. Also other people talking and either preventing recognition or causing spurious responses (at present this is largely defying attempts to overcome it).

The related problem of devices responding to conversational speech can be overcome by prefacing commands with an appropriate code word - 'TV', 'Cooker', or whatever.

Direct Communications

Recent applications of direct communications, in the form of automatic telephone dialogue systems, include Omnitel 2000 and Swedish National Railway's Talking Train Timetable. The former is an Internet portal provided by an Italian mobile phone operator that is accessible via a combination of speech recognition and hyper-text over any phone, as well as directly through the Internet or via Wireless Application Protocol (WAP) mobiles. The railway application provides timetable and travels information using natural dialogue; with the system provided by Telia, a supplier of telecom and information services, using Philips SpeechMania (a software package for human-computer dialogue). Earlier examples of Philips train timetable systems have been in use in Germany and Switzerland for some years. AT&T has a similar system, the result of their Toot project. An extract from a transcript of dialogue between it and a user is shown in Figure 5 (there were no trains at the specified time, but the user changed to 1pm and there was a choice of two).

S.3.1 What city do you want to go to Boston from?

U.4.1 Washington DC

S.5.1 On what day of the week do you want to go to Boston from Washington-D-C?

U.6.1 Thursday
U.6.2 3 thirty pm [ASR result: Thursday]

S.7.1 What time do you want to leave on Thursday?

U.8.1 3 thirty pm
S.9.1 Do you want me to find the trains going to Boston from Washington- D-C on Thursday
S.9.2 around 3 thirty p-m now?

U.10.1 yes

S.11.1 I am going to query the Amtrak web site for you

Figure 5. An extract from a transcript of dialogue between AT&T Toot Project and a user.

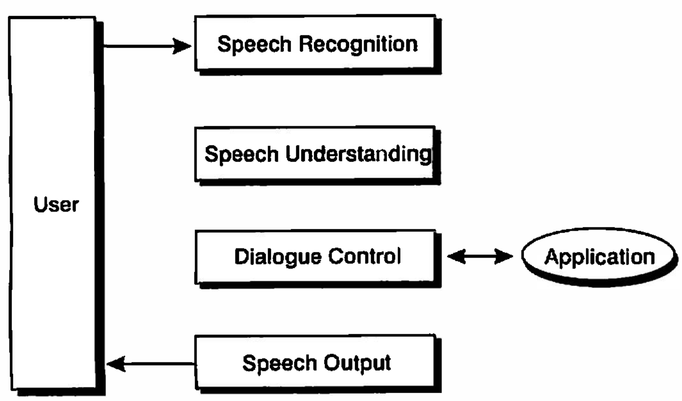


Figure 4.

Philips has also just entered into an agreement with PricewaterhouseCoopers, the world's largest professional services organisation, to promote speech-processing technology. Initially, the companies will target the banking, travel and mobile telecomm industries, using Philips SpeechPearl and SpeechMania software.

AT&T has taken the idea of natural communications a stage further and has developed a talking head system for those situations in which people, and particularly children, might feel more relaxed than with just a disembodied voice. There are two variations: a computer generated 3D head (see Figure 6a) and a video sampled head of a real person talking - 'Tracie' (see Figure 6b). In both cases the mouth moves in response to TTS phonemes and, for naturalness, the main facial features and head itself move (the facial features are animated individually to save memory).

Wearable computers also make use of both speech recognition and TTS - usually via a headset. When there is not room for a keyboard and there is only a tiny LCD screen it makes vocal communication very practical if not indispensable.

Another practical application is in cars, which will enable drivers to keep their hands on the wheel and eyes on the road while adjusting the controls. Those systems that are already available include making phone calls, on-board navigation, a web browser for information and e-mailing - all voice controlled.

Speech recognition on its own also has a variety of uses beyond that of command and control and dictation. Compaq's SpeechBot and Dragon's AudioMining are two very similar cases in point - both transcribe audio programmes to text. SpeechBot is a web search facility provided by Compaq for those who want to search for particular (US) radio programmes. Keywords are entered and, if a match is found, a transcript can be viewed or all or part of the programme can be played on RealPlayer. The Dragon system is intended for a broader commercial base such as call centres, TV and radio broadcasters, conference management, etc.

The BBC is also experimenting with speech recognition for recording radio and

Figure 6a.

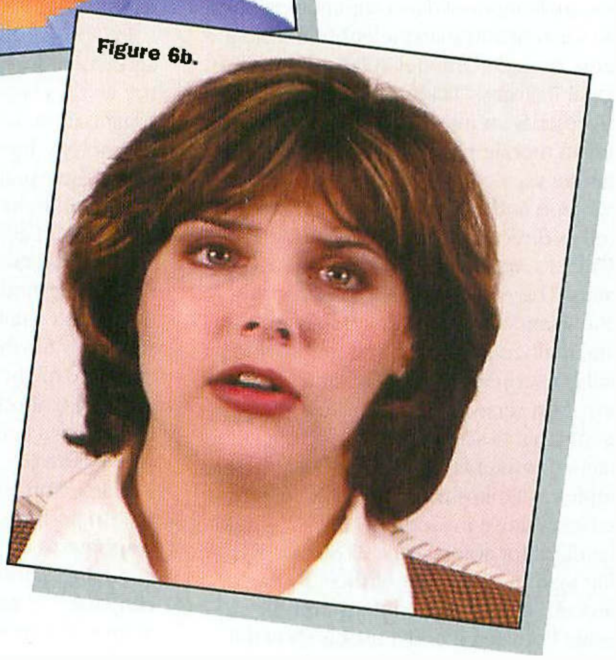


Figure 6b.

TV news and current affairs broadcasts. This European Project - THematic Indexing of Spoken Language (THISL) - uses the Abbot large vocabulary ASR developed at Cambridge and Sheffield Universities, and further developed by SoftSound who supplied it The resulting text files are then indexed ready for searching on the BBC intranet.

Dragon is one of the leading companies in the field of speech processing, with systems at the top level of usage. Others are AT&T, BT, IBM, Lernout & Hauspie and Philips. But there are many more with less ambitious systems; and others that take the former companies' systems and add further facilities to increase the usages.

These different levels are reflected in the Application Programming Interfaces (API), which sit between the controlling application and define the access to the functions of the speech recogniser or synthesiser. At the top end are Microsoft's Speech API (SAPI) and Sun's Java SAPI (JSAPI). At the lower end is a proposed new standard for speech recognition called Voice Control

API (VOCAPI), is a small API intended for command and control of phones, TVs, car navigation, domestic appliances, etc. (see Figure 7).

ECTF

The enthusiasm for speech processing is reflected in the number of projects that have sprung up recently as a result of the increasing viability of the technology. The latest is Beyond, which will look at vocational training including the integration of speech processing. Another is the Enterprise Computer Telephony Forum (ECTF), to enable interoperability between different vendor's products and services, including speech technology. The Mbrola Project, which has the goal of obtaining a set of high quality, multi-language speech synthesisers for academic research and use in non-commercial applications. Picasso, will integrate speech recognition and speaker verification/identification technology for easy and secure transactions over the phone. The Verbmobil Project, which has the aim of developing an interpreting machine - the Verbmobil System - for spontaneous language translation. The Voice Technology Initiative for Mobile Enterprise Solutions (VoiceTIMES), will achieve agreed standards for the integration of speech technology into mobile products.

Philips FreeSpeech Browser

If you are interested in trying speech-processing technology, then Philips is offering their FreeSpeech Browser free at www.speech.philips.com/fsbrowser/. The company is also a shareholder in Spridge, a company set up to market mySpeech in the US. This enables voice activation of links on web sites. There is also mySpeech Scout that provides voice links to news, sports, TV guide, etc (all American bar some international news). I did not delve into it. the web pages took far too long to download for that, but if you are interested the URL is **www.myspeech.com** - both items are free. If you are more interested in listening rather than speaking, then the Mbrola Project provides free downloads of TTS programs at: **tcts.fpms.ac.be/synthesis/mbrola.html.**

The real, albeit incidental, beneficiaries of the commercial enthusiasm for speech processing will be those with physical and visual disabilities. The losers will be those with hearing and speech disabilities... And those who just like peace and quiet.

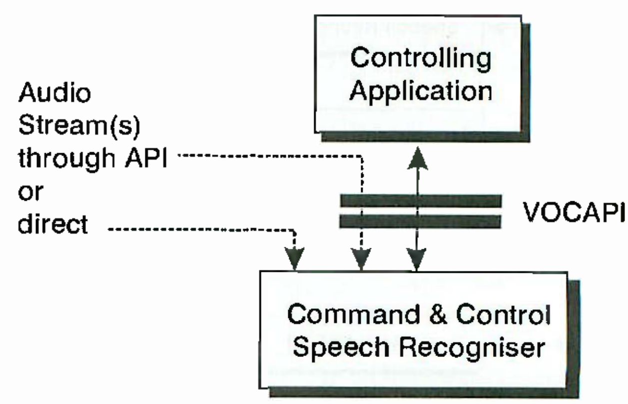


Figure 7.

The Very LONG WAVES

PART 3

In part 3 of this study George Pickworth explains how the systems progressed from two wires to no wires

In the previous part of this study we saw how the earth was a conductor of electric current and it enabled one wire of a two wire telegraph line to be eliminated by employing the earth as the return current conductor. We also saw how earth conductivity resulted in 'wire-less' signalling systems based on earth loops which foreshadowed the extremely long wave radiators employed by the Sanguine system for signalling to sub-marines.

We now look at 'wireless' systems that developed from Tesla's original concept of employing a layer high in the atmosphere as the conductor for outgoing current thus eliminating single wire of an earth return telegraph system. See Figure 31.

As we will see, the concept of electrically charged, or conductive layers high above the earth foreshadowed the discovery of the ionosphere. Moreover, propagation of energy via a conductive layer, as visualised by Tesla, bears a striking resemblance to the Sanguine system. See Figures 35 & 45.

Loomis

Whilst Tesla's concept was based on actual transmission of electrical energy, an earlier pioneer, Mahlon Loomis conceived and patented a 'wireless' system in 1872 based on drawing current from stratified electric charges which were known to occur naturally in the atmosphere. See Figure 32.

The philosophy of Loomis's system was that current could be drawn from individual charged layers by means of a cord made conductive by an interwoven copper wire and elevated to a particular layer by means of a kite. Drawing off current would cause a drop in the potential of a particular layer, without effecting the charge in adjacent layers. The drop in potential would be made manifest by an electrometer connected to a similar but distant elevated cord.

A Morse key would be inserted between the sender's conductive cord and earth and signalling would be by observing the sudden drop in potential each time the key was pressed. There would be a somewhat slower build up to the original potential. During a demonstration to dignitaries and newspaper reporters, the electrometer responded to some influence and this was widely reported as being signals; it caused great excitement. However. neither Loomis nor anyone else present seemed able to read Morse code and thereby verify that the electrometer was responding to actual

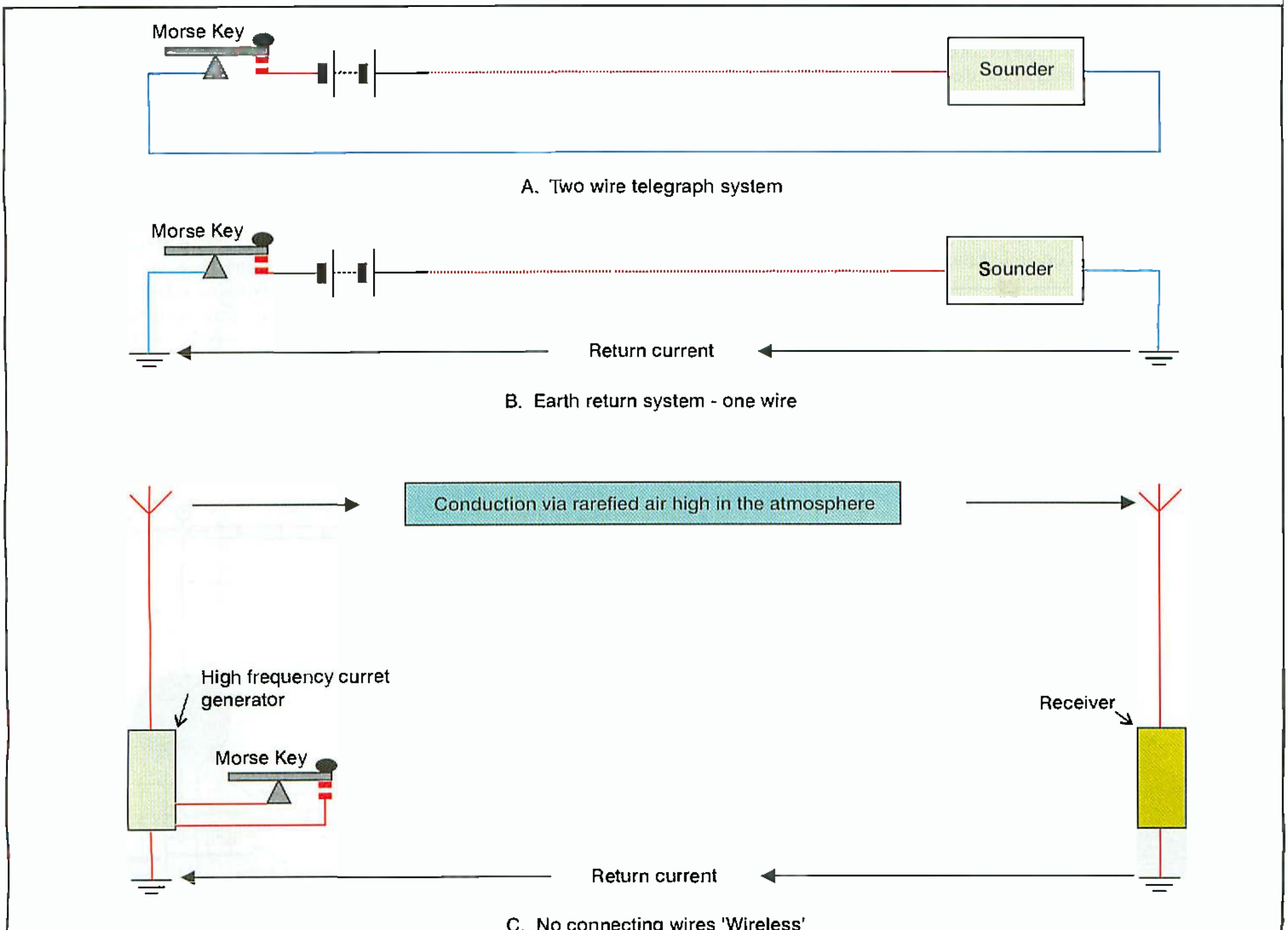
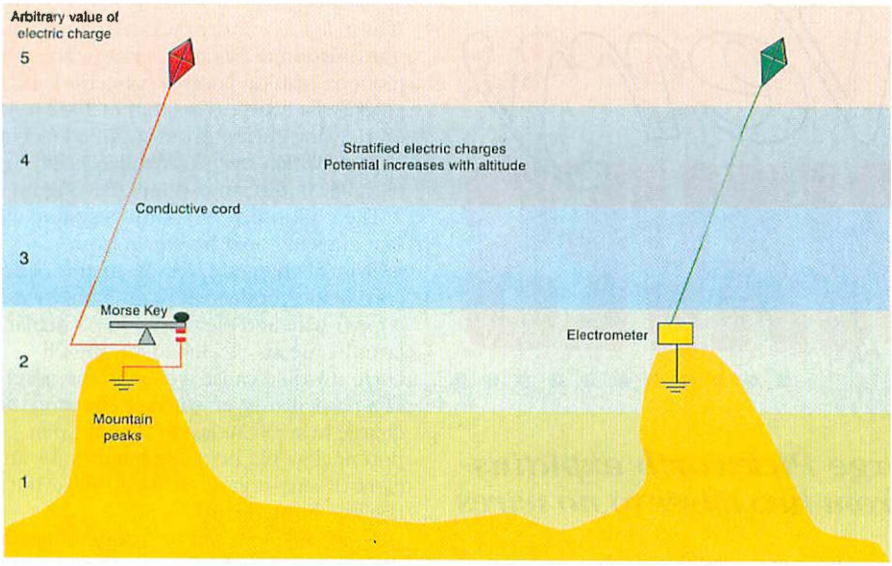


Figure 31. Evolution from two wires to no connecting wires.



When the Morse key is pressed the electric charge in a particular layer is discharged to earth.
Its potential drops but recovers to original layer.
Signalling was noting the drop in potential as shown by the distant electrometer.

Figure 32. Mahlon Loomis's 1872 patent for 'wireless' system, based on stratified electric charges in the atmosphere.

signals. This was unfortunate for the electrometer may well have been responding to signals!

We should bear in mind that stratified electric charges do exist in the atmosphere and their potential at altitudes as low as a few metres can be measured with an electrometer. Moreover, the charge is drained away when an earthed object is brought into the proximity of the electrometer.

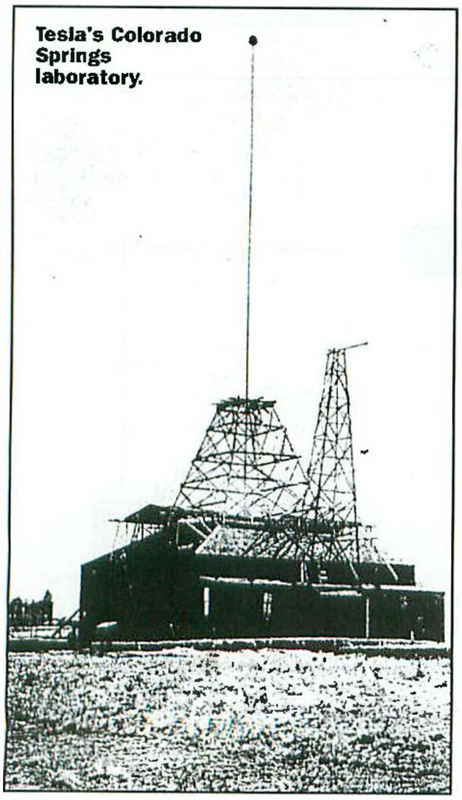
Natural Media

Tesla did not subscribe to em waves and based his system on 'Conduction through Intervening Natural Media' i.e. the earth and a conductive layer high above the earth. As the conductive layers encircled the globe, Tesla asserted that his system would have worldwide range whereas Marconi's Hertzian wave system, being based on rectilinear em waves, would not. Tesla described his system as being 'diametrically opposed' to Marconi's system

Generation of radio frequency (rf) current was fundamental to both Tesla's and Marconi's system so it is not surprising that the only significant difference in the two systems was with their antennas. See Photo & Figure 40. Nonetheless, for energy to propagate over transoceanic distances both systems also required a 'natural media' high above earth. With Tesla's system (Figures 34 & 35) this was a conductive layer whilst with Marconi's system it was the ionosphere which reflected radio waves. See Figures 39 & 44.

In order to radiate energy as radio waves, i.e. em waves within the radio wave range, it is necessary to cause rf current to flow linearly along a conductor and for acceptable radiation efficiency this has to be an appreciable fraction of a wavelength long. For example the enormous antenna structures necessary to radiate very long waves. See Figure 03 part1.

On the other hand, Tesla's transmitter was not intended to radiate waves but to create extremely high voltages and intense electric field so its antenna needed to be only a small fraction of a wavelength long. See Photo & Figure 37.



Tesla's Colorado Springs laboratory.

Rarefied Air

During 1896 Tesla's demonstrated that air pressure of 150mmHg, simulating the atmosphere at an altitude of about 12km, was a good conductor of very high potential (in the order of MV) high frequency current. See Figure 33.

Tesla's original intention was to employ this conductive atmospheric layer for transmission of electric power. Electrodes would then be elevated to the conductive layer by means of hydrogen filled balloons. The earth would serve as the return conductor. See Figure 34.

However, Tesla abandoned the above concept and experimented with a 'wireless' communication system based on the conductive layer serving as one 'plate' of a capacitor with the surface of the earth serving as the second 'plate'. The electric field between the two 'plates' would induce currents in short receiver antennas. See Figure 35. Tesla believed that an electric charge could be induced in the upper 'plate' by means of an intense electric field produced by a relatively short antenna energised with a potential in the order of several MV. Electrodes would make the earth connection. Currents would then propagate concentrically through both the conductive layer and the earth's surface from the points directly above and below the transmitter antenna. So with Tesla's system, wavelength applies to these currents whereas with Marconi's system it applies to radiated waves.

Electric fields would be created in the space between earth and the conductive layer and these would move concentrically in sympathy with the electric currents propagating along the surface of the earth and the conductive layer. The moving

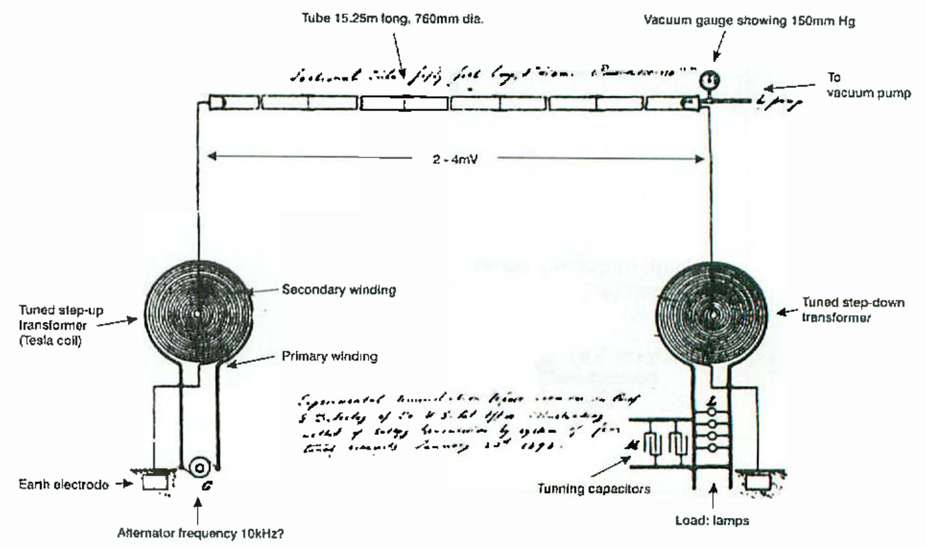
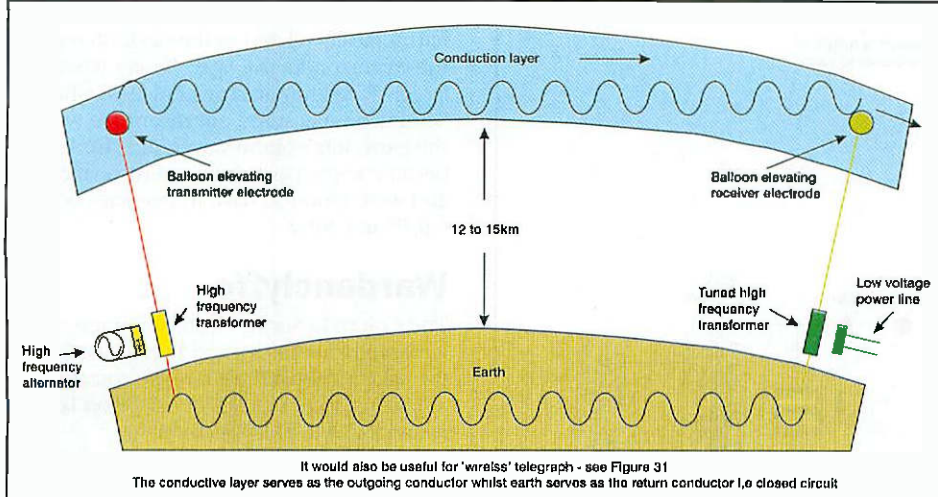
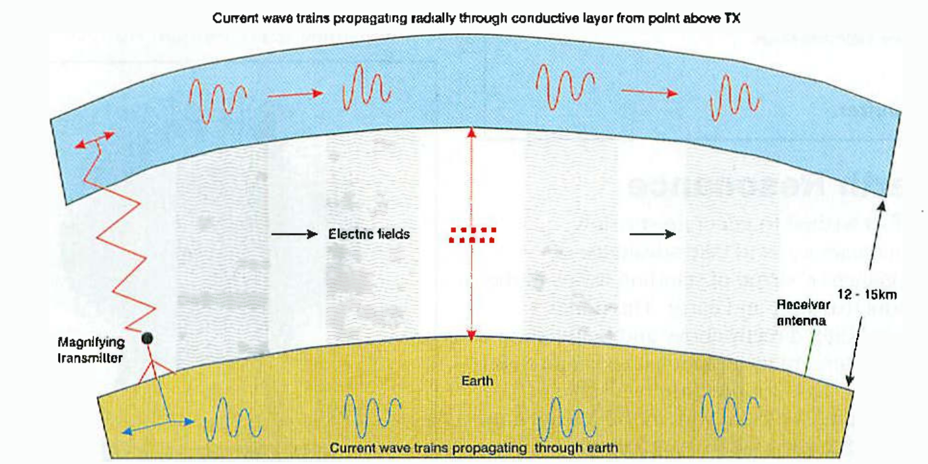


Figure 33. Tesla's demonstration showing that rarefied air is a good conductor of high potential, high frequency current.



It would also be useful for 'wirelss' telegraph - see Figure 31
The conductive layer serves as the outgoing conductor whilst earth serves as the return conductor i.e closed circuit

Figure 34. Tesla's 1893 propsed system for wireless transmission of electric power.



Electrical energy is transmitted via the conductive layer and earth.
Electric fields induce currents in receiver antenna.
Conductive region forms one plate of a capacitor. The earth forms the other plate. Polarity reverses with each half cycle.
Current trains begin with alternate negative and positive going half cycles. See Figure 36.

Figure 35. Tesla's propsed wireless telegraphy system based on natural conductors - shows equivalence with a capacitor (the author's interpretation).

electric fields would induce electric currents in distant receiver antennas. Moving electric fields can be visualised as longitudinal waves i.e. propagating similarly to sound waves but with variations in the strength of the electric fields. See Figure 35.

High Frequency Current

Both Tesla and Marconi employed a spark discharge to generate high frequency (radio frequency) current. The spark served as a high-speed switch that suddenly released energy stored in a capacitor into an inductor. As the capacitor and inductor formed a resonant circuit, the discharge initiated a train of exponentially declining oscillations with a frequency set by the value of the capacitor and inductor. See Figure 36. The energy available for radiation from each train of oscillations was therefore set by the value of the capacitor. However, there is an optimum LC ratio for an oscillatory circuit. So, for any given frequency there is a limit to how far capacitance can be increased with a corresponding decrease in inductance. Obviously capacitance can be greater at lower frequencies whilst still maintaining an optimum LC ratio and for this reason that spark systems were best suited to long wave systems.

Unfortunately, there were significant losses, especially resistance across the spark gap. However, ionisation greatly reduced resistance across the spark gap. Nonetheless losses occurred and amplitude of the oscillations declined exponentially even if energy was not being drawn off for signalling. Obviously, the greater the load on the oscillatory circuit, the greater the damping of the oscillations.

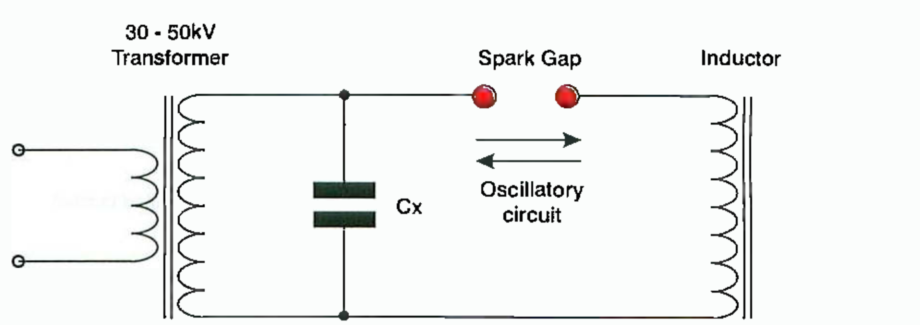
Re-Charging

For signalling, the capacitor had to be constantly recharged so that trains of oscillations were generated in rapid succession. Tesla employed the transformer to provide the charging current with the Colorado Springs Power Company supplying the power. The capacitor was therefore recharged during each negative or positive-going half cycle of the supply current. Polarity of the charge in the capacitor reverses with each half cycle so trains of oscillations were initiated with alternate positive and negative-going half cycles.

The peak potential of the charge in the capacitor was set by its value in Farads and the peak potential and duration of the charging half cycle. The duration of the charging half cycle was set by its frequency and in a practical system it was too short to charge the capacitor to a potential equal the open circuit peak potential of each half cycle. So to avoid the difference in the open circuit potential of the transformer and the charge in the capacitor being excessive, capacitance had to be limited. See Figure 36. The spark gap width was set so that a discharge occurred when the potential of the charge in the capacitor reached its peak value. When a discharge did occur, the current was oscillatory and by virtue of the inductance of transformer's secondary winding the oscillatory circuit is effectively isolated from the transformer. See Figure 36.

'Magnifying Transmitter'

Tesla required trains consisting of many oscillations with peak potential in the order of several MV and containing a large amount of energy. His approach was to employ a high value capacitor, charged to the maximum practical potential, about 30kV, in a low-inductance (few turns) primary circuit which was inductively coupled to a low-capacity high-inductance (many turns) secondary circuit. Despite their differing LC



Capacitor, spark gap and inductor form resonant circuit. Each high voltage half cycle charges the capacitor to a point where discharge occurs across the spark gap. Each discharge produces a train of oscillations. Repetition rate is twice the mains supply frequency i.e 80 - 100/sec. Ionisation between spark gaps reduces resistance to oscillatory current. Inductance of transformer secondary winding isolates the oscillatory circuit during discharge period. See also Figure 37. Typical values - $Cx = 0.005\mu F$ to $0.0225\mu F$. Potential of charge = 10 to 30kV. Charge in capacitor in Joules = $^{1}/_{2}CV^{2}$

Figure 36. Essential features of Tesla's spark type oscillator.

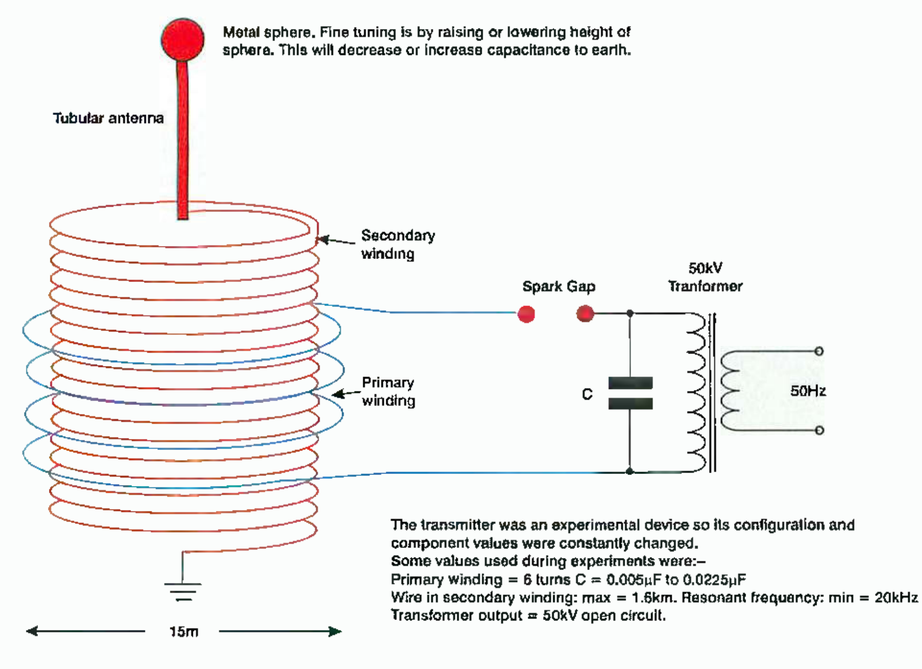


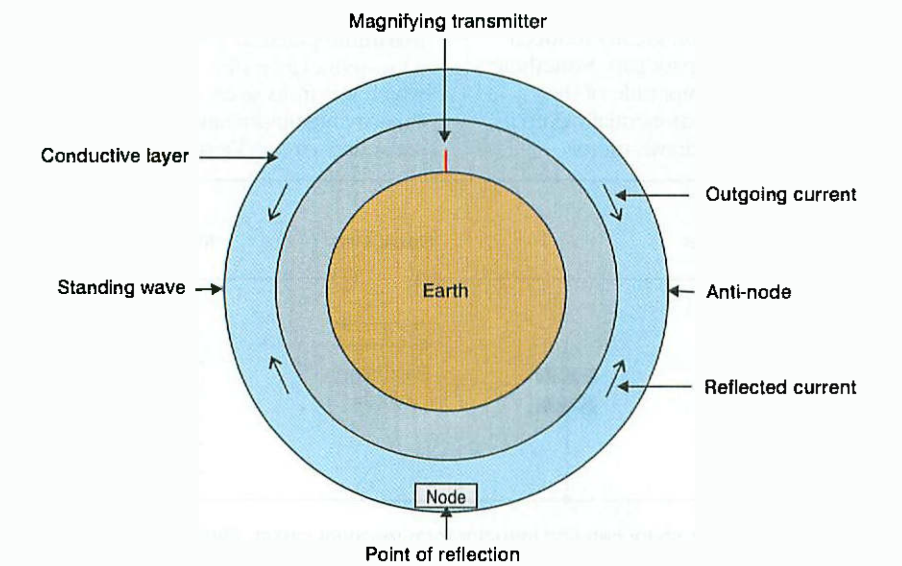
Figure 37. The essentials of the magnifying transmitter.

ratios, both the primary and secondary circuits were tuned to the same frequency. Moreover, oscillations were sustained in the secondary circuit largely because of its high LC ratio. See Figure 37.

Because the secondary winding had many more turns than the primary winding, there was a step-up in voltage. Tuning further increased the potential across the secondary winding thus making it capable of producing extremely high voltages. Indeed it was a tuned transformer now commonly known as 'Tesla Coil'.

Earth Resonance

Tesla wished to generate very low frequencies so as to take advantage of resonance by virtue of standing waves in the conductive layer and earth. The nodal points being directly above and below the transmitter and its antipodes. See Figure 38. However, Tesla found it impracticable to incorporate sufficient wire in the Magnifying transmitter's secondary winding for generation of such low frequencies and seems to have conducted most of his experiments on frequencies in the order 20kHz. Nonetheless, Tesla determined that resonance in the fundamental mode would occur 8.0Hz with 14Hz & 20Hz in the



Tesla determined the fundamental frequency as 6Hz with harmonics on 18 & 30Hz.
Current extends radially from the transmitter and converges at its antinodes from where it is reflected.

With Schumann Resonances, standing em waves occur in earth/ionospere waveguide.
The fundamental frequency for Schumann resonances is 8Hz with harmonics on 14 & 20Hz.

Figure 38. Tesla's concept of a standing wave in the conductive layer.

harmonic modes i.e. wavelengths equal or harmonically related to the circumference of the earth/conductive layer. Tesla's work was largely forgotten until around 1950 when Schumann measured em resonance within the earth/ionosphere waveguide; these became known as Schumann resonances and were found to have frequencies of 6.0,18 and 30Hz.

Wardenclyffe

The Colorado Springs installation was really a research laboratory, and having obtained the data he required, Tesla began construction a new installation at Wardenclyffe on Long Island in 1900. This was to be his operational installation. But instead of the vertical tube antenna employed at Colorado Springs, the radiator on the Wardenclyffe tower was a metal hemisphere. It was from this Tower that Tesla intended to send a signal to Paris. See Photo.

Unfortunately, J. P. Morgan stopped

The Wardenclyffe Tower.

financing Tesla after Marconi and Kemp in Newfoundland claimed to have heard transatlantic signals radiated by Marconi's Poldhu (Cornwall) transmitter. So the Wardenclyffe installation was never completed and as it is unlikely that a replica will be made, we will probably never know its real purpose. Unfortunately, unlike the Colorado Springs installation, notes on the Wardenclyffe transmitter seem to be few.

However, it was reported that Tesla intended to install powerful radiant heaters on a platform around the top of the Wardenclyffe tower. Some authorities suggest that the heaters were intended to modulate dynamo currents flowing in the upper atmosphere thereby pre-dating

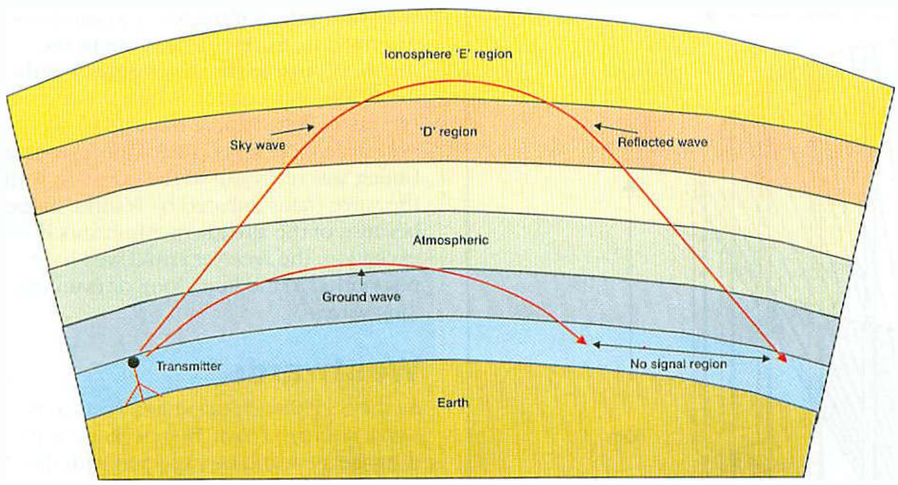


Figure 39. Propagation of long and very long waves, ground waves and ionosphere reflected waves.

American experiments with super long wave systems for signalling to submarines. See Part 1.

Refraction & Ground Waves

Meanwhile, range with Marconi's maritime systems steadily increased and by 1900 had over-the-horizon range. So after originally asserting that such range was impossible with em waves, the scientific establishment now had to amend its thinking to explain how such range was possible. But as radio waves and light form part of the em spectrum it was understandable for the pioneers to reason that if variations in the density of the atmosphere caused light to bend by refraction, as manifest by mirages, the same may well apply to radio waves. See Figure 39.

Over-the-horizon propagation of em waves was therefore attributed to refraction in the atmosphere. Indeed, the dielectric constant of the atmosphere normally decreases with increasing altitude and as a result refraction causes radio waves to bend downwards to earth.

Refraction becomes more pronounced as wavelength increases, but diffraction caused by the curvature of the earth seems to be insignificant. However, some authors believe that energy is actually reflected back towards earth by stratified atmospheric layers. Shades of Tesla's conductive layer!

Skip Distance

The range of early maritime transmitters was only in the order of 200km. So, notwithstanding that the ionosphere had yet to be discovered, reception would have been within the skip distance for waves reflected from the ionosphere. See Figure 39. Moreover, I very much doubt if early maritime transmitters were capable of radiating the amount of energy necessary for detection of ionosphere reflected waves with receivers used at that time.

So with early maritime systems, the role of the ionosphere can therefore be virtually ruled out and propagation of the waves would almost certainly have been via ground waves. Indeed, very long ground waves can have a range of up to 1,000km or even more. Even long ground waves have considerable range.

For example I can hear Atlantic 252 (252kHz) located in the Irish Republic loud and clear on a portable receiver here in East Anglia. So, whilst at first sight reception over its 650km path and a 'hump' about 7,000m high would seem only possible via ionospheric reflection, the best information I have is that reception is via ground waves.

Resistance Wire Analogy

With early maritime systems, signal strength was found to decline more or less linearly with distance that is consistent with ground waves. It was therefore understandable that some pioneers considered attenuation as analogous to resistance to an electric current in a wire conductor.

Marconi reasoned that with sufficient power this resistance could be overcome and signals be detected on the other side of the Atlantic Ocean. So, during the latter part of 1901 Marconi constructed the already mentioned transmitter at Poldhu, Cornwall - it was the most powerful in existence at that time. See Figure 40.

