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THE MAPLIN MAGAZINE

ELECTRONICS and Beyond

May 2000 Vol. 19 No. 149

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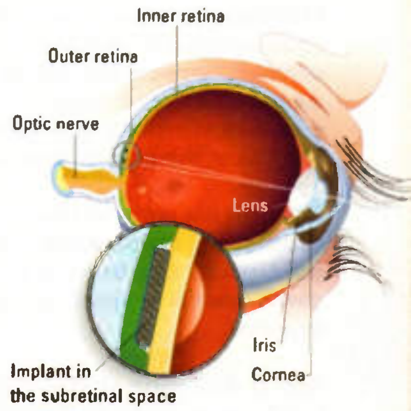

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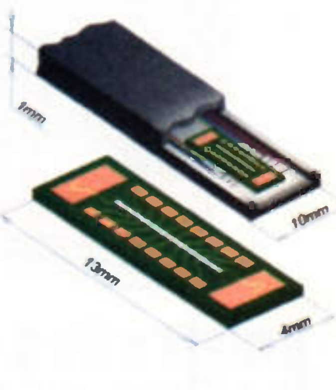

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ELECTRONICS and Beyond

This month we offer a very diverse range of subjects from the final part of Mike Bedford's series Valves in the 21st Century, and Mike Holmes design for a 100W amplifier to Chris Lavers's Research News article about microtechnology, integrated chips and miniature microsystems.

Chris proclaims that there will be three fundamental benefits of the technology - miniaturisation, multiplicity and the integration of microelectronics. Multiplicity, combined with miniaturisation and microelectronics with communication between the different components, will be like an army of ants in a colony, who work together in a coordinated fashion to complete seemingly impossibly large tasks. The mind boggles at the possibilities that this technology could open-up!
Although not quite so futuristic, but equally astonishing, Douglas Clarkson in his article; Creating the Artificial Eye, looks at some of the remarkable developments in providing 'sight' to the visually impaired.

George Pickworth starts a fascinating series on Very Long Waves, and how they are used to communicate with submarines. This type of communication dates back to the first part of the 20th Century - and some of the wavelengths involved are quite extraordinary.

April 2000 Catalogue
The latest Maplin Catalogue and CD-ROM will be available from the beginning of April, with a new style layout, and is packed with new and exciting products.

Finally, the new Maplin Store at Kingston-upon-Thames opens on the 15th April at 2-4 Alderman Judge Mall, Eden Walk KT1 1BS.

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

Be Creates BeIA for Internet Appliances

With its desktop operating system BeOS now being distributed free, Be, the company created by former Apple executive Jean-Louis Gassee, is now launching its new BeIA operating system for Internet appliances.

The BeOS operating system has been used primarily by software developers and has never made significant inroads into the commercial market; the company has higher hopes for BeIA's ability to penetrate the growing market for Internet appliances.

BeIA will have a small footprint, and will be able to access media-rich content on the Web, through software such as RealNetworks's RealSystem G2, Macromedia's Flash, and other multimedia and Internet technologies.

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

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

CDT Scales Up LEP Material Production

CDT has announced the completion of its £2 million chemistry facility on its Greenwich House site, Cambridge, UK. The new facility will run in parallel with CDT's device laboratory at its Huntingdon Road site, Cambridge, UK.

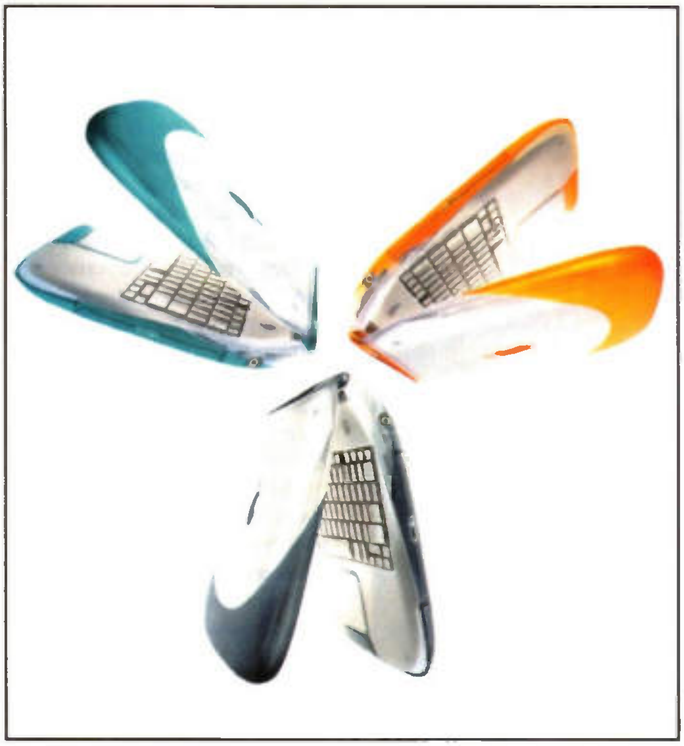
The new 6,000 sq. ft, chemistry facility will enable the company to increase its research and development capability and scale-up its production expertise. The laboratory will enable CDT to improve its analytic and characterisation techniques, in addition to allowing the company to increase its output of polymer materials.

CDT's intention is to use its chemistry facility for the development of a production process for LEP materials that can then be used to supply materials for pre-production development on the part of its licensees and ultimately transfer a production material to its partners and licensees.

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

Contact: CDT, Tel: (01223) 723555.

Apple Enhances iBook



Apple has enhanced its iBook line-up, with three additions including the debut of iBook Special Edition.

Featuring double the memory and hard drive size, all three new iBook models come standard with 64MB of memory and a 6GB hard drive. iBook Special Edition features a faster 366MHz PowerPC G3 processor and comes in a Graphite-colour enclosure.

All three models are available immediately from the Apple Web site, priced from £1,250.

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

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

Lego Vision System Launched

Our photo shows Lego master builder David Meehan setting up wall-climbing robots at the annual International Toy Fair in New York.

Lego launched the Mindstorms Vision Command System at the toy show, a fully functioning PC camera that allows your Lego devices to see and react to their environment.

More details will be reported in future editions of News Report - when released by Lego.

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

Contact: Lego, Tel: (01753) 495000.

Storage Leaders Endorse Prism Architecture

Quantum a developer of back-up tape systems has announced the Prism Storage Architecture initiative, with an endorsement from more than 20 storage industry leaders.

The new initiative overcomes the limitations of server-attached back-up architectures and realises the benefits of network storage.

Prism is a modular architecture featuring large-scale integration of data management and media management software into reliable automated tape libraries - creating Network-Attached-Storage (NAS) Appliances for workgroups and remote sites, as well as high-availability Storage-Area-Network (SAN) Systems for the data centre.

PRISM
Storage Architecture

The Prism architecture is endorsed by more than 20 storage market leaders who have joined the Prism Strategic Alliance and signed developer agreements to ensure compatibility of their products with Prism-based backup and archive systems.

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

Contact: Quantum, Tel: (01256) 818300.

NEWS BYTES

Intel Demos 1.5 GHz Chip

Intel has reasserted its lead in the race for faster chips by demonstrating a future Pentium chip, code-named Willamette, running at 1.5GHz. The company also introduced two Pentium III processors running at 1GHz, which will begin shipping in limited numbers shortly.

According to senior technologist Albert Yu, Intel is increasing its manufacturing capability from four to six plants running on the 0.18μm manufacturing process in order to bring the new chips quickly to market.

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

Contact: Intel, Tel: (01793) 403000.

Microsoft Faces European Legal Battles

The European Union has launched a probe into allegations that Microsoft is bundling its new Windows 2000 operating system with other software in such a way that only its own products will be fully interoperable, placing rivals at a disadvantage.

Microsoft, which is still embroiled in a US antitrust suit, denies the charges, claiming it has complied with EU competition law.

If the European Union finds the allegations to be true, it could force Microsoft to make changes to the operating system, or face fines of up to 10% of global revenues.

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

Contact: Microsoft, Tel: (0870) 6010100.

Internet Tills Brings Together Retail and Online Ventures

The line between shopping in-person and online will get blurrier soon, thanks to the rollout of what IBM is calling the world's first Internet-enabled cash registers for retail stores.

The SurePOS line, which will start popping up in stores in March, will give customers and sales staff access to the Internet at the checkout.

A shopper might use the technology to change the colour of a fleece that was ordered online. A shop assistant could gain access to supply chain information, finding out, for example, when an out-of-stock item might be delivered.

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

Contact: IBM, Tel: (020) 8818 4000.

NEWS BYTES

Photo Finish for Kodak and HP

Kodak is entering a joint venture with Hewlett-Packard to develop and market photo-finishing products that will allow customers to use HP inkjet printers to print their photographs and also send copies to friends and family over the Internet.

The deal will help HP enter the photography and Internet markets, and helps Kodak protect its role as a film processor at a time when large numbers of consumers are adopting ink-jet technology.

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

Contact: Kodak, Tel: (01442) 261122

BBC and Science Museum Announce Human Body Partnership

The BBC and the Science Museum in London have been brought together in a unique partnership designed to further the public's understanding of science.

The agreement represents an opportunity for the two partners to share skills and learn how to enhance and deepen the public's accessibility to science, whether it is in the Museum, on the Web or on television.

The BBC has an exceptional record of making programmes accessible to a wide audience, from the hugely successful Walking with Dinosaurs to Tomorrow's World.

This complements the Science Museum's shared success in the creation of popular exhibitions involving the public in engaging, interactive experiences such as Science of Sport, Future Foods and Launch Pad.

For further details, check: <www.nmsi.ac.uk/press/bbc.html>.

Contact: Science Museum, Tel: (020) 7942 4455.

Search Software Compares Apples and Oranges

Researchers are developing new search software that lets users search digital photographs.

The technology under development by IBM analyses specific features, such as colour, texture, and shape. IBM's Query-by-Image Content (QBIC) software, developed more than five years ago, analyses colour and patterns within an image.