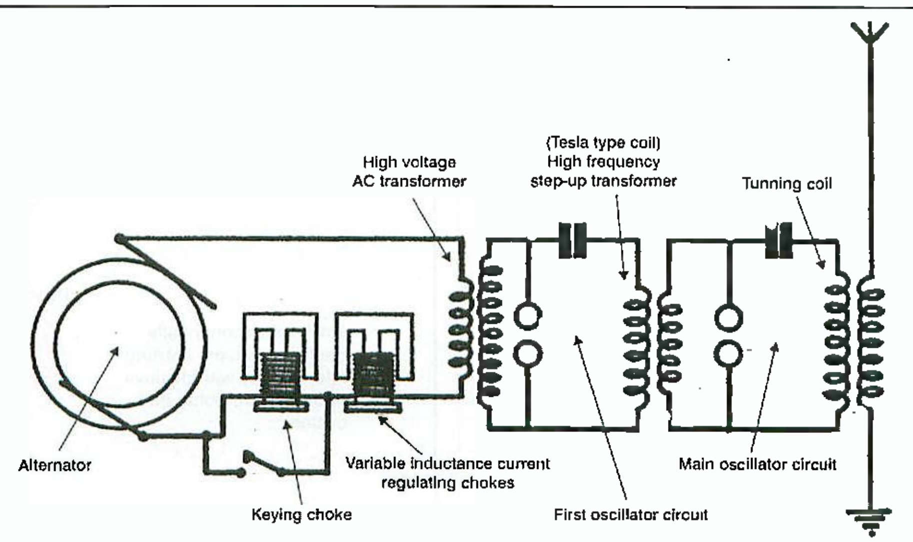
The Poldhu transmitter was basically similar to Tesla's Magnifying Transmitter in that it was a spark type oscillator that produced trains of oscillations but its antenna was an inverted cone. See Figure 41. Energy was therefore radiated as wave trains that induced current wave trains in the receiver antenna. After rectification, a group of say 20 current trains produced the sound of a 'dot' in the headphones whilst a group of say 100 trains produced a 'dash'. More about this in part 4.

The transmitter was a two-stage oscillator; the first stage generated rf current and its potential was stepped up a high voltage by what was essentially a Tesla Coil; this charged the capacitor of the second stage. The philosophy was to charge the second capacitor to the highest possible potential thereby maximising stored energy whilst still maintaining a favourable LC ratio. However the heavy load on the spark gap limited transmission to the short periods representing 'dots' of the Morse code.

Signal Hill

On December 12th 1901, Marconi and Kemp set up a receiver at Signal Hill, St Johns, Newfoundland and between 12.30 and 14.30 local time they claimed, as already mentioned, to have heard the famous 'S's' radiated by the Poldhu transmitter. Reception was over a daylight path 3,500km long.

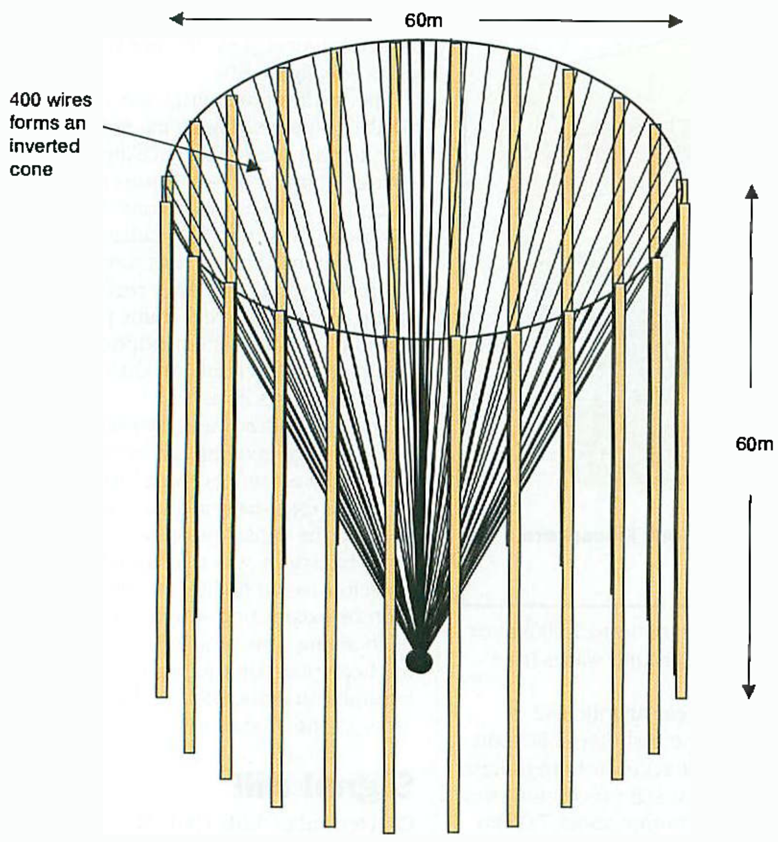
Their antenna was suspended from a kite and their receiver employed a mercury type coherer that could also behave as a rectifier. Let us assume that the rectifier conducted positive going half cycles; these would be dissipated whilst negative going half cycles would be routed through the headphones. See Figure 42. My reproduction of the Signal Hill receiver, but using a modern diode showed sensitivity to be poor. But on the basis of the resistance wire analogy it



The first oscillator produces high voltages to charge the capacitor of the main oscillator to a potential higher than that obtainable directly from the AC transformer thereby maximising stored energy

Alternator = 25kW, 20kV 50Hz - wavelength see text. See also Figures 36 & 37

Figure 40. Marconi's original Poldhu transmitter 1900.



The antennas were structurally unsound and both were destroyed during gales. Compare with Tesla antenna Figure 37 and Photo A.

Figure 41. Poldhu antenna 1901 - similar antenna at Wellfleet, Cape Cod.

determined from the calculated values of the transmitter's inductors and capacitors. Accurate measurement was out of the question prior to the development of the neon lamp wavemeter. Whilst the receiver on the SS Philadelphia was said to be syntonized, i.e. tuned to Poldhu, syntonized tuning was really out of the question with the wave trains radiated by Poldhu. Indeed, because of the already mention shock excitation, the receiver could well have responded to medium, long or even very long waves

Westwards

As the SS Philadelphia sailed westwards signal strength (daylight?) declined with distance as would be expected with the resistance wire analogy and when the ship was 1,120km from Poldhu their strength was too weak for messages to be recorded. In the light of present day knowledge, the above was consistent with the propagation of ground waves 2,000-3,000m long. See Figure 39.

Then much to Marconi's surprise, signals were recorded during darkness again until the ship reached a position 1,890km west of Poldhu when signal strength fell too low for recording. Once again, in the light of present day knowledge, this is consistent with reflection of long waves from the ionospheric 'E' region. See Figures 39 & 44.

However, 'S's' were heard, or recorded (I am not sure which) until the ship was 3,600km from Poldhu which is consistent with a double hop via the 'E' region.

would have been difficult if not impossible to disprove Marconi's claim no matter how feeble the signal may have been. Nonetheless, in many quarters his claim was treated with suspicion.

The 'SS Philadelphia' Trials'.

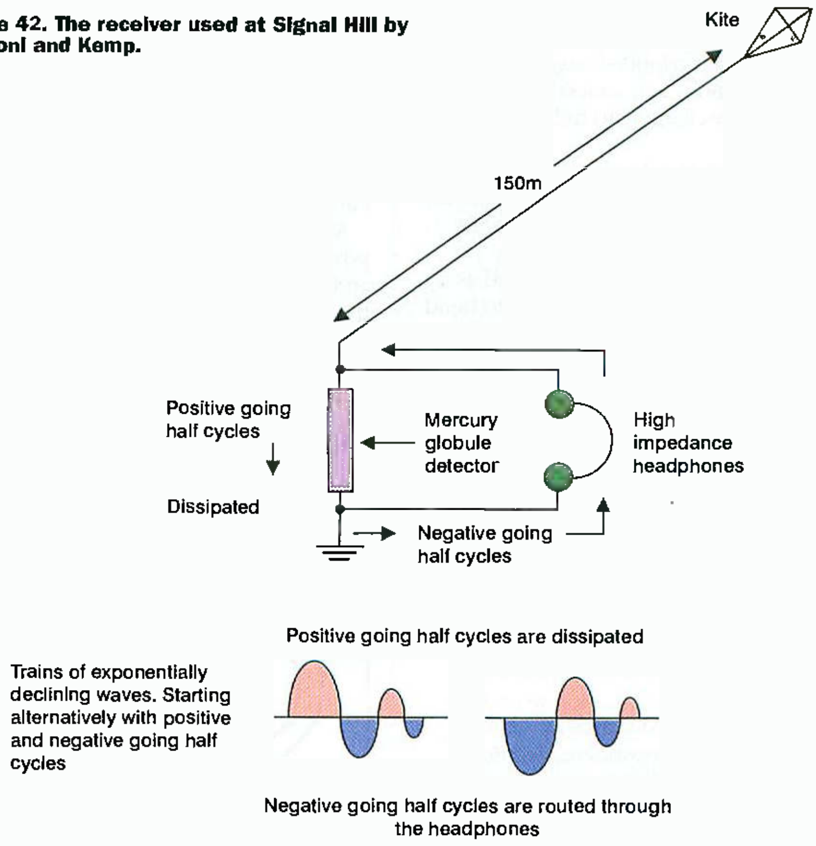
By early in 1902 Marconi had improved the Poldhu transmitter so that it could transmit actual messages at full power. A receiver tuned to Poldhu was then installed on the SS Philadelphia. In order to support the antenna, the height of the ship's masts was increased to 45m. The objective being to constantly monitor the Poldhu transmitter as the ship sailed westwards.

Marconi hoped that the SS Philadelphia trial would validate his claim to have heard the 'S's' at St Johns. But it did not, as it completely demolished the resistance of a wire analogy and demonstrated for the first time that radio waves were reflected back to earth from a layer high above the earth. Moreover the characteristics of reflection showed that it would have been virtually impossible for Marconi and Kemp to have heard the 'S's'. See Figure 43.

During the Philadelphia trials, signals from Poldhu were recorded by means of a coherer/Morse register. However, the coherer could also be connected to headphones to produce an audible sound.

The wavelength of the Poldhu transmitter was officially given as 366m but some eminent authorities put wavelength in the order of 3,000m. A possible explanation for the wide discrepancy is that wavelength was

Figure 42. The receiver used at Signal Hill by Marconi and Kemp.



The Poldhu transmitter radiated trains of exponential declining waves. A large proportion of the radiated energy was packed in the first half wave of each train. Positive going half cycles took the path of least resistance through the detector and were dissipated. Negative-going half cycles were blocked by the detector and were routed through headphones. Each train caused a 'click' to be heard. A group of trains produced the sound of a Morse code 'dot'.

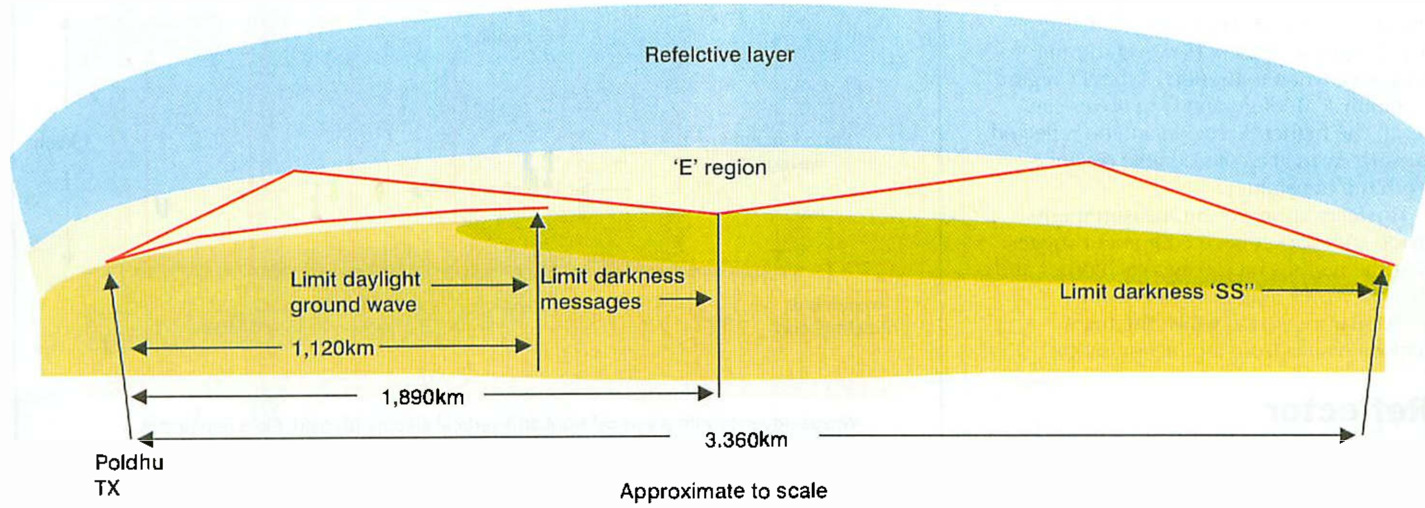


Diagram shows range at which signals from Poldhu were received on the 'SS Philadellphia' as she sailed westwards. Range attained by the ground wave suggests a wavelength in the order of several thousand km. Range of darkness messages is compatible with reflection from the ionosphere 'E' region. Maximum range suggests second hop from 'E' region. See also Figure 39.

Figure 43. The 1902 'SS Philadelphia' trials that confirmed the existence of a reflective layer high above the earth .

At a distance of 3,600km the waves had crossed a 'hump' in the ocean about 150km high but as the existence of the ionosphere had yet to be discovered the only plausible explanation at that time was that the waves were reflected from a layer high above the earth.

Workers could only speculate on the nature of such a reflector but it was most likely an electrically conductive layer. Calculations taking distance and curvature of the earth into account showed the reflective layer to be at least 75km above the earth and therefore much higher than the conductive layer visualised by Tesla.

Heaviside

Oliver Heaviside was not convinced that radio waves were reflected solely by conductivity of a layer of rarefied gases as visualised by Tesla. So, in 1902 together with Arthur E Kenedy working in the USA, they suggested that refection was caused by a well defined ionised layer in the upper atmosphere and that acted as a conducting surface just as the earth acted as a lower one. Their concept of a conducting layer was also of one much higher than that visualised by Tesla.

Heaviside reasoned, correctly, that sunlight caused ionisation of the rarefied gasses and these were responsible for the reflection of radio waves. However, the problem with the ionisation theory was that from experience by Marconi and numerous other pioneers, range increased during darkness hours when, if propagation was by ionosphere reflection it should have been minimal.

As we have seen in part 1, operators of the first generation superstations were generally able to reduce power when working over a daylight path. Moreover, in 1910 the Telefunken Company guaranteed only a 750km range for their 'E' type medium wave transmitters over a daylight path, but 1,500km over a nighttime path. One might ponder as to the role of atmospheric reflection as ground waves over a daylight path, especially with regard to very long wave transmissions.

In fact, the reason why range was greatest during darkness remained a mystery for many years. Ironically it was not solved until after the demise of the first generation superstations which had been conceived, built and operated on knowledge gained empirically.

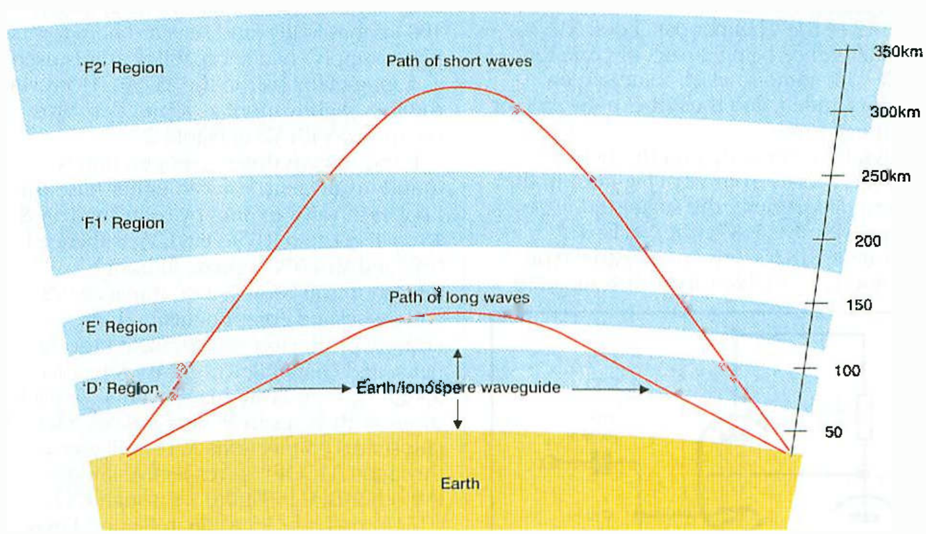
Ionosonde

In 1924, E. W. Appleton and M. A. F. Barnet working in the UK and G. Breit and M. Turve working independently in the USA, using an ionosonde, observed direct reflection of radio waves from what became known as the ionosphere. This became possible with development of the oscilloscope.

The ionosonde was essentially a pulsed transmitter that was synchronised with a receiver: it can be considered as the earliest radar but wavelength could be varied over a wide range. Rather than consisting of a single homogeneous reflective layer as originally visualised, the ionosonde experiments indicated that the ionosphere consists of three reflective regions ('E' and 'F1 & F2'). Paradoxically the region nearest to earth ('D') absorbs radio waves. See Figure 44.

The 'D' region is about 60km above the earth exists only during sunlight hours and its electron density is directly proportional to the height of the sun. Moreover, because of its low altitude, the density of atmospheric gases in the 'D' region is high so recombination of electrons and ions is rapid after sunset.

As already mentioned a strongly ionised



Waves are bent by refraction. During daylight, the 'D' region is strongly ionised and absorbs medium to very long waves. The degree of absorption decreases with increasing wavelength. 'D' region largely disappears during nighttime. The 'E' region reflects long waves. It is also the lowest region that reflects radio waves. The higher 'F' region reflects short waves. The earth/ionosphere waveguide is the cavity between earth and the 'E' region. See Figure 45.

Figure 44. The ionosphere showing height and boundaries of the four regions.

'D' region absorbs medium and long waves but the degree of absorption decreases as wavelength increases. However, during darkness, when ionisation of the 'D' region is minimal. Medium and long waves can reach the higher 'E' region and be reflected back to earth at a considerable distance from the transmitter.

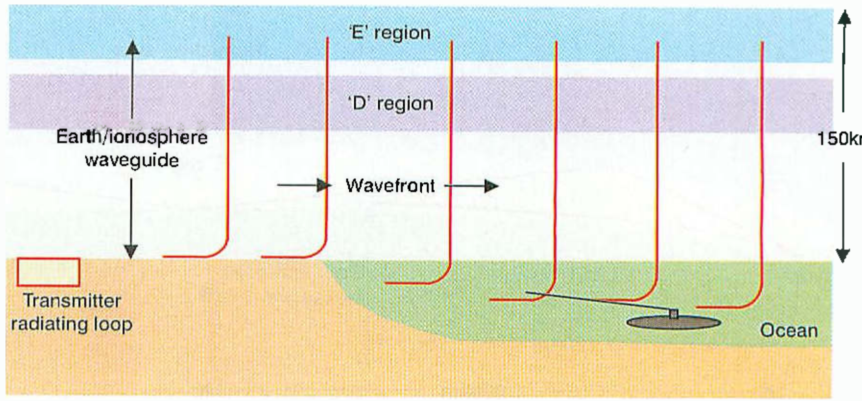
However, more recent measurements made with rocket born equipment suggest that the regions merge into each other and that the lower regions results from molecular ionisation whilst the high regions results from atomic ionisation

Reflector

The 'E' region is the lowest that actually reflects radio waves, but principally medium and long waves; it seems to be transparent to short waves. In Britain, the 'E' region is known as the Heaviside layer and in the USA as the Kennelly layer.

The atmosphere is still fairly dense at the altitude of the 'E' region so during darkness ions and electrons begin to recombine. Nonetheless, sufficient ions and electrons generally persist during the night to reflect medium and long waves. It was principally reflection from this region that gave the very long wave superstations their transoceanic range

The higher 'F' region, about 300km above the earth, is mainly responsible for reflection of short waves that have passed through the 'E' region. However, during daylight the 'F' region splits into two layers, F1 and F2.



Waves advance with a vertical front and vertical electric (E) field. Field penetrates ocean and induces currents in a submarine's antenna. Wave front bends near earth to become almost horizontal. Upper part of wavefront terminates in ionosphere and probably involves all regions. Compare with Tesla's system Figure 35. See also Figure 08 part 1.

Figure 45. Propagation of extremely long waves. (after Wait).

After sunset, the F1 layer decays and is replaced by a broadened F2 layer: this ionises very quickly after sunrise and decays very slowly during darkness reaching a minimum value just before sunrise. The 'F' region is, commonly known as the Appleton layer.

Open Mind

To conclude this part of the study, let us recall that propagation of waves up to about 30km long (10kHz) is essentially via refraction in the ionosphere, but refraction in the atmosphere as ground waves may also be significant. On the other hand, propagation of extremely long waves via the earth/ionosphere waveguide - see Figure 45 - does bear a remarkable similarity to Tesla's concept - see Figure 35. So perhaps we should keep an open mind on longitudinal waves.

In part 4 we look at the evolution of the first generation superstations particularly with regard to detectors and radio frequency generators.

100W VALVE AMPLIFIER DESIGN - UPDATE

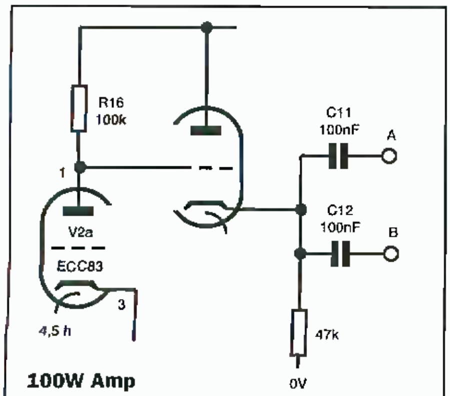
Mike Holmes discusses some queries raised from the design presented in the May 2000 edition.

The 100W amp design is loosely based on the Leak TL/50 Plus. In this respect the O/P stage is essentially the same, it also corresponds to table at bottom left of page 19 of the Chelmer data book XL52G, only difference being 2 pairs of same for 100W with some smallish value screen resistors added, and the Zobel networks for O/P transformer.

A reader commented on the lack of driving capability from V2 of Figure 1, in the current department, the suggested alternative valve 5687, (the Mullard equivalent E182CC), is an industrial type described as "double triode with separate cathodes for use in computers". It has a very high Ia (36mA, this may aggravate RF instability) and rather poor gain. The TL/50 uses nothing like but an ECC81 still with 100 kilohm loads (and selected here for its lower supply voltage capability as it is used as a long-tailed pair in the TL/50). However the Ia is slightly more at 1.5mA per valve compared with V2 in Figure 2.

If the current driver configuration is found insufficient, you can either raise the Ia of each valve to 3mA by reducing R16 & 18 to 47kΩ, and R17 to 82Ω, Vg is thence -0.5V and Va 150V approx., although distortion will be worse or, duplicate V2 and associated components in their entirety producing two paralleled triode pairs, and changing R17 for each pair to 330Ω. Vg = <-1V and Ia = 1.5mA for each triode with Va again at 150V approx. One pair serves connections A, D in Figure 2 through C11, C14 on respective anodes; the other B, C in Figure 2 through C12, C13. In this case R3 to R6 in Figure 2 may all be reduced to 330kΩ each, and the result will equate directly to the situation for the TL/50.

A third option is to add directly connected cathode followers to the anodes of V2a and b. Do this with another ECC83 with 47kΩ cathode resistors as shown in the accompanying diagram (if you want to use it).



100W Amp

There also seems to be some confusion over Figure 5, to wit, there is no 0V-reference point? The transformer does not have a full-wave HT secondary; Figure 5 replaces two 1N4006 rectifier diodes on the HT1 (output) side in Figure 4, and was only a suggestion!

Performance specifications were not in the article and a complete working prototype did not exist at the time due to the prohibitive cost of parts; the published design was made as an application circuit as a starting point in consequence of there being special components in the Maplin catalogue, but no circuit! Additionally, it would not have been possible to measure certain parameters. So, the following, adapted from that for the TL/50 Plus, would not be too far removed from actuality:

Theoretical Specification

Power Output:	100W rms max., 200W peak
THD:	In the order of 0.1% @ 90 Watts, 1kHz
Hum and Noise:	80dB below 100W
Sensitivity:	in the range -6dB - 0dB (350 - 700mVrms) input @ 1kHz for full o/p
Frequency Response:	ideally should be within 1dB from 30Hz - 20kHz. Zobel networks on T1 primary must begin to roll-off response at 50kHz min.
Damping Factor:	15 @ 1kHz - projected
Input Inpedance:	220kΩ
Feedback Magnitude:	29dB

The 8031 SINGLE BOARD COMPUTER

PART 3

Richard Grodzik continues his description of a compact and versatile computer

Printing a Message

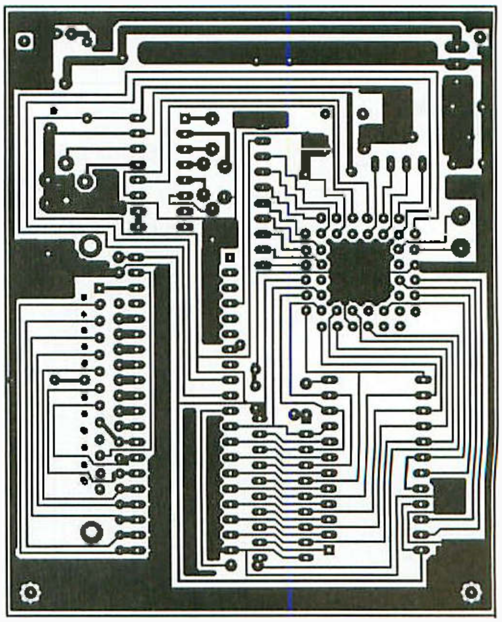
The centronics printer interface has been designed as a use and go facility so that no special knowledge of programming the 81C55 is required. The only restriction is that the message must not total more than 256 bytes of data.

```
;MESSAGE

#INCLUDE SFR51.EQU
.ORG 0H
            LCALL INIT
            MOV A,#0

AGAIN:      PUSH A
            MOV DPTR,#MES
            MOVC A,@A+DPTR
            CJNE A,#24H,NEXT
            LJMP 0
NEXT:       ACALL PRINT
            ACALL STATUS
            POP A
            INC A
            ACALL DELAY
            LJMP AGAIN


INIT:       ACALL DELAY
            MOV DPTR,#0800H
            MOV A,#05H
            MOVX @DPTR,A
            RET


PRINT:
            MOV DPTR,#0801H
            MOVX @DPTR,A
            RET


STATUS:
            MOV DPTR,#0800H
CYCLE:      MOVX A,@DPTR
            ANL A,#1
            JZ CYCLE
            RET

MES:        .TEXT "RG8031 SBC DEVELOPMENT BOARD"
            .BYTE 0DH
            .BYTE 0AH
            .BYTE 024H

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

.org 0800H
END
```

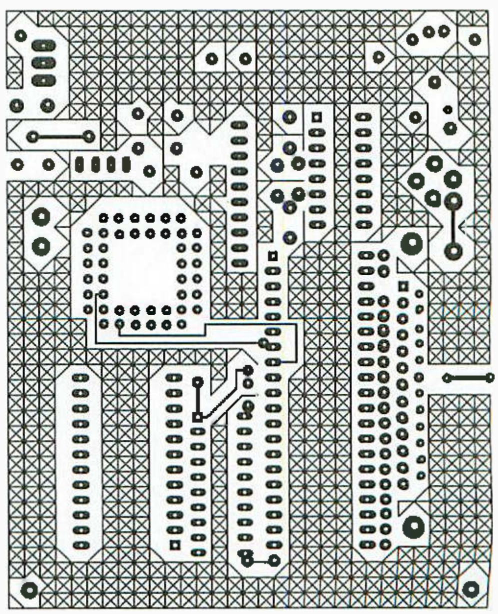
PROJECT PARTS LIST

RESISTORS	
R1	82k Min Res
R2	270R Min Res
CAPACITORS	
C1	100µF Ceramic
C2, 3, 4, 5	22µF 16V Elect
C6	470µF 25V Elect
C7	100µf 16V Elect
SEMICONDUCTORS	
IC1	80C31 (Farnell 445-927)
IC2	81C55
IC3	MAX232
IC4	74HC573
IC5	27C16
IC6	7805 IA
MISCELLANEOUS	
P1, 2, 3	0.1in Header Pins
S1	25-W D-type Socket Female
S2	3-pin Min Din Socket
S3	2.5mm DC PCB Mounting Socket
SW1	Press-to-make Switch
X1	11.0529MHz Crystal
LED	5mm LED
	44-W PLCC Socket
	EPROM Emulator Order Code GT00A

PCB bottomside



PCB topside



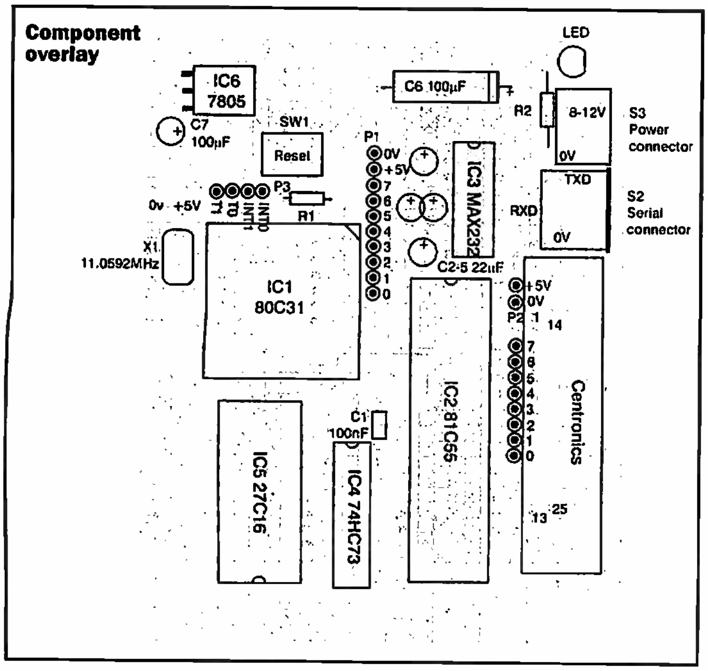
Writing and Reading External Peripherals

Since the 81C55 is equipped with 1 page (256 bytes) of internal ram it may used for storing variables. It is accessed by address 0000, which is also the start address of ROM. However, the PSEN line is held high during external memory read/writes and therefore the EPROM remains disabled and no data bus conflict will occur. The following program demonstrates simple write and read functions of the 8031 utilising the DPTR address pointer.

```
;WRITE
#INCLUDE SFR51.EQU
.ORG 0H
        ;WRITE TO RAM
        MOV DPTR,#0          ;RAM ADDRESS 0000H
        MOV A,#055H
        MOVX @DPTR,A         ;SAVE BYTE IN RAM

        ;READ RAM
        MOVX A,@DPTR         ;TRANSFER RAM CONTENTS
                             AT ADDRESS 0000H
        ;TO ACCUMULATOR
        MOV P1,A             ;DISPLAY AT PORT 1
STOP:   SJMP STOP            ;STOP
.ORG 0800H
.END
```

Single Stepping the 8031 in Real Time.

The following program makes use of an interrupt function of the 8031 that allows single stepping of a user program. The A B and R0-R7 register contents together with the program counter, flags and port P1 contents are converted to an ASCII data stream and sent from the serial port to a PC running a Terminal emulation program. The values of the registers are displayed after each instruction executed.




```
;SINGLE
#INCLUDE SFR51.EQU
;+5v push to break (N.C. Switch)
;in series with the INT0 pin

.ORG 0H
        LJMP BEGIN

.ORG 03H
        CLR EX0
        ACALL SINGLE
        RETI
BEGIN:
        ACALL INITIALISE
        CLR P3.2                  ;ENABLE SINGLE STEP
;==============================

;USER PROGRAM

CYCLE:
        INC P1
        MOV A,#0H
        SUBB A,#1H
        ADD A,#1
        ADD A,#1

        SJMP CYCLE
;==============================

INITIALISE:
        SETB EA
        CLR IT0
        SETB EX0
        RET
SINGLE:
        LCALL SPACE

        PUSH A

        MOV A,8                   ;IP
        LCALL CONVERT
        LCALL SPACE

        MOV A,090H                ;P1
        LCALL CONVERT
        LCALL SPACE

        POP A
        PUSH A                    ;A
        LCALL CONVERT
        LCALL SPACE

        MOV A,0F0H                ;B
        LCALL CONVERT
        LCALL SPACE

        MOV A,0                   ;R0
        LCALL CONVERT
        LCALL SPACE

        MOV A,1                   ;R1
        LCALL CONVERT
        LCALL SPACE

        MOV A,2                   ;R2
        LCALL CONVERT
        LCALL SPACE
        MOV A,3                   ;R3
        LCALL CONVERT
        LCALL SPACE

        MOV A,4                   ;R4
        LCALL CONVERT
        LCALL SPACE

        MOV A,5                   ;R5
        LCALL CONVERT
        LCALL SPACE

        MOV A,6                   ;R6
        LCALL CONVERT
        LCALL SPACE

        MOV A,7                   ;R7
        LCALL CONVERT
        LCALL SPACE

        MOV A,0D0H                ;PSW 'FLAGS'
        LCALL CONVERT
        LCALL SPACE

        LCALL MESSAGE

        POP A
        SETB EX0
        RET

        DEL:
        PUSH 0
        PUSH 1

        MOV R1,#$40               ;40
        LOOP2: MOV R0,#$FF
        INLOOP:DJNZ R0,$
        DJNZ R1,LOOP2

        POP 1
        POP 0

        RET
MESSAGE:
        PUSH A

        MOV DPTR,#REGS
        MOV A,#0

AGAIN:  PUSH A
        MOVC A,@A+DPTR
        CJNE A,#24H,OVER
        POP A

POP A
        RET

OVER:   ACALL TXD
        ACALL DEL
        POP A
        INC A
        SJMP AGAIN

REGS:
        .BYTE 0DH                 ;RETURN
        .BYTE 0AH
        .TEXT " IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW "

        .BYTE 0AH                 ;LINEFEED
        .BYTE 0AH                 ;LINEFEED
        .BYTE 0DH                 ;RETURN
        .BYTE 024H

CONVERT:
        PUSH A
        PUSH B
        PUSH DPH
        PUSH DPL

        MOV B,A                   ;SAVE BYTE

        RR A
        RR A
        RR A
        RR A                      ;MSN
        ANL A,#0FH
        MOV DPTR,#ASCII
```

```
        MOVC A,@A+DPTR

        ACALL TXD
        ACALL DEL

        MOV A,B                   ;GET BYTE
        ANL A,#0FH                ;LSN
        MOVC A,@A+DPTR
        ACALL TXD
        ACALL DEL

        POP DPL
        POP DPH
        POP B
        POP A

        RET

        ASCII:

        .TEXT "0123456789ABCDEF"

SPACE:
        PUSH A
        MOV A,#020H
        ACALL TXD
        POP A
        RET

                  ;TXD SUBROUTINE

TXD:    MOV SCON,#050H            ;SERIAL MODE 1,RECEIVER
        ENABLED
        MOV TMOD,#020H            ;TIMER 1, 8-BIT AUTO RELOAD
        MOV TH1,#0Fdh
        CLR EA                    ;DISABLE GLOBAL INTERRUPT
        MOV SBUF,A                ;LOAD SERIAL BUFFER WITH
        DATA
        SETB TR1                  ;TIMER 1 ON
LOOP:   JNB TI,LOOP               ;IF FLAG TI IS SET,BYTE HAS
        BEEN
        CLR TR1                   ;TIMER 1 OFF
        CLR TI                    ;CLEAR BYTE RECIEVED FLAG
        SETB EA
        RET                       ;RETURN TO CALLING
        PROGRAM
.ORG 0800H

.END
```

The following is the resultant display on the PC:

```
10 00 00 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

12 00 FF 00 28 24 49 33 49 33 49 33 C0
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

14 00 00 00 28 24 49 33 49 33 49 33 C0
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

16 00 01 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

0C 00 01 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

0E 01 01 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

10 01 00 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

12 01 FF 00 28 24 49 33 49 33 49 33 C0
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

14 01 00 00 28 24 49 33 49 33 49 33 C0
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

16 01 01 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

0C 01 01 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

0E 02 01 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

10 02 00 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

12 02 FF 00 28 24 49 33 49 33 49 33 C0
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

14 02 00 00 28 24 49 33 49 33 49 33 C0
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

16 02 01 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW

0C 02 01 00 28 24 49 33 49 33 49 33 00
IP-P1-A—B—R0-R1-R2-R3-R4-R5-R6-R7-PSW
```

The Instruction Set

ADD A,RR	ADD REGISTER TO A
ADD A,DIRECT	ADD DIRECT BYTE TO A
ADD A,@RI	ADD INDIRECT RAM TO A
ADD A,#DATA	ADD IMMEDIATE DATA TO A
ADDC A,RR	ADD REGISTER TO A WITH CARRY
ADDC A,DIRECT	ADD DIRECT BYTE TO A WITH CARRY
ADDC A,@RI	ADD INDIRECT RAM TO A WITH CARRY
ADDC A,#DATA	ADD IMMEDIATE DATA TO A WITH CARRY
SUBB A,RR	SUBTRACT REGISTER FROM A WITH BORROW
SUBB A,	DIRECT SUBTRACT DIRECT BYTE FROM A WITH BORROW
SUBB A,@RI	SUBTRACT INDIRECT RAM FROM A WITH BORROW
SUBB A,#DATA	SUBTRACT IMMEDIATE DATA FROM A WITH BORROW
INC A	INCREMENT A
INC RR	INCREMENT REGISTER
INC DIRECT	INCREMENT DIRECT BYTE
INC @RI	INCREMENT INDIRECT RAM
DEC A	DECREMENT A
DEC RR	DECREMENT REGISTER
DEC DIRECT	DECREMENT DIRECT
DEC @RI	DECREMENT INDIRECT RAM
INC DPTR	INCREMENT DATA POINTER
MUL AB	MULTIPLY A&B
DIV AB	DIVIDE A BY B
DA A	DECIMAL ADJUST A
CLR C	CLEAR CARRY FLAG
CLR BIT	CLEAR DIRECT BIT
SETB C	SET CARRY FLAG
SETB BIT	SET DIRECT BIT
CPL C	COMPLEMENT CARRY FLAG
CPL BIT	COMPLEMENT DIRECT BIT
ANL C,BIT	AND DIRECT BIT TO CARRY FLAG
ANL C,/BIT	AND COMPLEMENT OF DIRECT BIT TO CARRY FLAG
ORL C,BIT	OR DIRECT BIT TO CARRY FLAG
ORL C,/BIT	OR COMPLEMENT OF DIRECT BIT TO CARRY FLAG
MOV C,BIT	MOV DIRECT BIT TO CARRY FLAG
MOV BIT,C	MOV CARRY FLAG TO DIRECT BIT
ACALL ADDR11	SUBROUTINE CALL
LCALL ADDR16	LONG SUBROUTINE CALL
RET	RETURN FROM SUB ROUTINE
RETI	RETURN FROM INTERRUPT
AJMP ADDR11	ABSOLUTE JUMP
LJMP ADDR16	LONG JUMP
SJMP REL	SHORT JUMP (127) RELATIVE ADDRESS
JMP @A+DPTR	JUMP INDIRECT RELATIVE TO DPTR
JZ REL	JUMP RELATIVE IF A IS ZERO
JNZ	JUMP RELATIVE IF A IS NON ZERO
JC REL	JUMP RELATIVE IF CARRY FLAG IS SET
JNC REL	JUMP RELATIVE IF CARRY FLAG CLEAR
JB BIT,REL	JUMP IF DIRECT BIT IS SET
JNB BIT,REL	JUMP IF DIRECT BIT IS CLEAR
JBC BIT,REL	JUMP IF DIRECT BIT IS SET AND CLEAR BIT
CJNE A,DIRECT,REL	COMPARE DIRECT TO A AND JUMP IF NOT EQUAL
CJNE A,#DATA,REL	COMPARE IMMEDIATE TO A AND JUMP IF NOT EQUAL
CJNE RR,#DATA,REL	COMPARE IMMED. TO REG.AND JUMP IF NOT EQUAL
CJNE @RI,#DATA,REL	COMPARE IMMED. TO INDIR. AND JUMP IF NOT EQUAL
DJNZ RR,REL	DECREMENT REGISTER AND JUMP IF NOT ZERO
DJNZ DIRECT,REL	DECREMENT DIRECT AND JUMP IF NOT ZERO
NOP	NO OPERATION
MOV A,RR	MOVE REGISTER TO A
MOV A,DIRECT	MOVE DIRECT BYTE TO A
MOV A,@RI	MOVE INDIRECT RAM TO A
MOV A,#DATA	MOVE IMMEDIATE DATA TO A
MOV RR,A	MOVE A TO REGISTER
MOV RR,DIRECT	MOVE DIRECT BYTE TO REGISTER
MOV RR,#DATA	MOVE IMMEDIATE DATA TO REGISTER
MOV DIRECT,A	MOVVE A TO DIRECT BYTE
MOV DIRECT,RR	MOVE REGISTER TO DIRECT BYTE
MOV DIRECT,DIRECT	MOVE DIRECT BYTE TO DIRECT
MOV DIRECT,@RI	MOVE INDIRECT RAM TO DIRECT BYTE
MOV DIRECT,#DATA	MOVE IMMEDIATE DATA TO DIRECT BYTE
MOV @RI,A	MOVE A TO INDIRECT RAM
MOV @RI,DIRECT	MOVE DIRECT BYTE TO INDIRECT RAM
MOV @RI,#DATA	MOVE IMMEDIATE DATA TO INDIRECT RAM
MOV DPTR,#DATA16	LOAD DATA POINTER WITH 16 BIT ADDRESS
MOVC A,@A+DPTR	MOVE CODE BYTE RELATIVE TO DPTR TO A
MOVC A,@A+PC	MOVE CODE BYTE RELATIVE TO PC TO A
MOVX A,@RI	MOVE EXTERNAL RAM (8 BIT ADDRESS) TO A
MOVX A,@DPTR	MOVE EXTERNAL RAM (16 BIT ADDRESS) TO A
MOVX @RI,A	MOVE A TO EXTERNAL RAM (8 BIT ADDRESS)
MOVX @DPTR,A	MOVE A TO EXTERNAL RAM (16 BIT ADDRESS)
PUSH DIRECT	PUSH DIRECT BYTE ON STACK
POP DIRECT	POP DIRECT BYTE FROM STACK
XCH A,RR	EXCHANGE REGISTER RX WITH A
XCH A,DIRECT	EXCHANGE DIRECT BYTE WITH A
XCH A,@RI	EXCHANGE INDIRECT RAM WITH A
XCHD A,@RI	EXCHANGE LOW ORDER DIGIT INDIRECT WITH A
ANL A,RR	AND REGISTER TO A
ANL A,DIRECT	AND DIRECT BYTE TO A
ANL A,@RI	AND INDIRECT RAM TO A
ANL A,#DATA	AND IMMEDIATE DATA TO A
ANL DIRECT,A	AND A TO DIRECT BYTE
ANL DIRECT,#DATA	AND IMMEDIATE DATA TO DIRECT BYTE
ORL A,RR	OR REGISTER TO A
ORL A,DIRECT	OR DIRECT BYTE TO A
ORL A,@RI	OR INDIRECT RAM TO A
ORL A,#DATA	OR IMMEDIATE DATA TO A
ORL DIRECT,A	OR A TO DIRECT BYTE
ORL DIRECT,#DATA	OR IMMEDIATE DATA TO DIRECT BYTE
XRL A,RR	EXOR REGISTER TO A
XRL A,DIRECT	EXOR DIRECT BYTE TO A
XRL A,@RI	EXOR INDIRECT RAM TO A
XRL A,#DATA	EXOR IMMEDIATE DATA TO A
XRL DIRECT,A	EXOR TO DIRECT BYTE
XRL DIRECT,#DATA	EXOR IMMEDIATE DATA TO DIRECT BYTE
CLR A	CLEAR A
CPL A	COMPLEMENT A
RL A	ROTATE A LEFT
RLC A	ROTATE A LEFT THROUGH CARRY
RR A	ROTATE A RIGHT
RRC A	ROTATE A RIGHT THROUGH CARRY
SWAP A	SWAP NIBBLES WITHIN A

Rammed Earth BUILDING

June 2000 sees the opening of the first commercial Earth-block and wood building at the Centre for Alternative Technology. Could this set a new trend in low cost building? Paul Freeman-Sear finds out.