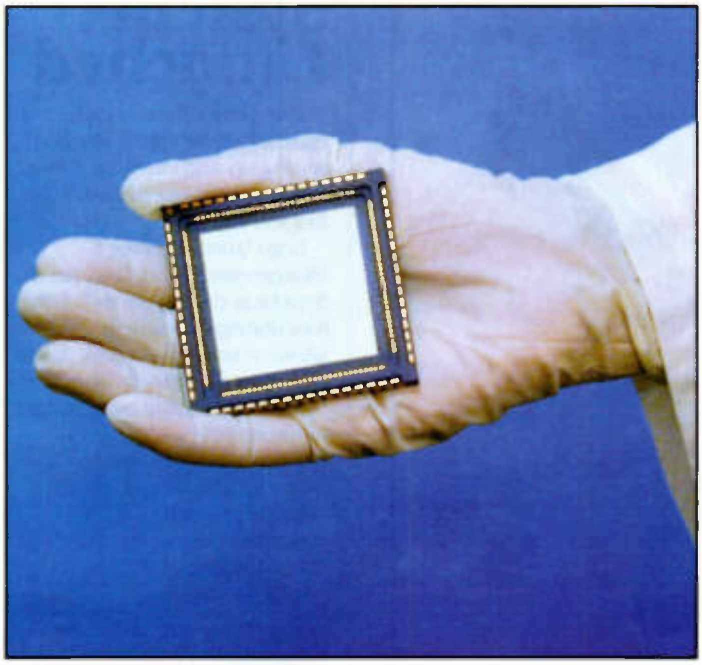
For instance, when searching a database of stamp images, users looking for a stamp with a green tint can request a colour search to find matching images.

QBIC is now beginning to be incorporated into office software products such as those by Lotus to enable users to search for images such as presentation slides.

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

Contact: IBM, Tel: (020) 8818 4000.

Rockwell Unveils World's Largest Infrared Sensor for Astronomy



The Rockwell Science Centre has announced the successful development of the world's largest infrared image sensor for detecting the small amounts of heat radiated from distant celestial bodies.

The sensor's high resolution and exceptional electrical properties provide an unprecedented ability to detect very faint galaxies created at the beginning of the universe. The device has the sensitivity to record images below one-billionth the level of typical room light.

The sensor was developed for deep-space astronomy, including next-generation telescopes, as part of a two-year program funded by a consortium of observatories led by the University of Hawaii.

This breakthrough in infrared image sensors has nearly 4.2 million picture elements, or pixels, and over 13 million transistors. The latter number exceeds the number of transistors found on most of today's state-of-the-art computer chips.

Rockwell's imager is unique in having a very high percentage of working picture elements compared to other high performance infrared sensors used for astronomy. A total of 99.98% of the pixels are operational in the 2048 by 2048 device. Each pixel is made from Mercury Cadmium Telluride, a compound used for infrared sensing. Light with wavelengths between 0.9μm and 2.5μm can be detected with the sensor.

A key element of the array is its complementary metal oxide semiconductor (CMOS) electronics that can precisely read the infrared light from each detector element and convert it to a usable signal.

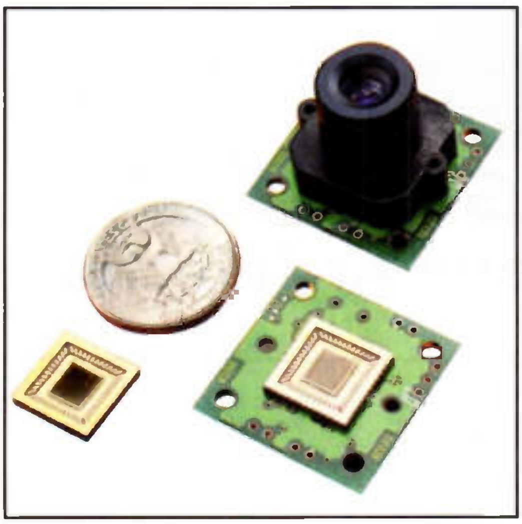
This device, which measures 4 x 4cm, is the largest known CMOS chip in the world. It was fabricated using an advanced, high-performance, low noise mixed signal CMOS process developed by partner Conexant Systems, Inc. in their semiconductor wafer fabrication facility.

The first of the new sensors is currently on its way to the University of Hawaii, Institute for Astronomy. Subsequent devices will be delivered to the European Southern Observatory and the Subaru Telescope, the two additional founding members of the consortium, for use in their giant telescopes on Cero Paranal, Chile and Mauna Kea, Hawaii.

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

Contact: Rockwell, Tel: (0118) 926 1111.

OmniVision Announces VGA Rival to CCD



OmniVision Technologies has announced the availability of two new camera chips, the OV7620 (colour) and OV7120 (black and white). Both chips feature VGA resolution with real-time frame rates (30 frames/second) for video and other imaging applications.

The OV7620/7120 devices integrate all necessary camera functions on a single chip. Automatic controls include Automatic Gain Control (AGC), Automatic Exposure Control (AEC), Automatic White Balance (AWB), Gamma Correction, Automatic Level Control (ALC) and Automatic Black Level Calibration.

These devices offer power-up pin-programmability along with convenient serial I2C bus control to allow interactive user modification to any camera parameter.

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

Contact: OmniVision, Tel: +1 408 733 3030.

IBM All-in-One Internet Appliance Announced

IBM has given a sneak peak of it's spring line-up of bold new products, designed to provide easy access to networks and the Internet while addressing the unique computing needs of the individuals who will use them.

The photo shows IBM's sleek, All-in-One flat panel personal computer and its Internet Appliance, a simple, lightweight device that offers instant access to the Web.

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

Contact: IBM,
Tel: (020) 8818 4000.

Quality Digital Camera Drops Below £100

UMAX Technologies has made owning a digital camera more affordable, with the AstraCam 1000 - an easy-to-use, USB-connected digital camera that retails for around £100.

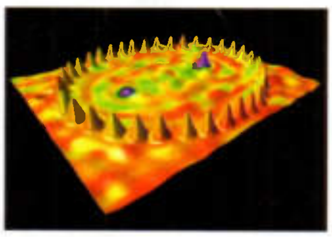
The product is designed to enable novice photographers and casual users to take high quality pictures for desktop albums, sharing over the Web or via e-mail.

The AstraCam 1000's one-touch operation combines computer-ready photography with unprecedented ease of use. Its USB-cable connectivity simplifies the bridge between camera and PC, since it can be plugged in hot without rebooting the computer.

USB-enabled PCs will recognise the camera immediately to let users download photos and save, edit or print them directly.

For further details, check: `<www.umax.de>`.
Contact: UMAX, Tel: + 49 2154 9187 0.

Quantum Mirage May Enable Atom-scale Circuits



IBM scientists have discovered a way to transport information on the atomic scale that uses the wave nature of electrons instead of conventional wiring. The new phenomenon, called the quantum mirage effect, may enable data transfer within future nanoscale electronic circuits too small to use wires.

As computer circuit features shrink toward atomic dimensions - which they have for decades in accordance with Moore's Law - the behaviour of electrons changes from being like particles described by classical physics to being like waves described by quantum mechanics.

On such small scales, for example, tiny wires don't conduct electrons as well as classical theory predicts. So quantum theory for many traditional functions must be available if nano-circuits are to achieve the desired performance advantages of their small size.

IBM's new quantum mirage technique may prove to be just such a substitute for the wires connecting nano-circuit components.

Three physicists at IBM's Almaden Research Centre here, Hari C. Manoharan, Christopher P. Lutz and Eigler discovered the quantum mirage. They reported their findings in the cover story of the February 3, 2000, issue of Nature, a prestigious international scientific journal published in London.

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

Contact: IBM,
Tel: (020) 8818 4000.

NEWS BYTES

Are You the Next Bill Gates?

Successful start-ups look out - the search is on to find the next Entrepreneur of the Year. If you know or are a successful business you could be in with a fighting chance to win one of these coveted titles.

Vodafone joins Ernst & Young and national co-sponsors Citibank Private Bank and The Times. Vodafone has made it simple for those budding Bill Gates to enter the Programme - all you need to do is call 0845 604 1012.

Run for the first time in 1999, the Entrepreneur of the Year Awards attracted some of the most successful business people in the UK. The search is now on to find the best of the best for 2000

Last year's categories included Master Entrepreneur, Retail, Technology and Communication, Consumer Products and Services and Young Entrepreneur, which are judged at both regional and national levels.

For further details, check: `<www.vodafone.com>`.

Contact: Vodafone,
Tel: (07000) 500100.

Orange Backs UK Innovation

Orange has announced the names of the companies that were involved in the development of its state of the art Orange 'videophone'. These include some of the UK's leading names in innovative design and hi-tech engineering, including Cambridge Consultants, Celestica, Motion Media, NMI and the University of Strathclyde.

The Orange videophone, first announced last year, is scheduled for launch in the spring. The videophone, a palm-held device, will provide full video and audio communication capabilities, as well as complete personal digital assistant functionality, including e-mail access, Internet browsing, Microsoft Pocket Office applications and handwriting recognition.

For further details, check: `<www.orange.co.uk>`.

Contact: Orange,
Tel: (0500) 802080.

NEWS BYTES

Intel and Ericsson Team up on Flash Memory

Intel and Ericsson have agreed to work together on producing flash memory chips in a deal estimated to be worth almost £1 billion. The alliance gives Intel a position in the mobile phone market, and ensures that Ericsson will have enough chips available to meet rising demand for its mobile products.

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

Contact: Intel,
Tel: (01793) 403000.

Cambridge Silicon Radio Receives Investment from Intel

Cambridge Silicon Radio has announced that it has received investment funding from Intel. The investment provides CSR with additional resources to aid its growth by expanding its Bluetooth development and marketing activities.

CSR has developed what is believed to be the industry's first fully integrated 2.4GHz radio, baseband and microcontroller solution on one CMOS chip, offering the advantages of small size, low power consumption and compatibility with the Bluetooth standard for short-range wireless communication.