Among the many exhibits at the Centre For Alternative Technology at Machynlleth Wales stands a new public building. Nothing unusual about a public building you may say, but this one is different, it is made of earth - Rammed Earth. The Autonomous Environment Information Centre as it's called has been made from some 1700 earth blocks and 'green oak' wood. The £633,000 project financed from a variety of sources including £115,000 from UK Waste through the Landfill Tax Credit scheme, is a pioneering project to test many new ideas and techniques.

Project Manager, Cindy Harris said "Earth Buildings can withstand the tests of time and intensive usage. We need to find alternatives to 'building as usual', both in terms of the energy and other non-renewable resources used, as well as the comfort and thermal efficiency of the finished structure. Earth buildings score well on both counts, and on top of that, have the aesthetic appeal of a natural material that is superbly functional".

Earth blocks have a low embodied energy, they are locally available, are a cheap resource and are pleasing to look at. What's more, when the building is to be disposed of, the blocks can return to their natural state on site. Earth blocks also have a high thermal mass so that means the building will be slow to cool down in the wintertime and slow to warm up in summer. They also regulate humidity as they are hygroscopic, a point worthy of note in today's 'dry' buildings.

Lime and clay plasters and mortars have also been used with limecrete foundations. No concrete has been used throughout because of the carbon dioxide emissions involved in producing concrete.

Insulation

We now all know that most energy savings in a building are to be made in the prevention of heat loss. Naturally we must expect this building to be no different in its approach. Here is some typical insulation thicknesses. The roof has 450mm, 325mm are in the walls with 250mm under the floor. The double-glazing uses Low E glass with inert gas in between. Daylight comes mainly through rooflights. These are electrically operated for ventilation. It is a sobering thought that roof lights are twice as effective as normal windows for general lighting in buildings. Interestingly this simple move that would lead to more pleasant surroundings and a saving of energy has been slow to be adopted in private dwellings. Sheep's wool is used as an insulator in the wall cavities. It is a local renewable environmentally friendly source which also regulates moisture levels. Performance differences between sheep's wool and mineral or fibreglass insulation are marginal.

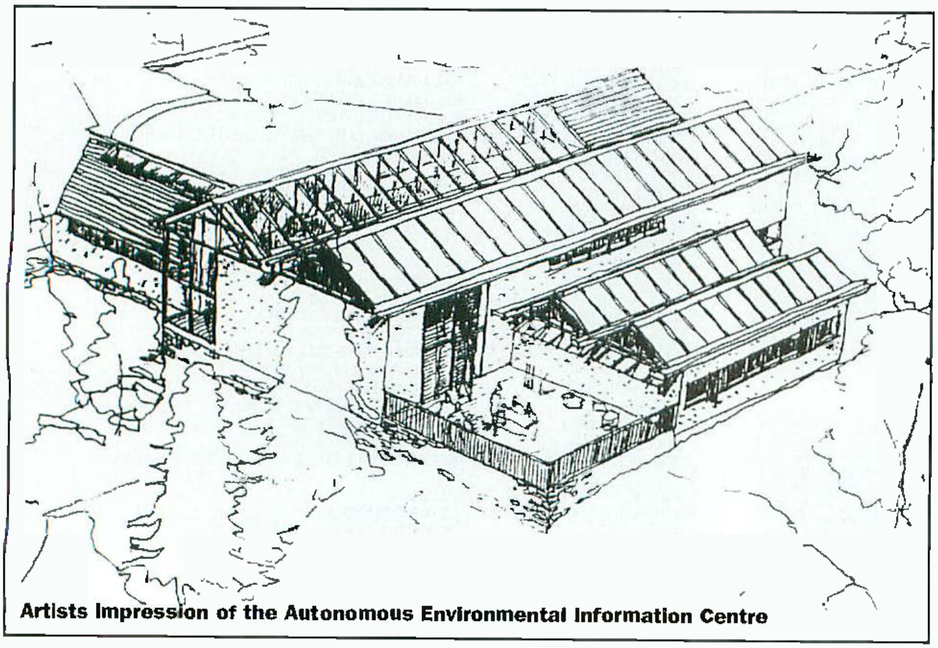
Earth building blocks

Heating

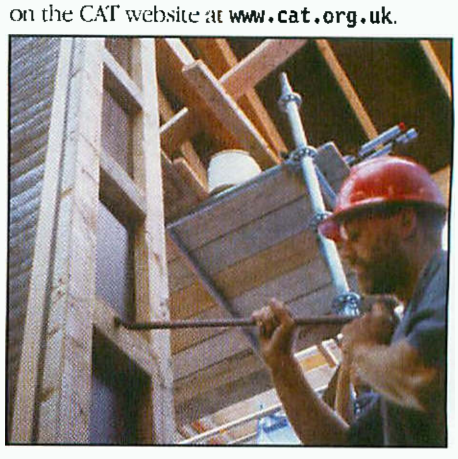
Supplying heat for the building in winter will come from the local district heat main'. This is another interesting idea installed on the site. The new heat main will obtain heat from a variety of heat input sources, namely the wood chip boiler and the solar heating panels newly installed on the Information Centre roof. The total area given over to these panels is 130m² with 5m³ of heat store linked to the underfloor heating. The heat main will supply seven major buildings at the centre in winter and heat will be 'traded' where the requirement is most needed.

Electrical energy demand is low as low-energy lighting is used with automatic dimming facility. The building will eventually have its own PhotoVoltaic panels on the roof to supply electricity.

The Autonomous Environment Information Centre was built because there is now an increasing demand for information on environmental technologies. The building is now open to the public at the Centre For Alternative Technology, Machynlleth in Wales. Full details of its construction can be found on the CAT website at **www.cat.org.uk**.



Artists Impression of the Autonomous Environmental Information Centre



A La Modem

Maplin order code: TA26
Price £39.99

With all the talk about broadband, fast access to the Internet - ADSL, cable, and mobile G3 phones - just around the corner, it's no surprise that the Internet access method most of us actually use has taken a back seat. Yet modems, whatever the pundits might tell you, still actually form the backbone of Internet communications for the vast majority of Internet users worldwide.

Modems have come a long way over the last few years, with each successive generation of them providing faster and faster Internet access than the last. The latest generation of modems, however, would appear to be the last and fastest that we'll ever see. The aim of each modem generation is quite simply to pump digital data along scratchy old telephone lines a bit faster than the previous modem generation. With 56K modems, it seems that about as much digital data as can physically be pushed through an analogue telephone has finally been reached. If your computer's modem connection to the Internet still doesn't appear particularly fast, then, at 56K, you've simply reached the end of the line.

Well, maybe. Maybe not! It might be that your 56K modem isn't achieving its maximum throughput, and there are several reasons for this, some of which are highly dependent on each other. Thankfully, some reasons you can do something about to improve your connection while on the other hand some you can't. Note that it's very rarely the case that the modem itself is at fault. Also, it's worth remembering that 56K modems adjust their connection speeds up and down during a connection according to line conditions. As a result, initial connection speed (that is, the speed reported back to you as you log on to the Internet) might be quite high, but within seconds may drop significantly - accordingly, you might think you're surfing at 48K (around the fastest you can expect out of a 56K modem), but within seconds you could be limited to around 24K.

Without doubt, having the most up-to-date firmware can make a significant difference to modem operation, so check with your modem manufacturer that you have the latest firmware revision. If not, download and install it from the manufacturer's Website - if the modem is made by a reputable and reliable supplier you'll find the latest firmware fairly easily. Some el cheapo modems fitted in el cheapo PCs may not give you this possibility, as in everything to do with computers you get what you pay for, and that includes after-sales care.

It's worth bearing in mind that while, on the face of it, 56K modems follow a standard, known as V90, it appears that the standard's not perhaps as standard as we might hope. A situation can arise if the modems (or at least the chipset used in the modems) your Internet service provider has at its servers aren't manufactured by the same manufacturer of your computer modem's chipsets, where an unreliable connection can result. There are actually only two main modem chipset manufacturers, Rockwell and 3Com, so it's a relatively easy job to check with your Internet service provider whether the same chipsets are used. If not, see if the Internet service provider has an alternative phone number with alternative modems. Otherwise, try another Internet service provider that you know uses the same modem chipsets as yours. As it's easy to find Internet service providers these days, it's probably worth trying several until you find one that gives consistent, fast connections.

You can try adjusting your modem's settings. These might be controlled in one or two ways. First is the modem initialisation string, which is a data burst each time your computer instructs your modem to dial out to your Internet service provider. Second is the full modem driver, which controls other aspects of your modem as well as initialisation string. Remember though, that playing around with your modem's settings could prevent your modem from connecting reliably at all, so make sure you keep a copy of the default settings so you can return to where you started if all else fails. The variations you can make to your modem's settings should be described in the modem's user manual.

If none of this helps, it might be that your telephone line itself is at fault. If an exchange hasn't been upgraded to digital ability, there may be more than one analogue section between you and your Internet service provider - the result being a maximum connection speed of 33.6Kbps. Although this happens rarely now in the UK, there are still some exchanges that haven't yet been upgraded to digital status, and if you are connected to one of them then anything faster than 33.6Kbps connections might simply be just out of your reach.

Also, your telephone line or your internal extension circuit might be noisy. Some noises, pops, hisses, crackles and so on are audible, and you might be able to hear them when you use the telephone line for an ordinary phone call - if so, then the noises are bound to impinge on your modem's ability to pass digital data. However, some noise may be inaudible (or, at least, so quiet as not to affect a voice conversation - but could affect your modem communications nevertheless). If you feel that noise is the problem, get your telephone supplier to check out the line. Unfortunately, the UK's main supplier BT only guarantees a good voice connection over its telephone circuits, so if your problem is inaudible noise you might not be able to improve your modem communications at all.

If you feel that noise could be the problem, and if you have other telephone devices (fax machines, answering machines and so on) plugged in to other sockets on your extension circuit, unplug the other devices to see if they are conflicting with your modem's connection. You can go a step further, and isolate your internal wiring by plugging your modem directly into your phone line's master socket. This should improve matters if you are either suffering interference from electrical appliances or have bad connections in the internal wiring.

Finally, for further information and help relating to 56K modem problems, checkout 56K.com, at: <**www.56k.com**> where you'll find more detailed help in getting the best out of your modem.

Forrester Predicts Demise of Dot Com Retailers

The combination of weak financials, increasing competitive pressures and investor flight will drive most of today's Dot Com retailers out of business by 2001. According to a new Report from Forrester Research at <**www.forrester.com**>, to survive in the online retail battleground, firms will need to redirect extravagant branding investments into three categories of hard assets, defined by scale, service, and speed.

Last year, enthusiasm about the increasingly mainstream Internet population expanded online retail beyond early entrants selling books, music, computers, and travel. Dot Com entrepreneurs tapped eager investors for millions, planted flags in new categories from pets to perfume, and blew their budgets on marketing chatter. But, the tide is turning against Dot Coms, and consolidations will soon steamroll across the weak ones.

Forrester believes that consolidation will occur in three waves. First, firms selling commodity products that have been successful since the Internet's early days - such as books, software, and flowers - will consolidate by the fall of 2000 amid slowing annual growth rates.

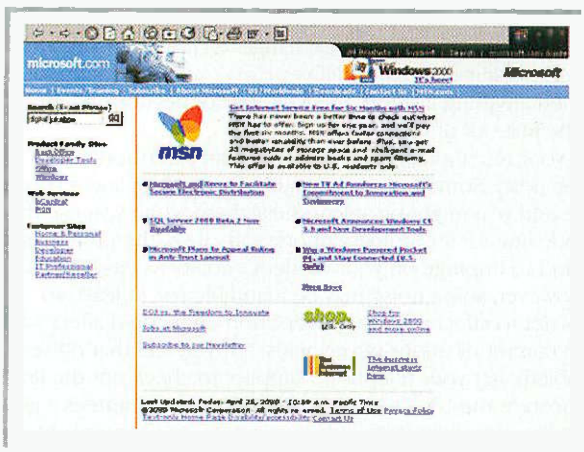
Second, the plethora of merchants selling undifferentiated products at razor-thin margins - including pet supplies, toys, and consumer electronics - will collapse before marketing expenditures ramp up for the next holiday season. Finally, online merchants selling heavily branded, high-style products like apparel and furniture will remain stable until 2002.

To survive consolidation, online retailers must anchor themselves by building sustainable assets that will attain scale, service, and speed. Leaders will need to focus on hard assets that support high sales volumes and lower costs per transaction: a large, loyal customer base; in-house fulfilment capabilities; and a rock-solid internal organisation.

Online retailers must strike back at brand confusion and product duplication by distinguishing themselves through customer service. Presence across multiple channels and platforms, exclusive manufacturer deals to carry specific products, and a range of delivery options will help to build lifetime relationships.

Speed will keep retailers ahead of rivals, but it will also require a flexible business foundation. Retailers should adopt technologies and strategies that adjust to unforeseen competitive forays and customer demands.

Microsoft Debuts Digital Jukebox



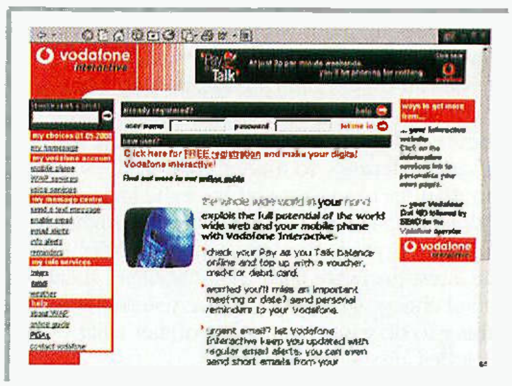
Microsoft at <**www.microsoft.com**> has released a preview of its digital jukebox software that records and stores music on a PC. The digital jukebox software will be incorporated into Windows Media Player, which plays audio and video files on a PC.

In the future, Microsoft will bundle its Windows Media Player with its operating system and new versions of Internet Explorer.

By releasing the jukebox software, Microsoft is increasing its competition with RealNetworks, which offers the market-leading programs RealPlayer and RealJukebox.

Although RealNetworks currently leads the PC jukebox market, the company does not offer a single program that offers all the capabilities of Microsoft's new software.

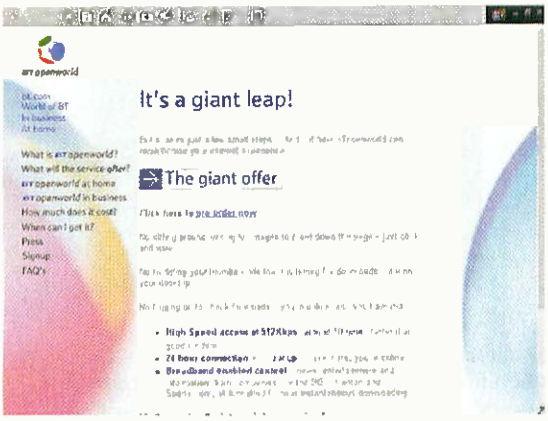
Vodafone Builds WAP Directory Services



Vodafone has launched an extensive WAP directory. It lists WAP sites by category such as entertainment, business and news. To make WAP browsing as quick and easy as possible, there is a direct click through from the Vodafone directory to every site listed. On <**www.vodafone.net**> owners of WAP sites can register their details for entry into the directory.

Vodafone will soon be further expanding its WAP services to include mobile email with optional voice activation, mobile commerce with the ability to buy flowers, flights, tickets, CDs and books through the precinct in your pocket. There will also be a voice activated virtual personal assistant. Additionally, business users will soon be able to access information from office databases via WAP.

BTopenworld Broadband Internet



Btopenworld at **<www.btopenworld.com>**, BT's new high growth Internet business, has announced plans to launch a mass-market broadband portal and high-speed Internet service from July.

The service - branded BTopenworld - will be aimed at consumers, small businesses and teleworkers. The consumer service is competitively priced at £39.99 a month. It will provide high-speed, always-on access to the Internet and a range of highly personalised, content-rich and interactive applications through consumer and business broadband portals.

Based on asymmetric digital subscriber line (ADSL) technology, BTopenworld will emphasise compelling content and applications, personalisation, ease of use, competitive pricing, and comprehensive customer support - positioning it at the forefront of the second wave of the Internet.

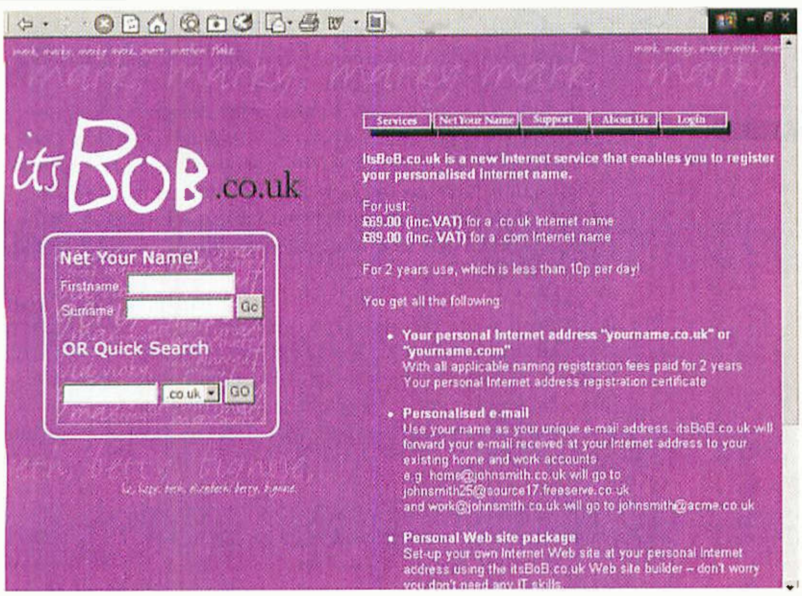
Option Overload Leaves SMEs Out in the Dot-Com Cold

68% of SMEs admit they have not set up a Web site because they are intimidated by the range of IT options available.

According to research carried out by Digital Exchange at **<www.digitalexchange.co.uk>**, the business-to-business ISP, the range and choice of ISPs, bandwidth and telecoms available are leaving SMEs so daunted that they avoid setting up a site, therefore delaying the take-up of e-commerce.

The Digital Exchange offers a series of Web-related services which, when combined, offer a cost-effective and no-nonsense solution for all things Internet. It offers Web site design and hosting, e-commerce consultancy, Voice over IP and security services.

Lovers embrace Email courtship



Email is now the preferred medium for first time romantic advances, according to a survey by itsBoB.co.uk at **<www.itsBoB.co.uk>**, the personal Internet services company.

Almost 70% of young professionals have been asked out by email in the last year, according to a survey of 200 people aged 18 to 30, while less than 40% were approached over the phone.

The survey also revealed that those trying for a second date were twice as likely to get in contact via email after a casual encounter, rather than over the phone.

The news may be unwelcome for those with long-winded, complex email addresses such as tracy_smith106@dial.pipex.com. Results from itsBoB.co.uk's email challenge last month showed that only personalised, quirky addresses are remembered consistently after a few pints.

itsBoB.co.uk offers users the chance to Internet their personal names and use them as Web addresses, such as **<www.davejones.co.uk>**. The package includes email forwarding which passes all emails sent to this personal address to your existing email account, and easy templates to set up your own Web site.

Easyspace Offers Dot Com Domains for £10

easyspace.com at <www.easyspace.com>, the ICANN accredited domain name registration and hosting company, is offering .com .net and .org domains for just US$15 per year inclusive of all InterNIC fees.

At around 60% cheaper then the industry average, Easyspace may be the cheapest domain registrars in the world.

Currently Easyspace has approximately 2% of the dot com domain name world market. It aims to grow that market share to 15% by offering its customers a great service at a fair price.

Think It, Type It, Find It

Looking for a holiday, a car, a new home? Just think it, type it and then find it with QAZ.com at <www.qaz.com>.

Internet users looking for Web sites can now find a comprehensive page of independently reviewed UK-relevant sites almost as soon as they realise they want them.

In development and trailing since November 1999, QAZ.com is now fully operational. Using QAZ.com's addressing system, users can access the more than 1,500 reviewed Web sites by simply typing in what they are interested in before they get to the Web site.

QAZ.com has more than 100 directly addressed topic pages. A user wanting to buy CDs simply types cd.QAZ.com in their browser and up comes a list of sites for buying CDs online plus other CD-related Web sites.

For holidays users type in holiday.QAZ.com, for cars it's car.QAZ.com and so on. The site also uses around six hundred aliases to direct users to relevant sections. For example dogs, dog and cat all lead to pet.QAZ.com. golf.QAZ.com points to the general sport.QAZ.com topic but soccer.QAZ.com resolves to the separate football.QAZ.com page.

But QAZ.com is not just about a novel addressing structure. All the Web sites featured on QAZ.com have been independently reviewed and given a star rating. The sites themselves are then grouped into relevant topics creating almost a magazine of site reviews.

Are Your Staff Pushing Porn or Spreading Secrets?

Computer users can now get free, expert advice on how to protect against e-mail-borne threats.

Content Technologies at <www.mimesweeper.com>, the content security specialist, has just published a guide to establishing and managing an e-mail policy. The document is aimed at helping companies harness the benefits of e-mail without exposing themselves to threats such as viruses, spamming, spoofing, circulation of obscene material, confidentiality breaches and legal liability.

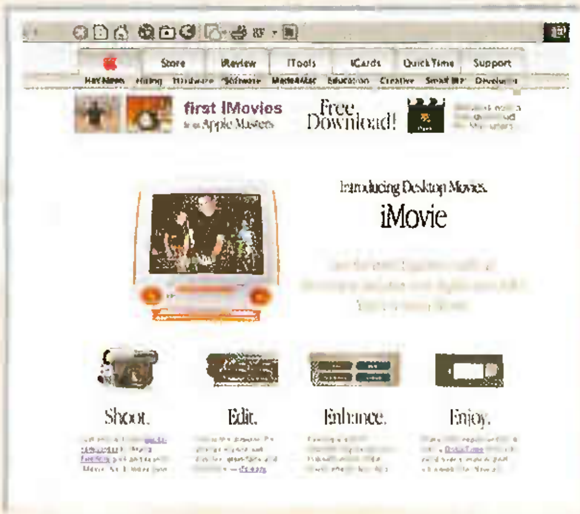
The 'E-mail Policy Guide' gives step-by-step advice on creating an e-mail policy tailored to an organisation's specific requirements.

The document contains a series of comprehensive checklists and is designed to help businesses define their content security needs, implement a corporate e-mail policy and to evaluate software solutions to ensure that they can provide the right level of protection.

The guide covers issues such as managing file types and sizes, Java scripts, executables, spam and spoof, as well as virus scanning, text analysis and legal disclaimers.

The guide also explains how to effectively maintain a content security policy once it has been implemented. It offers companies advice on how to introduce a 'security awareness' culture and how to keep their policy and content security solution updated to combat the latest e-mail borne threats.

Apple Offers iMovie as Free Download

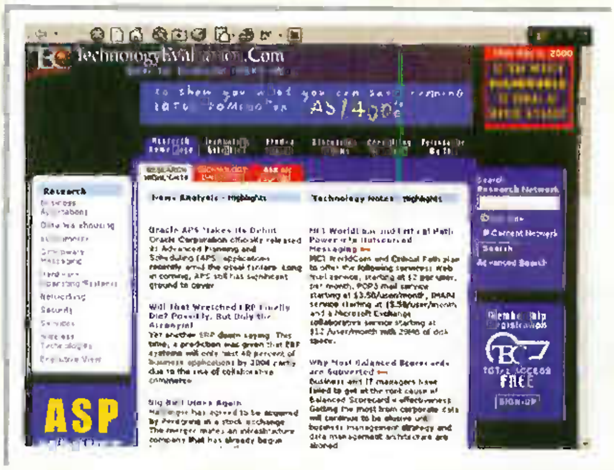


Apple has made iMovie, its video editing software, as a free download for its PowerBook and Power Mac G4 users.

iMovie was introduced in October 1999 and has earned rave reviews as the easiest to use video editing software ever, allowing users to create their own pro-quality movies. iMovie comes preinstalled on all iMac DV and iMac DV Special Edition systems, and will now be available to all PowerBook and Power Mac G4 users as a free download at <**www.apple.com/imovie**>.

With iMovie, users can import video from a digital video camcorder directly into their FireWire-enabled iMac DV, iMac DV Special Edition, Power Mac G4 or PowerBook, rearrange clips and add special effects like cross-dissolves and scrolling titles. Completed iMovies can be stored on the computer, as well as transferred back to a camcorder for viewing on standard TV or VHS videotape.

TechnologyEvaluation.com Expands Access to Web Community



TechnologyEvaluation.com at <**www.technologyevaluation.com**> and Blink.com at <**www.blink.com**> have announced an agreement that will provide users of both sites easier access to the TEC Web site.

Under the terms of the agreement, Blink.com users will have access to TechnologyEvaluation.com Recommended Folders, giving them direct access to TEC's recent News Analysis, Technology Notes, and Research Directory.

In addition, TEC users will have the ability to bookmark any page of TEC analysis through Blink.com, giving them access to the specific pages no matter what computer or device they use to access the Internet.

TechnologyEvaluation.com (TEC) is the premier business-to-business Internet portal for information technology research.

SearchArrow.com Overcomes Shoddy Search Engines

Internet users today are faced with the challenge of finding relevant, in-depth information. Existing search engines do not drill down to any specific content, nor do they return links to specific content within a specific Web site. They merely index a Web site's URL and certain keywords describing the site. Consequently, they often yield diverse and incomplete results.

This leads to out dated Web pages, metatag manipulation-which leads to irrelevant results, and irrelevant results due to poor indexing.

Currently, there are too many Web sites on the Internet and new ones are being added daily. Almost all sites on the Internet have too much competition, each with different information. Consumers are forced to spend time searching numerous sites to obtain the information needed.

The solution is a super search engine that searches each and every page of each site. SearchArrow.com at <**www.seacharrow.com**> drills down, retrieves, collects, aggregates, sorts, reformats and finally displays the detailed content to the user. This process is equivalent to a child's scrapbook of articles about a favourite basketball player, cut from numerous magazines and newspapers.

SearchArrow.com can conduct a search of sites that are particular to a user's query. This type of searching results in: no out dated information, no dead links, links to actual content on the sites searched, and no unrelated information. We literally aggregate the Web into ONE site.

We search multiple Web sites simultaneously in real time in order to find the user the most accurate results. Search Arrow does not use a database and conducts all of it's searches in real time by using state of the art search technology and artificial intelligence.

HP Announces New Version of Scan to Web Technology

Hewlett-Packard has announced an upgrade to its scan to Web image-uploading technology, and an expansion of its scan to Web resources with the addition of Zing.com's online photo community.

HP's scan to Web technology enables HP ScanJet scanner users to effortlessly share their photos with family and friends around the world by streamlining the process of scanning photos directly to select Web sites. Zing.com at **<www.zing.com>** joins HP Cartogra and MyFamily.com at **<www.myfamily.com>** as one of the photo-sharing Web sites optimized for HP's scan to Web solution.

The enhanced scan to Web technology offers upgraded features that allow users more flexibility and choices when scanning photos to the Web.

Users will now be able to scan in photos at higher resolutions optimised for printing and viewing from scan to Web resource sites, an improvement over the low-resolution images (72 dots per inch) currently available online.

Users will be able to reduce the time spent scanning photos by using HP's multiple-photo-scanning feature. This feature allows users to place numerous photos on the scanner and scan them all at once. The scanner will upload the individual photos as separate files, saving the user time. Another new feature gives users even more scanning control by enabling them to rotate scans in 90° increments before uploading the images to the Web.

The451.com Launches News Analysis Service

The451.com at **<www.the451.com>** has launched a business-to-business news analysis tool for decision-makers in the technology industry and its associated investment community. A paid-for service, the451 guarantees independent, exclusive and original thinking from a global team of experts.

The451.com is one of the first companies to emerge from Durlacher's research-driven business-to-business incubation channel.

Written specifically for an influential and time-conscious business audience, the451.com delivers hundreds of hours of daily research as a business tool for making timely and informed decisions. The451.com confronts and analyses the key issues driving the information technology, communications and media industries.

Anticipating dramatic changes in the way news will be consumed and to address the growing demand for mobile information services, the451.com is setting the standard with an editorial strategy that offers business intelligence to WAP-enabled smartphone users. The WAP service is available to all smartphone users at wap.the451.com.

The service delivers exclusive breaking news to mobile phones, the Web, corporate Intranets, e-mail and PDAs, via AvantGo.

The key component of the451.com's service will be its specialist commentary on the industry's Burning Issues, which are reflected in its name: 451 Fahrenheit is the temperature at which paper burns. The451.com will investigate emerging markets and their players, identify new technology trends and define business opportunities.

At launch, the451.com will be reporting from a number of Burning Issues battlegrounds including Traffic Report, which will report on the quality of service on Internet routes and M-Commerce which will examine the struggle to win eyeballs on mobile and pervasive devices.

GatherRound.com Shows 360 Degree Photo Panoramas

Intel has expanded the capability of its photo-sharing GatherRound.com Web site at **<www.gatherround.com>** to offer photo panoramas.

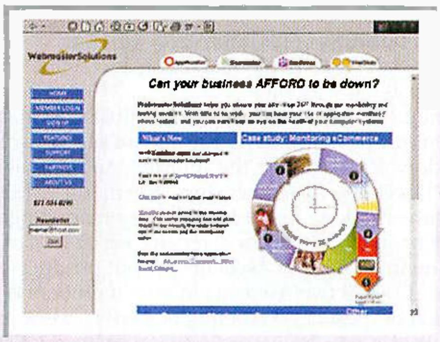
The new function allows GatherRound.com members to create their own 360° photos, an ideal application for creating and viewing vacation vistas, building interiors, landscaping scenes and images of fun events. The site also now incorporates photo gift items such as Photo Post-it, coffee mugs, T-shirts and photo puzzles.

GatherRound.com members create panorama photos using a special version of MGI PhotoVista software, which is available for free download from the site. In a few, easy steps, members can transform pictures into a seamless panorama, simplifying a task that previously needed the skill of a Web developer. The panoramas can then be uploaded and viewed in a GatherRound.com album.

In addition to creating panoramas, GatherRound.com members can now purchase photo gifts, including Photo Post-it, photo puzzles, mouse pads, coffee mugs, and T-shirts, that feature their favourite panoramas or pictures. The GatherRound.com Gift Shop is enabled by iPrint.com, a leading online provider of professional print and private-labelled print technology services focused on the business market.

Intel also plans to incorporate MGI's recently introduced PhotoSpace technologies on GatherRound.com later this year. Among the features offered will be the ability for GatherRound.com members to combine their personal pictures with cool and fun images and templates to create and print picture projects such as greeting cards, birth announcements and party invitations.

Site Provides Prevention and Detection of Denial of Service Attacks



WebmasterSolutions.com at <www.webmastersolutions.com> has developed two powerful tools for the prevention and detection of denial of service (DOS) attacks.

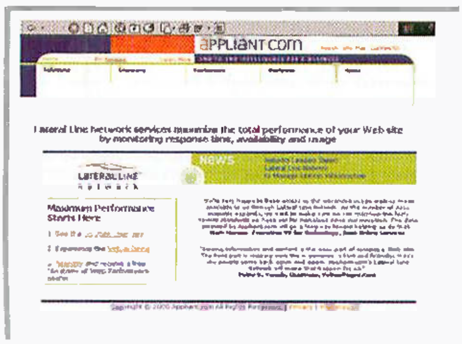
The company's AppMonitor service detects Web site failures, including those causing DOS attacks, and the SiteStress service accesses a site's threshold and pinpoints weaknesses as a preventive step against DOS attacks.

WebmasterSolutions.com's AppMonitor service detects DOS attacks and all other Web site failures by monitoring sites from external servers. Should any type of error occur, such as an inaccessible site or if the server is slower than normal, an immediate pager email is sent to the client.

The company's SiteStress service simulates thousands of users hitting the site at once, ensuring its ability to handle the load. This service can be used to simulate an actual DOS attack, thus arming eBusinesses with detailed knowledge of their Web site robustness as well as test their ability to stop the attack before the system crashes or becomes unstable.

A recent addition to WebmasterSolutions.com's elite suite of services is VitalStats, which measures the health of a server, including a webserver, application server or database server. VitaStats monitors the CPU load, memory usage, disk space, and network load and provides this data in an easy to read graph format. Pager alerts are sent to the client if the system exceeds the user-defined thresholds.

Appliant.com Tool Explains Web Performance in Layman's Terms



Appliant.com has announced that it is offering an Anatomy of Web Performance poster via its Web site at <www.appliant.com>.

Appliant.com designed the poster to explain the elements of a Web transaction and break down Web performance into understandable and manageable components. Understanding Web performance is critical to ensuring the best end-user experience.

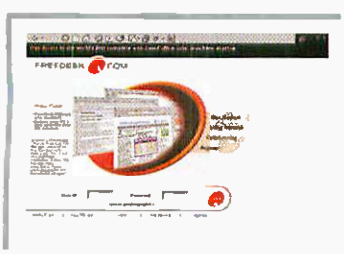
InsideChips.Ventures Joins SuperSite eCommunity

InsideChips.Ventures at <www.insidechips.com>, the semiconductor industry's newest online venture tracking emerging chip companies and technologies, has joined with the SuperSite Network as a content/marketing partner.

SuperSite.Net's partnership with InsideChips.com will bring users in-depth discussions of emerging semiconductor chip ventures and technologies, backed by over 20 years' experience in semiconductor market development, strategic market studies, technology assessment and industry economic analysis.

Industry watches that track up-and-coming chip ventures will find InsideChips Ventures's industry reports essential in keeping ahead of the pack.

FreeDesk.com Enables Users To Access And Share Personal Hard Drives



FreeDesk.com at <www.freedesk.com>, an Internet application service provider (ASP) has announced that its users are now able to access their own hard drives and directories from any computer, anywhere through the FreeDesk Web site.

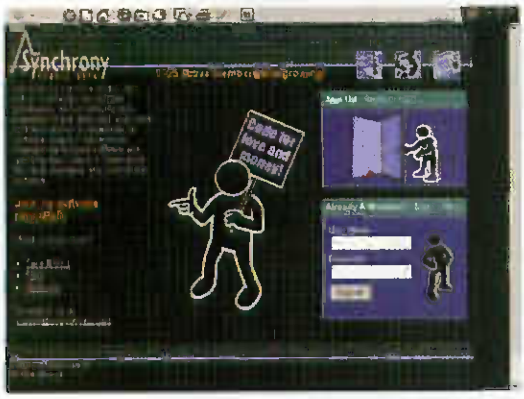
FreeDesk's PC Share software also allows users to share personal files with any other users they designate. The FreeDesk service, including PC Share, is free to all users.

PC Share is located in the File Manager on FreeDesk's Web site. Users can install the program on their personal computers free of charge. The program is approximately 800kB and takes three to four minutes to download. Directions for creating and modifying a shared user directory are located in the File Manager help menu.

Currently, FreeDesk is available for Windows and Linux PCs as well as certain versions of the Macintosh platform. It runs on virtually any java-enabled browser, such as Netscape Navigator or Internet Explorer.

FreeDesk.com, formerly MyFreeDesk.com, is an Internet application service provider (ASP) that provides Web-based office suite software applications and online collaboration capabilities on a free, ad-supported basis to businesses, consumers, ISPs and major portals.

Internet Start-Up Asynchrony.Com Hosts 1,000 Developers



Just three weeks after releasing the public beta version of its Web site, Asynchrony.com at <www.asynchrony.com>, has more than 1,000 active members participating in its virtual software development incubator. This allows programmers worldwide to collaborate via the Internet on software programs and receive the majority of Internet revenues from the sale of their creations.

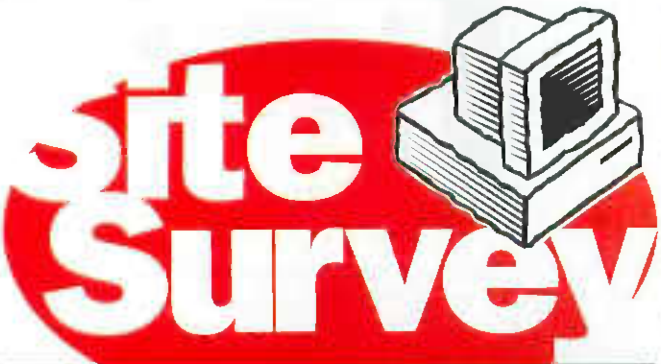
Asynchrony.com members, who work with fellow site members on their own projects, have already initiated more than 60 projects that represent a variety of software programs, including games, business applications and utilities. Asynchrony.com expects to begin marketing and selling finished software projects as early as May.

Products created at Asynchrony.com will initially be marketed via online download from the Asynchrony.com site, as well as more than 50 download sites on the Internet. Additionally, Asynchrony.com will negotiate licensing agreements, where appropriate, with shrink-wrap, OEM and other marketing channels. Asynchrony.com members receive up to 90% of the Internet revenue from sales of Asynchrony.com products.

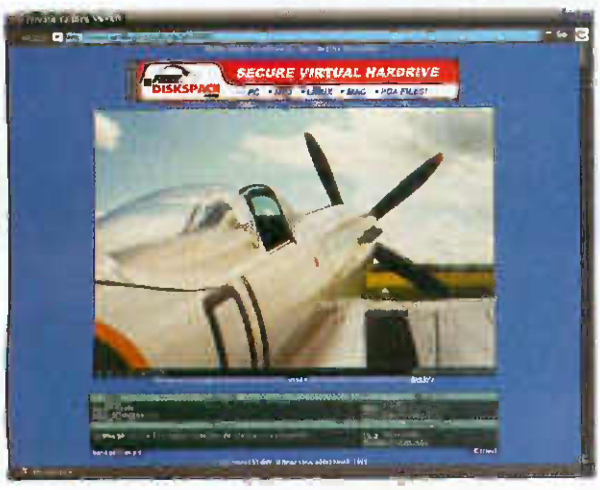
The power of 1,000 active Asynchrony.com members is immense. If each of these 1,000 members were to work just four hours per week, development on the Asynchrony.com site would equal the development efforts of a 100-person full-time programming staff.