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

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

BT Selects Corning as Photonics Research Partner

BT has selected Corning, the provider of advanced optical and photonic products for telecommunications and other high technology industries, to exploit its intellectual property portfolio in photonics research.

The agreement will enable BT to build on its world-leading know-how in the field by bringing photonics technology into the commercial marketplace through manufactured products from Corning.

BT is licensing its photonics technology and transferring its Photonics Technology Research Centre (PTRC) to Corning.

All 43 employees at the photonics centre are voluntarily transferring their employment to Corning, which will also lease the PTRC building at BT's Adastral Park Advanced Communications Technology Centre at Martlesham, as part of the £39 million deal.

For further details, check: <innovate.bt.com/adastral-park/index.htm>.

Contact: BT, Tel: (0800) 309080.

SmartDRIVE2 CD-R Offers Anti-Piracy

MediaFORM has introduced SmartDRIVE2, the most advanced and innovative CD Drive on the market.

After twelve months of development and a six-figure investment, the end result is a CD-R Drive, which stands alone in quality, features and capabilities.

SmartDRIVE2 boasts features including Copy Protection; Watermarking; SmartSTAMP; SmartMEDIA; SmartRID; Frame Accurate Recording; and Mini-Disc & Business Card CD-R Compatibility.

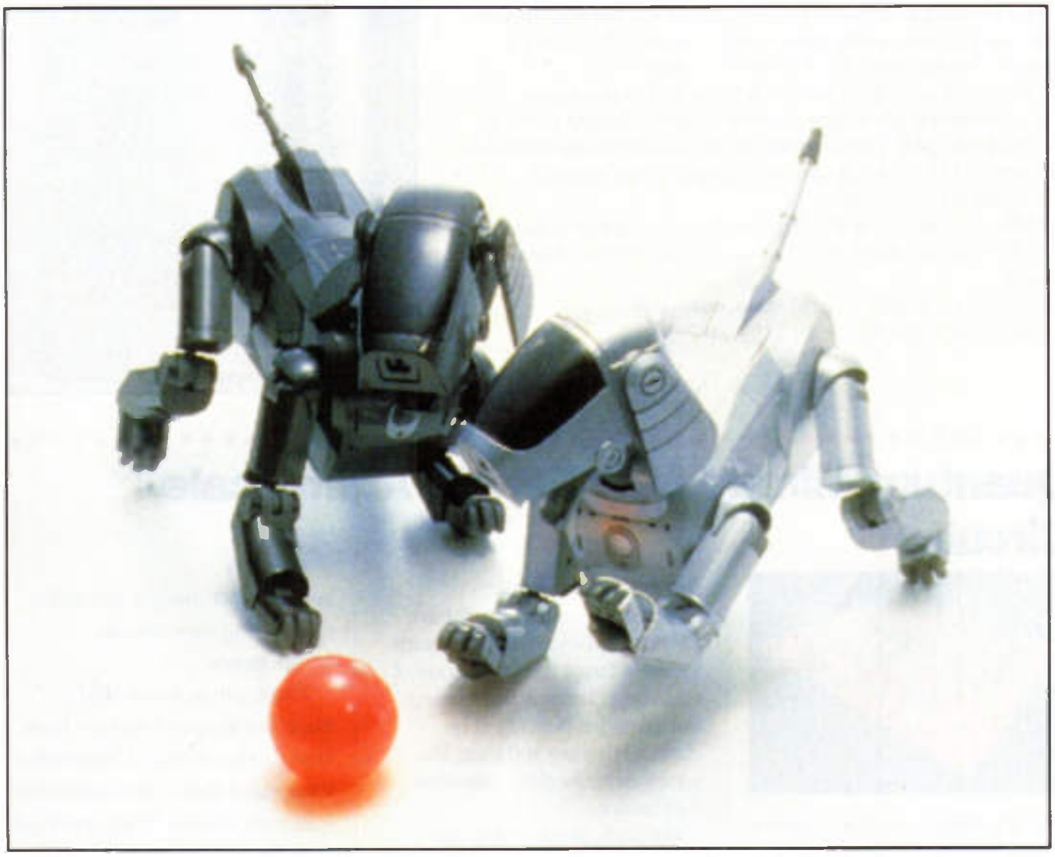
The SmartDRIVE2 protects content developers from pirating and revenue loss through illegal copying of CD-R and intellectual property. No other CD-R drive on the market offers copy protection of any sort. On MediaFORM stand-alone systems copy protection is pre-defined for a single area of the disc.

The electronic watermarking on audio and data discs is an effective fingerprint on every CD-R produced by SmartDRIVE2 equipped MediaFORM products. SmartDRIVE2 watermarking can, for instance, imprint the date, time and specific drive burning the CD. Watermarking on SmartDRIVE2 is compliant with all the industry standards including Red Book, Orange Book and Yellow Book.

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

Contact: MediaFORM,
Tel: +1 610 458 9200.

Sony Wants Aibo In Every Home



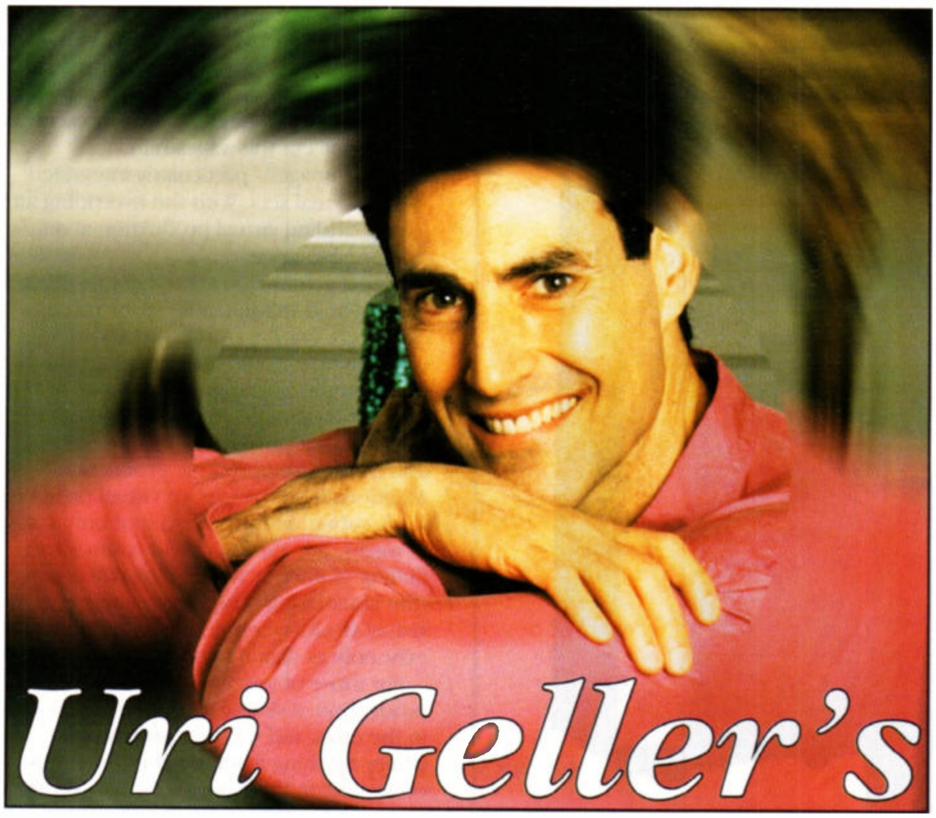
According to a recent survey conducted by Opinion Research for Sony Electronics 56% believe that the AIBO entertainment robot could become commonplace in the future. Sony wants to go on this and put an entertainment robot in every home.

The AIBO entertainment robot from Sony is an autonomous robot that combines state-of-the-art technology with artificial intelligence. When purchased, the AIBO entertainment robot first acts as if it's a puppy and then matures over time into an adult pet.

The AIBO entertainment robot displays emotions and learns by communicating and interacting with people and its surroundings.

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

Contact: Sony,
Tel: (0990) 111999.



Uri Geller's EXTENDED REALITY

Wallaceism?

Since writing my January column in which I mentioned Alfred Russel Wallace, the co-discoverer with Charles Darwin of the theory of natural selection, I have been finding out more about a man who is less known today than he should be. Everyone has heard of Darwin, but a good many people have never heard of Wallace, or if they have, they have never read any of his many books, not even the one he generously called just Darwinism. Also, not many biologists seem to have read his contributions to the Theory of Natural Selection (1871). He raised all kinds of objections to his own theory, and pointed out a number of reasons why 'Darwinism' was not the answer to quite all the mysteries of life or "the all-powerful, all-sufficient, and only cause of the development of organic forms".

For instance, he wrote, how do we explain the fact that primitive humans had brains that were much larger and more developed than they needed to be in order to cope with the needs of their time? "Natural selection could only have endowed savage man with a brain a little superior to that of an ape, whereas he actually possesses one very little inferior to that of a philosopher."

The conclusion he drew from this and many other awkward facts must have horrified the atheistic Darwin. "The inference I would draw from this class of phenomena is, that a superior intelligence has guided the development of man in a definite direction, and for a special purpose, just as man guides the development of many animal and vegetable forms... Some more general and fundamental law underlies that of 'natural selection'."

I was amused to learn that the joint presentation by Wallace and Darwin of the theory each had worked out on his own without any knowledge of what the other was up to, was a bit of a flop. When the President of the Linnean Society (where they had given their joint presentation on July 1st 1858) gave an address the following year in which he reviewed the Society's activities during 1858, he made the following memorable remark:

"This year has not been marked by any of those striking discoveries which at once revolutionise, so to speak, the department of science on which they bear."

However, Darwin soon brought out his classic Origin of Species (1859) and the cat was well stuck into the pigeons. Feathers flew in all directions. There was the story of two devout ladies praying in church - the first said "Dear God, tell us that Mr. Darwin's theory is wrong", to which the other one added "And if it is right, please help us cover it up".

I hope those ladies kept in touch with Wallace, at least, for in 1874 he published a book that might have cheered them up. Here, he showed how far he had come since 1858. The conclusions he reached after the research he had been carrying out during the 1860s can be summarised like this:

1. Man is a duality, consisting of an organised spiritual form, evolving coincidentally with and permeating the physical body.
2. Death is the separation of this duality, and doesn't bring about any change to the spirit.
3. Our destiny is progressive intellectual and moral evolution, with the knowledge we acquire during life forming
4. The basis for our afterlife existence. Shock, horror! This is pure spiritualism, and indeed Wallace did become an ardent spiritualist, remaining one until the end of his long life - he died in 1913, aged 90.

He was also a prominent member of the Society for Psychical Research, and his interest in psychical matters went way back to the 1840s when as a young schoolmaster he carried out experiments in mesmerism with some of his pupils. Then during his wandering around the world a decade later he began to read about the table-tilting craze that was sweeping Europe and the U.S.A.

Almost as soon as he was back home he set about studying this at first hand, in his own home. By 1865 he could write that he had earlier considered himself "so thorough and confirmed a materialist that I could not at that time find a place in my mind for the conception of spiritual existence... Facts, however, are stubborn things. The facts beat me. They compelled me to accept them as facts before I could accept the spiritual explanation of them." In a later column, I hope to describe some of these dramatic and very meticulously observed facts.

Isn't it ironic that Darwinism, originally seen as a strongly anti-religious theory, has now become something very like a religion itself? And, as the eminent biologist Sir Alister Hardy pointed out, if Wallace had published first, as he would have if he had not heard about Darwin's earlier but still unpublished work, "we might not be talking of Darwinism today, but of Wallaceism".

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**

Future Digital TV PRODUCTION

Reg Miles looks at future 'virtual' digital production techniques - and the distinct possibility of virtual presenters and actors!

The comparative ease with which digital signals can be manipulated is leading to new production techniques and new forms of production that will change TV completely - both behind the screen and on-screen.

Of course, digital production is nothing new, it has been used for years because it has been the only way to achieve many of the techniques and effects that are increasingly employed in mainstream production, either because it would be impossible - or too costly - to manipulate the signals in analogue form or because the repeated copying required would noticeably degrade analogue signals. The difference in the near future is that there will be no requirement to convert the digital results back to analogue for transmission, and so there is an additional incentive to develop the equipment and techniques. Particularly so as an increasing amount of the content will require consumers to pay for it; and thus stimulate competition to make the programmes as attractive as possible to capture the viewers in a surfeit of channels.

Mirage

As you might expect a number of European projects have been and are being devoted to the development of enhanced production techniques. One that has recently finished and gives a good idea of the overall intentions of the broadcasters is MIRAGE (Manipulation of Images in Real-time for Artificially Generated Environments); with participants from the UK: A&C, AEA Technology, Independent Television Commission and TeleVirtual; from Belgium: de pinxi; from Germany: Comtec Studios; and from Spain: TVVE. This had four aims:

1. Virtual production - to develop the technology and techniques to produce programmes in virtual reality studios.
2. Virtual edit suite - for the control, manipulation and alteration of virtual environments, both during and after production.
3. Virtual host - to create virtual presenters (that will cut the wages bill).
4. Stereo images - particularly integrated with virtual sets. With the overriding aim of providing virtual production at an affordable price.

Virtual production should cut production costs; would utilise studio space more effectively, (which as a secondary consequence would further cut production costs); and facilitate greater control over the production process, not only through the use of virtual production techniques but also by the use of robotic production. Additionally, in the case of virtual presenters (and, subsequently, actors), not only savings in wages, but also complete control - no fluffing of lines or walking into the scenery (the latter being much more likely in a virtual studio where most of the scenery will exist only as digital signals).

For those of you unfamiliar with virtual production, a simple form of it can be seen in the news and weather programmes, where anything from the chart to almost everything in the studio is virtual. Those are easy to achieve because the presenters remain in shot at all times - the camera does not have to track them. If it did then the presenters in the foreground would appear to float over the virtual background (another reason for having virtual presenters who would be an integral part of the virtual whole).

Chromakey

Those and the more adventurous virtual studios used for drama, etc, all rely on variations of the chromakey process - also known as blue screen. This was introduced with colour television in the late Sixties - an upgrade of B&W keying. Essentially, anything that is blue (actually any colour can be used, but blue - or green - are the normal choices for the key colour because they are the most distinct from skin tones) is replaced by an image - computer generated in real-time, pre-rendered, or motion or still video. Thus, the weather presenter's chart is just a blue square on the studio wall, and he or she must look at the monitor to see where to point. In a virtual studio every part of it that will come into shot will be blue - including the floor.

Everything in the key colour will be replaced. Although, in practice, modern chromakeyers do allow the key colour to appear in the foreground without it merging into the chromakey background. This is particularly so with Ultimatte, which is a widely used system. It differs from a chromakeyer in that it composites the background and foreground using a fully additive mix rather than doing it in proportions determined by the level of the key signal - plus a few other advantages that retain greater subtlety of detail. The latest Ultimatte 9 was recently launched.

It was in the Seventies that the first attempts were made to allow actors to move. These were mechanical systems, employing a still picture on a motorised

Ultimatte 9

easel that moved in synchronism with the movements of a camera pan and tilt head and, thus, the movements of a foreground actor. But, although used successfully, they were limited in their scope and required careful setting up.

Silicon Graphics 'Onyx'

It was in Europe in the early Nineties that chromakey was first successfully combined with a computer generated moving background linked to camera movements to produce the modern virtual studio. The computer must generate its images in real-time (1/50 second) so that they and the foreground video images can be combined into realistic composite images by the keyer. The introduction of the Silicon Graphics Onyx supercomputer with Reality Engine 2 Graphics made this possible in the early Nineties; and its successor, the Onyx2 Infinite Reality Graphics, still plays a leading role in virtual studios. But the problem remains of how to accurately track the position of a camera at all times, and to measure the precise amounts of pan, tilt and zoom so that the computer can generate the background as if it were coming from the camera along with the foreground.

However, this does presuppose that cameras will be moving and creating changes in perspective; whereas in the majority of cases the cameras actually remain static for much of the time and the only movements are pans, tilts and zooms that do not affect the perspective. In these circumstances it is only necessary to have a fixed 'wide-angle' image for the background, with a frame floating in that image to delineate the picture area that is being recorded (see Figure 1). Its size and position being determined by the pans, tilts and zooms that are measured by sensors on each camera - normally optical encoders to achieve an accuracy of up to 1/100th of a degree. This 2D arrangement can be achieved with an image manipulator - a glorified digital video effects (DVE) unit, which is considerably cheaper than real-time computer generation.

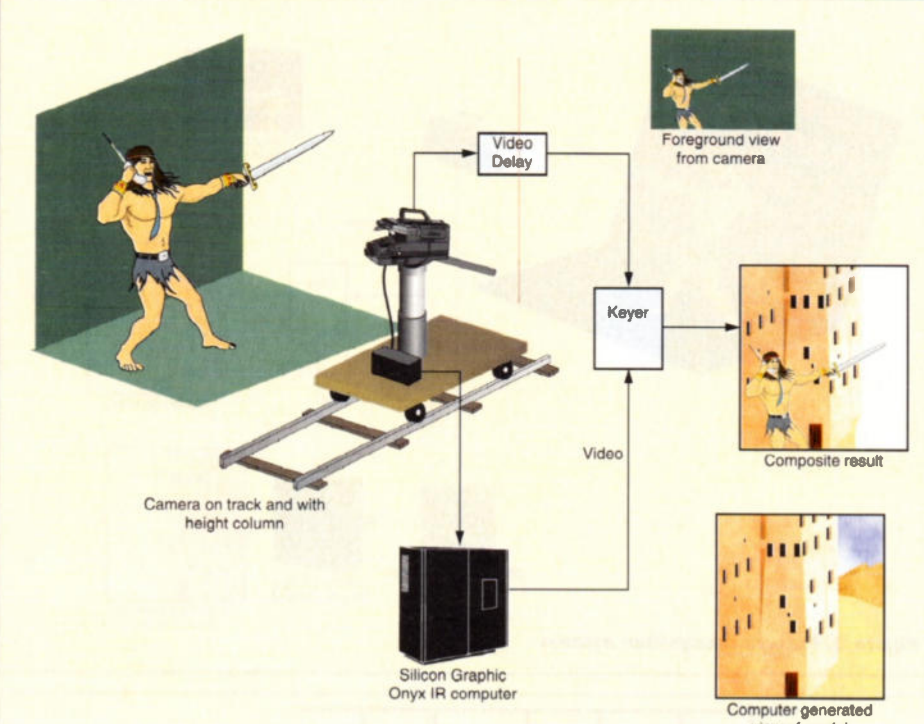


Figure 2. Main components of a 3D system

If the cameras are going to move, backwards and forwards, side to side, up and down, then this third dimension must be accurately tracked. Several ways are used to achieve this. A sensor can be added to cope with variations in camera height and the position of each camera accurately measured from a datum point during the setting-up process. Alternatively, a camera can be mounted on a track - with its position having been measured accurately (see Figure 2). However, both these methods limit the available movements. Greater freedom of movement can be achieved by having sensors on the camera mount that scan barcodes on the studio walls or magnetic stripes on the floor.

To achieve still greater freedom of movement, and to allow handheld cameras to be used - which they increasingly are (not necessarily for any good reason), camera-mounted sensors need to be minimised or removed altogether.