Members of Asynchrony.com include not only software programmers but also technical writers, testers, designers, graphic artists and others who contribute to the creation of a total software package. Each development team has a project manager who is responsible for coordinating the work of the individual team members. Team members are assigned tasks, and there are shares associated with each task. Once the software is sold, the shares represent the percentage of the sales revenues each team member receives.

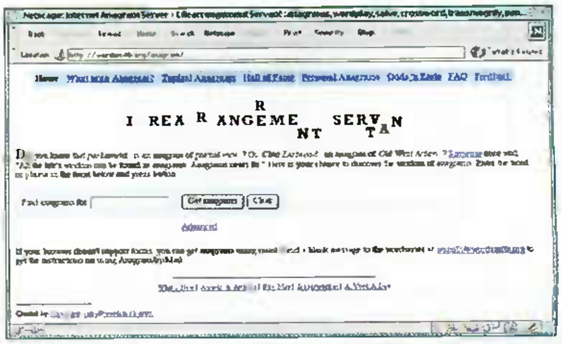
To become a member of Asynchrony.com, simply visit the Web site. There is no charge to become a member.



The months destinations

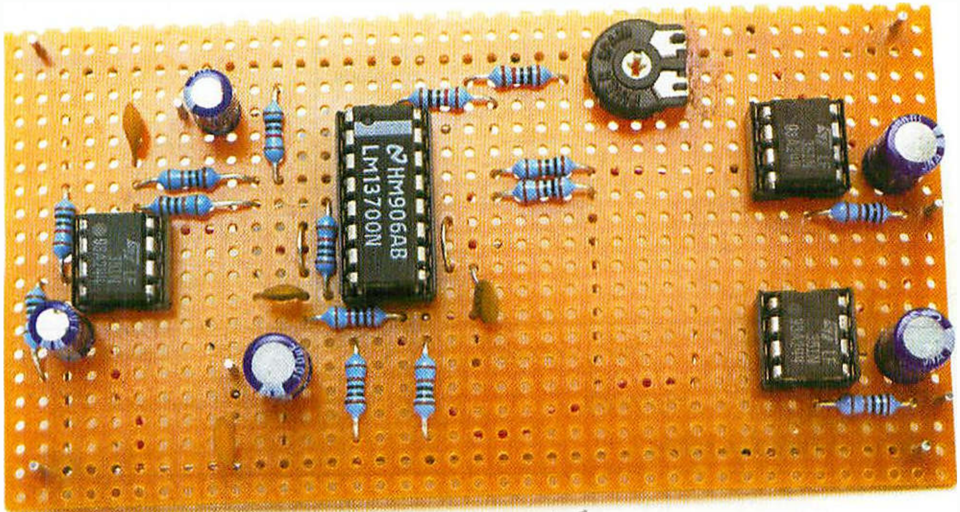


Airliners, at: <www.airliners.net>, is a wonderful source of images of aircraft of all descriptions. After searching for and locating the image of any particular aircraft you want , you have the option to send the image as a postcard to the recipient of your choice. Rather cool.



Stuck for words? The Anagram Server, at: <http://wordsmith.org/anagram> lets you enter a well-known phrase, saying, or name, and will list all its possible anagrams. Great for crossword puzzlers.

Mythstories is a fabulous source of reference about myths, legends and fables around the Shropshire area. Great for teachers (it's a National Grid for Learning affiliated site), it's located at: <www.mythstories.com>.



An Introduction TO FILTERS

Gavin Cheeseman discusses various types of filter circuits and offers practical designs.

Introduction

Filters of one kind or another can be found in most areas of analogue electronics. They perform a host of different functions and take many diverse forms ranging from simple smoothing capacitors in DC power supplies to complex audio and radio frequency filters. In this article we take a brief look at some of the techniques in use and cover some practical circuit examples. The idea is not so much to cover the theory of filters in detail but to give readers who are unfamiliar with the technology a brief insight into this wide and fascinating area of electronics. For reasons of complexity digital filter techniques have been largely avoided.

The function of a filter is to separate one quantity from another and electronic filters of the type discussed here are normally used to separate signals varying in frequency. Filters may be broadly categorised by their function. Examples are Low Pass, Band Pass and High Pass types. Figure 1 shows a graphical illustration of a number of different filter characteristics. In practice the curves vary considerably depending on a several factors (more of this later). The required filter response depends on the application in which the filter is being used. For example, it is common to limit the bandwidth of radiotelephony circuits to a few kHz so as to minimise spectrum usage. For this function, the filter response is designed to pass only the frequencies that are required for intelligible speech, exhibiting a high degree of attenuation outside this range. Filters are also used extensively in radio receivers for tuning and to prevent interference from unwanted signals. Other common applications include tone controls, graphic equalisers and loudspeaker crossovers; these are all examples of audio filters.

An ideal filter would only allow signals within a specific frequency range to pass, entirely removing frequencies outside a given 'pass band'. However, it is important to understand that practical filters usually fall considerably short of the ideal. Rather than entirely cutting off everything except the required signal, in practice the attenuation slowly takes effect over a range of frequencies. Therefore, the cut-off point of a filter is commonly quoted as the frequency or bandwidth at which the signal is attenuated to a specific degree, when compared to the maximum signal level within the filter pass band. The 3dB point is normally used although there are some exceptions.

How Do Filters Work?

Most simple filters make use of components such as capacitors or inductors that exhibit characteristics that vary with frequency. Simple filter networks may be constructed from resistors and capacitors. This type of arrangement is often referred to as 'passive' because the circuit does not provide any amplification and no power supply is required. Capacitors and inductors exhibit reactance; on a basic level, this may be thought of as a kind of resistance affecting only AC signals. Like resistance, reactance is measured in Ohms and the reactance of a capacitor falls as the frequency of the applied signal is increased. Two different configurations are shown in Figure 2.

The circuit shown in Figure 2a exhibits a low pass characteristic. Low frequency signals are passed largely unaffected but the attenuation progressively increases at higher frequencies. Figure 2b shows an alternative arrangement that exhibits a high pass characteristic. This time low frequencies are attenuated while high frequencies pass comparatively unimpeded. The values of the resistor and capacitor determine which frequencies are allowed to pass through the filter. The theoretical -3dB cut-off point may be determined using the formula $1/2\pi RC$ where R is the resistance in ohms and C is the capacitance in Farads. Filters of this type provide a predictable response and are often used in audio circuits. This type of circuit offers the advantage of simplicity and low cost but because the design is passive there is always a degree of unwanted signal loss within the required pass band. However, in many applications the amount of loss is insignificant and does not present a problem.

Standard single pole filters of the type shown exhibit a response curve that drops off at around 6dB per octave outside the pass band. In other words if the signal frequency is doubled the amplitude will be halved. However, one problem with this type of simple filter is that the response is not very sharp. That is to say, the transition between the region of minimum attenuation and the region where the signal drops at 6dB per octave is slow. It is possible to cascade a number of single pole filters to produce a steeper final slope but careful design is required to minimise the effects of loading. These drawbacks can be largely overcome using active filters (more of this later).

Notch Filters

One interesting variation of the passive RC filter is the notch filter. Notch filters are designed to pass all frequencies except those occurring within a specified band. An example of a notch filter characteristic is illustrated in Figure 3. A filter that will produce increased attenuation centred on a

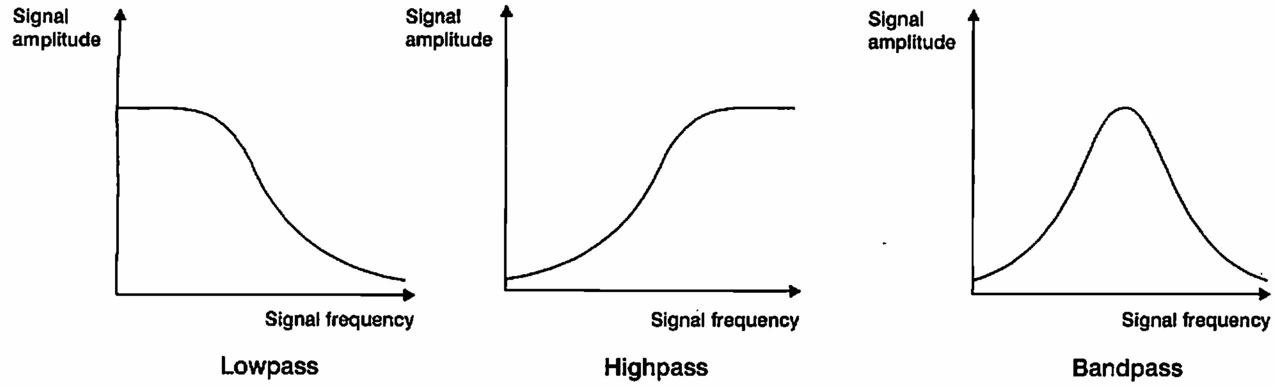


Figure 1. An illustration of typical filter frequency response curves

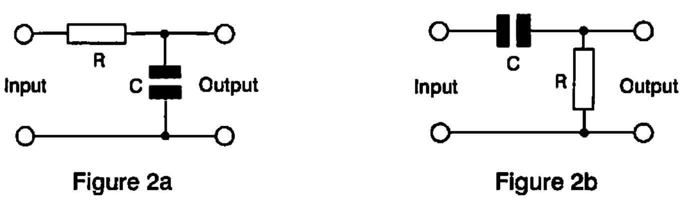


Figure 2a. Simple RC low pass filter
Figure 2b. Simple RC high pass filter

specific frequency may be designed by cascading single pole high and low pass filters as described above. However, this does not produce a particularly deep null. A more effective method is to use the type of circuit illustrated in Figure 4. This circuit often called the 'Twin T' filter relies on the phase shift introduced by a RC combination. The frequency response curve is not particularly sharp but with correct component matching the null can be extremely deep.

Resonant Circuits

One method of producing a sharp response with only passive components uses inductors and capacitors connected to form a resonant tuned circuit as shown in Figure 5. This arrangement is capable of producing a very sharp response and is widely used in radio frequency circuits. If a capacitor and resistor are connected together as shown in Figure 5a, a parallel tuned circuit is formed. At the frequency of resonance, the impedance is high. The response of the circuit peaks around this frequency, dropping off rapidly either side.

A similar arrangement is illustrated in Figure 5b; however, this time the capacitor and inductor are connected in series. Once again the response peaks at a specific frequency but unlike the parallel tuned circuit described above the impedance drops at resonance and increases at other frequencies.

Complex combinations of resonant circuits are often used to create a response that is tailored to a specific application or to interface between two radio frequency circuits of different impedance. Circuits using capacitors and inductors are also used in loudspeaker crossovers.

It is possible to obtain a very sharp peak in response using resonant circuits. The sharpness of the response is dependent on the 'Q' of the circuit and is determined by a number of factors. Of particular consequence is the ratio of inductance to capacitance (LC ratio). Using a comparatively high value inductor and a low value capacitor will result in a sharper peak than using a large capacitance and a small inductance. Series and parallel resistances are also important. The impedance of a parallel tuned circuit is typically many thousands of ohms at resonance. It is easy to see that if a low value resistance is present in parallel with the tuned circuit, the response will be considerably damped. Therefore when using resonant circuits in filter applications it is important to consider the required input and output impedance and the effects of loading. Sometimes resistors are deliberately connected across parallel tuned circuits to limit the Q or to provide a specific response curve.

LC resonant circuits often provide a simple method of producing filters particularly at radio frequencies. Whilst their use in audio circuits is not uncommon, there are some inherent disadvantages. In particular, the large values of inductance often required at low frequencies can make such circuits physically unwieldy. Also large inductors tend to exhibit a high series resistance and this can adversely affect the Q of the circuit. Therefore at signal level, it is often more appropriate to use active filter techniques to produce the required response.

Crystals and Resonators

Quartz crystals may also be used to obtain a sharp response but are mostly used for specialist radio frequency applications such as in the IF stages of communications receivers. They give a very sharp, stable response but can have very specific interface requirements. The response curve is complex and depends on the cut of the crystal.

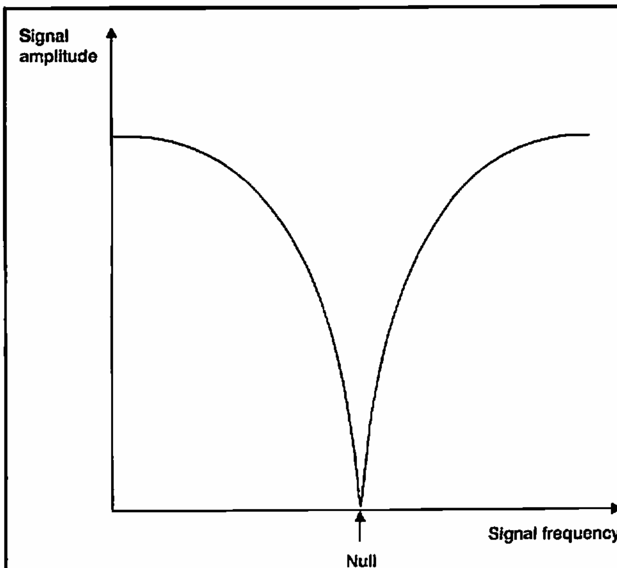


Figure 3. Example showing the frequency response curve of a notch filter

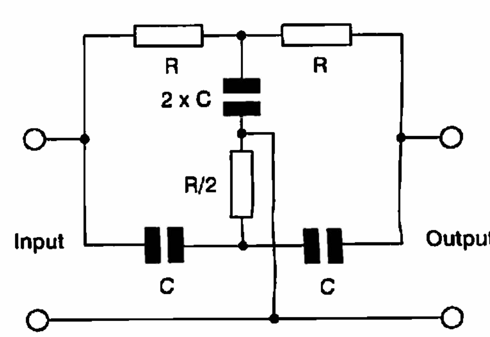


Figure 4. Passive notch filter

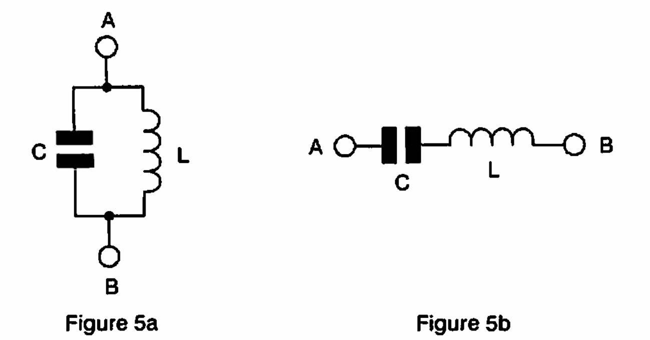


Figure 5a. Parallel tuned circuit
Figure 5b. Series tuned circuit

Ceramic resonators are a similar technology and are very common in the IF stages of FM broadcast receivers. These devices are available off the shelf for the more popular frequencies. SAW or Surface Acoustic Wave filters are also a popular choice for use at radio frequencies.

Active Filters

All of the filters discussed so far are passive and do not require a power supply to operate. These circuits often form the fundamental building blocks for more complex active filters. Unlike their passive cousins, active filters exhibit voltage and/or current gain and require an external supply of power.

Active filters based around operational amplifiers are often used for audio frequency applications and there are many different types. Op-amps are well suited to this function as they feature high input impedance, low output impedance and are available in dual and quad packages. Effective active filters may be designed using a number of op-amps and a handful of resistors and capacitors. The use of active circuitry overcomes many of the problems of impedance matching that can present a disadvantage with passive filters. Active filter blocks may often be simply cascaded.

A very simple filter circuit using a single operational amplifier is shown in Figure 6. The circuit produces a low pass characteristic analogous to the single pole, passive RC filters discussed earlier. At low frequencies within the pass band, the gain of the circuit is mostly determined by the ratio of the two resistor values (R2/R1). At these frequencies the impedance of C1 is high and has little influence on the operation of the circuit. However, at higher frequencies the impedance of C1 is lower, resulting in a higher degree of feedback. This effect progressively reduces the gain of the circuit as the frequency is increased.

Positive feedback techniques may also be used. Figure 7 shows the circuit of a 2-pole low pass filter with a frequency response slope that falls off at approximately 12dB per octave well above the cut-off frequency. A similar high pass circuit is shown in Figure 8. This type of circuit is sometimes referred to as a Voltage Controlled Voltage Source filter. As you might expect, cascading a number of filters with the same component values together results in a steeper response curve but this is only effective considerably above the cut-off frequency. To produce a sharper bend in the response curve it is necessary to use a number of stages, each with different component values. Using this technique it is possible to produce a number of classic filter responses each with well-defined characteristics. For example the Chebyshev filter exhibits a very sharp rolloff by sacrificing a flat response within the pass band. Alternatively, the Butterworth filter has a very flat passband but the rolloff is gentler.

Another characteristic of filters that can be extremely important is phase delay. When filtering a complex waveform significant distortion may be introduced due to changes in the phase of the signal. This is because non-sinusoidal signals are made up of a number of different frequencies and when passed through a filter, the phase of each frequency is delayed to a different degree. One way to counteract this effect is to use a circuit that corrects the phase. All pass filters may be produced that feature a flat amplitude response but introduce a specific phase delay. Some filter circuits provide a number of different outputs. The state variable filter is an example of this.

Active filter design is a wide and complex field and to cover the subject in any depth is outside the scope of this article. Readers requiring more detailed information are referred to relevant textbooks on the subject.

Dedicated ICs

Many dedicated filter ICs are available off the shelf. These enable high quality filters to be produced simply and efficiently. Examples are the UAF42AP and the MF10. The MF10 is a switched capacitor filter building block that allows the construction of effective low pass, high pass, band pass, notch and all pass filters using just a few external components. The frequency characteristics of the filter are accurately controlled by an external clock and may be easily tuned over the operating range of the device by varying the clock frequency. One point to consider with this type of filter is that the clock frequency appears superimposed on the output waveform. However, for many applications this does not present a problem because the clock frequency is usually far outside the filter pass band and can be simply removed from the output using a fixed low pass filter. Figure 9 shows an example of a filter circuit using the MF10 IC. This circuit is shown for reference only.

Practical Circuit Examples

The following circuits are intended to provide a starting point for constructors wishing to experiment with simple analogue filters operating in the audio frequency range. The circuits shown are not optimised for specific applications but nevertheless are capable of providing a reasonable level of performance when correctly set up. The component values and configurations may be adjusted to suit individual requirements.

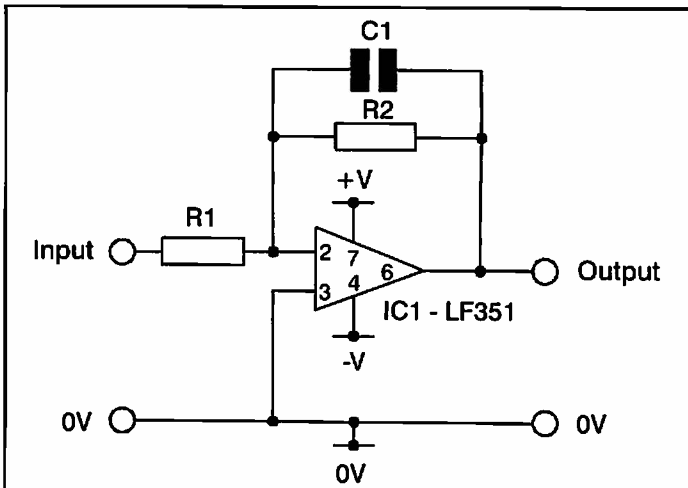


Figure 6. A very basic low pass filter using an operational amplifier

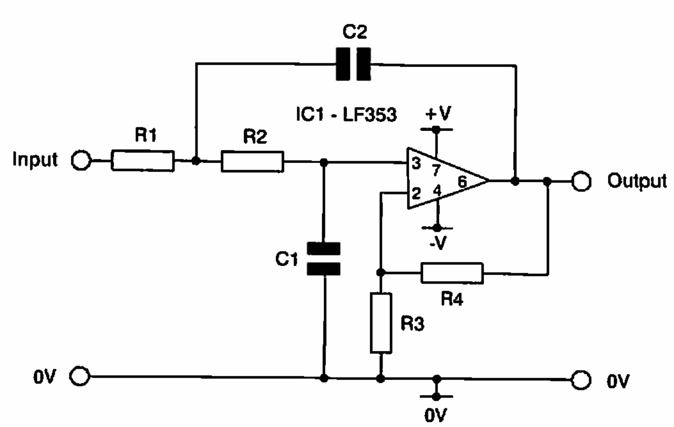


Figure 7. An active low pass filter

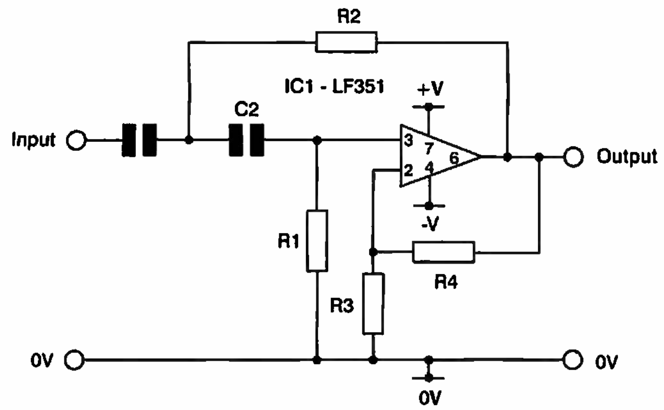


Figure 8. An active high pass filter

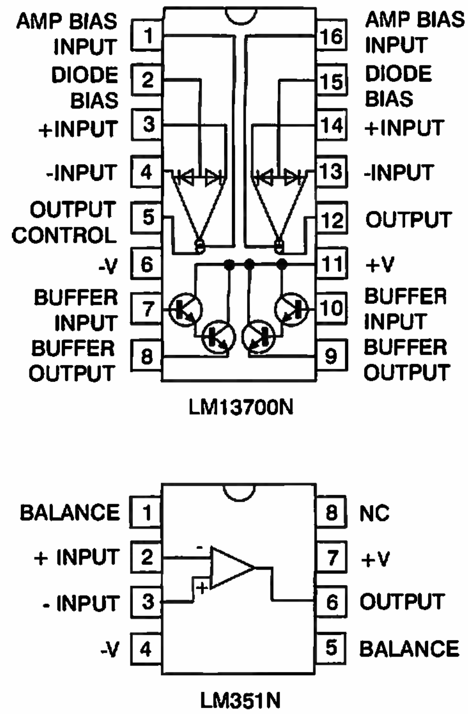


Figure 10. IC Pinout Information

A Note On Circuit Construction

The circuits may be constructed using matrix board. As with most audio circuits layout is an important consideration. Unnecessarily long wiring runs are best avoided and input wiring should be kept away from output wiring to reduce the chance of spurious oscillation. The use of screened lead for off board wiring is recommended for all but the shortest connections.

Please ensure that the ICs and electrolytic capacitors are connected observing the correct polarity. IC pinout details are shown in Figure 10 for reference. The polarity of electrolytic capacitors is usually indicated by the lead length and by markings on the component body. The negative lead is normally the shorter of the two and is marked by with a minus (-) symbol on the capacitor case.

Voltage Controlled Lowpass/Bandpass Filter

This circuit is based around the LM13700 transconductance operational amplifier IC and provides both a 2-pole lowpass output and a single pole bandpass output. Op-amps are used to buffer the outputs allowing the circuit to drive into impedances as low as 100 ohms.

Figure 11 shows the circuit diagram of the voltage controlled filter. IC1 is used to create a half supply reference for IC2. This allows IC2 to function as if it were operating from a split rail supply. C1, 2, 4 and 7 are decoupling capacitors. Input signals are applied to the filter between terminals P3 (input) and P4 (0V). The input signal is fed to IC2 via coupling capacitor C3. The capacitor allows the input signal to be referenced to 0V without affecting the DC biass conditions at the input of IC2. The filter pass band is controlled using variable resistor VR1. The frequency range over which the filter may be tuned using the control is determined by the value of C5 and C6. Both the bandpass output on IC2 pin 8 and the lowpass output on IC2 pin 9 are fed to unity gain buffers (IC4 and IC3 respectively). The outputs are made available on terminals P6 (lowpass) and P7 (bandpass). P8 provides a connection point for the output 0V return.

Power supply requirements and testing

The circuit is designed to operate from a 12V DC supply. The power supply should be regulated in order to maintain the frequency stability of the circuit. The power supply output must be free from noise and ripple as any variation in supply voltage will affect the frequency of the filter pass band. Although the current drain of the circuit is normally only in the order of a few mA, it is always sensible to use a power supply that is protected against short circuits.

In order to test the circuit you will require a suitable signal source and a method of monitoring the output. If available it is recommended that a sine wave generator is used to generate an input signal and an oscilloscope is used for monitoring purposes. The

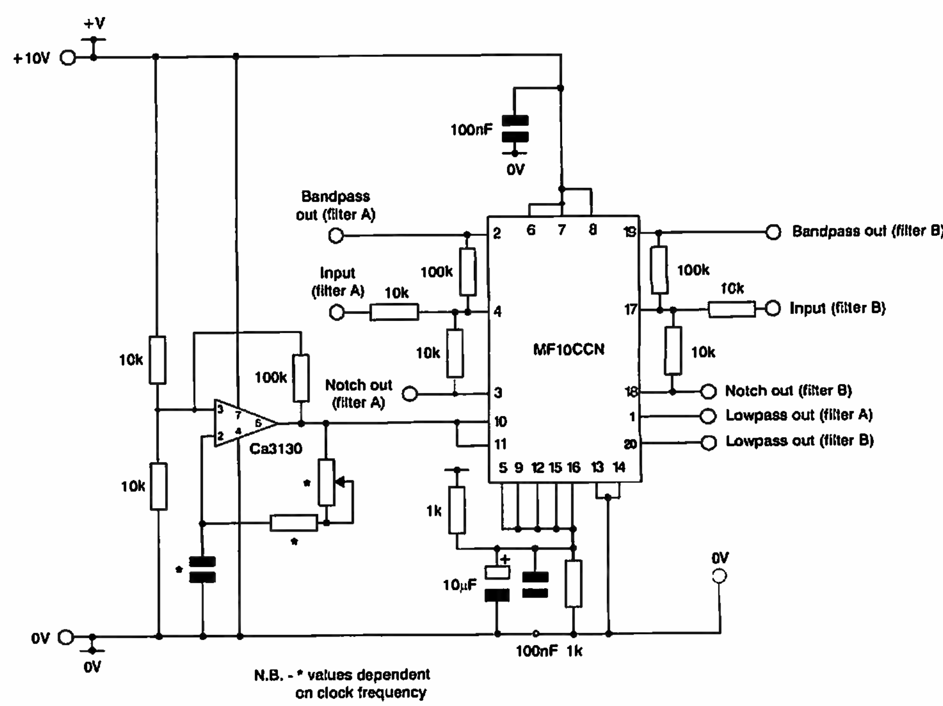


Figure 9. An illustrative example of a filter circuit based around the MF10 IC

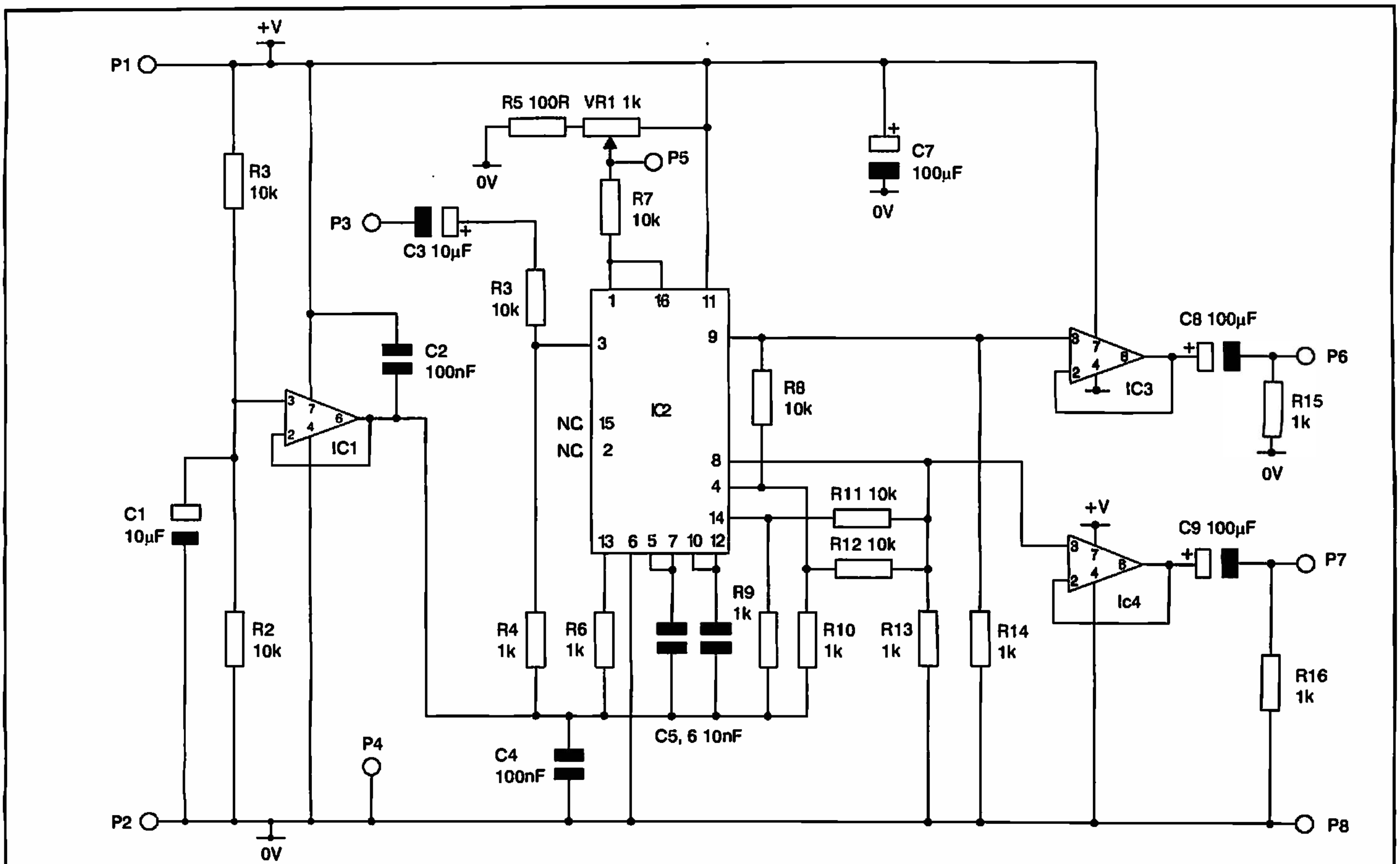


Figure 11. Circuit diagram of the voltage controlled filter

following test procedure is based on this method as it allows the frequency response to be measured accurately. If this equipment is not available other methods may be used to monitor the output level (for example an AC millivoltmeter).

To test the circuit, first connect an oscilloscope between terminals P7 (bandpass output) and P8 (0V). Connect a suitable 12V DC power supply between terminals P1 (+V) and P2 (0V). If a multimeter is available this may be used to measure the supply current. If the current exceeds a few mA, this suggests there may be a problem. In this case switch off and re-check component connections etc.

Apply a 1kHz sine wave between terminals P3 (input) and P4 (0V). By adjusting VR1 it should be possible to peak the signal. When the output level is peaked adjust the frequency of the signal generator either side of the centre frequency. The amplitude of the filter output signal should drop. Set the signal generator to a frequency of 10kHz. Measure the filter output level. Whilst maintaining the input signal amplitude adjust the frequency to 20kHz. When measured, the signal amplitude at the filter output should be approximately half its value at 10kHz (-6dB). If required similar tests may be carried out over a range of frequencies either side of the filter centre frequency to determine the filter response. Next connect the oscilloscope input to terminal P6 (lowpass output). Carry out tests over a range of frequencies to check the filter response curve. This time the filter output should ultimately fall off at 12dB per octave. When tested well above the pass band, the filter output should reduce by a factor of 4 if the frequency is doubled.

If test equipment is limited or you do not need to know the exact response curve of the filter, it is possible to carry out some tests with a line level audio signal and an amplifier. Although this does not allow accurate measurements to be made, the basic operation of the circuit can be tested. Please make sure that the signal source is protected against short circuits just in case there is an unexpected fault on the circuit board. Similarly if an amplifier is used for monitoring purposes, the volume level should be set to minimum when first connecting and switching on the circuit. The circuit inevitably produces a switch-on pulse due to capacitors charging. Please ensure that the amplifier input can cope with this before connection.

Applications

The voltage controlled filter circuit can be used in a whole host of applications. Examples are tone controls, output filtering for communications receivers and a host of electromusic effects. The tuning range of the filter may be adjusted by altering the value of C5 and C6. If the capacitor values are increased, the filter will operate at a lower frequency whereas a reduction in value will shift the tuning range upward in frequency.

If required the circuit can be controlled by an external voltage instead of VR1. In this case VR1 should not be fitted. The control voltage is applied between P5 an 0V (recommended +12V maximum). Do not apply a negative voltage to P5. Filter modules may be cascaded and controlled from the same external control voltage. In this way higher order filters may be created.

Low pass audio filter

In many applications a simple fixed low pass filter is required to remove some unwanted high frequency component from an audio signal. If the unwanted frequency is much higher than the wanted signal then all that may be required is a single stage filter with a rolloff of 6dB per octave. However, if the unwanted component is closer in frequency to the wanted signal a sharper slope is required. The following circuit is simple to construct and exhibits a frequency response that is relatively flat in the pass band and tails off rapidly above the cut off frequency. The circuit effectively uses three cascaded second order filters, resulting in a final attenuation of around 36dB per octave. With the component values shown the -3dB point is around 2.8kHz. The circuit is not a true low pass filter as it is AC coupled. Therefore the response rolls off at very low frequencies. However, in most applications this can be ignored.

Figure 12 shows the circuit diagram of the filter. Input signals applied to terminal P3 are coupled to the non-inverting input of IC1, which is configured as a simple unity gain buffer. The signal is then passed through a series of three 2-pole active filters comprising IC2 - IC4 and associated components. Each *op-amp is configured to*

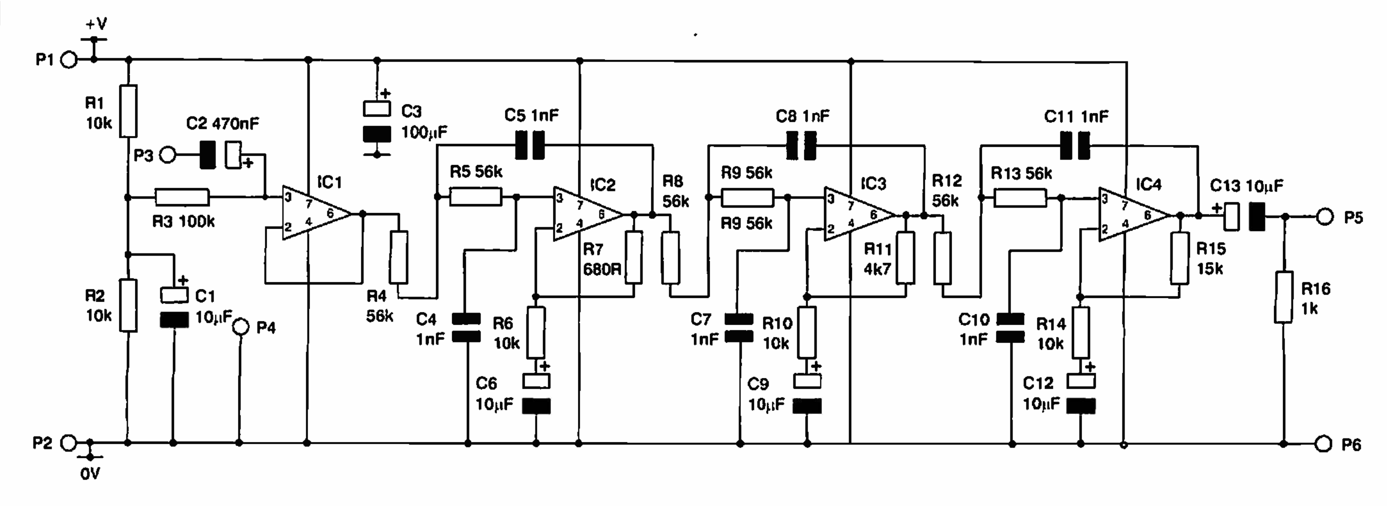


Figure 12. Circuit diagram of the low pass audio filter

provide a small amount of gain. The gain of each stage is different resulting modifying the overall response of the circuit.

Testing

The circuit is designed to operate from a 12V DC power supply. Unlike the voltage-controlled filter above, small variations in power supply voltage do not have a marked affect on the frequency response of the circuit. However, noise on the power supply rails may find its way onto the circuit output, so adequate supply filtering is still important. For this reason a regulated well-filtered supply is recommended. The current consumption of the circuit is in the order of a few mA.

Similar considerations apply regarding test equipment as with the voltage-controlled filter described above. The following test procedure is based on the use of a sine wave signal generator and an oscilloscope but other methods may be used as discussed earlier.

To test the circuit, connect a suitable 12V DC power supply between terminals P1(+V) and P2 (0V). Connect an oscilloscope between P5 (output) and P6 (0V). Apply a 1kHz sine wave signal between P3 (input) and P4 (0V). Slowly increase the input signal amplitude until a suitable test level is obtained at the output (the input level should not exceed 2V peak-to-peak). The output waveform should not be allowed to clip. Slowly increase the frequency of the signal, noting the effect on the amplitude at the filter output (P5). At frequencies above 3kHz the signal level should drop significantly. Check the output level over a range of frequencies to ensure that the filter is operating correctly.

Using the low pass filter

The filter may be used to remove unwanted high frequencies from speech signals before transmission over a communications link. The filter may also be used to filter a speech signal before digitisation in order to reduce aliasing. Another use for a low pass filter is to limit the bandwidth of the audio output from a radio receiver to reduce high frequency whistles etc. This is particularly useful with speech transmissions (for example amateur radio stations). Many transmissions of this type are limited to less than 3kHz bandwidth (particularly single sideband) and additional audio filtering at the receiver output can be particularly useful with simple receiver designs.

The cut-off frequency of the filter may not be suitable for particular applications. In this case, the component values may be modified to shift the filter pass band. The cut-off frequency may be varied by changing the value of capacitors C4, C5, C7, C8, C10 and C11. Increasing the value of the capacitors shifts the pass band downward whereas decreasing the value results in an upward shift. The value of the six capacitors should remain equal to maintain the shape of the frequency response curve. It should be noted that within the pass band the overall gain of the circuit approaches 4. Also as with the voltage controlled filter the circuit is AC coupled and therefore a pulse is produced at switch-on due to the capacitors charging.

Finally...

We have taken a relatively short look at a wide and complex subject. It has only been possible to touch briefly on just a few the many techniques in use. For simplicity mathematics has been avoided to a large degree. Readers who would like to learn more about filtering techniques are referred to the books section of the current Maplin catalogue.

VOLTAGE CONTROLLED LOW PASS/ BAND PASS FILTER PARTS LIST

RESISTORS			
R1, 2, 3, 7, 8, 11, 12	10k	7	M10K
R4, 6, 9, 10, 13-16	1k	8	M1K
R5	100R	1	M100R
VR1	Hor Encl Preset 1k	1	UH00A
CAPACITORS			
C1, 3	GenElect 10µF 63V	2	AT77J
C2, 4	Minidisc 0.1µF 16V	2	YR75S
C5, 6	Monores Cap 0.01µF	2	RA44X
C7-9	GenElect 100µF 16V	3	AT40T
SEMICONDUCTORS			
IC1, 3, 4	LF351N	3	WQ30H
IC2	LM13700N	1	YH64U
MISCELLANEOUS			
	DIL Socket 8-Pin	3	BL17T
	DIL Socket 16-Pin	1	BL19V
P1 - P8	Pin 2145	8 Pins	FL24B

LOW PASS AUDIO FILTER PARTS LIST

RESISTORS			
R1, 2, 6, 10, 14	10k	5	M10K
R3	100k	1	M100K
R4, 5, 8, 9, 12, 13	56k	6	M56K
R7	680R	1	M680R
R11	4k7	1	M4K7
R15	15k	1	M15K
R16	1k	1	M1K
CAPACITORS			
C1, 6, 9, 12, 13	GenElect 10µF 63V	5	AT77J
C2	GenElect 0.47µF 63V	1	AT73Q
C3	GenElect 100µF 16V	1	AT40T
C4, 5, 7, 8, 10, 11	Monores Cap 1000pF	6	RA39N
SEMICONDUCTORS			
IC1 - 4	LF351N	4	WQ30H
MISCELLANEOUS			
	DIL Socket 8-Pin	4	BL17T
P1 - P6	Pin 2145	6 Pins	FL24B

NEWS FROM FRANCE

Automatic Guidance for tractors

After two years research, Renault Agriculture, in a partnership arrangement, has developed a prototype tractor with an automatic guidance system using kinematic GPS.