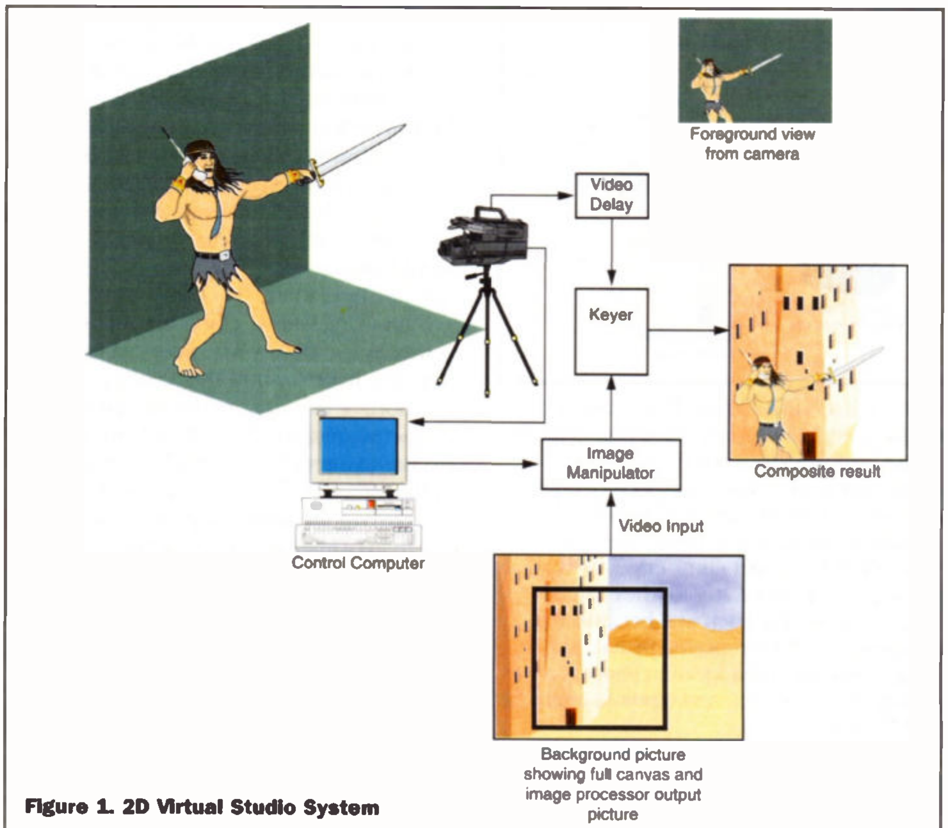


Figure 1. 2D Virtual Studio System

Pattern Recognition

One method of achieving this is by pattern recognition. Using a variable pattern of light and dark chromakey colours - painted or projected - that are imaged by the camera and fed to an image processor that compares the recorded pattern with internally stored patterns to locate the position (see Figure 3). Additionally, it can normally be used without any camera-mounted sensors. This was first developed by an early European project called Mona Lisa.

Among those participating in that project was the BBC; who recently developed a system of their own, employing optical markers, which has been licensed to Radamec and is sold under the name of 'free-d'. This employs a small, upwards pointing video camera attached to the

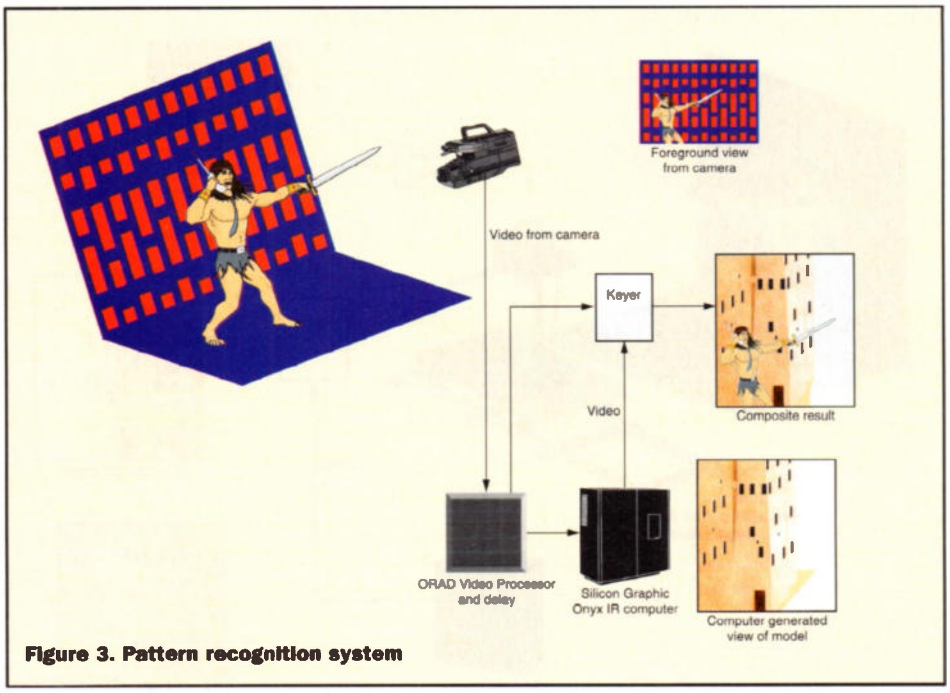


Figure 3. Pattern recognition system

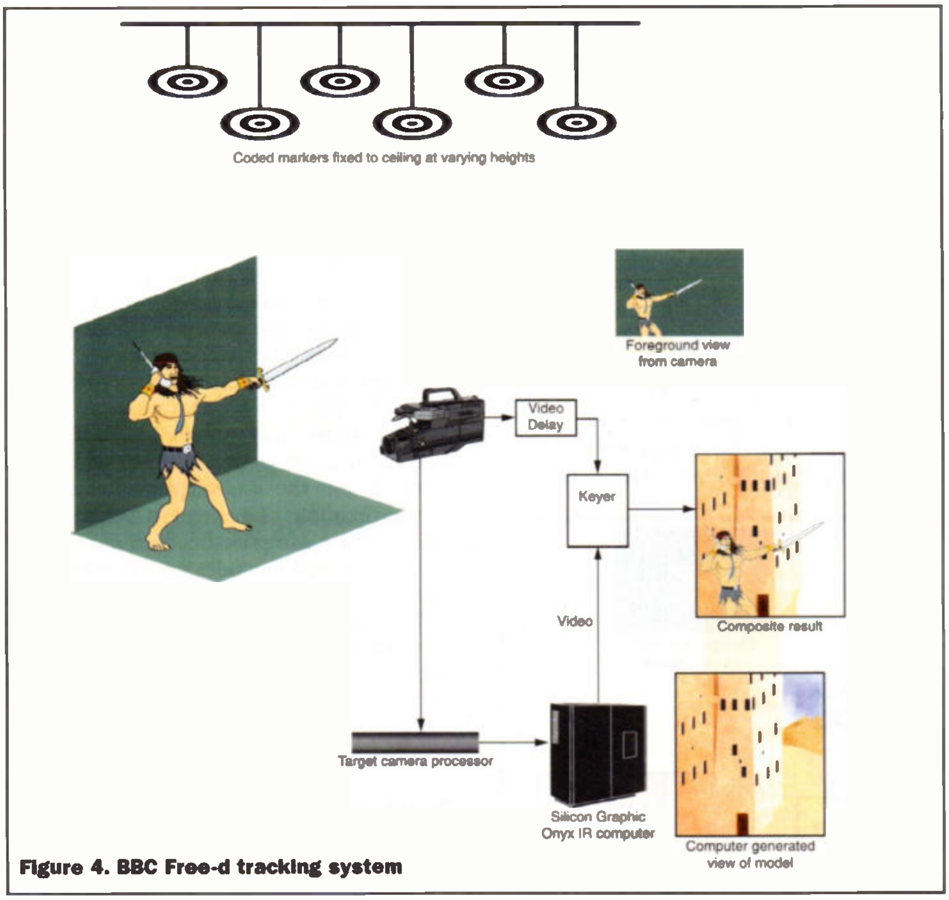


Figure 4. BBC Free-d tracking system

production camera to view circular markers suspended from the ceiling between the lights (see Figure 4). Each marker has a unique black and white pattern in the manner of a barcode, and their positions are memorised by a processing unit and compared to those in the image from the auxiliary camera. In order to ensure their visibility against the studio lights, they are made from a retro-reflective material and the auxiliary camera has a ring of bright LEDs around its lens. The production camera only requires zoom and focus sensors.

A third method is to rely entirely on the image produced by the production camera, with no external patterns, to produce the necessary positional data. This is achieved by using memorised reference points in the image, which are tracked from frame to frame, using specialised methods of image processing, pattern recognition and computer vision. These reference points can be small props or details or edges of furniture. In a virtual studio, they can be fixed marks on the back wall because the background will be replaced by a virtual image; however, on a location shoot the finding of suitable reference points might be problematic.

This method of determining camera position and orientation is currently the only way that virtual props can be introduced into a scene with pixel precision and in real-time. This is necessary if they are going to be fully integrated with real objects and 'manipulated' by people in the scene. Even with normal production methods the more material that can be shot in real-time the less studio time is required; and with things like chat and game shows, real-time is the only time. To achieve it an anchor point is marked to show the intended position of the virtual prop, while fixed reference points will be used to calculate the correct projection. Regardless of the camera position and orientation, the prop's position, size and shape will remain correct (at least, if that is the intention - a virtual prop does not have to conform to innate physical laws). The process can also be used to transform real objects and people into virtual ones.

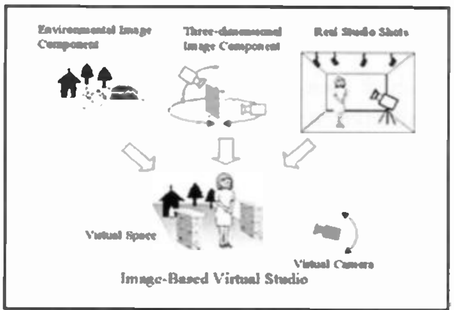
The problem with virtual props - and virtual scenery - is that they are all in the background, whereas the actors and the real props and scenery are in the foreground. Therefore, he trick is to mix the two so that they combine in a realistic manner so that, for example, an actor does not grasp an object above its virtual position nor stand in a wall. Which means:

1. That the actions and positions of the actors must be known
2. That the actors must know the positions of virtual scenery and the positions and sizes of virtual props.

In the case of replacing real objects and actors, or parts thereof, the computer must be able to recognise those things to be able to replace them.

Unfortunately, pattern recognition has not advanced to the point where a computer can track all the movements of actors with anything like the accuracy necessary to replace them in real-time by virtual actors - nor to enable them to handle virtual props in real-time (the orientation and any actions of which must comply with the actor's moves). Instead they must carry obvious reference points, such as small lights - which is hardly realistic - and even then there is currently no means of realistically manipulating something that requires intricate operation.

Interacting with virtual props and scenery is usually avoided. A blue light can be shone onto the floor to show the actor's next position; or an image of the set can be projected onto the floor. To achieve some degree of interaction between the virtual set in the background and the actors in the foreground the keyer must be fed with depth information - the virtual depth of the scene, and the camera's real depth information. At present this is done by simply switching or by having infrared transmitters on the actors so that they can appear to touch or walk behind something. To make the latter look plausible an object-shaped matte is generated to cover the actor and the virtual object is switched to replace the matte so that it appears to be in front.



Robotics

Going back to camera tracking, an alternative means is to use robotics. Here the cameras follow predetermined moves that have been rehearsed and refined, and is often used for weather and news programmes. The image quality will be good because pre-rendered or pre-videod backgrounds are used, being replayed from disk to match the moves. However, once programmed this does limit the scope for any changes to be made, and prevents adjustments on shot. It does provide more scope than a track, though; and consequently some 3D systems employ motorised pedestals and motion control heads, with sensors to determine its position in the studio and the orientation of the camera, to enable real-time computer generated backgrounds.

The MIRAGE project used motorised pedestals and a motion control head for both pre-rendered/videod and real-time computer generated backgrounds - in the latter case controlled by their virtual edit suite. The motion control head was also used for recording complex camera moves on location and recreating them in the virtual studio. The head is now sold by A&C as the Powerpod 2000.

The Japanese broadcasting company, NHK, has similar - but on-going - projects to Mirage, one of which is to create an intelligent robotic camera system that will perform with the skills of a real camera operator. This is being achieved by studying the shooting techniques of camera operators, and by studying techniques to track moving objects. The cameras can exchange information with each other, and decide what and how to shoot. Alternatively, one camera operator can simultaneously operate several cameras.

Then there are the big motion control rigs. These can make precisely repeatable moves at virtually any speed. The resulting camera information is recorded in a form that can be used in the post-production rendering process to give better image quality than can be achieved in real-time (the information also enables a film camera to be used). But, being big, their use is limited to large studios and, generally, they cannot be moved once in place.

MIRAGE - VSS

This would not do for another product of the MIRAGE project, the MIRAGE Virtual Studio (VSS) system, which is compact enough to be packed into a truck - and is now sold by TYVE. This is based on PC control with hard disk storage, and is intended to be used with pre-rendered backgrounds with robotic camera moves for studio news and discussion programmes.

At the opposite extreme NHK is working on an advanced virtual studio for high definition use. Here the virtual props and scenery are real images, to blend with the real objects and actors. The props are recorded from all angles and the three dimensional modelling and surface images are held as separate data to allow the view and light to be altered. The scenery consists of high definition spherical surface images taken from all around the scene to create an image in real-time at high resolution (see Figure 5).

There will probably be different levels of realism for virtual presenters and actors but will they come into mainstream use, as well? This will depend on the programme makers' intentions and budgets.

Motion Capture

A popular way to achieve virtual characters is by motion capture - the recording of real people' movements, which are used to animate the virtual character in a reasonably realistic manner. This requires the person to be marked at strategic points. In the case of an optical system these will be by reflectors, that will be recorded by a number of cameras. It can also be done magnetically by recording sensors in an electromagnetic field (AC or DC - which, incidentally, can also be used to track cameras in a virtual studio). The optical system tracks only the position of the marker, whereas the magnetic can also record its orientation. But both have advantages and disadvantages. The results then become the skeleton and its movements, and the animator can attach body parts or a mesh.

ViSiCAST

One particularly useful role for a virtual character is going to be as a signer for the deaf. This signer will be generated at the viewer end, from a digital set top box, and overlaid on the normal TV image. This will obviously remove objections to signers as distracting, and save on bandwidth. To achieve this it will translate from the Teletext subtitles, using stored motion capture data gleaned from expert signers. This is another of the European projects, called ViSiCAST (Virtual Signing: Capture, Animation, Storage & Transmission). TeleVirtual is one of the participants again, with their expertise in motion capture; also the ITC who will set the standards in the UK for the ITV companies; plus the University of East Anglia's School of Information Systems.

But motion capture is not the only way of achieving virtual characters. NHK has developed a computer generated TV production system, in which characters speak and act according to lines of text-based script. This TV making language (TVML) gives commands to create the required set, lighting, 'camera' movements, characters actions, dialogue, etc. Once the TVML script has been created, it is read by a player that automatically generates the TV programme. The TVML Player is freeware and can be downloaded from NHK's Science and Technical Research Laboratories at www.strl.nhk.or.jp/TVML/index.html.

NHK has also been working on 3D TV like the MIRAGE project. If the virtual backgrounds are going to be in 3D (and this can be video or computer generated) it would seem logical to have the foreground in 3D, as well. The MIRAGE project used conventional two lens cameras - built by AEA Technology; one a studio camera the other a miniature camera. The NHK Integral Photography system, conversely, uses microlenses to record the depth information. In Figure 6 an object is recorded by an HDTV camera through a gradient index (GRIN) lens array and a depth control lens; and is reproduced on an LCD screen with microlenses.

I suppose that we can eventually expect 3D productions that are entirely virtual, including presenters and actors, created by someone sitting down at a computer and typing in a script? Beyond that, perhaps the virtual characters will get together in the computer and devise their own productions, and the only human involvement will be passive!

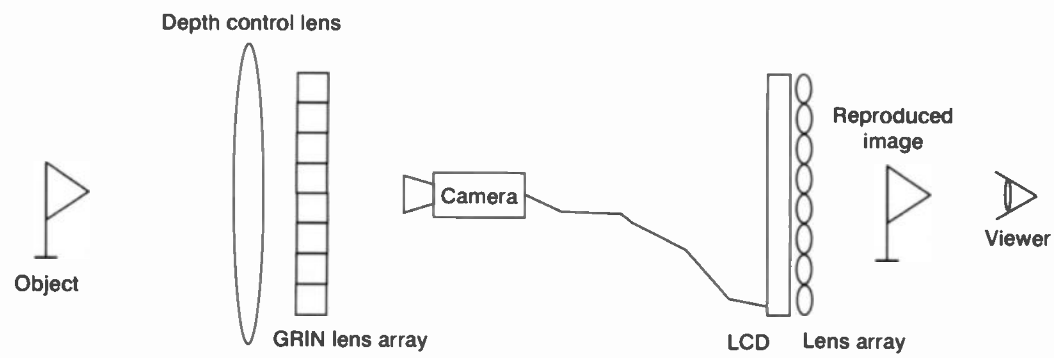


Figure 6.

AIR YOUR VIEWS

E-mail your views and comments to:
AYV@maplin.demon.co.uk

Write to:
***Electronics and Beyond*, P.O. Box 777, Rayleigh, Essex SS6 8LU**

The Millennium

Dear Sir

Reading with interest the comments from E. C. Barrie in the March 2000 issue of your magazine, I have had the following thoughts. Counting normally begins with One. A decade, century and millennium contains 10, 100 and 1000 units respectively. Therefore to have a decade, century or millennium I think that it will be necessary to complete 10, 100 or 1000 units (years). If this is accepted, then I cannot see why a new Century or Millennium does not start with 1801, 1901, 2001, 2101, 3001 etc. It is therefore immaterial when the birth of Christ actually was, as we are now counting as if it was nearly 2000 years ago. As nobody would say that a person is 10 at their ninth birthday, it seems odd that Christ should be thought to have been born 2000 years ago at the end of year 1999. This is actually the 2000th year since the birth, but let us see it out before we celebrate the completion of 2000 years. I therefore agree that the new millennium will start 1st January 2001. Celebrations? - yes, I will be celebrating the new Millennium in about eight months time, that is 1-1-2001.

Kjell Nilsen-Nygaard
Glasgow

This is certainly another way of looking at the dilemma.

The Magnetron Myth

Dear Sir

Issue 148 perpetuates the myth that the magnetron was invented during the Second World War. In fact, Albert W. Hull invented both the magnetron principle and the name in 1921. Dr. Hull was working in the laboratories of GE in the United States - see Telecommunications Engineering, Dunlop & Smith.

The early magnetrons were lower power devices but had the ability to produce oscillations at higher frequencies than any other devices available. They were used for experimental microwave communications in the 1930s. A small split anode magnetron formed the basis of the famous Wireless Set No. 10, which provided a series of secure microwave links after D-Day for General Montgomery's staff.

With the advent of radar in 1939 there became a need for high power microwave generators so that the existing devices, the klystron and the magnetron, were investigated. Drs. Randall and Boot replaced the conventional split anode in a magnetron with a single anode containing resonant cavities. The combination of the resonant cavities and the electron multiplication obtained through some emitted electrons returning and bombarding the cathode provided very high power microwave energy. The cavity magnetron, unlike its predecessor, can only provide a pulsed output.

Guy Selby-Lowndes
Billinghurst

Thanks Guy for that interesting piece of history. If my memory is correct, when I was at EEV Ltd. in Chelmsford in the late 60s, there was an old building there that was the used as a canteen, which I believe was used by Marconi Ltd. during the war to develop the magnetron.

A Train Effects DoorBell!

Dear Sir

It might be of interest to some of your readers of an alternative use for the Train Effects Generator.