Automatic guidance is already in operation for air and sea navigation and this latest development could eventually help farmers. Tractors using kinematic GPS, have an accuracy of the order of a few centimetres in three dimensions. This brand of GPS has already found practical applications in civil engineering, seismology and volcanology.

The on-board operational guidance system now make it possible to assist the driver in guiding his tractor over a whole field.

The farmer has two modes of operation available. He or she can either guide the tractor around the field recording its shape, the entry point and the width of the trailer, and the route to be followed. The complete operation is then calculated automatically.

Alternatively, the operator carries out a complete sequence of the work required, which the device records and can then fully reproduce. The route taken will be faithfully reproduced including U-turns, as well as the operations of lifting, power take-off and reversing. The recording can be transferred onto a farm's PC and can be enhanced, especially as it is compatible with precision agriculture software.

According to risk analysis, it is essential, for safety reasons, to retain a driver in the cab, who will be able to concentrate on monitoring equipment

A launch is planned for 2003.

Longest Wooden Bridge in France

The largest wooden bridge in France opened in December 1999. The Merle Bridge spans 54 metres over the Maronne valley and is the second largest of its type in Europe. The bridge provides physical proof that wood has excellent engineering capabilities, and also provides a harmony in an environmentally important site.

The bridge replaces the previous steel suspension bridge, which could only stand a load limited to 12 tonnes and had insufficient width for two vehicles. The new bridge is built from Douglas Fir apart from the decking. This consists of a 25 cm thick reinforced concrete slab. It is classified as Class 1, with no weight restriction.

The FF8m bridge, not the cheapest from the variety of bridges on offer was funded by the CNDB (National Committee for the Promotion of Wood), via a subsidy from Interbois Limousin (a regional forestry/timber association) and FFlm of European funding.

The architectural requirement was for a rustic, simple and timeless design, so the architect ruled out traditional solutions of an arch, suspension or cable-stayed design. The architect also had to avoid a modern design that would have been out of place in this landscape that has changed little since the Middle Ages. The result is a 57.5m long and 10m wide bridge and is formed from five box beams resting on six crossed supports from 12 to 25m in length.

Douglas fir was chosen because of its good mechanical properties and its durability. The heartwood of Douglas fir when stripped of sapwood, does not require treatment with fungicides, since the members of the structure are either protected by the roadway or in highly inclined positions which prevents standing water.

New DVD 8.5Gb Re-writable Disks

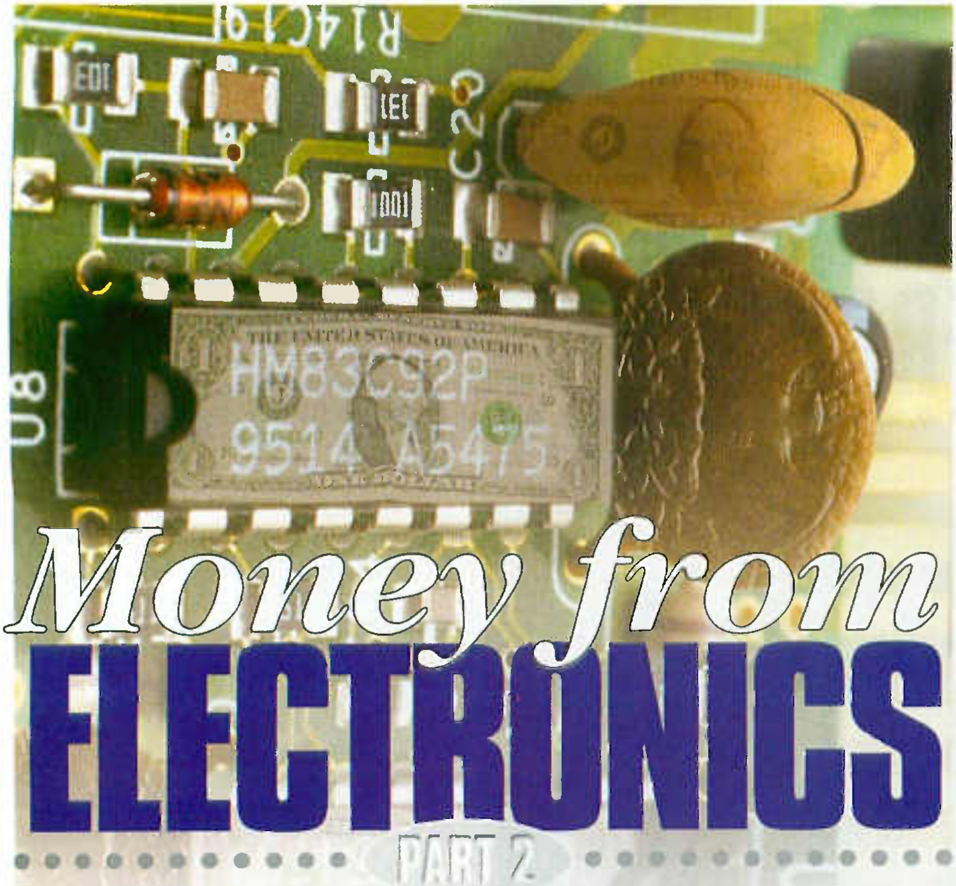
French company MPO Media/Hi-SPACE has been working with researchers to develop a new generation of dual-layer rewritable DVD disks with a capacity of 8.5 gigabytes. These new recordable discs, with capacities equal to those of pre-recorded discs, will make it possible to replace the traditional VHS video cassette.

Optical components used in the current generation of DVDs those lasers emitting red light at 650nm, were used to develop the first dual-layer recordable DVD with phase-change technology. This means that the disks are compatible with existing DVD Video and DVD-ROM drives.

A capacity of 8.5 gigabytes from only one side means that a rewritable DVD has a playing time of more than three hours, and a very high definition image (high speed MPEG-2), high fidelity sound (Dolby AC-3) without any wear.

Prerecorded optical DVD discs - for video and software - can, thanks to their dual-layer technology, hold 8.5 gigabytes on a single side with dual layer focusing. The same applies for recordable discs, the two layers are therefore quickly accessible from the same side.

This technology is the result of a research and development partnership within the framework of the European Eureka Remod programme, launched in 1996. The project received support from French and German governments, as well as the German company Deutsche Thomson Brandt, a subsidiary of Thomson Multimedia, Balzers, and the University of Aachen.



Money from ELECTRONICS

PART 2

In part 2, Gregg Grant looks at cash and the computer and, of course, http.millionaire.com

Introduction

There are few papers, periodicals or magazines these days that don't carry advertisements for personal computers, or PCs. The basic unit - electronics plus monitor - will be accompanied by all manner of extra gizmos such as a colour printer, flatbed scanner, speakers and more software than you need, or probably ever will need. These devices have gone from the massive, ultra secret machines of World War Two to the workstation on which I'm writing this - in just over half a century.

The first 'public,' general-purpose computer was the Electronic Numerator, Integrator and Calculator, ENIAC. It had been designed under a United States (US) Army contract and cost some $400,000. Its inventors - John Eckert and John Mauchly - were firmly of the belief that there would be a market for their creation, despite the scientific and engineering communities being firmly of the opposite opinion.

The Second One

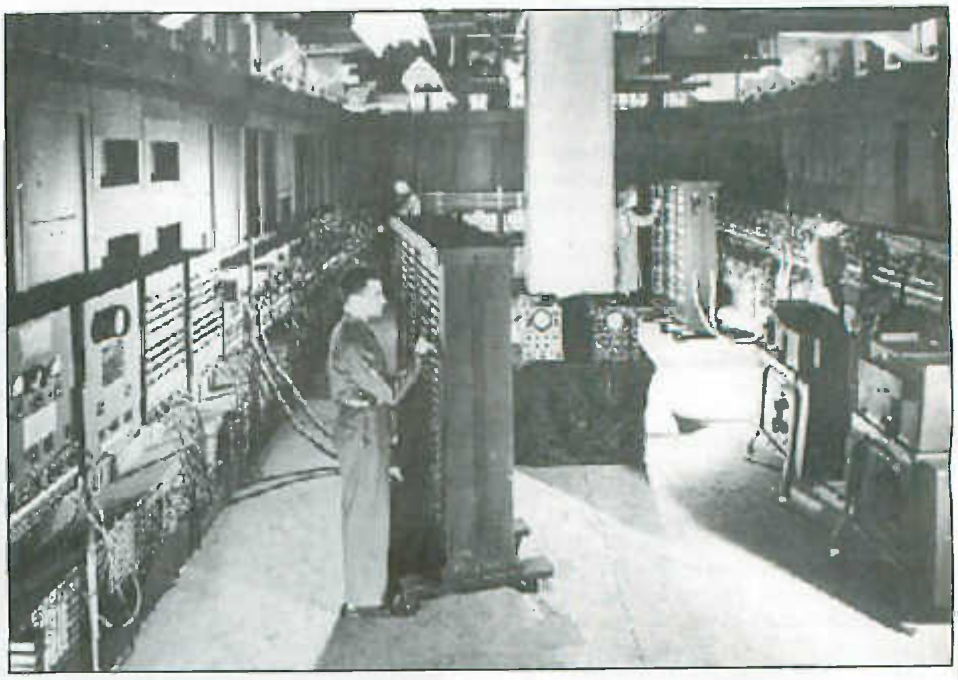
Mauchly and Eckert's concept of how computing would change industry, business, academia and elsewhere was expressed in their next design, the Universal Automatic computer, or UNIVAC. This, one of the earliest of computer systems, was visionary in every way and - in the course of its construction and testing - almost drove its creators '. . . into a red sea of bankruptcy.'

Nevertheless, by mid-1948 the pair had five UNIVAC contracts under way, worth about US $1 million in all. Whilst this appeared reassuring, it was in fact not, for Eckert and Mauchly's working capital amounted to a mere $200,000 or so. In reality they needed at least another $500,000 and - since the banks would not lend to them at anything approaching a reasonable rate of interest - the pair sought outside investors and re-structured their company as the Eckert-Mauchly Computer Corporation.

The man who came to their rescue was Henry L. Straus, the joint inventor of the Totalisator, a special-purpose electromechanical calculator used at racetracks. Straus was also the founder of the American Totalisator Company, or AmTote. He put up $112,000 in loans and bought 40% of the Eckert-Mauchly Computer Corporation's shares, which gave him control of the corporation's

John Mauchly

John Eckert



AP Wide World

ENIAC computer system

nine-man board of directors.

This lifeline lasted for some 15 months until, in October 1949, Straus was killed in an air crash. His company immediately pulled out of the deal this dynamic electrical engineer had created and - after yet another search for a rescuer or further investors, Eckert and Mauchly decided - reluctantly - that they had to sell, despite their having six contracts for the UNIVAC system.

Several companies showed interest, but the first firm offer came from the famous office equipment manufacturer Remington Rand. Although UNIVAC's creators remained, by February 1950 Remington Rand were in full control.

The new owners re-negotiated the contracts and by the following year, the first UNIVAC machine was delivered to the US Census Bureau. Eckert and Mauchly's long hard slog to establish a computer company was over.

They were dealt a further blow in October 1973, when their patent application for ENIAC was invalidated, despite the US Patent Office having issued it in 1964. There still appeared too little or no justice for engineer-inventors.

Watson and Big Blue

To many people world-wide, there is only one computer manufacturer: International Business Machines, IBM, known throughout our small planet as Big Blue. One man, Thomas J. Watson, largely put the company on the map.

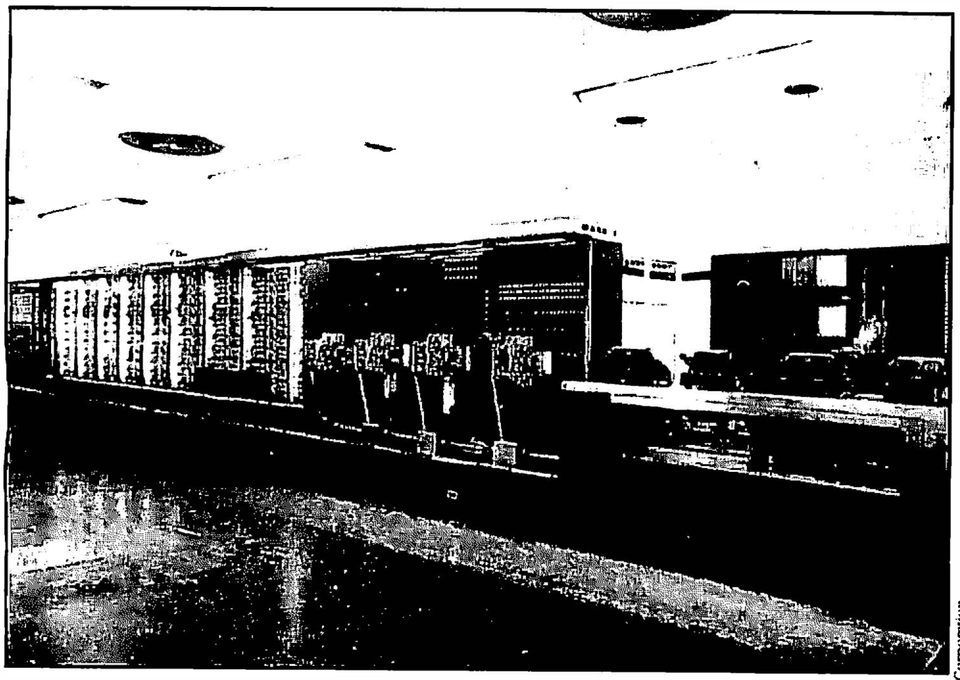
He began his career as a salesman with the National Cash Register Company, NCR, in Buffalo, New York. That he was a very good salesman can be judged from the fact that, in his most successful week, he reputedly earned $1,225. Given that the machines retailed at between $100 and $200, the young Watson must have persuaded between 60 and 80 customers to buy his equipment throughout a working week!

Watson joined the Computing-Tabulating-Recording Corporation, CTR, as its general manager in May, 1914 and, in the following year, became the corporation's president. Nine years later, he changed CTR's name to IBM and by the outbreak of World War Two, the company was the leading manufacturer of business machines in America. Its income was such that it almost equalled those of the four other leading players in the industry combined. By the end of the war, IBM had an income of $141.7 million, of which almost 11% was profit. It therefore had the money, customer base and managerial skill to enter the computer business.

In fact Watson had got involved as early as 1939, when he agreed to underwrite the building of Professor Howard Aiken's Automatic Sequence-Controlled Calculator, the ASCC, at Harvard. This electromechanical, program-controlled monstrosity was incapable of storing even simple instructions, it being nothing less than '. . a costly exercise in obsolete technology.' [2] But, it provided Big Blue with one thing that not even its wealth could buy: experience in designing and manufacturing really large calculators.

There were major problems though. Aiken had a deep contempt for electronic valves, regarding them as power-hungry and inefficient, hence his use of relays. Watson remained what he'd always been - a salesman. True an extraordinarily good one but a salesman nevertheless, with little understanding of technology. Consequently he could see almost no future for computers. Furthermore, both men had gigantic egos, making co-operation difficult.

Fortunately, Watson's son Tom - who'd spent the war flying military aircraft - was completely at home with radar, communications equipment and electronic landing aids and so could well understand what his father - and senior company executives of his generation - could not. It would be Tom who would turn IBM round from the inside whilst the corporation's customers - to his father's astonishment - would apply pressure from the outside. It was these two factors that would turn IBM into the world's leading computer manufacturer, earning profits that not even Watson Senior had dreamed of!



Intel Corporation

UNIAC computer system

Kenneth Olsen

Watson Senior had envisaged no more than about half a dozen computers being sold world-wide, and then only to the really big outfits such as IBM itself, the government and the armed services. The invention of the transistor however changed electronics fundamentally, and shortly computers became a lot smaller. Moreover new people were beginning to enter the field, some of whom had worked for the big battalions such as IBM, NCR and others, and were not overly impressed by what they saw. One such man was Kenneth Olsen.

Deciding to go into business for himself Olsen - along with his brother and a colleague - managed to raise $70,000 from a Boston venture capital company, American Research and Development Corporation, ARD and set up the Digital Equipment Corporation. Three years later, his company unveiled its first computer, Programmed Data Processor One, or PDP-1, which retailed for some $120,000. By 1963, the Digital Equipment Corporation had introduced its PDP-8, which became the first, successful, mini-computer.

This most interesting machine - utilising transistors and a magnetic core memory - cost a mere $18,000 and was contained in a cabinet no bigger than a domestic refrigerator. This was a computer that almost all businesses could afford and promptly did.

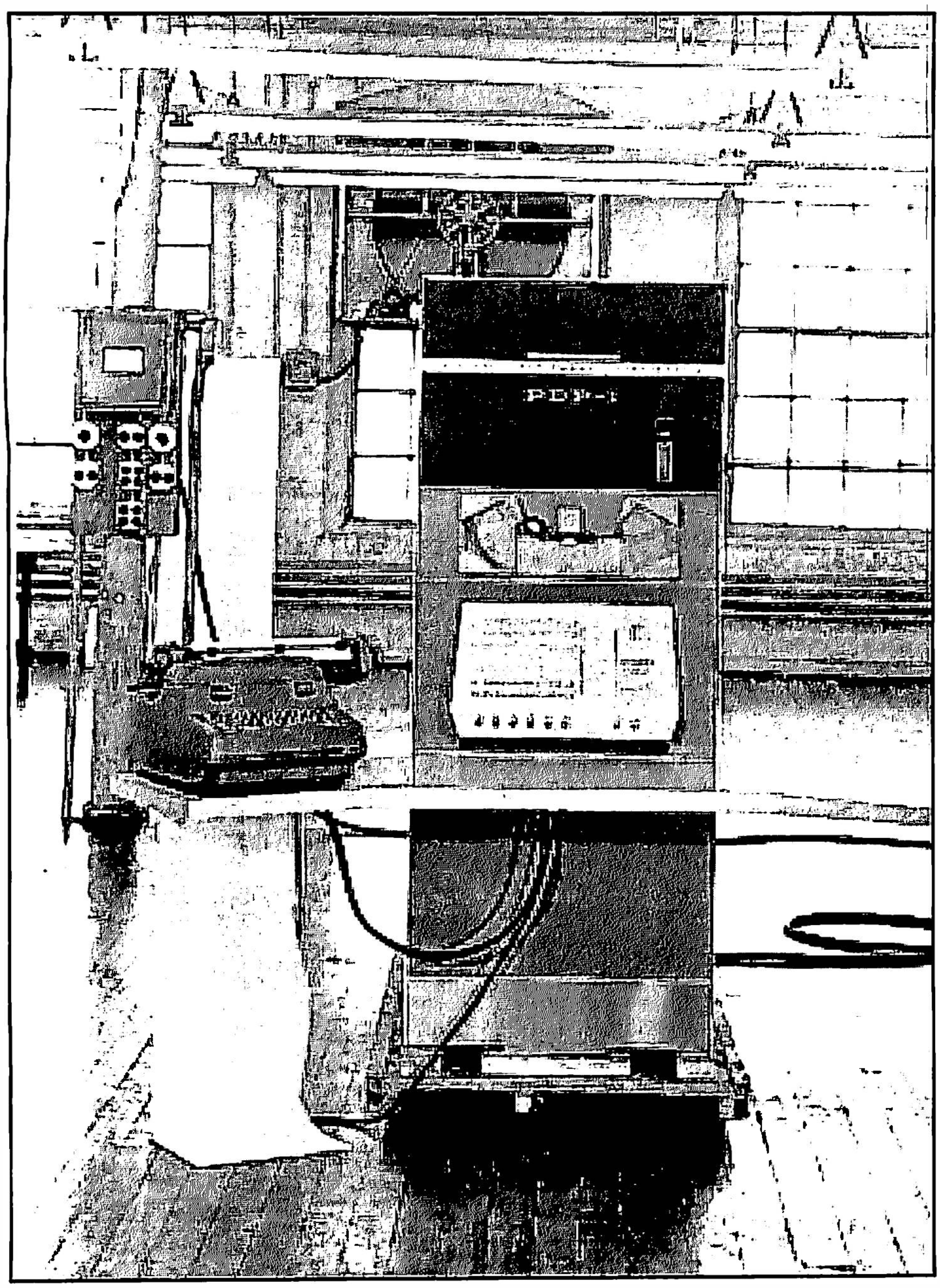
This dynamic piece of equipment was bought by engineers (like Olsen himself), by the US Navy for their submarine fleet for the obvious, space-saving, reasons and by scientists who found that - quite apart from the price - its economy of space was as crucial in a crowded laboratory as in a submarine. The chemical business, machine-tool manufacturers, logistics warehouses and banks too took up Digital's machine, and the price began to fall.

In the five years between 1965 and 1970, Digital's sales increased ninefold and its profits almost twenty times. This meant that ARD's initial investment of $70,000 was now worth an astonishing $229 million!

Olsen - who was an excellent manager - kept a careful eye on his creation, re-investing the profits back into the business, which was still run from the old woollen mill where it had all started. By 1983, Olsen's creation was one of the largest computer companies in the world with some 78,000 staff and an annual sales profile of $4.3 billion!

New Kids on the Block

Kenneth Olsen had shown that a computer need not be massive to do its job. Others too were coming to the same conclusion. In 1968, Robert Noyce and Gordon Moore - having resigned from the Fairchild Camera and Instrument Corporation where Noyce had been the general manager - set up their own company, Integrated Electronics or Intel. Both men put up $250,000 of their own money and a venture capitalist, Arthur



Rock, raised a further $2.5 million, simply on Noyce and Moore's reputation.

The standing of both men was considerable, to say the least. Noyce - a minister's son from Iowa - had developed a chemical etching technique that enabled him to manufacture the first silicon integrated circuit in 1958. Moore was a first-class physicist, with a fine understanding of materials science. The new company spent its first two years developing more sophisticated memories than those in existence at that period and, towards the close of 1970, their first microprocessor appeared. Termed the 4004 and invented by Intel's Marcian E. Hoff, this device would subsequently prove to be '.. the universal motor of electronics.' [3]

Two years later, Intel introduced the 8008 which - as its number implies - was the first 8-bit microprocessor. By 1974, the company had developed the 8080, the first microprocessor capable of running a minicomputer. All of these devices were around two tenths of an inch long and a tenth of an inch wide.

Moreover, their development period - two years in each case - became the basis of what would come to be known as 'Moore's Law.' The way was now open for virtually everyone to own a computer. The world of the Personal Computer, the ubiquitous PC, had dawned.

The PC Revolution

The PC revolution was unique. Firstly, because it made a great deal of money for young entrepreneurs, secondly because the price of individual machines - from the beginning - began to fall. The first true PC was the Altair 8800, based on Intel's 8080 microprocessor. Retailing at $650 complete, or $395 in kit form, it did have a snag: if you wanted it to do any work you had to write your own program - in machine code - and then enter it into the machine via the front panel switches.

What this neat little box of electronics obviously needed was an interpreter in a user-friendly, high-level language. The computer was first advertised in the electronics hobby journal Popular Electronics, a copy of which was bought by Paul Allen, a young programmer based in Boston before he continued his journey to meet his friend, Harvard student William Gates.

Having read the article, the pair got in touch with the Altair's designer, Edward Roberts, and offered to write a BASIC language interpreter for the PC. Six weeks after making their offer Allen flew to Albuquerque - where Altair were based - with the interpreter. Roberts not only bought the design: he also convinced Allen to join the company as Director of Software.

Back on the East Coast, Allen's friend William Gates decided to forego a higher education at one of the world's most prestigious universities, setting himself up instead as a freelance software writer. Later, the pair would set up their own software house, which they called Microsoft. The rest - as our small planet knows and I've touched upon earlier - is history.

In the United Kingdom (UK) too, young engineers and programmers were making a mark on the new industry. In fact a number of them had either been educated in the US, or had worked for American companies prior to setting out on their own. One such example is Peter Rigby. He worked for a couple of leading American computer outfits before deciding to go into business for himself.

Aged 28, and with £2,000 of savings, he set up Specialist Computer Holdings, which sells systems to top-of-the-range clients. In 1998, Rigby's firm had total sales of £536 million, making its founder a wealthy man indeed.

Another Briton with an American work experience background is Gordon Crawford. He began his working life as a town planner before joining a US computer company. In 1987 he set up his own business, which he termed London Bridge Software, which specialises in software which enables banks to identify customers who are less reliable than others. Hardly surprisingly, all the major banks use this most useful product and Crawford and his family have a near-60% stake in the company, a holding that makes him the 82nd richest individual in the UK.

In May 1998 a company called Computacenter was introduced to the Stock Exchange. It was founded in 1981 by the physicist Dr. Peter Ogden - who also holds an MBA from Harvard - and his old Harvard University colleague Philip Hulme. This most successful company specialises in the installation and distribution of complete computer systems and clearly benefits from the backgrounds of its founders.

In 1979 a young British software consultant wrote '.. a nifty little computer program' [4] which resulted in the biggest information source ever created by man - the Internet - which quite apart from purveying masses of facts, images and sounds, has also created not a few millionaires.

http://millionaire.com

In the Sunday Times newspaper's Rich List for 1999 '.. the rise of the computing, Internet and mobile phone millionaires is the dominant feature.' [5] In fact no less than half of the top ten Internet millionaires are new entries to the list.

To many people however, the 'Net' seems a somewhat intangible business concept at best. After all - the doubters point out - in manufacturing, retailing, distribution and other business activities an individual needs premises, banking arrangements, staff, communications systems and much else besides. With the Net it would appear all you require is a 'Website.' There is of course far more to it than that. So, what's the secret of becoming an Internet millionaire and - as a result - a potential wealth creator of the future?

How It Started

Nothing epitomises the freedom, drive and enterprise of the Western World in the way the Internet does. Yet this vast information source was a creature born of cold war military paranoia. In the early sixties the cold war - and the possibility of it becoming hot at any given moment - was very real, despite the peaceful ending of the Cuban Missile crisis in the early sixties.

The US Department of Defence, the DoD, worried that a Russian missile strike would destroy their computers sought a solution. In 1964 the Rand Corporation, one of the think-tanks hired by the DoD, suggested that the military's computers ought to be linked together, so as to operate as one. Therefore if one was destroyed, information would still be available. However, at this time this was easier said than done.

The DoD set up what it termed the Advanced Research Projects Agency Network, or ARPAnet. Five years later, on October 20th 1969, the Stanford Research Centre and the University of California at Los Angeles made the earliest attempt to connect two computers such that they could communicate. It was a success and soon the University of Utah and the University of California at Santa Barbara were locked into the system.

Shortly many other learned institutions joined, University College London for example linking up in 1973. In the following year two American physicists, Robert Kahn and Vinton Cerf, created a system which enabled information to be passed to a world network of computers, a system they termed The Internet. Their endeavour, a system operated and financed by the US government's National Science Foundation, the NSF, consisted of five university super computers being linked together. Shortly, other universities joined the net.

What had begun as a defence system was becoming an information and education tool. By 1983, ARPAnet was a two-tier system, the DoD having set up its own Military Net, the Milnet. In the UK the universities too created their own version of the Internet, the Joint Academic Net, or JANET. Seven years later, Cerf and Kahn's Internet consisted of more than 60,000 computers worldwide, and the business world saw a terrific opportunity to reach a truly global market. They put pressure on the NSF to terminate its ban on the commercial uses of the net. The system did however have a drawback: you had to be something of a computer whiz to use it. Shortly a solution was put forward to resolve this difficulty.

Tim Berners-Lee

HyperText

In 1980 a young British physicist, Tim Berners-Lee, was working as a software engineer at the European centre for particle physics in Geneva, and was trying to solve a problem: how could he sort out all his notes and observations in an organised way?

After some thought, he came up with a scheme in which words in a document could be linked to other documents in other files, a system which could look after ' . . all the random associations one comes across in real life and brains are supposed to be so good at remembering but sometimes mine wouldn't ' as he put it. His arrangement worked well.

From there, it was a short step to ask what would be needed to add some files that were located on another computer? First - and most obviously - you'd have to get permission from the individual or company that owned that particular machine. Then would come the tedium of transferring the information to a central database. Wouldn't it be much simpler to open up the file - indeed the entire work-station - to everyone?

Consequently, in 1989, Berners-Lee put forward the concept of the WorldWideWeb, (WWW), based on a system he had designed called HyperText Mark-up Language, or HTML. This is, quite simply, as universal a 'language' as Latin was and English is rapidly becoming. He added a Universal Resource Locator, or URL, an addressing technique which gave each page on the Web a unique address and rounded things off with a set of rules which enabled HTML documents to be linked together across the entire computer system. This last he termed HyperText Transfer Protocol, the http of this section's title. Finally, Berners-Lee designed the Web's first Browser, in other words the software used for viewing the Web.

In 1991, the WWW made its debut on the Internet and, almost immediately, the pair developed as one entity. Like Johann Gutenberg five centuries earlier, Berners-Lee had synthesised arts and technologies already available to transform ' . .a powerful communications system that only the Elite could use . . . into a mass medium.' '

Tim Berners-Lee did not make a fortune from his creation. To him, this was an anathema, for the Web - as he saw it - should be non-profit making and available to everyone. So who did profit - indeed are still profiting - from the WWW?

The Browser Kings

Although http's creator designed the first browser, the first truly popular one was Mosaic, designed by a 22-year old Illinois University graduate, Marc Andreessen. His system placed images alongside text in the manner commonplace in periodicals, newspapers, professional journals and magazines worldwide.

To further develop his browser, he then co-founded Netscape with Jim Clark. The result was that an individual could now find his or her way around the Net from a PC. By 1994, both Mosaic and Netscape became publicly available and as a result, Andreessen became one of the World Wide Web's first millionaires.

By the following year some 200 million people were using the Web and William Gates and Microsoft had been caught napping. Thanks to Netscape's innovative founders the ' . . centre of gravity in software shifted from the personal computer to the Internet. ' ' Consequently, Gates got heavy-handed, informing Netscape that unless they gave Microsoft a share holding in their company plus a seat on their board he - the Cyber Pope - would drive them out of business.

Bill Gates

Clark didn't hesitate: he immediately phoned a lawyer, who informed the US Department of Justice, who began an investigation into the world of Microsoft. Eventually, Justice Department lawyers brought an action against the corporation, claiming it was breaching anti-trust regulations and attempting to dominate the computer market. At the time of writing, the verdict is still awaited, apparently with some trepidation, by Microsoft. In November 1998, Netscape was sold to yet another Internet company, America On Line, AOL.

Undoubtedly the British Internet software whizz kid of the moment is Charlie Muirhead who, at age 24, set up Orchestream, a software house with a difference.

Yet another university drop-out - he passed up a chance to graduate from Imperial College London, in computer science - Muirhead had, four years before putting studying behind him, a revolutionary idea: create traffic prioritising software for the Internet.

He knew that although Netscape enabled people to search for information it did nothing about the Net's performance. For example, suppose you wanted to use your credit card for a purchase. Naturally, the Net provider of the good or service you wished to buy would want to verify your card, and do so speedily. Could he therefore have his verification request take precedence over - say - someone simply browsing? No was the short answer, he couldn't.

Muirhead's software - called Orchestream - provides exactly such a service. That this idea is one whose time has come is borne out by the businesses who have invested in his company, names such as Deutsche Bank, Reuters News Agency and - perhaps most impressively of all - Intel. They lead the 45 backers he has attracted so far who, together, have come up with more than $32 million!

The software is currently under test with some Internet Service Providers or ISPs, telecommunications outfits and large business corporations. This is understandable when - to have Muirhead's brainchild installed on their networks - they will be picking up a tab which could be anywhere between $40,000 to $3 million!

As to the future, it seems bright indeed, for Orchestream will aid the Net's infrastructure, in the way Tim Berners-Lee's concepts did. The people who have designed and made the servers, the search engines and those who created the software for these technologies have, for once, made some real money from their inventive, technical and creative gifts. However, what of the others, all those alleged e-millionaires? Where - exactly - has their money come from?

Internet Entrepreneurs?

On the final day of the last millennium the London Times journalist Chris Ayres pointed out - in an article - that 14 men had, in the space of the previous year, made some £1.1 billion with the aid of a few computers, some reserve cash and the odd idea that was less than first rate.

They'd achieved this figure by floating 11 Internet companies on both the London Stock Exchange and the Alternative Investment Market, or AIM. What exactly do these outfits do? Four of the companies offer e-commerce services to other companies and in a further three, they operate sports and gaming web sites.

The remainder organise on-line auctions, advise on personal finance, offer shoppers free Internet access and finally, design web sites for other businesses. The current value of each individual business ranges from £117 million to - wait for it - £5.4 billion!

This means that the stock market value of those Internet companies launched last year is an astonishing £9.7 billion, more in fact than British Airways or the Royal Bank of Scotland, to mention but two of the major UK market-quoted companies. How has this come about, given that many such outfits offer similar services?

A number of analysts have asked the same question and concluded that there are scores of thousands of investors - both private and institutional - who perceive Internet stocks to be the great growth vehicle of the near future. A seedbed for future entrepreneurial millionaires in fact, who will push growth to heights not seen before. But will the Net grow as spectacularly as they hope?

No, according to others, it won't. As Teresa Hunter pointed out in a London Sunday Telegraph newspaper article, bogus speculation has been behind almost all historical financial disasters, from the South Sea Bubble to Nick Leeson and the collapse of Baring Brothers.

The piece went on to note that almost the entire Internet companies have assets that are ephemeral at best and their profits are virtually non-existent. This makes any value put on them speculative to put it mildly. [9]

Generally speaking, there are two ways to influence stocks and investors, potential or otherwise. To begin with a business could attempt to push down the share value of a company it wanted to take over by intimating that its stock was not performing as brilliantly as it should be and that - therefore - the company could well be in trouble.

Conversely, the company who feels threatened by takeover speculation could 'talk-up' its position to financial journalists, institutional shareholders, politicians and other so-called opinion-moulders, in the hope that the price of its stock would rise such that the business intending a takeover will think twice before moving in.

The reason this rarely happens is simple: there are tough laws in place throughout the major Western economies to ensure that the perpetrators of such activities are brought before the courts. There is though one area where such laws don't apply: the Internet. Given this, how do the world's financial authorities go about preventing, say, another Robert Maxwell or Nick Leeson from using the Net as their private petty cash till?

With great difficulty and not a little trepidation it would appear, simply because the WWW is so vast and growing more so by the minute. At least America's Securities and Exchange Commission, the SEC, has made an attempt to tame the Net's wilder denizens. Quite apart from having some 60 successful prosecutions behind it, the SEC has also created its own Internet Enforcement Division. Yet compared to the Net's ever-increasing expansion, this is a tiny drop in a very large ocean.

Given the above, will the Net create the wealth that other technical inventions did such as the Internal Combustion Engine (Ford, Morris), or the aircraft (Douglas, de Haviland)? It depends on how you define 'technical invention.' Neither Ford nor Morris invented the motor car. That distinction belongs to the German engineers Nikolaus Otto and Karl Benz and neither could be said to have made fortunes from their creations.

The same is true of the aeroplane. If it had inventors as such - discounting Leonardo de Vinci that is - they were Sir George Cayley and Otto Lilienthal respectively. Like Benz and Otto, their pioneering experiments were hardly financially rewarding. Nor, for that matter, can it be said that the Wright Brothers succeeded in entering any of the Rich Lists of their day! As in the case of the horseless carriage, it was those who came after who made the serious money.

Paradoxically, the people who have made, or are about to make, real money from the Internet so far are those who thoroughly deserve to: the computer physicists, equipment engineers and software designers who have made it all possible. Their creativity, technical expertise and software skills have brought them more recognition than any of their predecessors enjoyed.

In time of course, the Net may well prove to be the commercial success some of today's pioneer businessmen hope it will be. And when it does, those who made it possible will - if the past is anything to go by - be long forgotten. Such is the way of commerce!

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COMMENT

by Keith Brindley

It's all a very big joke, of course. Or, at least, if it wasn't so infinitely stupid it certainly should be all a very big joke. Several times over the last year or so there have been moves to prevent sales of certain equipment and technologies, and to restrict and monitor the use and availability of other equipment and technologies, which have become decidedly farcical in their regularity and regulatory misdirection.

Four good examples of this sales restriction are in the computer, television, electronics games, and Internet markets. Last year, Apple Computers launched its Macintosh G4 range of personal computers, the most powerful of which - running at a processor speed of 500MHz and using the PowerPC microprocessor - became the first personal computer ever to reach a power in excess of a gigaflop of information (that is, it is capable of performing a thousand million floating point operations each second). Not only was the Mac G4 the first personal computer capable of this, it did so at a significant price advantage - the next-cheapest computer able to perform at a gigaflop is priced at something like five times the Mac's cost. The US government had previously decided that computers capable of gigaflop power are to be classed as military technology - in other words, a weapon - so can not be sold to certain countries with conflicting interests.

Likewise, Microsoft's WebTV set-top console came to be classed as a weapon, though not because of its speed. Instead, the encryption routines it uses are more advanced than the limits the US government allows to be exported.

The latest technology device to become classified as of military importance is, almost unbelievably, the next-generation games console, the Sony PlayStation 2. The PlayStation 2 has such a powerful graphics processing unit that the Japanese government believes that if it's allowed to fall into the wrong hands it could be used as the basis of a missile guidance system, so it too is a weapon.

As a highly trained cynic, my initial thoughts when these sorts of things come to light is that they create an almost unsurpassable public relations exercise. Apple's immediate response when it became apparent that the Macintosh G4 was to fall foul of the gigaflop rule was to launch a series of adverts announcing that the G4 was indeed a weapon, showing army tanks squashing mere Pentium-based computers. Further, when the US government looked as though it was likely to change the gigaflop rule and increase it accordingly, Apple wasn't the slightest bit interested, instead preferring to point out the Mac's advantage over Pentium-based computers in such a dramatic way. After all, it's only within the last few weeks that Pentium devices have crawled over a gigaflop, and Apple has had the power edge all this time.

In the same way, it's likely that Sony will also play the power game to its own advantage over the coming months. After all, an electronic game being officially classed as a weapon must be a public relations company's dream come true.

The UK Government's proposed Regulation of Investigatory Powers Bill, which is progressing through Parliament, is my final example of attempted regulatory control. The Bill will give total power to the State to demand that all UK Internet users' use of the Internet can be monitored by the State, and at the State's discretion. Interestingly, the Bill acknowledges the fact that encryption of messages over the Internet will occur (unlike the US government's head-in-the-sand position where it is assumed that by preventing Microsoft selling its WebTV outside of the US that encryption itself will not exist outside of the US). Instead, the proposed Bill states that any user must provide their encryption key on demand, with a penalty of two years' imprisonment if it is not provided (even if the user has simply forgotten the key, or misplaced it). If a user objects to this and decides to complain in public, a five-year prison sentence can be imposed under the Bill.

If the Bill is passed every UK email message and e-commerce transaction can be monitored. To allow this, the Bill also requires that the burden of providing equipment to monitor the Internet should be installed by Internet service providers. Interestingly, on the other side of the Irish Sea, the Irish government is legislating to make it illegal to monitor Internet traffic at all. The cynic in me might suggest that the UK would lose out considerably in e-commerce terms if it can just hop on a ferry to Ireland.

Of course, a governmental restriction on power isn't the only game to play. Companies themselves can play the power game too, specifying what can and what cannot be made available. The best example of this is how the various entertainment companies, Sony included, are lining up to do battle with MP3 and its users. The entertainment companies see MP3 as a breach of copyright restrictions, allowing music to be freely downloaded over the Internet or stored on digital media, without royalties being paid. MP3 users on the other hand see MP3 storage and transmission as their right for if a user buys a CD with music on it then the user has every right to do with that music what the user wants.

The underlying cause of all these regulatory attempts has been the simple speed with which technology moves. Not so long ago a computer was one of those things you saw in sci-fi movies, had to be housed in an air-conditioned sealed room, and had to be operated by a full team of highly-trained scientists. Nowadays we've all got at least one on our desks that a trained monkey could use. Not so long ago a mobile phone was a box weighing in at 10kg, had to be operated from a car battery, and didn't work unless you were within a couple of miles of the GPO Tower in London. Now, a pocket-sized device will operate over most of the world. Better than this, not so very long ago you almost had to have Papal dispensation to have a telephone line to yourself, without the seemingly obligatory party line shared with someone else up your street.

The point is that technology has caught up with, surpassed, and is now rapidly out-maneuvering company and governmental regulations with a speed so fast that no regulatory body can ever hope to catch up. In effect, technological regulations are arbitrary, and technology simply makes them redundant. No company or government will prevent that.