In the original article under applications it was suggested it could be used as a novelty doorbell. But for me it is more than a novelty, as I am hard of hearing, and I was missing callers at the front door. Most callers just touch the button resulting in a short ring that I could easily miss. With the level crossing bell and its six rings, now I don't miss a thing. However, the lead from the bell-push to the unit should be as short as possible, as I found that nearby light switches sometimes set it off. So if someone in your family is hard of hearing, then they might welcome one of these.

P. J. Crawley
Basingstoke.

Well that certainly is a very practical and worth while application and we are glad it has been a great benefit to you. Do any other readers have interesting 'alternative' applications?

Crystal Palace & District Radio Club

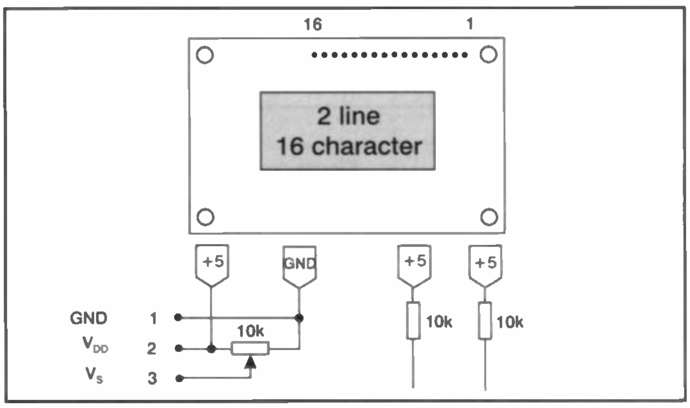
Dear Sir

I would be grateful if you would mention that we are having a Spring Sale on Saturday 22nd April from 1030 to 1300, at St. John's Hall Sylvan Road London SE19. Admission will be £1 for adults, (which includes one free drink) and children enter for free. Further details, including booking a table for sellers, can be obtained from Bob G300U on 01737 552170 or by visiting our website at http://ourworld.compuserve.com/homepages/bob_and_cathy_burns.

CORRIGENDA

A Hardware MPEG3 Player Part 2 - Issue 148

We apologise for inadvertently missing off the voltages on Figure 15. This part of the drawing is reproduced with the relevant voltages indicated.



Uri Geller's Extended Reality - Issue 148

The correct email address for Klara Heltay (The Egely Wheel) is klheltay@compuserve.com. This was printed correctly in the March edition.

Circuit MAKER

High Quality 100 Watt Valve Power Amplifier

Mike Holmes describes an ultra-linear design using KT88 valves

This design was produced in response to requests for a higher power audio valve amplifier, with particular regard to maintaining a good quality of performance with low distortion for domestic and hi-fi applications, as is more easily achieved with class AB designs of 10 to 30 Watts. This is now possible due to the greatly expanded variety of valve transformers now available from Maplin, which include items specifically designed for an amplifier of 100 Watts output, as will be described here.

A single pair of the designated output valve type - in this case, the KT88 - is capable of producing an output of 100 W by themselves (as is the EL34, etc.); however, this would be mainly in pure push-pull 'class B' mode (to use the transistor comparison, actually class AB). While this is alright for general purpose public address applications - and many examples with output powers up to 1 kW or more, for halls and factory premises and the like, have existed - the sound quality is generally poor, with distortion levels and an overall frequency response that are generally unacceptable for anything approaching good music reproduction.

Choosing The Output Type

Pure single-ended class A, or triode mode push-pull (AB) is too inefficient, so it makes sense to perpetuate a compromise first adopted by designers more than 50 years ago, viz., the push-pull distributed load configuration, which very early on acquired the marketing label 'ultra-linear'.

To reiterate in brief, this is a scheme that aims to improve the basic class AB push-pull method. In such an output stage, triodes and tetrodes/pentodes differ in two important respects.

The first concerns amplitude distortion. Tetrodes and pentodes generally introduce the least second harmonic distortion, but at the expense of also adding third harmonic distortion (and also inter-modulation distortion in a push-pull output stage). However, second harmonic distortion is effectively cancelled in the output transformer (see 'Valve Technology - A Practical Guide' Part 7 (Graham Dixey), 'Electronics' Issue 73 (January 1992)), and so is removed from the output signal, but third harmonics still remain.

If triodes are used - in practice these are often power output tetrodes or pentodes wired up to emulate triode operation - then, while they produce more of the second harmonics, this is not a problem because these will be eliminated in the transformer. This leaves third harmonic distortion, which, in the case of triodes, is much reduced.

The second aspect is, ultimately, to do with controlling the movements of the loudspeaker cone. A good amplifier, it has been cited, should not only drive the speaker cone with an exact replica of its input waveform, but also damp out any tendency for the speaker to oscillate (ring), especially at its resonant frequency (or frequencies, in the case of enclosures having multiple drivers). Failure to do this may result in a 'boomy' bass response as the most common example.

However, triode mode output stages are in the order of five times more effective at damping loudspeaker resonances than tetrodes/pentodes. This is because the anode impedance (Ra) of a triode is much lower than that of the equivalent pentode or tetrode, and so can be much more closely matched to the primary impedance of the transformer.

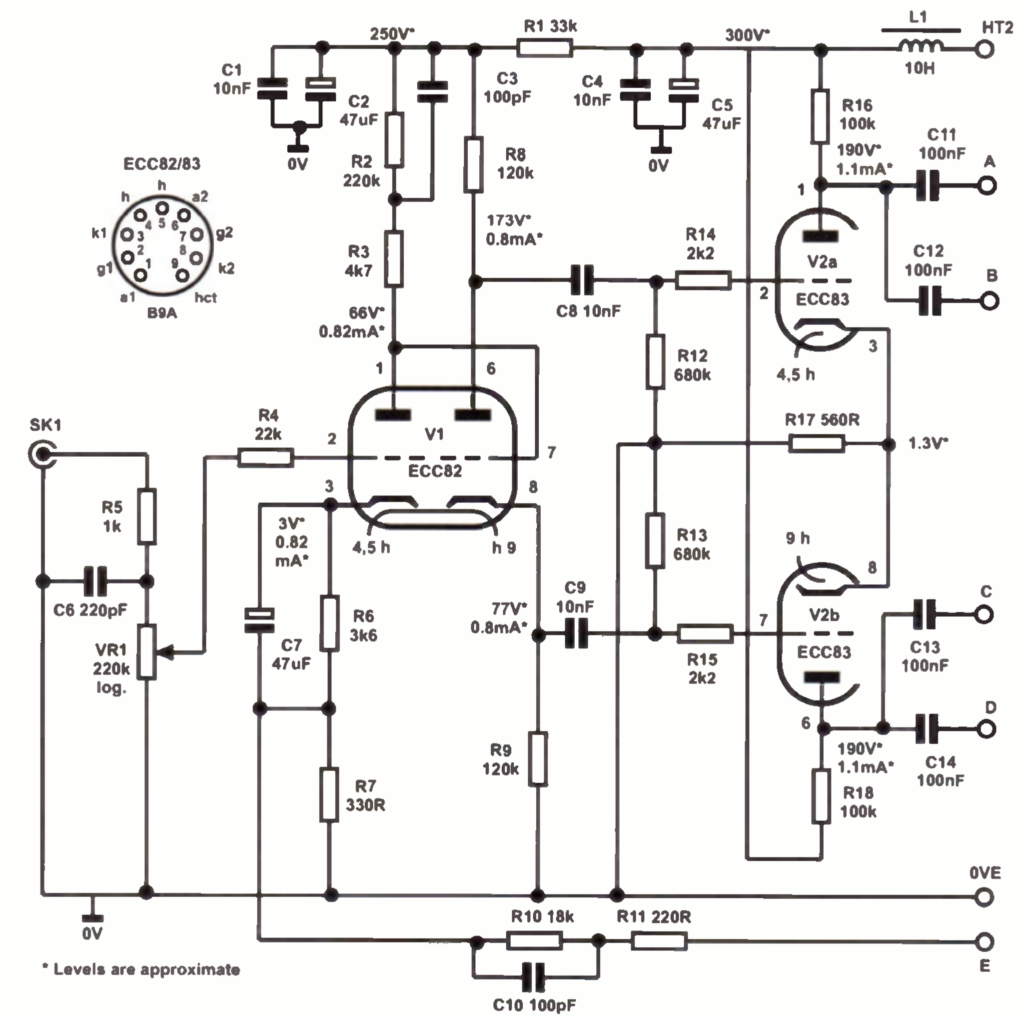
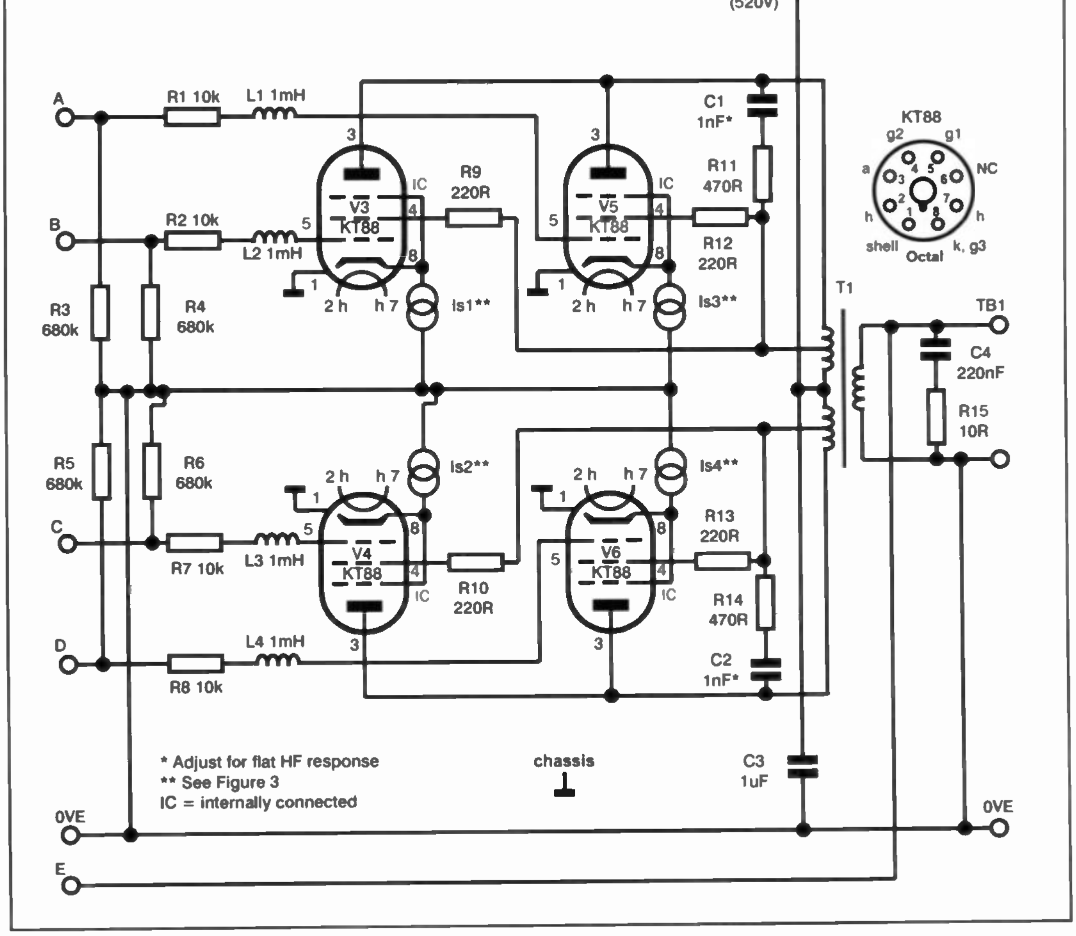