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

Life, Artificial life AND BIOMIMETICS

In this article David Clark looks at two new branches of science with exciting possibilities for the present and the future, Artificial Life, or A-Life, and Biomimetics.

Introduction

Social commentators frequently like to categorise periods of history, often decades or centuries or more recently millennia, by neat labels. Just as the nineteenth century is regularly labelled the age of electricity, and the twentieth century the age of electronics, the twenty-first century too will eventually have its own label. Many scientists believe the label for the twenty-first century will be the era of Artificial Life, or A-Life.

Changes in technologies such as electronics and materials are usually easy to follow, often within an individual's lifetime given the rapid pace with which these developments now occur. This is largely because these developments are usually driven by research aimed at deriving short-term commercially exploitable ideas rather than the pursuit of pure scientific knowledge. There seems to be little time or place (or money) for the search for knowledge as an end in itself. In fact, the idea of pure research now has an almost quaint nineteenth century feel to it, reminiscent of a leisurely age of gentleman scientists working quietly if enthusiastically in dark oak-panelled laboratories using instruments of mahogany and brass. However, those who defend pure research point out that many everyday inventions came out of research which seemed to have no practical use at the time. The formerly academic practice of morphology, a branch of biology concerned with the study of biological structures both small and large scale had its heyday in the nineteenth century when science first began to examine the natural world in more detail. It is currently being reborn as a very practical twenty-first century discipline, a discipline that overlaps biology, biochemistry and materials science, and one that has both commercial and environmental advantages. The discipline is called biomimetics.

The cutting edge materials and techniques of aerospace and F1 motor racing soon filter down into the workplace, the home and the family saloon car. But quietly occurring concurrently with these more high-profile developments has been a

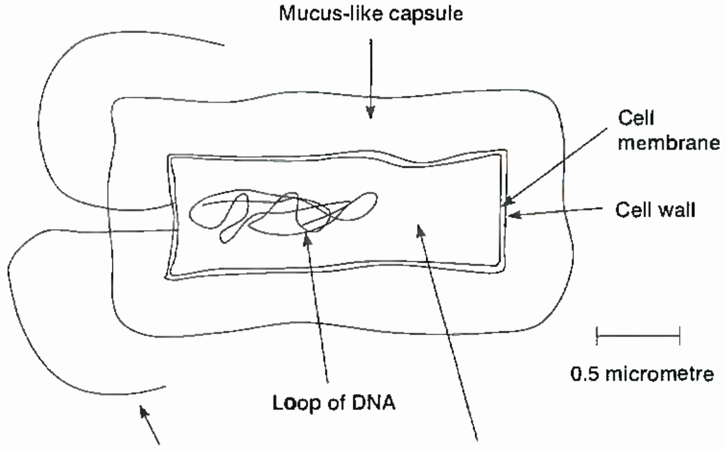


Figure 1. A typical bacterium

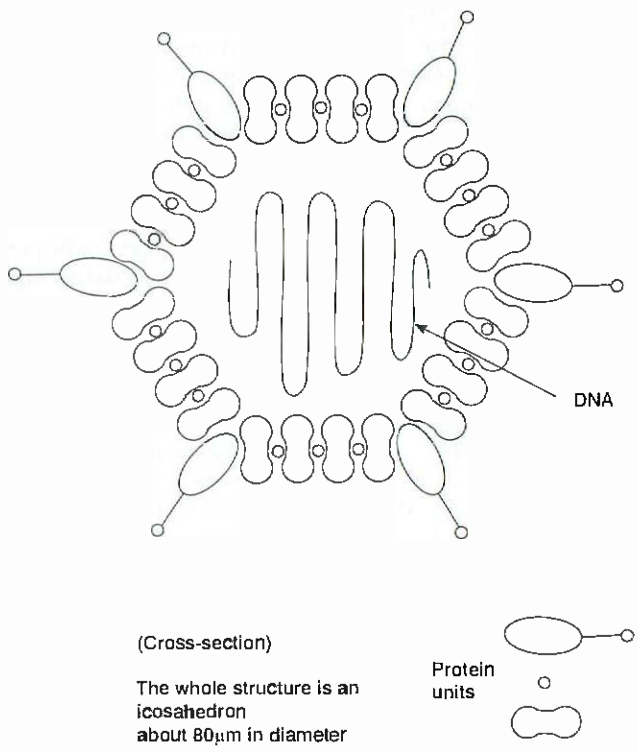


Figure 2. The human adenovirus

huge growth in the understanding of living systems, which has enabled the development of the means of manufacturing biologically-based materials and biochemical systems. This is one of the reasons for the rise of biomimetics, where scientists and engineers take advantage of evolution, nature's millions of years of research and development, and mimic these finally tuned systems, structures and materials. Many of the developments have been made possible through the use of computer models of these systems and materials, models themselves made available by the enormous increase in computing power available and the concomitant reduction in cost brought about by technological advances. These models have also made possible not only advances in simulation of intelligence (artificial intelligence) but also the simulation of behaviour. These are the developments that may justify the expectation for the twenty-first century to be the age of artificial life.

What Is Life?

To appreciate the exciting possibilities of artificial life and biomimetics it is necessary to understand what constitutes what might be called 'real' life. All currently-known life is based around the biological cell, and the structures and biochemical processes involved in the single cell organism and the human cell are so similar (see the box text for the biological cell) that it is generally accepted that all life evolved from a single starting point.

From this starting point organisms became more complex and developed internal structures that had specialised roles, the heart for example evolving from a pulsatile tube to the four chamber human heart.

Once the idea is accepted that this life must have evolved from a 'pool' of organic chemicals, then there must have been a point where something non-living evolved into something living, the question arises as to how life is defined. Over the years several attempts at defining life have been made, but none completely covers all examples of what we would instinctively feel was alive or not alive. Early definitions were based on factors such as taking in nutrients, metabolising (meaning literally to change) them, excreting the by-products, and using the energy liberated by this process to move, or respond to stimuli, or to grow. But many machines and industrial processes that are 'obviously' not alive fit this description and so it is inadequate. Another attempt at a definition was based on the fact that a living thing uses energy to maintain itself as an organised entity. In other words an organism is isolated from its probably hostile environment but maintains a constant internal environment by using active processes to control what passes in and out. But again most modes of transport away from dry land fit this description, spacecraft, aircraft, submarines and even ships all necessarily providing an internal isolated environment.

One of the most effective definitions of a living thing is that it is a system capable of growth, self-repair and maintenance and reproduction of itself by means of a code contained within itself. In a carbon-based system i.e. the only one known to exist in the universe this means a system containing hereditary information in the form of DNA (deoxyribonucleic acid) and/or RNA (ribonucleic acid). (See the box text for DNA.)

Even this definition of life begins to fail however when the simplest organisms are considered. Most people would agree a bacterium is alive. It contains DNA (see Figure 1) and can reproduce, causing disease in many cases. To control infection we 'kill' bacteria. However viruses also contain DNA (or RNA, acting as a single strand version of DNA) - see Figure 2; these are not considered to be 'living', but they survive and reproduce inside other living things, sometimes causing disease, sometimes existing un-noticed.

Furthermore, until recently it was thought that it was impossible to have an infective agent, which almost by definition must reproduce itself to have any noticeable effect that didn't contain DNA or RNA. That was until the advent of scrapie and BSE (bovine spongiform encephalopathy, or mad cow disease), which are caused by agents now called prions. These contain no DNA or RNA but can be deadly infective agents. (See the box text on the prion.)

Intelligence

'Real' life of course involves much more than having the property of being 'alive'. It also involves patterns of behaviour and interaction with the environment, either living or non-living. The complexity of this increases dramatically as the number of possible ways of behaving for each individual increases and with the number of individuals in, and the variability of, the environment. For simple organisms behaviour is simply a continuous response to physical and chemical gradients in its immediate (in space and time) vicinity, responses determined by the physical structure of the organism, itself determined by the design 'program' contained in the organism's DNA. (See Figure 3.)

More complex organisms can make decisions and exert choices in their options based on the information they are receiving from their environment, i.e. they can be said to have 'intelligence'. We can rationalise our existence, have abstract ideas, think about and learn from the past, consider the future and generally be said to possess 'consciousness'.

Just as the heart evolved from a pulsatile tube, similarly the brain evolved from simple neural networks to a central nervous system where individual parts of the brain control different functions. But also the

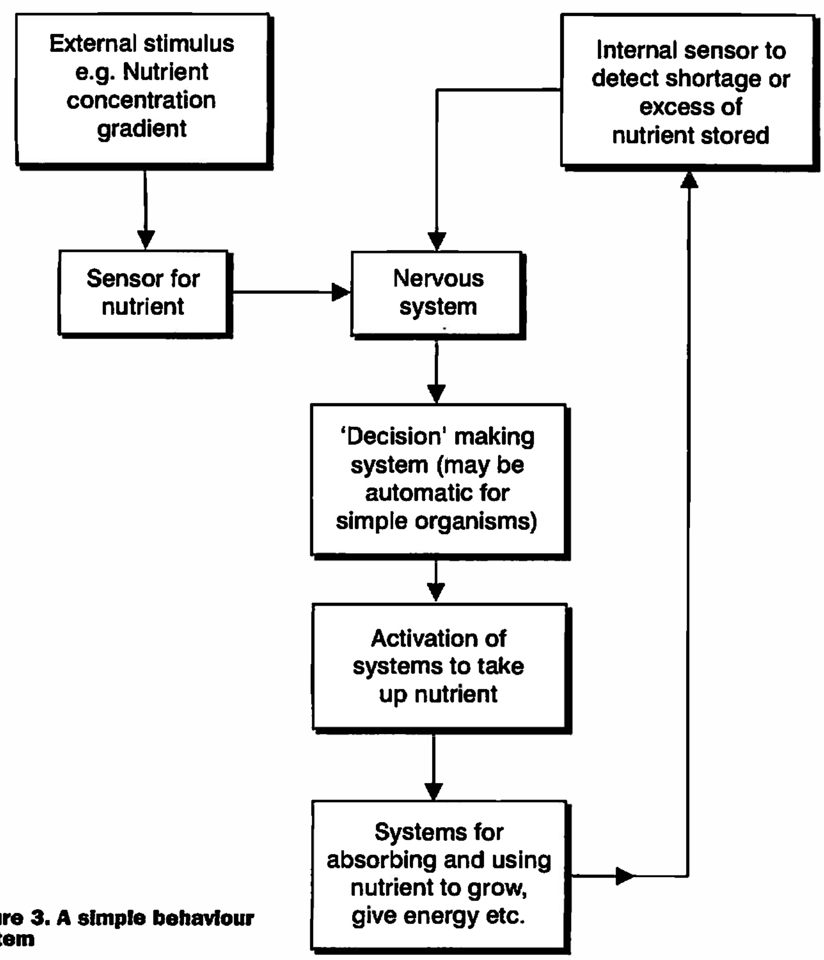


Figure 3. A simple behaviour system

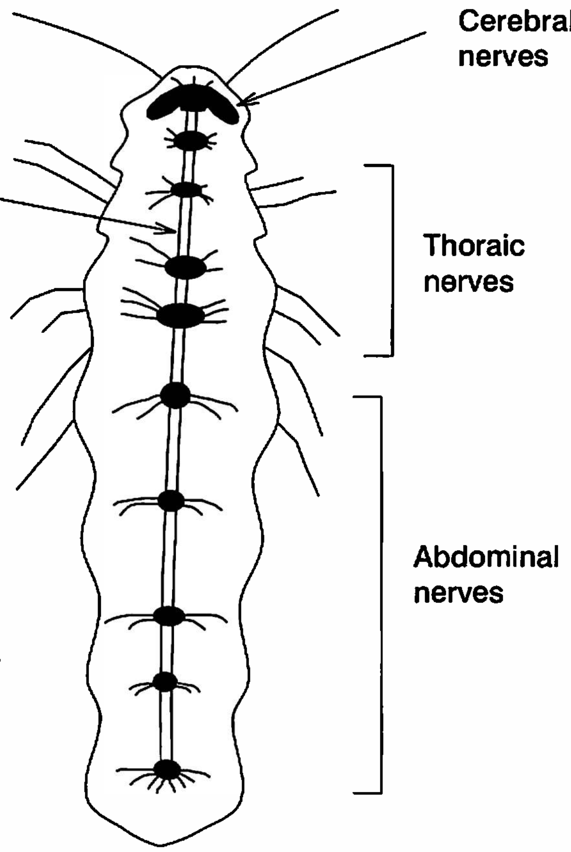


Figure 4. The insect nervous system

The insect brain is little more complex than the collection of nerve cells that co-ordinate the legs or wings.

brain can be thought to exist on three levels, each level an increase in complexity with evolutionary development, the lower parts controlling unconscious activities and the outer brain being responsible for all the higher activities, and this is where thought, creativity and consciousness occur. In mammals further down the evolutionary tree the higher brain is less developed, so this leads to argument over whether animals have consciousness or not. The lower parts of the brain automatically take care of all the activities that we might not even be aware of, the automatic reflexes and maintaining a constant internal environment, body temperature for example. But this also means that a great deal of seemingly intelligent activity occurs subconsciously. The brain can respond to things that have been seen or heard without the brain's 'owner' being aware that they have been seen or heard. This has been suggested as being part of the phenomenon of so-called extra-sensory perception (ESP), the extra sense being just below awareness or consciousness. So it is possible animals can seem to behave intelligently without having consciousness. But it is difficult to believe that evolution suddenly jumps from no consciousness to total consciousness. So a mouse for example is unlikely to have anything like the awareness and rational thought processes of humans. But it could be aware of its 'mouseness', and be 'conscious' to some degree that it was 'safe' to approach another mouse, and 'sense' that it needed to run away from a cat. There might be a 'feeling' undefined in its own brain but definitely unpleasant that if it didn't flee 'something' would happen that would put an end to its existence. So could a feeling of fear that might be generated by a certain combination of 'input' senses exist without a form of consciousness? Could a machine be given a very limited form of consciousness or awareness of itself?

It is perhaps too easy to forget how incredibly complex the systems of even a simple organism are. For example the brain is usually considered as a separate organ. But there isn't really an 'interface' between the brain and the rest of the body. All the 'sensors', the external sense organs like the eye, and internal ones like blood pressure sensors and so on, and the 'actuators', the muscles and glands that respond to the brain's conscious and unconscious decisions, are in reality extensions of the brain. Higher mammal's nervous systems are simply more developed versions of nervous systems that exist in much simpler creatures (see Figure 4).

Memory and experience also come into the equation, and teaching and learning. And some functions are 'built-in'. We don't need to be taught how to breathe. Are some aspects of intelligence and consciousness like this? What about creativity? Could an ability to write poetry, paint a picture that captures a quality of light on a surface, play an instrument with feeling be designed into an artificial system? It seems unlikely. Nevertheless some theorists think that all the attributes of awareness of self, or consciousness, emotions, feelings, pain, everything, is simply the effect of the automatic activity of the human organism responding to and interacting with its environment. This would mean that even free will is an illusion; our behaviour is an inevitable consequence of the hugely complex interaction of all the inputs from all the individual sensors of the body with a hugely complex set of interconnected neurons, the whole set-up being pre-programmed by our DNA. Chaos theory says that nothing is truly random, it is simply that some things are too complex to predict. This view of human behaviour is similar. It is almost the equivalent of being controlled by an unimaginably large logic array with a large number of input sensors and output actuators and if we were able to model its complexity we would be able to predict absolutely a response to any situation.

This is interesting philosophically (and dangerous territory morally) of course, but many scientists are coming to believe that we may have less free will than we would like to think. Perhaps behaviour, as much as susceptibility to disease for example, is a consequence of our genetic make-up and that little can be done to alter that without some form of manipulation and alteration, which of course carries very many other ethical questions with it.

So if we are not completely capable of understanding what life, intelligence and consciousness are can we really claim that machinery cannot have some of these properties albeit in an extremely simple or limited form, other than by a gut reaction of 'of course its not alive/intelligent/conscious'? Science and technology are now at a point where materials and systems can now be manufactured or engineered to the point where the boundary between what is alive, and between what has a degree of 'intelligence' and what does not, is becoming blurred. Complex (although not compared to the simplest 'real' living thing) software and machines are now in existence that are capable of such a degree of independent activity that it is considered realistic to put them into a category called Artificial Life.

What Is Artificial Life?

Like life itself, artificial life has not yet been absolutely defined; if life itself cannot be defined then perhaps artificial life cannot either. Nevertheless, again like the definition of life, there are some aspects of it that are 'obvious' if not completely definable. One aspect is that the study of artificial life is almost the opposite of biological science, a sort of bottom-up instead of top-down approach. Biology starts off with a living system and analyses it by dividing it up (metaphorically and sometimes less

The Biological Cell

The fact that all life evolved from a common point is hinted at by comparing a single human cell (see Figure 5) with the single cell organism the amoeba (see Figure 6), commonly found in fresh water ponds. Both function by absorbing gases and nutrients via the cell membranes, and also expelling waste products the same way. Both are completely controlled by the DNA contained within the nucleus membrane. The fact that a cell cannot exist without DNA is shown by the simple experiment of physically dividing an amoeba into two with a microneedle, leaving one half containing the complete nucleus. The membranes reform to give two organisms, but only the one with the nucleus carries on living, i.e. absorbing and expelling food and waste, moving and reproducing. The one without a nucleus can move but dies when its internal food store is depleted.

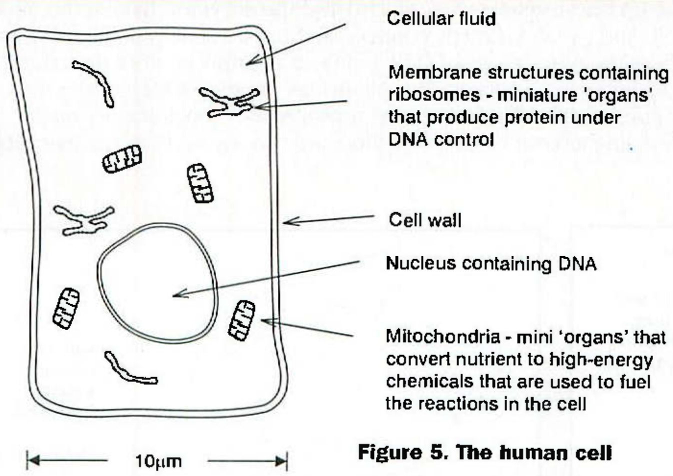


Figure 5. The human cell

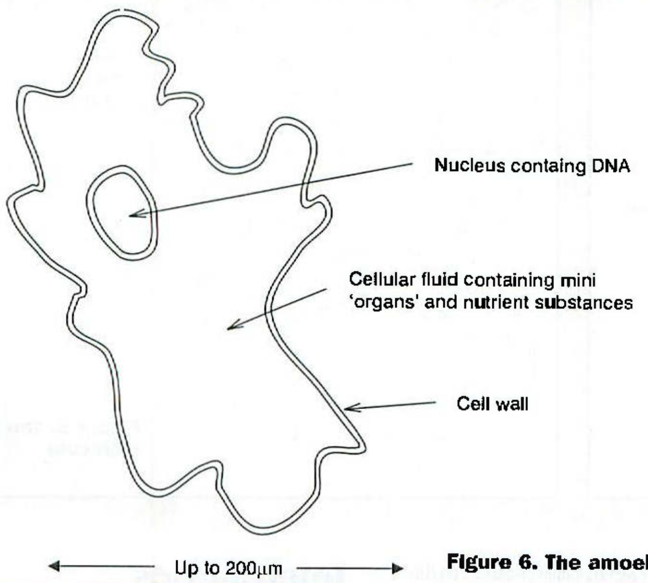


Figure 6. The amoeba

acceptably literally) into its component parts and then examines how they work in isolation. The study of artificial life takes building blocks representing or simulating life parts and builds them up into bigger systems to see how they interact in order to learn more about them and to create useful systems. These building blocks can be computer models, or organic or inorganic models, systems or substitutes, and may have 'artificial intelligence' which is likely to be though not necessarily an electronic system driven by software. The 'intelligence' itself may not be fixed but evolving and 'learning'. Intelligent systems and machines, cybernetics, robotics and bionics are one part of A-Life. The growth of biochemical knowledge has made it possible to add another part; now also involved are the areas of tissue engineering and biomedical engineering. Here the goal is the improved performance of the artificial substitutes for damaged tissues and organs that should be possible compared with purely mechanical or transplanted ones.

So one definition of artificial life might be that it is an attempt to simulate some or all of the aspects of what might be called life-like behaviour and so develop materials and systems and 'products' that are virtually indistinguishable from the real thing. Perhaps ultimately that might include a machine that could have some limited form of intelligence and a very limited 'consciousness' of itself as a machine. For the immediate future 'limited' is the operative word, but who can confidently predict what will or won't happen? In the meantime perhaps biomimetics might be considered to be a stepping stone between 'real' life and 'artificial' life.

Biomimetics

The new sciences of artificial life and biomimetics together provide a fascinating bridge between natural materials and the man-made, and could provide a means of integrating the natural and engineered worlds in a way that benefits humankind and minimises its detrimental effects on the environment. So what is biomimetics? Defining biomimetics is almost as difficult as defining life and artificial life in that it could be considered to encompass the whole of the natural world as a starting point for designs for the man-made world. Thus it ranges from examining plant and animal materials to see how for example they achieve strength with lightness (wood and bone). It includes how they use sunlight as an energy source to manufacture materials (photosynthesis), and how they manufacture materials at low temperatures (all biological processes). It addresses how they do this as efficiently as possible (most biological processes), and how nature produces particularly effective devices; a pump for example that can operate without a single failure 24 hours a day for up to and sometimes more than a hundred years (the heart). The list is virtually endless.

The Use of Artificial Life and Biomimetics

So what real use would artificial life be? At a basic level artificial intelligence makes it easier to interact with machinery in day to day tasks, banking etc. Financial institutions use intelligent systems to analyse and predict market performance. At first thought it might be difficult to imagine what use a machine that was 'conscious' or self-aware might be, but one important factor might be safety. A fundamental part of the basic behaviour of a living organism is the need to stay alive. Is it inconceivable at some future time that machinery that had a role in controlling an aircraft for example and had an awareness of its own existence would be safer if it had the machine equivalent of a basic instinct for survival? If it had the 'intelligence' to 'know' that the pilot had made an error?

Ideas like this may perhaps never come about. But biomimetics is having an impact right now, not least because it addresses fundamental issues of effectiveness and energy efficiency. The first modern invention to use biomimetics as inspiration is claimed to be Velcro, which was originally based on the hooks of seeds which evolved to become trapped in animal fur for

DNA

The DNA in a living cell is contained in the nucleus of the cell, and is in the form of chromosomes. There are forty-six chromosomes in a human cell and each one is a single molecule of DNA coiled around a 'scaffold' of supporting proteins. (Uncoiled, each single DNA molecule is several centimetres long, which incredibly means that every human being contains in total several billion kilometres of DNA.) The DNA molecule itself is a coil, a double stranded helix, and just as a protein is a chain of individual amino acid molecules (see Figure 7), each strand of the DNA helix is a chain of molecules called nucleotides.

There are twenty different types of biological amino acids possible in a protein but only four different nucleic acids possible in DNA. These are labelled A, T, G and C (standing for the names of the different nucleotides adenine, thymine, guanine and cytosine). Just as a computer file or a transmitted digital signal is a series of 1s and 0s containing information, DNA is a series of As, Ts, Gs and Cs containing information. And just as a computer file or digital signal needs a specific series of 1s and 0s to signify where each piece of information begins and ends, so DNA contains specific sequences of As, Ts, Gs and Cs to signify where each section of information begins and ends. (See Figure 8).

Each section of information is the code for making a particular protein, and each section of information plus the start and end code is a gene. Proteins (in conjunction with fats and carbohydrates) make up the structure of a cell, and also the enzymes that are the biological catalysts that control the reactions of all the substances in the cell. And so DNA directly controls all the cell's activity and behaviour.

That is only part of the superb elegance of DNA however. Each of the two strands of DNA is an exact complement of the other (A is the complement of T and vice versa, and G is the complement of C and vice versa). When the cell divides (a process itself under the control of DNA) the double helix divides, and the appropriate 'free' nucleotides in the cell attach to the appropriate complementary nucleotide on the divided helix. This leaves two identical DNA molecules each controlling its own cell, so that there are now two cells in existence, both identical to the first.

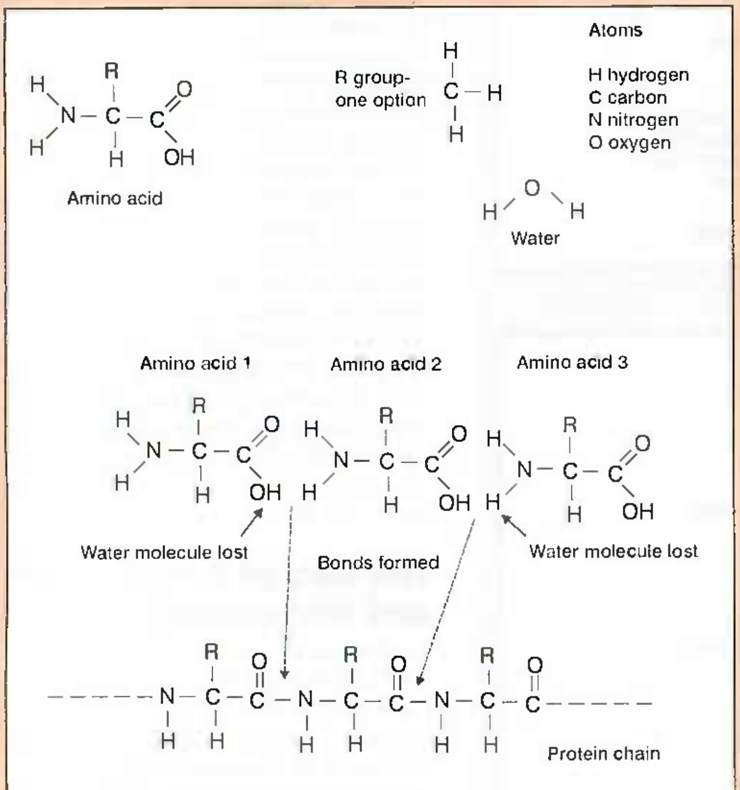


Figure 7. A protein chain is formed from amino acids

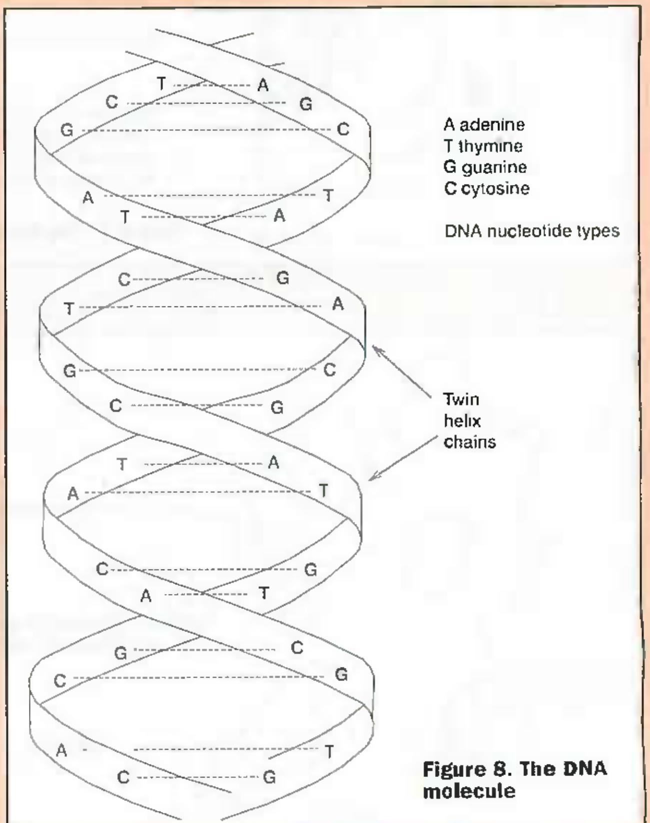


Figure 8. The DNA molecule

dispersion. Below are brief details of some other developments.

Underwater Vehicles

There is currently research into mimicking the motion of fish to propel underwater vehicles. This would be superior in efficiency and manoeuvrability. The endeavour also incorporates two other state-of-the-art technologies. The first is the use of an 'intelligent' material that mimics fish muscles by having two conformations which can be 'toggled' through heating and cooling. The second is an artificial intelligence system (a Genetic Neural Network) that 'learns' how the artificial fish's body responds to its immediate environment and modifies its actions to give the most efficient system for motion. (See web site **http://aero.tamu.edu/fluids/projects/2_application_of_ active.html**)

Human Parts

The use of materials with memory is also thought to have potential in medical applications, for example in the treatment for narrowed arteries. Current procedures include the use of passing a deflated 'balloon' into the narrowed blood vessel and then inflating the balloon once in position. This is an effective procedure but it often needs to be repeated as the blood vessel can narrow again with time. The use of a 'spring' that has a narrow diameter at room temperature but then 'uncoils' to a larger diameter at body temperature would provide a permanently wider support or 'stent'.

Telerobotics

The robot or android of science fiction would perhaps be the pre-conception of a man-made organism capable of intelligent thought and action. A robot that looks human is unlikely, and probably wouldn't be the best form for a specialised application anyway, but intelligent robots are currently being tested for use in aggressive environments. One such environment is the Antarctic where one is being used to search for meteorites, and another is space, where the signal delays between the Earth and the device, and the unknown environment it is in, necessitates a large degree of autonomous behaviour. (See web site **http://ranier.hq.nasa.gov/telerobotics_page/coolrobots.html**).

Nanomagnets

There is a known species of bacteria that contains a small particle of the magnetic iron compound magnetite. This bacteria 'detects' in the simplest sense of the word the Earth's magnetic field and in the Northern hemisphere moves towards the North pole and vice versa in the Southern hemisphere, which effectively means the bacteria constantly move downwards to the sediments on which they need to feed. (This has been shown to be due to the influence of the magnetic field and not gravity.) Biomimeticists are currently studying this in order to possibly manufacture magnets and other inorganic materials biologically, calling them biominerals, which would enable a purity and a lack of toxic by-products to be achieved at levels superior to any current industrial process. At the other end of the scale powerful 'magnetic drugs' might be produced which could be concentrated in the required parts of the body using magnetic fields thus preventing the build-up of possibly toxic drugs in organs where they are not required. (See web site `http://earth.agu.org/revgeophys/moskow01/node4.html`).

Another use for biomimetics in the drug industry is in the development of pharmaceuticals based on substances that are part of the natural body biochemistry and so are likely to be much safer and have fewer side-effects.

Biosensors

The fact that in living organisms the sense organs are usually sensitive down to molecule level is making biosensors based on biological/electronic interfaces of interest. This would enable the monitoring of the low-level electrical, chemical, thermal and light etc. properties of organic and inorganic material, which has enormous potential for medicine and environmental monitoring.

Conclusion

If as some scientists say our intelligence and even consciousness is simply a by-product of the biochemistry of the brain enabling a complex organism to function in its environment then even that 'simple' fact has provided us with the means to engineer materials and our environment to an unbelievable degree. But are basic reflex actions, intelligence, and consciousness different things altogether or just different points along a continuum? And what if even a simple form of life or a remnant of an extinct life not based on carbon is found somewhere in the universe? Will we then be more, or less, able to provide 'proper' definitions of life, intelligence and consciousness? And is our own intelligence sufficient to develop a system that can indistinguishably mimic that intelligence? Perhaps between them the studies of A-Life and biomimetics will provide some answers.

The Prion

The prion (a shortening of proteinaceous infectious particle) is the only known infective agent that doesn't contain DNA or RNA. It is responsible for scrapie in sheep, BSE in cattle, a form of Creutzfeld-Jakob disease in humans, and some other animal infections. It is a form of a protein that is found in the normal brains of mammals and birds. The normal form of the protein is a chain that forms into a spiral due to bonds between hydrogen and oxygen atoms on different parts of the chain (see Figure 9).

However, the bonds between the hydrogen and oxygen atoms can also link in a different way, and this gives rise to a pleated sheet configuration (see Figure 10).

The normal enzyme activity in the brain controls the concentration of the normal form, but if the abnormal form infects the brain it triggers the normal protein to become abnormal too. The enzyme cannot break down the abnormal form and it builds up, causing the distressing symptoms seen in the recent outbreak of the disease and eventual death.

Matters become even more difficult when it comes to defining another aspect of more complex forms of life, that of intelligence.

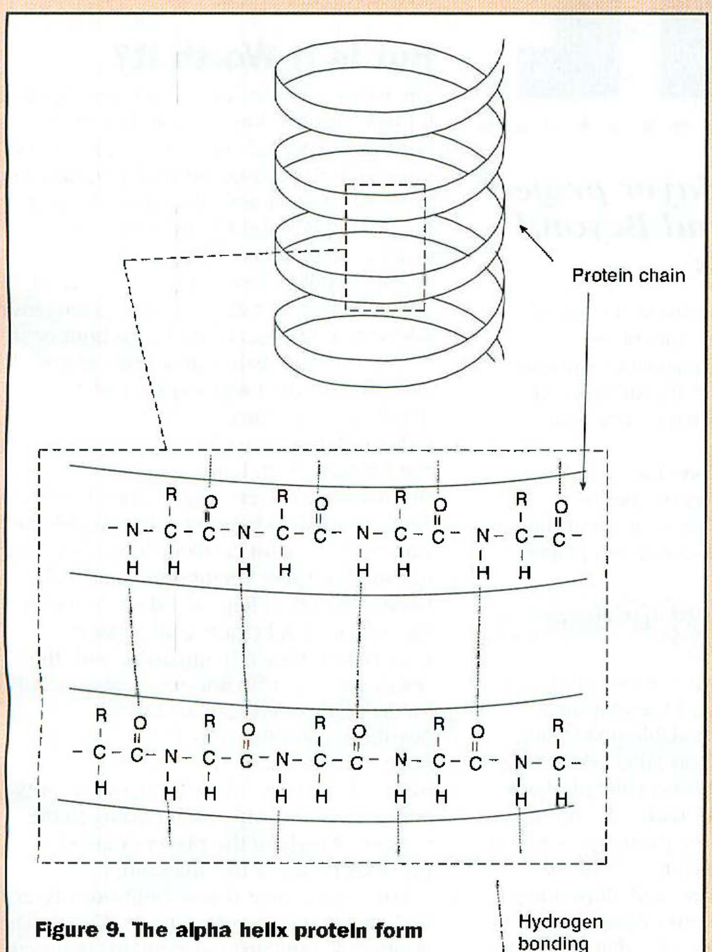


Figure 9. The alpha helix protein form

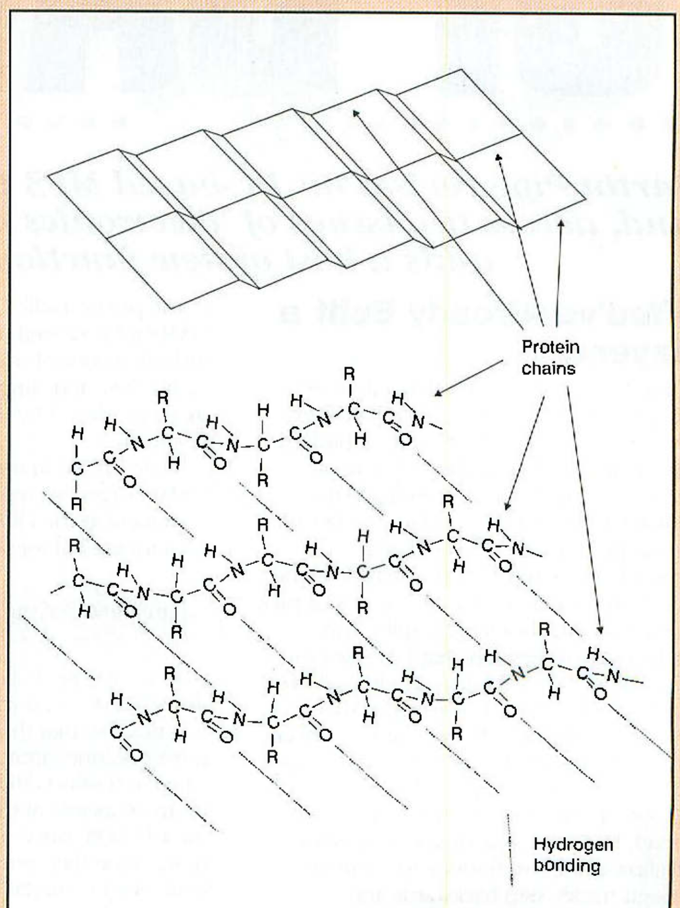
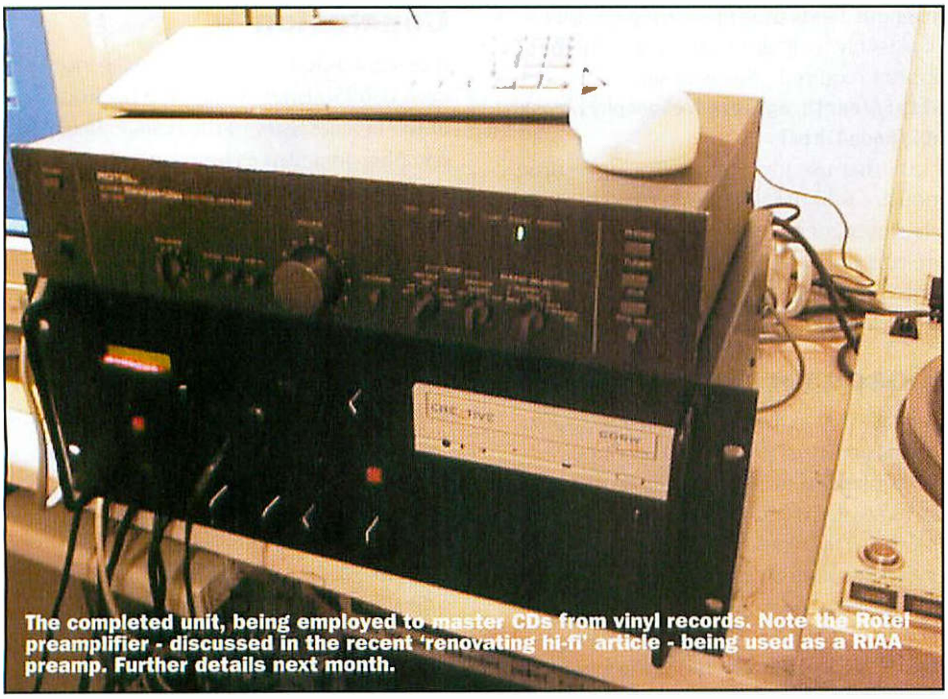


Figure 10. The beta pleated sheet protein form



The completed unit, being employed to master CDs from vinyl records. Note the Rotel preamplifier - discussed in the recent 'renovating hi-fi' article - being used as a RIAA preamp. Further details next month.

MP3 Player UPDATE

PART 1

Martin Pipe revises his PC-based MP3 player project and, across two issues of 'Electronics and Beyond', adds a host of new functions

If You've Already Built a Player...

Let me begin with a point that will be of definite interest to readers who followed the original articles, which were published in the March and April 2000 editions of Electronics and Beyond. Judging by the feedback I have received, a fair number of you are putting obsolete computer hardware to good use! If you're new to the mag, then why not order back issues or pick up copies from your local Maplin store? Readers may remember that I focused on using Hedgehog Software's freely-available DOS-based DAMP software as the MP3 playback application. If you visit the 'drivers' section of the DAMP web site (www.damp-mp3.co.uk), you will find a driver (in2_lpt.zip) that will enable the front panel keypad. Unzipped, the driver in question will allow those five buttons to sequence through tracks, skip backwards and forwards through the currently-selected track, and pause playback. At the same time, why not download the most recent version of the player itself? The latest version of DAMP adds several new functions - including control over playback of normal audio CDs, and support for MP2 files like those produced by Iomega's 'real-time' RecordIt.

As described in the previous articles, DAMP is run by entering the below command at the DOS prompt (or adding it to autoexec.bat for self-contained players)

```
damp.exe d:\*.mp3 -lcd -q 0 -noscop
```

To recap, the -lcd switch turns on the LCD driver. -noscope turns off the graphical functions so that the available processing power is concentrated on MPEG decoding, while -q 0 selects the best-quality playback (at the expense of CPU load). 'd:\' refers to the CD-ROM drive of the prototype - which, more often than not, is loaded with self-made MP3 compilations - and, depending on your configuration, may have to be replaced by some other path that points to the MPEG audio files that you want to play.

To take advantage of MP2 playback and front-panel control, you'll need to download one of the more recent versions of the software (0.95 WIP 9 or later), plus the aforementioned keypad driver. Everything you need is logically organised on the DAMP home page. The DAMP.INI configuration file associated with the program must be made aware of the input driver, or it won't be recognised. Bring up DAMP.INI in a text editor, and find the [input] section. Edit the line that follows to read:

```
driver = in2_lpt.sc
```

and save the file.

The command required to run DAMP after these changes is slightly different:

```
damp.exe d:\*.mp* -indrv -lcd -fnfnoquit -q 0 -noscope
```

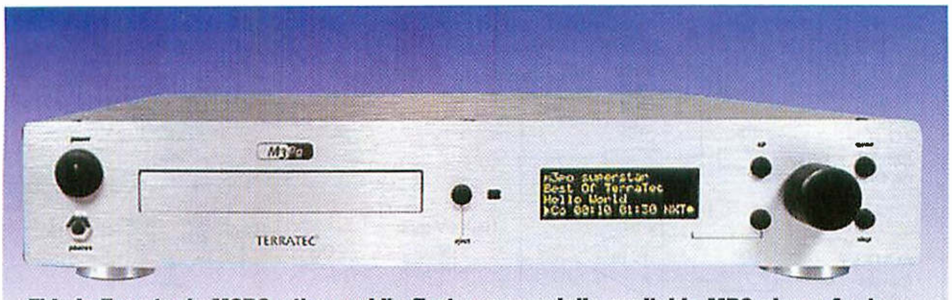
The -indrv switch tells DAMP to load the input driver specified in DAMP.INI, while the wildcard at the end of the filename extension tells the software to look for both Layer 2 (.mp2) and Layer 3 (.mp3) files. The -fnfnoquit switch tells DAMP not to quit if it can't find or recognise a particular file - it simply looks for the next one that can be decoded.

Note that the 2 x 16 LCD module described in the original article (order code RB36P) is no longer available from Maplin. I've just obtained a sample of one that continues to be stocked (NT57M). By next month, I should have figured out how the new unit can be integrated into the player - so hold on until then!

But Is It Worth It?

Since those articles were published, quite a lot has happened in the world of MP3 hardware. Spurred on by the explosion of interest in the format, several manufacturers are now producing players that will read MP3 CD-ROMs and CD-Rs - one of our original design objectives. Details of the Terratec M3PO player (the homepage of which resides at www.m3po.de) were hastily added to the original articles an hour or so before the submission deadline - at that time, the product was so new that few details were available! We're now seeing an influx of MP3-compatible DVD players from the Far East. Such hardware, from obscure (in this country, certainly) brands like Apex, Konko and Mico is being sold through Web sites and specialist retailers. The players in question are also 'region-free', and will handle imported Region 1 discs as well as the 'official' UK Region 2 titles. More importantly, they're compatible with the rewritable (CD-RW) and recordable (CD-R) media that's often used to archive and distribute compilations of MP3 music. The price of these players - £200 or under - makes them particularly attractive to MP3 enthusiasts. So why bother going to the trouble of making the player detailed in previous issues of this magazine?

For a start, once you've built our player, it is cheap to repair and upgrade. The design is, after all, built around standard computer components. Chances are that should your



This is Terratec's M3PO - the world's first commercially-available MP3 player for home hi-fi use. The elegantly-styled device, which has a pricetag of approximately £350, will play audio CDs as well as MP3 CD-ROMs. A new wave of DVD players are also capable of playing MP3 CDs.

Chinese player fail after the guarantee period, you'll have to throw it away and buy a new one - spare parts (assuming you can get hold of them) are likely to be expensive. Witness the situation with current examples of Chinese 'junk', such as midi systems and VCRs - thousands of uneconomical-to-repair examples turn up at boot sales and council refuse tips! PC components, conversely, are cheap and almost universally available (ironically, most are made in China these days!). In this player, the component most likely to fail is the CD-ROM drive - assuming, of course, that you're using CD-Rs as a storage medium. If the drive does pack up, you can simply replace it with a new one. MP3s don't demand state-of-the-art transfer rates, and a CD-ROM drive that's up to the job might only cost you £25 at a computer fair. Even elderly 2x or 4x drives are fine. These are now seen as obsolete, and are hence frequently discarded. You should be able to acquire them for less than a tenner second hand. Now isn't that more cost-effective than having to replace the entire MP3 player?

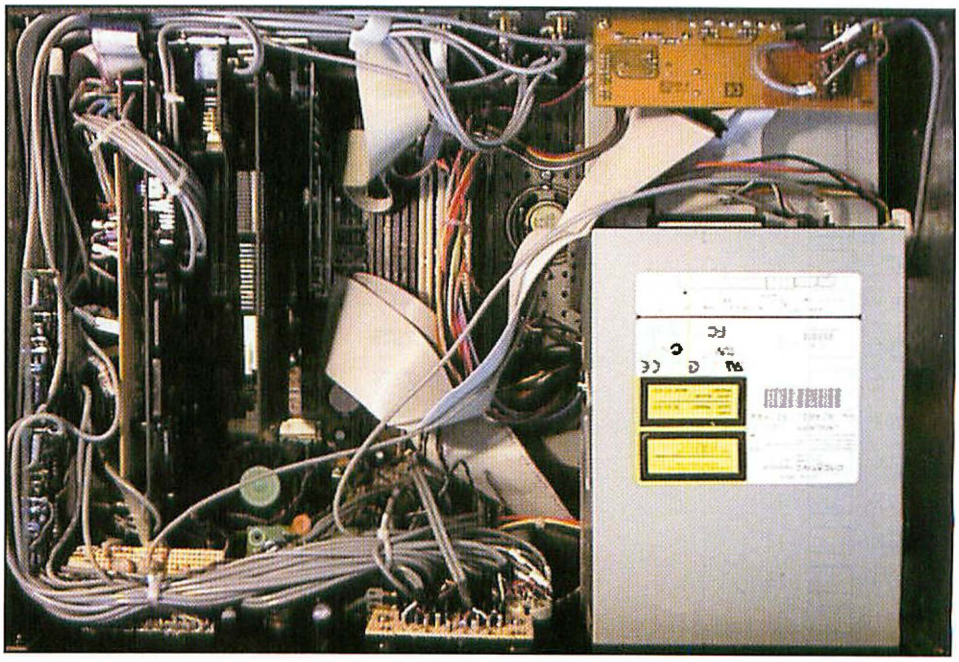
Then there's the issue of software. Purpose-designed players have their operating software burnt onto EPROMs or EEPROMs. At best, adding new features or modifications involves the replacement of chips - which might have to be done by a service facility. As an example, one only has to look at the fiasco regarding some of these players' inability to cope with certain DVDs - they had to be returned to the retailer! More advanced players, notably those from the major Japanese manufactures, can be updated simply by inserting a special CD-ROM in the disc tray. Current players of this type tend to be DVD-only. They won't handle CD-R or CD-RW media, let alone MP3 tracks. In any case, new features, such as the ability to handle MP3s or new audio compression formats like VQF, are unlikely to be added - particularly after the marketing lifetime of the product has ended. Our player is based around software, and can thus be easily updated to take advantage of new technologies as and when they arrive. The software can easily be downloaded from the Internet - no long waits or carriage costs to worry about here!

Our player can, of course, be used as a PC in its own right - how many DVD players can be used to do the accounts, play games or surf the Net? This processing power has been harnessed in one particular direction - making MP3 CD-ROMs and audio CDs in the first place. In other words, we now have a total audio solution based around a PC - and that's what we're going to talk about here in these two articles. The comprehensive solution described takes us ahead of component CD audio recorders, which give you very limited control over what is recorded onto the disc. Although Minidisc recorders offer far superior editing features to those built into CD audio recorders, the results can only be heard on Minidisc players. There are far more CD players in worldwide circulation - particularly as far as in-car use is concerned. Although Minidisc players are available for the car, they are few and far between. In any case, they tend to be more expensive than their CD equivalent.

Beefing Up the Hardware

To this end, the hardware of the original MP3 player was upgraded from a P133 and 'all-in' (onboard sound and graphics) motherboard to a rather more K6/255 and Intel TX motherboard. Obsolete by today's standards - but fine for audio applications. The memory was upgraded to 128MB, the hard disk swapped for a 3.2Gb UDMA model, and a CD-ROM replaced with an 8-speed Creative Labs CD-R/CD-RW/CD-ROM drive. The latter device, which is sold as the 'CD Studio', has numerous CD audio-related benefits. It supports digital audio extraction (DAE), which is particularly useful if you want to 'rip' tracks from CDs as WAV files - those files can then be converted into MP3s, or put onto personalised compilation audio CDs courtesy of mastering software like Adaptec's Easy CD Creator or Ahead's Nero. The revised hardware is more than capable of running such software. Creative's drive also supports - with compatible software - CDText. Some home and car CD players are CDText-compatible, and will scroll the track name and artist on their displays. The overall effect isn't unlike the MP3 ID3 tags that DAMP displays on the LCD screen of our player. Very few commercial CDs include CDText information, and none of the stand-alone audio CD recorders currently available offer the facility to add it to your own recordings. Ours can - and unlike those stand-alone recorders you can use cheap computer-grade CD-R media instead of those expensive 'audio' discs. The final advantage of the Creative drive is that an S/PDIF output is available in audio mode - this is harnessed in our design.

The original motherboard featured on-board VGA - which is something not provided by the replacement. A major change, then, was the addition of a Matrox G200-TV graphics card. This was selected on the basis of its in-built VGA-to-TV converter - in other words, you can now use your TV as a monitor! The card also has Motion-JPEG video capture and output, together with S-video and composite video connections. One of the programs supplied with the card, PC-VCR Remote, includes a timer. This can be programmed to record video, as well as audio, at a predetermined time. In other words, the system can be used as a digital video recorder - you will, of course, need a fairly big hard disk! Another of the bundled programs converts Motion-JPEG captures into MPEG files - the basis of Video CDs, which can be created with the Creative drive. Video editing software is also provided. All-powerful stuff, and way beyond the capabilities of MP3-compatible



Inside the completed unit

DVD players and other 'stand-alone' solutions. Welcome to the universal machine!

Sound Cards - What Choice?

Our Intel TX motherboard doesn't have the on-board sound of the original, either. Seeing as the machine is intended primarily for audio applications, the soundcard is arguably one of most important peripherals. After experimenting with a variety of cards, I have plumped for a two-card trick. The first is an old Creative Labs Soundblaster (SB) 16, chosen mainly because it is the best supported card in existence, especially as far as DOS applications like DAMP are concerned. The second card, which will be discussed in greater depth next month, is an Audio Excel AV511. This PCI card is designed primarily for Windows 9x - pure DOS support is restricted, and - as with most PCI audio cards - it isn't guaranteed to work with DAMP. Not that you would want to - analogue performance is rather poor. The AV511 has been specified because, at £10 or so, it's the cheapest soundcard in the universe to support pure S/PDIF digital input and output. When the machine is booted in Windows, you'll be able to make the best possible recordings from digital sources, using programs like RecordIt and CoolEdit. Next month, we'll explain how. If you can't wait until then, check out the web site operated by fellow Electronics reader Adrian Caspersz (www.digitalmods.com). Although the information concentrates on previous versions of the card, it's still valid. Adrian also operates an informative mailing list dedicated to the Audio Excel cards. He claims to be updating the site to include the AV511.

The analogue side, then, is handled by the Soundblaster 16. Initial results weren't too encouraging. Top-end noise performance fell short of expectations, while the low end was characterised by a thin and gutless sound. Far from hi-fi, in other words. But then again, what do you expect from 741 op amps - the Motorola equivalent of, which are dotted all over the board. Oh yes, and there are grotty low-value electrolytics throughout the signal path... The discrete nature of this soundcard invites one to tinker with it, though! Modern designs cram as much as functionality into as few chips as possible. Soundcards are now a cut-throat business, and the component count will determine the manufacturing (and hence selling) price. There's very little in the way of modification that you can do to these modern cards. The venerable SB16 is a completely different kettle of semiconductors, though. When it was originally designed, there were no other 16-bit soundcards or suitable chipsets on the market, and - presumably to reduce development costs - Creative based part of its design around 'off-the-shelf' components.

One of these chips, marked 'CT1703', is the all-important codec chip that contains the digital-to-analogue and analogue-to-digital converters, which forms the basis of the modifications that will be outlined. In reality, the chip is an AK4501 from Japanese manufacturer Asahi Kasei Microsystems (AKM). The House of the Soundblaster presumably told AKM to badge the chips with Creative's own part number in order to throw competitors off the scent. How do I arrive at such conclusions? My own card had the original AKM part number, covered with a Creative sticker. Another SB16 in my possession is identical in all respects other than the markings on the codec IC - and all signals are identical. Presumably, demand for the SB16 was so great that Creative ran out of its 'badged' AK4501s. Note, however, that some of the SB16's chips, such as the CT1745 (which handles analogue signal switching and mixing) do appear to be of Creative's own design. But then again, chips of this nature are specific to soundcards.

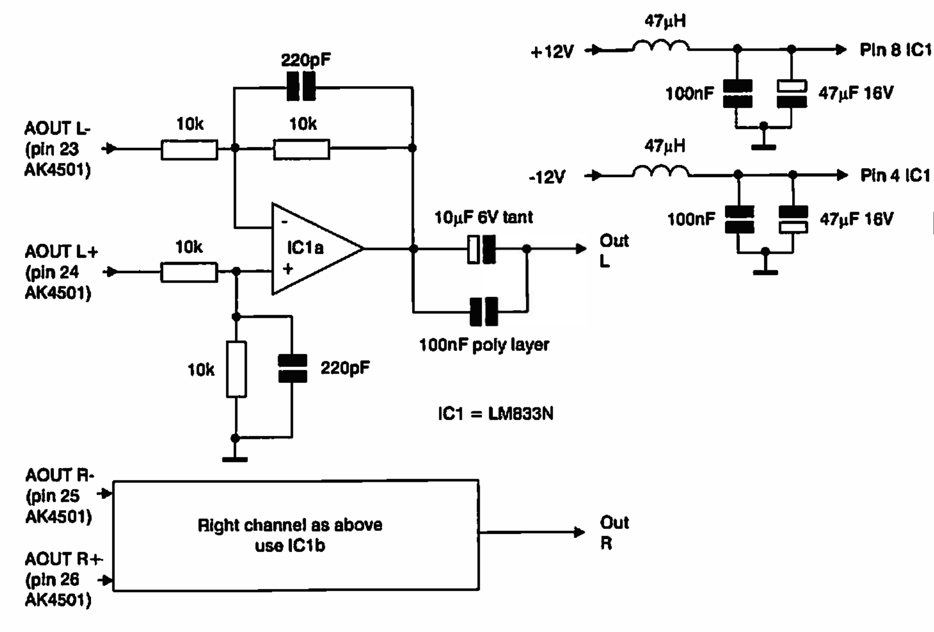


Figure 3. Modified SB16 analogue output stage

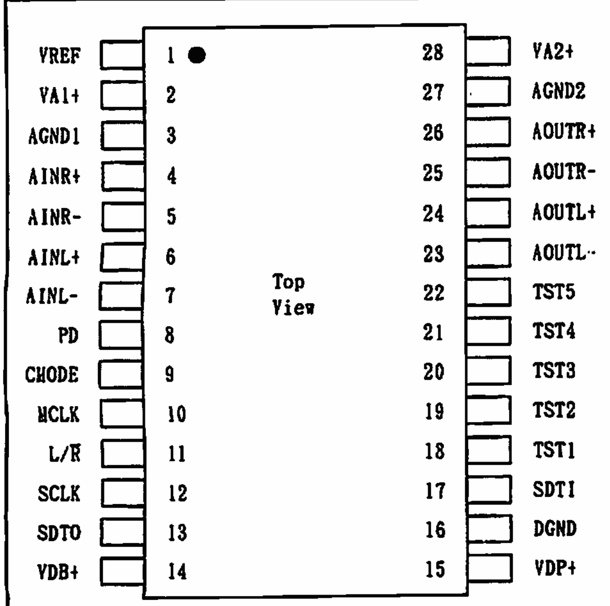


Figure 1. Pin-out of the AKM AK4501/Creative CT1703

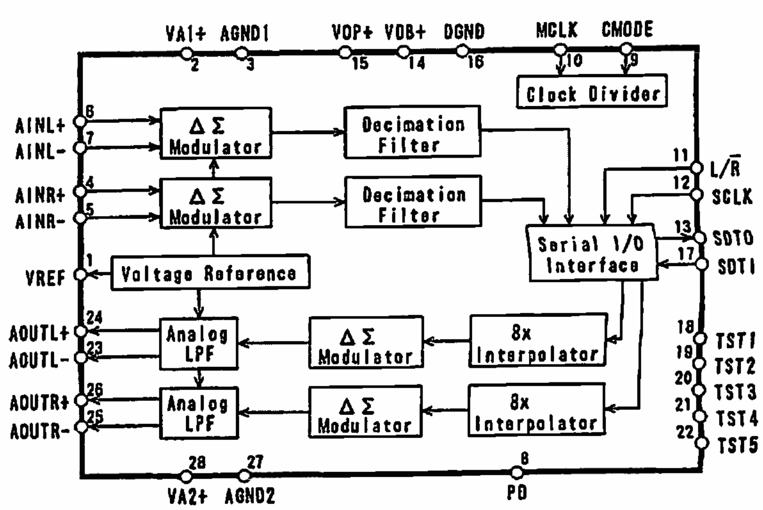


Figure 2. Block diagram of the AKM AK4501/Creative CT1703

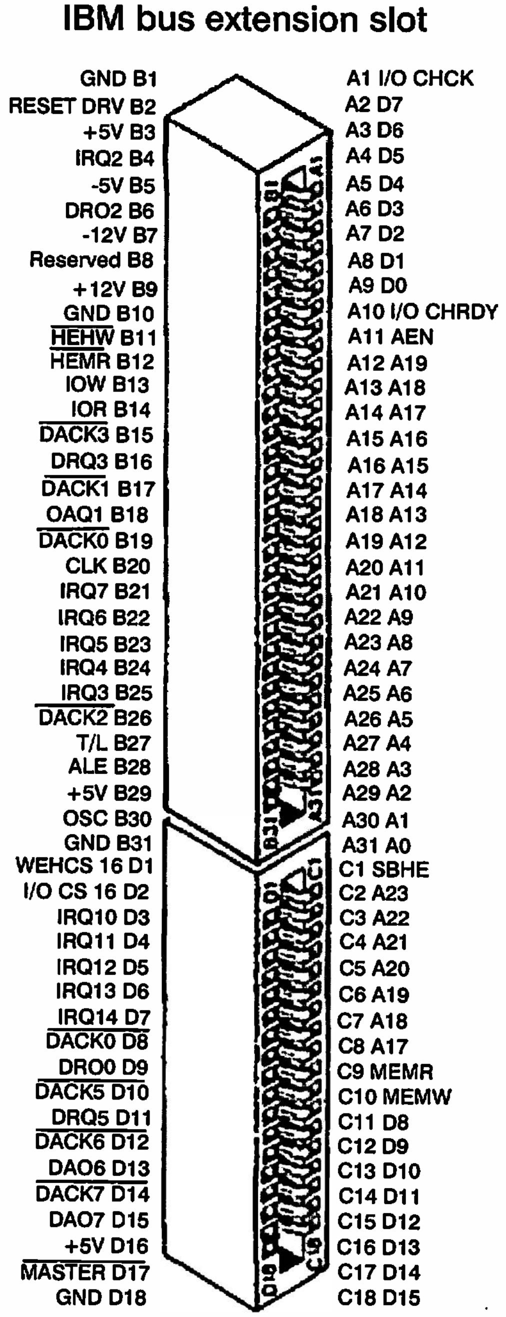


Figure 4. Pin-out of the ISA bus, as employed by the SB16 and other older 16-bit soundcards. From this, you should be able to figure out where you can tap off the -12V, +5V and +12V rails.

Modifying the SB16 - It's a Blast!

A data sheet from AKM revealed some interesting points. As can be seen from Figures 1 (pinout) and 2 (block diagram), you get differential analogue inputs and outputs for each channel, plus access to the digital signal paths. By taking the audio signals from the outputs, and feeding them into minimalist hi-fi grade circuitry, you should get a far superior sound quality. To this end, the circuit outlined in Figure 3 was constructed on a piece of matrix board. The circuit was fed directly from the chip's differential outputs, using screened wires soldered directly to its pins. Be careful - the chip is a surface-mounted design. The 16-bit digital-to-analogue converter is a 4th-order delta-sigma design, with on-chip filtering. Although the filtering ensures that only the audio signal gets through, the circuit of Figure 3 acts as a 1st-order low-pass filter to remove any out-of-band noise (particularly at lower sampling rates). The circuit also sums the differential outputs. The op-amp specified is a low-noise LM833 type, which is perfectly adequate for this type of application. Its power rails are obtained from the appropriate points on the SB16 - these were found by looking at a pin-out of the ISA bus (see Figure 4) and working backwards.

The chip's power rails are decoupled as close as possible. Additional electrolytics and a pair of chokes help to reduce the effects of unwanted noise generated by the PC's switch-mode power supply. The board was mounted on the SB16 - Creative has thoughtfully provided suitable holes on the card! The improvement in sound quality is quite astounding. There's far more detail, and the frequency response is considerably better. Indeed, the overall sonic presentation is arguably superior to just about any consumer soundcard currently available! Although noise levels are much lower than those associated with the unmodified SB16, there's still some background 'whining' that can be heard between tracks with the volume wicked up. Extra decoupling and filtering of the soundcard's own power supply rails (notably those that feed the AK4501) should attentuate it to the point where it's below the threshold of audibility. Purists might want to design a separate transformer-based power supply for the soundcard's analogue circuit, and perhaps even shield sensitive areas of the circuitry with grounded screening cans.

There's more to the AK4501 than analogue outputs, though. The chip's analogue inputs can be fed directly by a differential analogue source, without being unnecessarily deteriorated by the SB16's mixer. Because the ADC contains anti-aliasing filtering (to make the lives of designers easier), the circuitry required to give the SB16 a high-quality 'minimalist' input is rather simple. We'll discuss this next month. For now, though, console yourself with the fact that Creative specified the CT1703/AK4501 device in its soundcards for several years. Other products to use the chip include the upmarket AWE32 and AWE64 designs - these can consequently also be modified in much the same way. Note that by the time the AWE64 had arrived to market, Creative's analogue circuit design had got better! There's perhaps little sense in bothering to modify the AWE64's analogue output, since its sound quality is actually quite good. That's not to say that there's no room for modification, though. One of the most important features of the AWE64 was its S/PDIF output - which works on the codec, and not just the wavetable synthesiser as was the case with the earlier AWE32. Unfortunately, the output was - for some stupid reason - only available through Windows. Exactly why is bizarre, seeing that

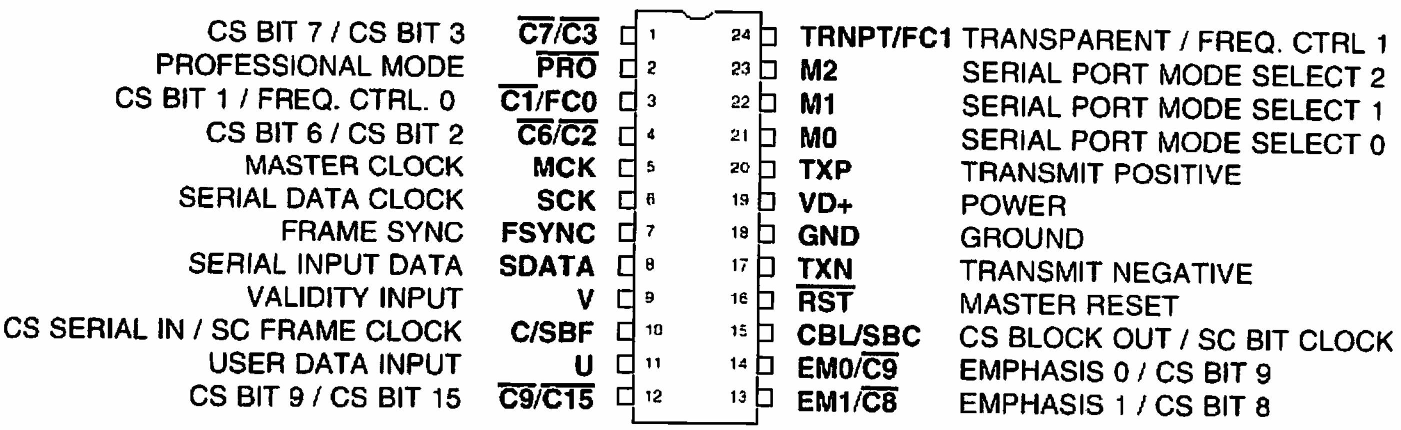


Figure 5. Pin-out of the Cirrus CS8402A

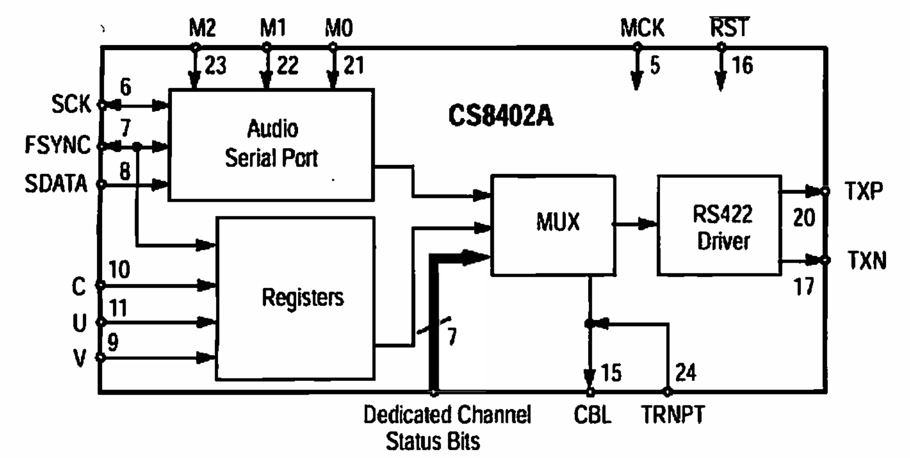


Figure 6. Block diagram of the Cirrus CS8402A.

S/PDIF is surely a hardware function! Other cards, including the CM8330 chipset built into the original player prototype's motherboard, suffer from exactly the same limitation. Extremely annoying if you want to partner the (DOS-based) MP3 player with an external DAC for the best possible sound quality. Thankfully, there's a S/PDIF workaround for AK4501-based cards - although it involves extra hardware.

Adding an OS-Independent S/PDIF Output

The digital audio and timing signals required by the AK4501 are pretty universal amongst consumer-grade DACs. Digital audio going into the chip takes the form of a serial stream of data (referred to as SDTI in Figures 1 and 2), that contains both stereo channels in a time-division multiplex arrangement. A timing signal, frame sync (or L/ /R), allows the AK4501 to extract the individual left-channel and right-channel samples from the datastream. Other timing signals include another clock signal that's used to synchronise transfer of audio data, and a master system clock. A search around the Web revealed a chip capable of converting these signals into S/PDIF format. The pin-out and block diagram of this chip, the CS8402A from Cirrus Logic, are given in Figures 5 and 6 respectively. A significant advantage of this chip is that little extra circuitry is required to deliver a S/PDIF output. That said, the frequency of the master clock (available at pin 10 of the AK4501) needs to be halved. The circuit depicted in Figure 7 employs a D-type flip-flop (half a 74HC74) for this very purpose. The circuit also inverts the frame sync signal (available at pin 11 of the AK4501), using one of the gates of a 74HCU04 hex inverter, so it's compatible with the CS8402A.

As can be seen from Figure 7, four of the other gates are used to buffer the other two signals (serial clock - pin 12, and serial data - pin 17). Mercifully, the propagation delay introduced by these gates is too short to affect digital audio signals. The output of the CS8402A, available on pin 20, is at TTL-level. The coaxial SP/DIF specification calls for a signal level of a volt or so - and an isolated output. We'll describe how this can be obtained next month, when we detail the digital circuitry associated with the AV511 soundcard. Adding the output is well worth it - for the first time, we have a fully SB16-compatible soundcard capable of generating a S/PDIF output under DOS! Ideal for getting those MP3s onto Minidiscs! Using a Sony Minidisc deck as a DAC (press 'record' with no disc present) revealed a sonic balance similar to that of the modified analogue stage - but with no residual background noise whatsoever! Note that the CS8402A has other applications, such as adding S/PDIF outputs to set-top boxes (the audio circuitry of the Sky Digibox, coincidentally enough, is based around a AKM DAC), CD players and other digital audio hardware.

Next Month...

In the next issue, we'll describe how the analogue input of the SB16 can be re-engineered for better sound quality - ideal for those who want to commit their old tapes and vinyl records to CD. We'll also describe the incredible-value AV511 and digital interfacing in more depth, and detail the interconnections, user interface, parts lists and other practical considerations. If you want old-fashioned record level control knobs and front-panel LED meters, hang on in there! We'll also detail the replacement LCD module.

Note: Neither Maplin Electronics nor the author can be held responsible if your soundcard or PC blows up - so be careful! The information in this article is provided on an 'as-is' basis.

Contact Cirrus Logic on (01628) 472211 for current details of CS8402A distributors. All of the other components are available from Maplin.

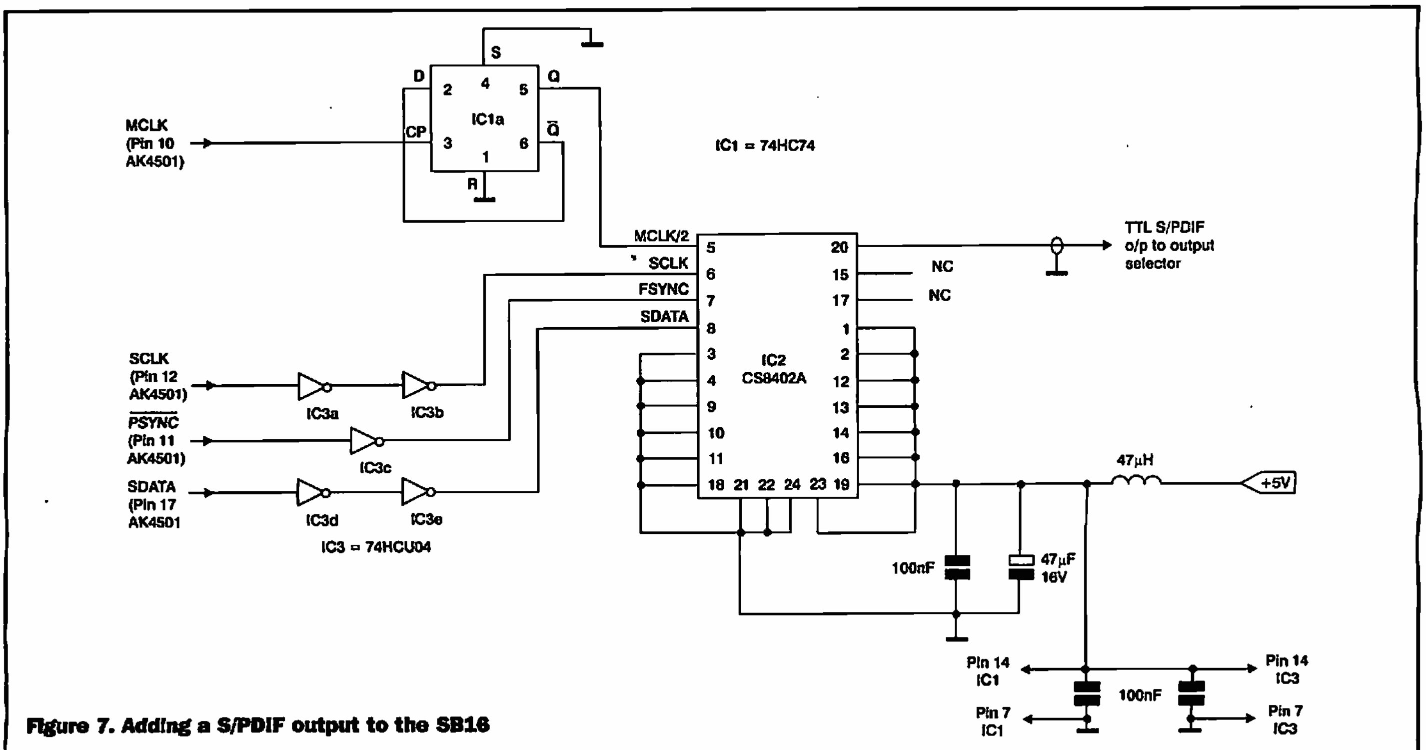


Figure 7. Adding a S/PDIF output to the SB16

When Moore's LAW FAILS

Mike Bedford explains why the microprocessor, as we now know it, will soon run out of steam!

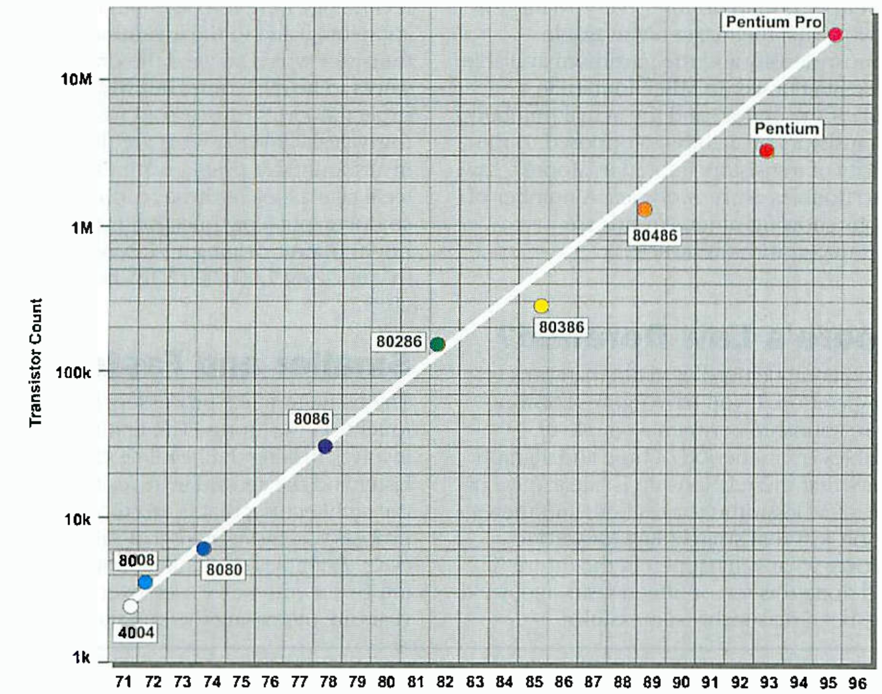


Figure 1. The number of transistors on a chip has doubled every two years since the early 70s. Here we see the number of transistors on each Intel's processor generations from the 4004 to the P6 (Pentium Pro II, II).

Two inventions that were to shape the world today - and perhaps for the next few centuries for all we know - took place around the middle of the 20th century. And despite the fact that they were apparently unrelated, these two developments took place within a few months of each other. One of these, the completion of the first stored program computer at Manchester University in June 1948, was well publicised a couple of years ago as part of its 50th birthday celebrations. The other, which had taken place just six months earlier, was to prove a key to the further development of the computer and the astonishing rate of growth we've seen over the last 50 years.

That first computer, the Manchester Baby, operated at a speed of 833 instructions per second, had a word length of 32-bits and contained 128 bytes of memory. Since it employed a novel technique using a CRT tube for the memory, the valve count was quite modest at about 600. Nevertheless, the computer measured 16 feet by 7 feet by 3 feet and consumed 3.5kW of electrical power. Had this been scaled up to the level of performance of one of today's top-end processors, the 22 million transistor AMD Athlon, it would have consumed 128MW and there would be few buildings in the world large enough to house it. Not only this but the electrical path length in such a computer would have severely limited its operating speed. Had it not been for the second invention, therefore, the phenomenal growth in the speed and power of computers that we've seen over the past half-century just wouldn't have been possible. That second invention, of course, was that of the transistor in December 1947, an invention that gave rise to the integrated circuit and eventually the microprocessor. And since the dawn of the microprocessor age in 1971 we just haven't looked back - the rate of growth has gone through the roof.

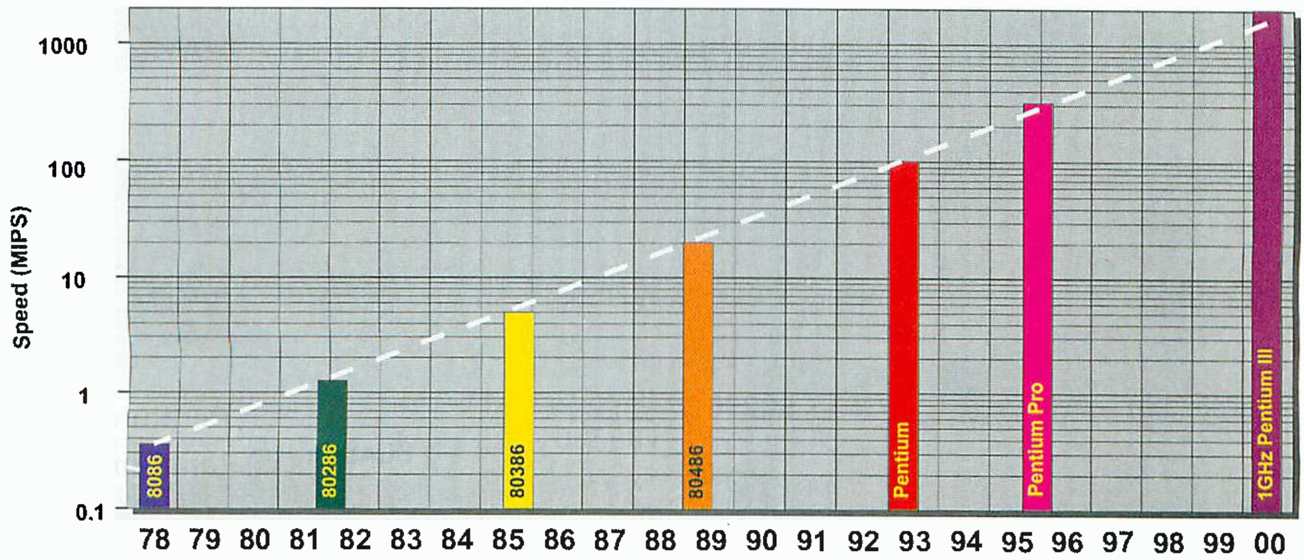


Figure 2. The performance of processors, measured in MIPS, also shows an exponential growth with no signs yet that this trend will run out of steam.

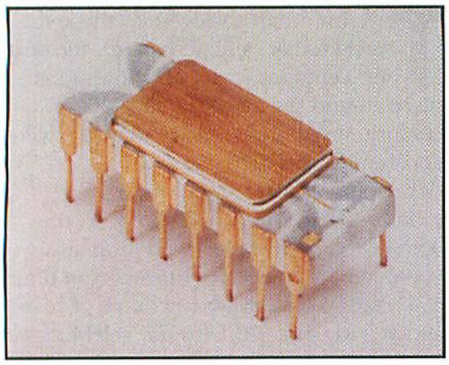


Photo 1. 4004 package

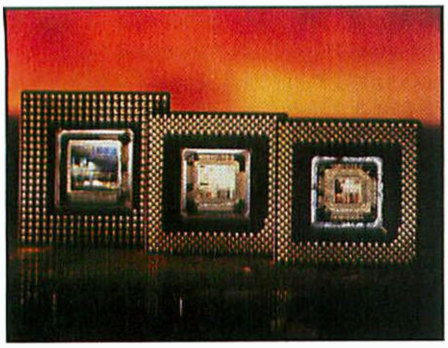


Photo 2. 386 package

Processor Growth Rate

The first microprocessor, the 4004, had a 4-bit architecture, a clock speed of 108kHz, executed instructions at 0.06 MIPS, could address 640 bytes of memory, and contained 2,300 transistors. It cost $45, which, in today's terms works out at the equivalent of a few hundred pounds. Today's top-end Pentium III processors have a 32-bit architecture, a clock speed of 1GHz, execute instructions at around 1,700 MIPS, can address 4Gbytes of memory, and contain 9.5 million transistors excluding the secondary level cache. They cost about £700 - perhaps not too different in real terms from the 1971 price of the 4004 - and if you were to settle for a 400MHz processor, you'd pay a fraction of that price. All this leads many people to believe that it will always be like this - year on year we'll get substantially more processing power for the same price if not for less. In fact, as you may be aware, Gordon Moore, one of the founders of Intel, predicted this over 30 years ago. The law which now bears his name originally stated that the number of transistors per square inch of silicon would double every year. In 1973 this was amended to a doubling every 18 months and this trend has indeed held true for almost three decades. But although this is Moore's Law, lots of associated trends also hold true and, although not strictly accurate, these have also been referred to as Moore's Law. For example, the processing power per pound doubles every 18 months to two years, the maximum available memory density and the maximum available processing power in MIPS doubles in a similar time period, and the actual number of transistors on a chip - as opposed to the density of transistors quoted in Moore's Law - also doubles every two years. A number of graphs showing various trends are reproduced with this article.

Moore's Law Derailed?

A technique beloved of mathematicians is extrapolation. If you have figures showing the relationship between a couple of variables over a period of time and a graph shows that the relationship is linear (give or take a few logarithmic axes here and there), just project that straight line forward to discover what will happen in the future. If we'd done this ten or fifteen years ago, we'd have been reasonably successful at predicting the state of play with processors today. Does this mean, though, that we can make a prediction for ten or fifteen years into the future? If so, we would have to surmise that the processor of 2015 would have around 4 billion transistors and clock up around 1,000,000 MIPS - that's around 200 times faster than Intel's forthcoming 1.5GHz Willamette. Unfortunately, though, despite the expectations which history has conditioned us to have, experts are now suggesting that the rate of progress we've enjoyed recently can't go on forever. And if this is true, our figures for the processor of 2015 will be wildly optimistic. It's been suggested that we can only expect this two-yearly doubling in just about everything but price to last until the end of the decade. Beyond that, if improvements are to occur at all, the rate of increase will be much reduced. Unless, that is, a totally new technology were to come into being - something akin to the invention of the transistor which allowed the drawbacks of valves to be overcome. But why can't we expect Moore's Law to hold true for another thirty years at least? What are these insurmountable problems? In this article we'll take a look at these roadblocks and, in so doing, put a big question mark over your hopes of ever owning a PC based around that amazing 1,000,000 MIPS processor of 2015.

Smaller and Faster

The battle to make processors faster is fought on two fronts. The first of these involves making the headline clock speed faster and the second involves improving the architecture, that is, making the processor achieve more in a single clock cycle. Examples of architectural improvements we've seen over the last few years are increasing the bus and register

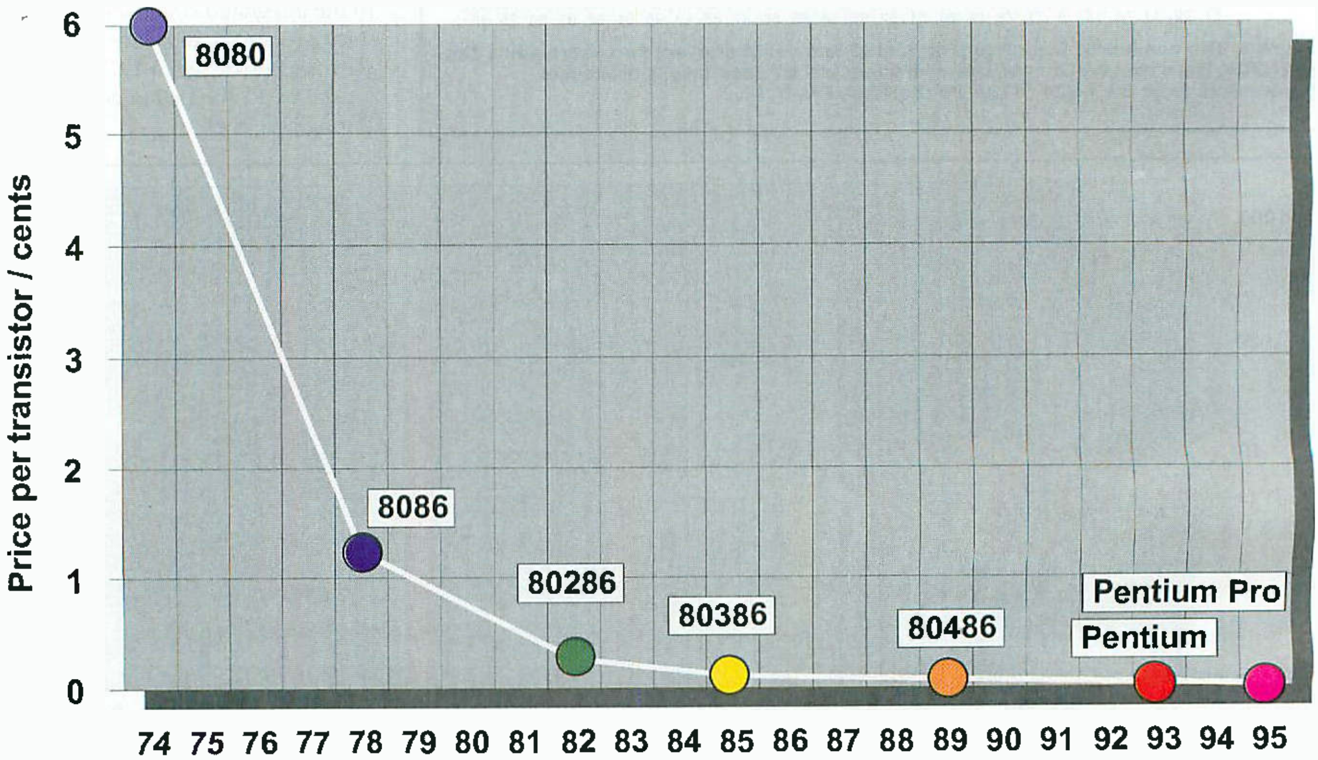


Figure 3. But whereas virtually all other trends show a line heading skywards, the price per transistor has plummeted.

Photo 3. Pentium PIII package

widths, pipelining, the introduction of multiple processing units, and speculative execution following branches. If you don't know what all these mean just let's say that their introduction has changed the state of play from the days of the 386 when a single instruction took multiple clock cycles to the situation today where multiple instructions are executed in a single clock cycle. And undoubtedly innovations of this type will continue although we have to question whether we're getting to the state where the law of diminishing returns starts to play a part. Nevertheless, let's be optimistic and assume that architectural improvements will continue at the rate we've seen over the last couple of decades. However, to achieve that doubling in performance every couple of years we also need a continuing increase in the clock speed and this is where the problems lie.

Just making a faster clock is, of course, no challenge whatsoever. 1GHz processors have been announced by Intel and AMD indeed they could well be on the market by the time you read this. However, it's been possible to build 1GHz oscillators for many years. Even ordinary valves of the type which have been around since the days of that first stored program computer could be persuaded to oscillate at a few gigahertz. What is considerably more difficult, though, is to make the processor do something useful if you clock it at 1GHz or above. This is clear if we look at the practice of over-clocking. Despite the protestations of Intel, some PC manufacturers use a higher frequency clock than the semiconductor manufacturers specify for a particular chip to achieve a useful increase in performance. In reality, of course, they're relying on the fact that manufacturers are conservative in their rating of processors but if the over-clockers try to go too far the chip simply won't operate or it may fry. So what are the limits on how fast you can clock a processor? Actually there are a number of limitations but let's cut a long story short by saying that as the frequency increases the inductance of the conductors and capacitance between them becomes more of a problem and that this has to be overcome by reducing the dimensions. So this increase in the packing density of transistors on the silicon die which Moore's Law refers to is necessary in order to continue increasing the clock speed. In other words fast transistors have to be small transistors and this explains the constant reduction in the feature size.

Back in the 70s, that first microprocessor, the 4004, had a 10 micron feature size, a micron being a millionth of a metre or a thousandth of a millimetre. Today, the fastest processors are fabricated using a 0.25 or 0.18 micron process. However, 0.1 microns is considered by many experts to be the end of the line, a barrier which technology is unlikely to be able to overcome and if this proves true then it could also mark an end to further increases in the clock speed. But what is so difficult about making chips with a feature size smaller than 0.1 microns? Actually there are quite a few problems, some technology related, some concerned with the fundamental laws of physics, and some tied up with economics. Remember that it only takes ones of these to remain insurmountable for the further development of the microprocessor to come to a grinding halt. Let's take a look at some of these difficulties.

Lithography

Like most people who have an interest in electronics, you probably understand the basics of integrated circuit manufacture even though the practicalities are undoubtedly much more involved than most of us could possibly imagine. So you'll be aware that the process is not too dissimilar - albeit on a much smaller scale and with more exotic materials - from that used for etching printed circuit boards. With a PCB, of course, the minimum feature size is much larger than the wavelength of light so there is no difficulty whatsoever in achieving a sharp image. With integrated circuits, though, the feature size is sufficiently small that severe constraints are being placed on the light source used in the photo-lithography. And as the feature size continues to reduce, the problem is getting ever more severe.

Something you may be aware of if you're a serious amateur photography is that you can't rely on an SLR's normal through-the-lens focusing system if you're using infrared film. The reason for this is that the lens focuses infrared to a different point from visible light. In fact, there are even differences within the visible spectrum - although our eyes won't notice this, if a red object in a photograph is perfectly sharp, a blue object at the same distance from the camera will be slightly out of focus. But although this isn't a problem with ordinary photography, it would be a problem for photo-lithography in semiconductor manufacture. If you were to use ordinary white light - a broad mix of different colours of light - then you'd end up with a fuzzy area around the edges of features. Perhaps this fuzzy area may only be a few microns across but when we're dealing with features smaller than a micron this is a major problem. For this reason, photo-lithography in semiconductor manufacture has traditionally used monochromatic light generated by a discharge bulb. But whereas a mercury vapour lamp was an adequate light source when features were larger than 0.5 microns, as the feature size has got smaller other problems have come to the fore as we'll see if we take a quick look at the laws of physics.

The third Baron of Rayleigh showed that the sharpness of the image in an optical system depends on the wavelength of the light and the aperture of the lens. To improve the degree of sharpness you need either to reduce the wavelength of the light source or increase the aperture of the lens. Unfortunately, though, increasing the aperture has its own associated problems, specifically a reduction in the depth of field.

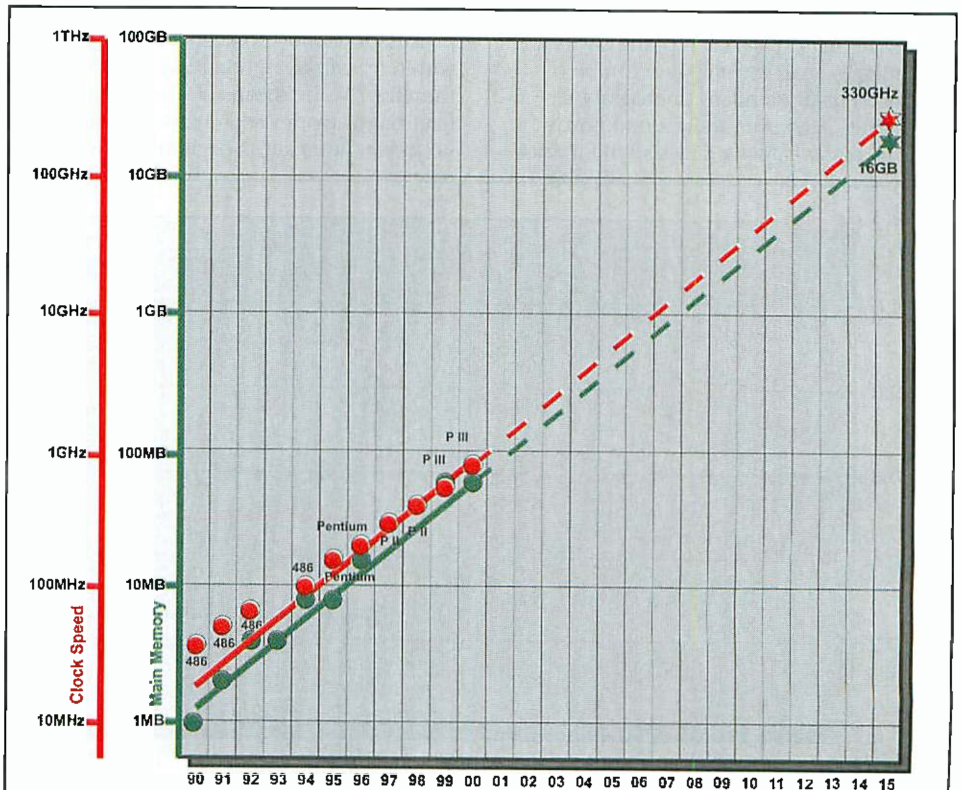


Figure 4. With such well-defined trends, it ought to be possible to predict the processor speed and memory size of an average PC in 2015 by extrapolation. However, some experts reckon that Moore's Law will break down before then.

And whereas we might assume that a silicon wafer is flat and so depth of field isn't an issue, at the sorts of dimensions we're talking about, a minute degree of undulation can make the difference between the image being in focus and it being blurred. To use a large aperture, therefore, the silicon wafer has to be machined to a very high degree of accuracy and this is not as easy as you might think. But it gets worse than this - once you start etching the silicon it will no longer be flat and so, once again, focussing is a problem. Obviously, therefore, there's a limit to the aperture of the lens so attention has to be turned to reducing the wavelength of the light source. So the mercury vapour lamp has been pensioned off in favour of a krypton fluoride ultraviolet laser (wavelength - 248nm or 0.248 micron) for devices manufactured using the 0.25-micron process and a shorter wavelength UV laser has been developed for the 0.18-micron process.

Nevertheless, despite the transition to these exotic and expensive light sources, even this technology will run out of steam as the feature size continues to tumble. One of the problems with these short wavelength light sources, if 'light' is the right word for invisible radiation like UV, is the lens. Glass becomes opaque at ultraviolet forcing a shift to quartz lenses. As the wavelength decreases further there are problems in making a lens which can withstand repeated high-energy laser pulses. It's felt that extreme ultraviolet may be useable down to a 0.13-micron process but after that X-rays seem to be the next logical progression. But the challenges of using X-rays are even greater. In conventional photo-lithography a lens is used to project an image at reduced size onto the surface of the silicon. So the masters or masks that define the pattern on each of the layers are much larger than the chip and can be produced using standard photographic techniques. However, there's no known material that will focus X-rays so the masks would have to be produced at the same size as the chip itself. Needless to say this is another interesting hurdle to be overcome. Although the range of wavelengths available with X-rays should allow the feature size to be reduced beyond what we can possibly conceive of today, because of the problems with focussing X-rays, other researchers are talking in terms of electron beam lithography. Here the technique would be quite different. Rather than exposing the photo-resist through some sort of photographic master, the electron beam could be deflected, in much the same way as an electron beam is deflected in a CRT, to draw the required pattern. Needless to say, both X-ray and electron beam lithography are so far removed from today's techniques, that vast resources of both time and money would need to be expended for either to come to reality. Plus, of course, with any unproven technique, there's always a nagging doubt as to whether it's feasible at all.

Hot Stuff

Most of the electrical power consumed by a microprocessor ends up as heat. When processors had comparatively few transistors and, consequentially, consumed very little power, that waste energy in the form of heat was dissipated naturally by the usual methods of conduction, convection and radiation. What a different situation we find today. The 1GHz Athlon processor, which AMD has recently announced for example, consumes 65W of electrical power, and when we bear in mind how much heat a 60W electric light bulb kicks out it's clear that this processor could get pretty warm. However, there's a big difference between a light bulb and a processor - a light bulb can withstand high temperatures whereas a processor cannot. To keep a processor within its safe operating temperature range, therefore, some means of dissipating the heat has to be devised - natural cooling is no longer adequate. Specifically a heatsink or, more commonly, a combination of a heat sink and a fan is employed and, with today's processors this is adequate. However, this is a problem that will become much more acute as the minimum feature size of processors decreases in order to achieve that increase in clock speed.

First of all some good news. As the feature size has reduced over the years, so has the supply voltage. At one time all digital ICs, including microprocessors, operated from a 5V supply. Over the last decade this has tumbled through 3.3V and 2.5V to 1.8V on today's fastest processors. And what makes this good news even better news is that the power consumption is proportional to the square of the supply voltage. In other words, all other things being equal, a 1.8V processor will consume little more than an eighth of the power of a 5V processor. Unfortunately, though, all other things are not equal and this is where we come to the bad news. That transition from 5V to 1.8V has occurred in step with a reduction from a 0.8 micron process to a 0.18 micron process and this equates to an almost 20 fold reduction in the packing density. Another bit of bad news is that, once again keeping all other things constant, the power consumption is proportional to the clock speed and this has risen from about 60MHz in the days of 5V processors to 1GHz today - a 16-fold increase. Clearly, therefore, the reduction in supply voltage isn't keeping pace with the increase in clock speed and the reduction in feature size - far from it. Consequentially, the power per unit area - a measure of how difficult it is to cool a processor - has increased significantly and will continue to do so. The 1GHz Athlon, for example, has to dissipate 64W/cm2. Believe it or not, this is about ten times greater than the heat dissipation per unit area of an electric hotplate - just imagine trying to keep one of those below 80° as you have to with a processor.

So in the past the beneficial effects of reducing the supply voltage haven't kept pace with the detrimental effects of reducing the feature size and increasing the clock speed. And things will get even worse in the future. Needless to say designing electronics to cope with an ever-decreasing supply voltage isn't as trivial as it may appear. We're not going to look at this in any detail but suffice it to say that there are physical limits to how low we can go. Silicon p-n junctions have a volt drop in the region of a half to one volt depending on the amount of doping and this marks the absolute bottom end. If we stick with silicon, therefore, voltage levels could be cut, perhaps, by a factor of three or four at the most, giving a nine to sixteen fold reduction in power consumption. So unless semiconductor manufacturers come up with some very exotic cooling systems, this seems to place a limit on the feature size and the clock speed. One industry expert has worked out that if processors come down to molecular dimensions - as they will sooner than you might expect if recent trends continue - the heat dissipation per unit area will be about the same as exploding gunpowder.

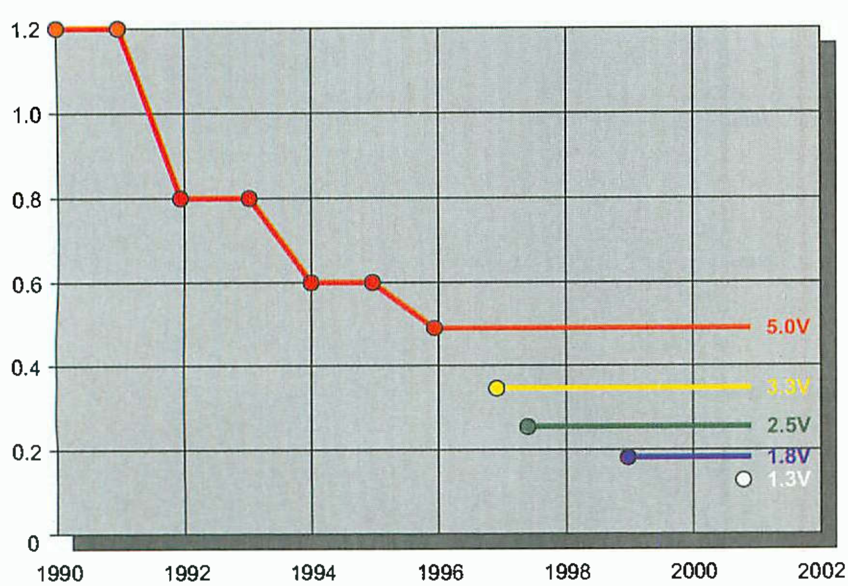


Figure 5. The *supply voltage* has come down hand-in-hand with the reducing feature size but this is not happening rapidly enough to overcome the problems of heat dissipation.

Tunnelling Electrons

OK, that's enough on the problems associated with manufacturing ever-smaller processors and the difficulties of getting rid of the waste heat. Let's turn our attention now to something much more fundamental - how continuing miniaturisation will affect the electrical properties of chips. In particular, we'll see how conductors will become less conductive and insulators will become less insulating as the feature size plummets.

For example, as their dimensions decrease, the metallic interconnections become more resistive and this is already starting to become a problem. This is why the PowerPC chip now has copper rather than aluminium interconnections and Intel intends to make the same transition when it introduces its next process - that based on a 0.13 micron feature size. Exactly the same applies to the silicon dioxide insulating barriers. As their dimensions decrease their insulating properties diminish and it becomes increasingly easy for high-energy electrons to penetrate them. So just as aluminium is being traded in for copper, researchers are investigating alternative insulating materials with higher dielectric properties. However, it would be wrong to assume that this can go on forever. Copper will give processors a new lease of life but for how long? After all copper is only marginally more conductive than aluminium. And what happens when copper runs out of steam - gold interconnects?

Another potential problem relates to the electric field strength in a transistor. If this becomes sufficiently high various undesirable effects can occur. An excessively high field will rip electrons from atoms and once free to move these will generate unexpected and undesirable currents. High field strength can also cause electrons to flow from the transistor's channel to the insulator and this will cause permanent damage to the processor. When we bear in mind that, for a given supply voltage, the electric field strength increases as the feature size decreases, it's easy to see why this is a cause of some concern. Obviously reducing the supply voltage can moderate the increase in field strength brought about by the reduction in feature size but, as we've seen, there's a limit to how low this voltage can go. In fact, it's been suggested that since the minimum threshold voltage for turning a transistor off is 0.3V, dropping the supply voltage below 1V will cause a greater loss in speed than can be countered by shrinking the feature size. However, there is a glimmer of light over the horizon. Cooling reduces the thermal energy of electrons and this permits a transistor to operate at a lower voltage. Cooling will also result in less electron scattering and hence a higher current and faster switching. Needless to say, however, cooling a processor to minus fifty degrees will not be a cheap option, however, and its doubtful whether the performance gain achievable would justify the high incremental cost of nitrogen-cooled transistors.

We don't have space to look at this next point in detail, but I will simply quote Joel Birnbaum, Hewlett-Packard senior vice president of research and development. "In 2010 we will run into the physical limitation of having a fraction of an electron show up at the gate to switch the state of the transistor." Now that's an interesting thought to get your mind around.

To conclude this section, though, let me introduce you to the strange world of quantum mechanical tunnelling. We've already seen that thin insulating barriers may cease to prevent the passage of electrons as the feature size continues to drop. This corresponds to common sense, of course, and to our experience with larger insulators in electrical systems. However, there's another and altogether stranger reason that insulating barriers will soon start to fail. You'll be aware, no doubt, that although light is normally considered to be a wave function, it also behaves as a stream of particles under certain circumstances. In fact, this dual nature also applies to things that we normally think of as particles. Large and slow objects such as elephants or even speeding bullets are barely wave-like but once we get to objects that are as small and fast, electrons for example, this wave nature becomes quite pronounced. Now according to the theories of quantum mechanics, a wave, and hence a particle, can, under certain circumstances, pass straight through a solid object. This phenomenon is called quantum mechanical tunnelling. The probability of this occurring increases with the velocity of the particle and decreases with it mass and with the thickness of the barrier. Needless to say, it transpires that the probability of our elephant miraculously appearing at the other side of a six-foot concrete wall is rather slim. Even the possibility of the speeding bullet passing straight through a piece of paper - without making a hole - is vanishingly small. However, if you do the sums you'll find that there's a very real possibility of an electron tunnelling through the insulating barrier of a processor of the next decade.

Economics

In the introduction I suggested that Moore's Law probably wouldn't hold true for the next thirty years as it has for the previous three decades. And despite the fact that this seems contrary to the hopes and expectations of most people we've now seen a number of reasons why this might be true. Some of these reasons are technological and, as such, we might reasonably assume that they could be overcome. Others, such as the quantum mechanical tunnelling, for example, are the result of the laws of nature and might seem, therefore, to be insurmountable. However, let's assume, for the moment, that the scientists haven't fully thought this through and there is indeed a solution. Even if all these obstacles can be overcome, though, some industry experts are still suggesting that Moore's Law is about to be derailed.

Moore's Second Law states that the cost of building a semiconductor fab line is doubling every three to four years. According to Dan Hutcheson, the president of VLSI Research, 'The price per transistor will bottom out sometime between 2003 and 2005. From that point on, there will be no economic point in making transistors smaller.' In other words, the end of line for the microprocessor could be economic rather than technological. And if this seems hard to believe it's a sobering thought that although the technology has been around for over 30 years, supersonic passenger aircraft are still very much the exception rather than the rule. Economics rather than technology has dictated that we still fly at the same speed as we did three decades ago, before Concorde took its maiden flight.

So will Moore's Law really end in three years time? Even if this estimate proves to be unduly pessimistic, is there really life for silicon beyond the second decade of the century? - and there's some compelling evidence that it might not. Will that 330GHz PC of the future never really come to fruition? And will the processor-intensive applications of Star Trek never break free from the realm of science fiction? Not being a master of the crystal ball I'm not able to give you answers to any of these questions. However, even if processors and memories based on silicon semiconductors do have only another 15 years of life left in them, this doesn't necessarily mean that this age of technological progress will soon be a thing of the past. Throughout the world, mindful of the fact that silicon may be doomed, researchers are delving into exciting new technologies. Some are evolutionary - others are revolutionary. Some appear down to earth, some seem very futuristic, whereas others look weird in the extreme. What are these alternatives to silicon? This is a question I'll answer next month in an article on non-silicon based computers.

Photo 4. Intel Fab 14 plant in Ireland. Some experts believe we will soon get to the point where it is no longer economically viable to build a next generation marketing facility.

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.

May 2000

7 to 12 May. World Telecommunications Congress/ISS 2000, IEE, Birmingham. Tel: 020 7344 5471.

8 May. Wireless Communications Workshop, Bracknell. Tel: 020 7861 6385.

8 to 11 May. IFSEC/Security Solutions, NEC, Birminham. Tel: 020 8742 2828.

9 May. PLD and FPGA, Sandown. Tel: 020 7861 6369.

9 to 10 May. Dealer Expo and Channel Expo, NEC Birmingham. Tel: 01923 676 867.

9 to 11 May. Networks Telecom, NEC, Birmingham. Tel: 020 8742 2828.

9 to 11 May. Mobiexpo, NEC, Birmingham. Tel: 020 8910 7910.

15 to 17 May. Mediacast 2000, Earls Court, London, Tel: 020 8910 7910

17 to 18 May. Batteries Conference and Exhibition, Solihull. Tel: 01372 367021.

23 to 25 May. Internet World, Earls Court, London. Tel: 020 8232 1600.

24 to 25 May. Embedded Systems Show, London. Tel: 020 7681 1000.

June 2000

16 to 18 June. Theme World - Theme Park & Attractions, Alexandra Palace, London. Tel: 0208 451 6385.

27 to 29 June. Networks Telecom 2000, NEC Birmingham. Tel: 0208 742 2828.

27 to 29 June. Computer Telephony Expo, NEC Birmingham. Tel: 0208 742 2828.

September 2000

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

October 2000

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

November 2000

14 to 16 Nov. EID - Electronic Information Display 2000, Sandown Exhibition Centre Esher. Tel: 01822 614 671.

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?

3Com's Benhamou Details Effects of the E-commerce Revolution

E-commerce is growing exponentially worldwide and is a catalyst for transforming businesses and lives, Eric Benhamou, boss of networking firm 3Com explained this month during the keynote address at the Internet Commerce Expo in Boston, US.

Benhamou said that e-commerce has paved the way for e-business, the use of Internet technologies to transform every aspect of the way companies conduct business.

During his keynote, Benhamou showed small and medium companies and 3Com itself as examples of organisations whose businesses have changed because of e-commerce and e-business.

"E-commerce is easily one of the greatest equalisers for business - especially for small businesses," Benhamou said.

"Because of e-commerce, the little guys can now compete on a level playing field with international corporations, enjoying the brand impact, customer intimacy and global reach of big business."

3Com has focused on the role of the network in e-commerce and e-business, especially for small and medium-sized businesses. 3Com offers web-enabled networking products with rich network connectivity that are simple and easy to use.

During the address, Benhamou explained that 3Com is an example of a company using a web-enabled business model to deliver radical simplicity to millions of customers.

"You cannot operate an e-business without a powerful network to support and scale e-commerce and other business processes," Benhamou said.

"For 3Com, a robust network was the first step to transform itself into an e-business. Today, we use the web to expand customer relationships, streamline operations, reduce expenses, extend our brand and simplify doing business."

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

Contact: 3Com, Tel: (0118) 927 8200.

Byers Announces 3G Mobile Licence Winners

At the end of April, Stephen Byers, Secretary of State for Trade & Industry, announced the winners in the third generation (3G) mobile spectrum licence auction. The provisional licence winners are:

Licence	Company	Value
Licence A	TIW UMTS (UK) Limited	£4,384,700,000
Licence B	Vodafone Limited	£5,964,000,000
Licence C	BT(3G) Limited	£4,030,100,000
Licence D	One2One Personal Communications Ltd	£4,003,600,000
Licence E	Orange 3G Limited	£4,095,000,000

"The outcome of this auction supports the Government's commitment to early licensing of 3G and to increasing competition in the UK mobile telecoms market. It will ensure the UK maintains its position as a world leader in mobile telephony, and is a vital step towards our goal of making the UK the best place in the world for e-commerce," said Byers.

"I welcome the introduction of a new entrant to the UK mobile telecoms market. This has been a direct result of the decision to auction five licences. Greater competition will spur faster roll-out of more innovative services, as well as delivering greater choice and lower prices to the consumer.

"3G has the potential to transform everyday life, opening up full scale, multi-media access to millions of people. 3G users will be able to surf the net, download e-mails, music and high quality pictures and hold video conferences all on the move.

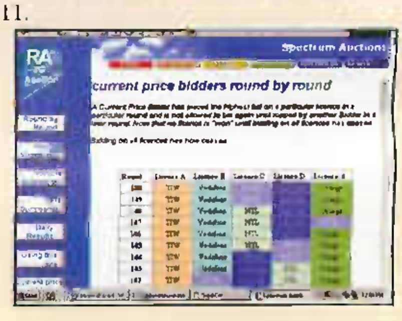
This is the first time spectrum has been allocated in the UK by auction allowing the licensing process to reflect the commercial value of spectrum. Previously licences have been allocated by comparative selection with licence fees set to cover administration costs.

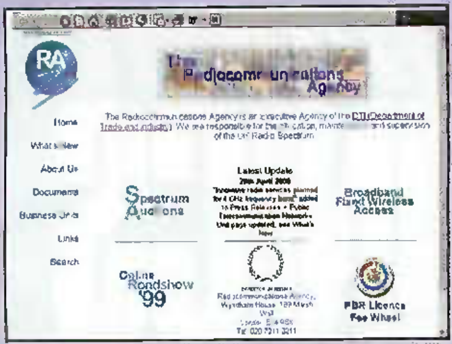
The auction began on Monday 6 March and was managed by the Radiocommunications Agency, which is responsible for the licensing and administration of the radio spectrum. Thirteen bidders, of which nine were potential new entrants to the UK mobile market, competed in the auction for spectrum licences to provide 3G mobile communication services. Five licences were on offer with the largest licence (Licence A) reserved for a new entrant.

The winner of licence A, TIW UMTS (UK) Limited, is a subsidiary of TIW, the telecoms company, which also owns the UK TETRA operator Dolphin. The other bidders in the auction were: 3G (UK) Limited; Crescent Wireless Limited; Epsilon Telecom PLC; NTL Mobile Limited; One.Tel Global Wireless Limited; SpectrumCo Limited; Telefonica UK Limited; and WorldCom Wireless (UK) Limited.

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

Contact: Radio Communications Agency, Tel: (020) 7211 0211.





Hewitt to Auction Airwaves for Multimedia Access

Having netted more than £20 billion auctioning off 3G bandwidth to mobile telecom operators, Patricia Hewitt, the Small Business and E-Commerce Minister, has announced another online auction of the nation's airwaves this September.

The next auction will be for broadband fixed wireless access (BFWA) services. BFWA allows users to take advantage of cheap, fast Internet and multimedia access by radio links rather than down a telephone line. Proposals include:

* an auction to be held this September for the spectrum available at 28GHz for broadband fixed wireless access
* three licences to be awarded in each coverage area which will be defined in the next month. Each licence will contain a forward and return channel to send and receive data
* licences to be awarded on a regional basis.

"There is an increasing demand for broadband services in all sectors of the economy including small businesses. I want these services to be developed as quickly as possible," said Hewitt.

"Awarding licences by auction will ensure that those operators best placed take them up to develop services most efficiently. The licence package is designed to encourage new entrants and the development of a competitive market."

The Government has invited views by 19 May from interested parties on these proposals, including the number and size of regional coverage areas

For further details, check:
<www.radio.gov.uk>.
Contact: Radio Communications Agency, Tel: (020) 7211 0211.

Forensic Computing: Fight Against E-Crime

IT professionals could soon find themselves in the forefront of a fight against new forms of crime, as the Internet is increasingly exploited for the electronic distribution of pornography, the operation of fraudulent 'e-businesses' and breach of copyright on all forms of transmitted material, such as computer software or recorded music.

That is the message of a paper given at the World Telecommunications Congress at the ICC in Birmingham from 7 to 12 May, which directly addressed some of the most

important issues involved in the fight against 'e-crime'.

Ahmed Patel and Seamus Ó Ciardhuáin of the Department of Computer Science at University College Dublin discussed the likely impact of 'forensic computing', the examination of IT equipment and systems in order to obtain evidence of malpractice.

They pointed out that all of the mechanisms and procedures involved in the use of the Internet - such as operation of a web server and the downloading of data over a public network - are perfectly lawful in themselves. In addition conventional computer security techniques, such as the use of passwords, do not inhibit the use of the Internet for criminal activities and might even serve either to disguise them or lend them a spurious air of credibility.

Forensic computing, however, is still a relatively young branch of IT and has so far been mainly concerned with the retrieval and analysis of data stored on computers used in the commission of crimes. But as the use of the Internet for e-commerce undergoes continued rapid growth, so will the need to apply forensic computing techniques to telecommunications and networking issues, as well as computer hardware.

The authors warned that the level of illegal activity would rise, as criminals become more experienced in carrying out computer crime. In addition further opportunities will be opened up for them by legitimate commercial and technical developments within the telecommunications industry. One such is the advent of 'open source' software that will make possible for the first time the development of specialised 'criminal software'. Important elements of the communications infrastructure will be widely available and subject to alteration by anyone with appropriate technical knowledge.

A further complication is that as computer crime becomes more widespread many of the individuals investigating it will increasingly come from non-technical backgrounds, such as the police service and accountancy profession. IT specialists will, therefore, be called upon to provide them with support and advice.

The authors warned WTC delegates that as the value of e-commerce grows to an estimated $1.3trillion by 2003, there is every reason to expect an escalating IT 'arms race' between computing and telecommunications specialists on one side and criminals on the other.

To win the war the IT industry will need to aware of the problem and have at its disposal tools, possibly including expert systems and artificial intelligence, that can work in the distributed, heterogenous, multi-supplier and international environment that now characterises the telecommunications world.

For further details, check:
<www.wtc2000.org>.
Contact: IEE, Tel: (020) 7240 1871.

Engineering: Risky Business?

Increased public interest in emerging technologies and subsequent concern over the safety of areas such as mobile phones, genetically modified food, rail travel and nuclear power has been dominating the headlines. Yet often the public's perception of risk differs to that of the scientific and engineering community. Why is that, who's to blame and what is the engineer's role in the communication of risk to the public?

To address these issues, the Institution of Electrical Engineers is organising an afternoon seminar on 'Too risky? Understanding risk and the public's perception of it' to be held at 1 Great George Street, London on Thursday, 8 June 2000.

Today engineers must not only understand how to analyse and minimise risk but be also aware of how any risk will be perceived by society. As recent cases have demonstrated, a crisis of confidence can easily lead to 'safe' products in the public domain causing wide spread concern resulting in a loss of faith in the technology itself.

The IEE seminar will look at not only how the risks are measured but also at the importance of information management and educating the public through the media. Presentations will be given by a range of speakers involved in both the assessment and communication of risk, followed by an extended discussion panel.

For further details, check:
<www.iee.org.uk/Events/m08jun00.htm>.
Contact: IEE, Tel: (020) 7240 1871.

IEE

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:

PROJECT RATING 1 — 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.

PROJECT RATING 2 — 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.

PROJECT RATING 3 — Average. Some skill in construction or more extensive setting-up required.

PROJECT RATING 4 — Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.

PROJECT RATING 5 — 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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Kits, components and products stocked at Maplin can be easily obtained in a number of ways:

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Internet

You can contact Maplin Electronics via e-mail at <recipient>@maplin.co.uk or visit the Maplin web site at http://www.maplin.co.uk.

Prices

Prices of products and services available from Maplin shown in this issue, include VAT at 17·5% (except items marked NV which are rated at 0%). Prices are valid until 7th July 2000 (errors and omissions excluded). Prices shown do not include mail order postage and handling charges. Please add £2.95 to all UK orders under £30.00. Orders over £30.00 and MPS Account Holding customers are exempt from carriage charges.

Technical Enquires

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics and Beyond*, the Technical Service Dept. may be able to help. You can obtain help in several ways; ● Over the phone, telephone 0906 550 1353 between 9.00am and 5.30pm Monday to Saturday, except public holidays (calls charged at £1/min BT rates); ● By sending a facsimile, Fax (01702) 554001; ● Or by writing to Technical Services, Maplin Electronics PLC., P.O. Box 777, Rayleigh, Essex, SS6 8LU. Don't forget to include a stamped self-addressed envelope if you want a written reply! Technical Services are unable to answer enquires relating to third-party products or components which are not stocked by Maplin.

Kit Building

A kit building service is on offer for any of our kits. Please contact our customer service department for any pricing details.

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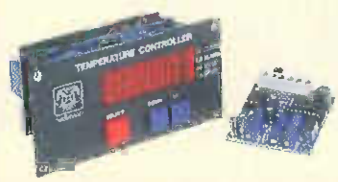

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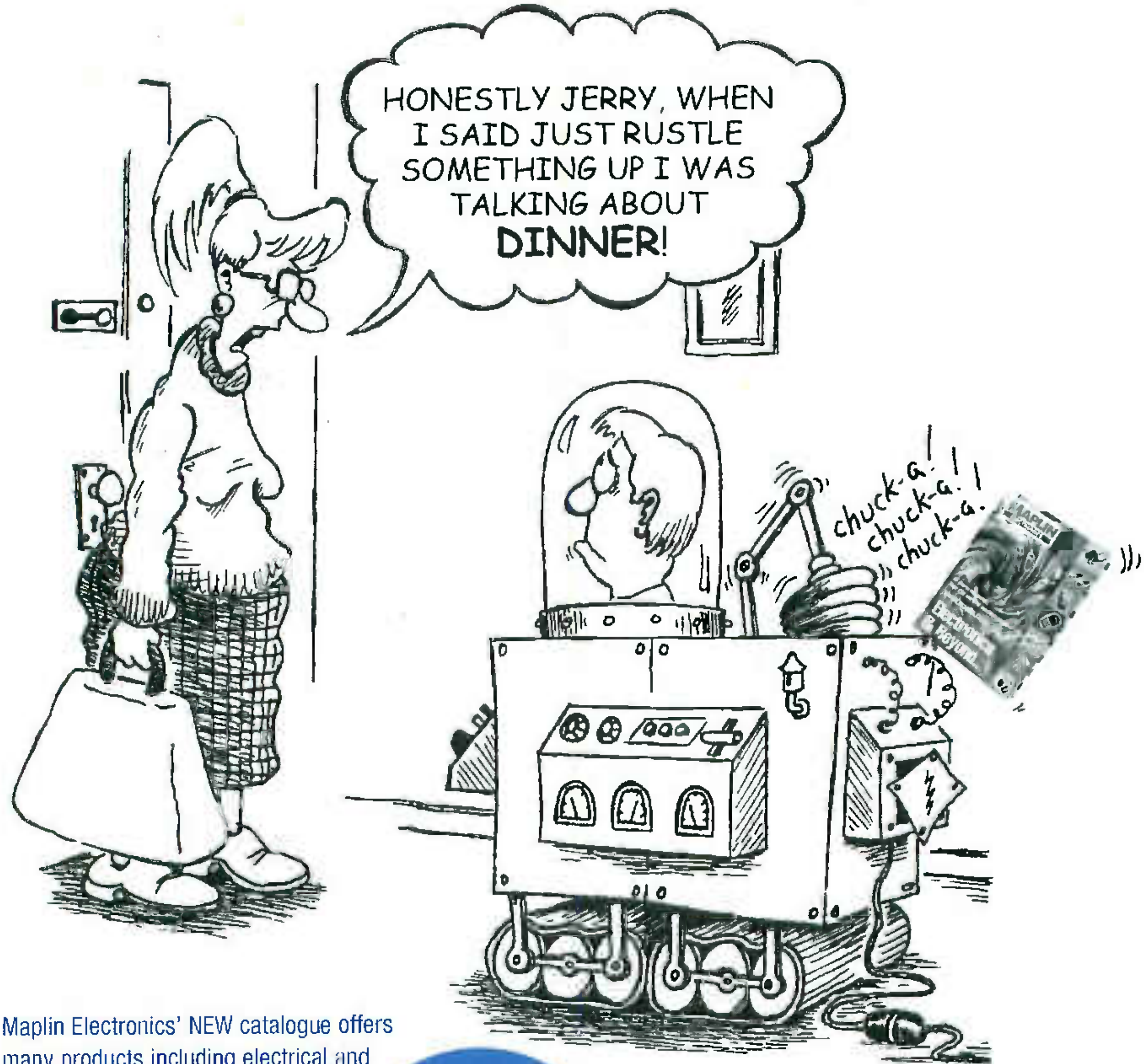

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