Figure 1. Input and Driver Stages

Figure 2. Output Stage



The big fly-in-the-ointment is the very poor gain of the purely triode configuration. The so-called 'ultra-linear' configuration addresses the balance by going 'half way' to true tetrode or pentode operation. Instead of the screen grid being connected directly to the HT line (referred to as 'tetrode connection' in the data), as in the basic class AB output type, it is alternatively tapped into the transformer primary itself (hence 'distributed load' or 'ultra-linear' connection). The voltage present on it therefore varies in sympathy with anode voltage and is a constant proportion of it, in our example, using the 100W transformer for KT88s, 40%.

The result, as output class AB1, combines the low distortion of triode mode with useful gain, and in fact the total distortion (before any negative feedback is applied) for a pair of KT88's thus connected is half that of the same pair working in straight tetrode connection.

The trade off is that the output power is halved also, therefore two pairs working in parallel are needed to achieve an output of 100 Watts, and the transformer specified here has been designed for exactly this. Intended for a speaker load of 8Ω only, the full power output voltage on the secondary is therefore approximately 30V rms.

Input and Driver Stages

Due to its complexity the circuit will be described in three parts, beginning with the input and driver stages, see Figure 1. This follows a fairly classic configuration much featured in Williamson's designs and others.

This comprises a differential input stage (although at first sight it doesn't look like it); a phase splitter and a push-pull driver stage. V1(a) is essentially a common cathode amplifier (ignoring R7 for the moment), receiving input from SK1 (a phono socket) via volume control VR1. (VR1 also functions as the grid bias resistor.) R5 & C6 form a simple, RC low-pass filter to help exclude unwanted ultrasonics, RF, etc. from the signal.

R4 is a 'grid-stopper' (to use the vernacular); this forms an essential RC filter with the valve's own internal $c_{a}c_{k}$ capacitance's to promote stability in the HF range. Similarly, R3 & C3 work together as a Zobel network to provide additional anode loading in the upper HF range, thus lowering the gain of the stage at very high frequencies. Open loop gain is nominally in the range of 20 - 23 dB in the AF band.

The phase splitter, V1(b), receives its DC grid bias directly from V1(a) anode. This level - adjustable by varying the value of R6 - is set to produce a voltage approximately one third that of the HT supply at the cathode of V1(b). Because the values of R8 & R9 are equal, the anode voltage is also equal to the HT minus one third. The valve outputs two equal waveforms in opposite phase (shifted 180°) at unity gain.

Although the open loop gain is on the small side, the ECC82 was selected for the first two valves' roles as it is more conducive to working at comparatively low anode-to-cathode voltage levels compared with an ECC83, say. Similarly, the choice of a very low noise device such as the EF86 pentode, for example, is really unnecessary since the EF86 was designed for very small signal applications such as ribbon microphone and tape head preamplifiers. In this application the maximum input level is expected to be approximately 0 dB, so it will be largely wasted here, especially after negative feedback is applied.

The final driver stage comprises a ECC83 pair as V2. The signal grids of the output stage valves each require a large signal swing of at least 50V peak to achieve maximum output, therefore V2a & b are organised as a push-pull pair. There is also a certain amount of 'loose' cathode coupling between the two, due to their sharing R17. This is not very useful by itself as the value is very small, however, it allows the pair to equalise any level imbalance between the two signals on their respective control grids, at least in part.

The final pair of anti-phase outputs, from V2 pins 1 & 6, are delivered to the output stage via two pairs of audio grade polypropylene, DC blocking capacitors, C11 - 14. This ensures that the grid of each KT88 output valve is isolated DC wise and able to develop its own bias voltage. (There is always a small negative charge on the grid of a valve due to it collecting some electrons from the cathode, and precise levels vary from valve to valve. This finds an earth return via the bias, or 'grid-leak', resistor.)

If the anode voltage swings of V2a & b show signs of substantially uneven clipping when overdriven (i.e., concentrated on positive or negative half cycles only) it may be prudent to adjust the value of R17 to obtain an anode DC level as close as possible to half that of the total HT level. Each anode must be able to develop 50V peak minimum (translated to 100V peak-to-peak; 35V rms sinewave).

Note also that the values for R16 & R18 are the lowest recommended for the ECC83 to maintain minimal distortion. These values can be reduced to lower the output impedance and therefore improve 'driving capability', but distortion will be worse. The open loop gain of each valve is at least 30dB.

Also, this part of the circuit has its own HT supply from the PSU. Any 100Hz ripple on this HT line is suppressed in the LC filter L1 with C5 & C4 (the latter trapping fast transients), with further isolation between the two halves of this part of the circuit performed by R1 with C2, C1. Apart from C11 - C14, non-electrolytic capacitors are ceramic types best able to survive a high temperature

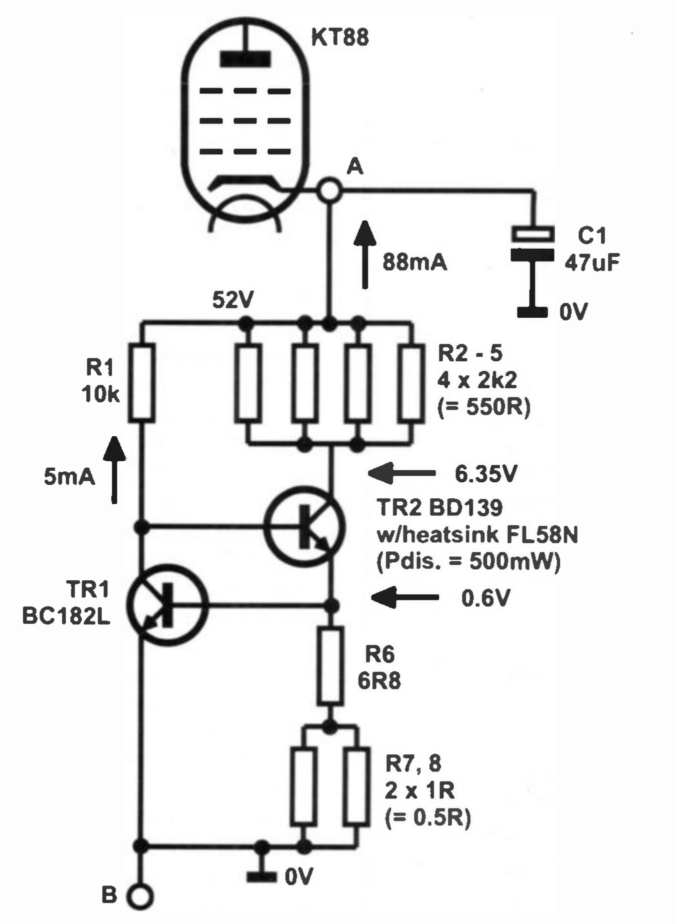


Figure 3. Circuit of Current Generator

environment.

A negative feedback loop is formed by resistor chain R10, R11 and includes R7, and has been calculated to develop a signal voltage drop across R7 in the range 500 - 700mV rms from 30V rms at the output transformer secondary. Allowing for losses in the V1(a) cathode circuit, this sets an input sensitivity of approximately 0dB (1V peak) for maximum output.

C10 provides bypass to promote HF stability, buffered by R11. Overall closed loop gain is therefore 32dB (approximate). This may be lowered by reducing R10 only, but gain must not be significantly increased, nor should the amplifier be operated in an open loop mode, else the necessarily large voltage swings on the anodes of V2a & b may result in too much distortion from the driver stage. The design relies on a combination of a fairly high open loop gain (>50dB in the 'front end' alone) and negative feedback to control distortion.

The Output Stage

As inferred earlier, this design involves the use of no less than four KT88 output valves. Like its siblings in the same family (which includes the KT33, KT55 and KT66), the KT88 is a 'beam pentode'; in the position normally occupied by a pentode's suppressor grid it has a pair of beam forming plates a la the beam tetrode. The result is that the anode cylinder collects electrons over an area consisting of just two wide 'strips' of its total inside surface. In addition, the wires of the screen grid are placed directly in the 'shadow' of the signal grid wires, a particular feature of this design.

By way of explanation, the arrangement completely negates the phenomenon called 'secondary emission' from the anode - through the effect of it being bombarded with primary electrons from the cathode. Secondary emission results in the bizarre, and completely opposite to expected effect, of a rise in anode voltage as the valve is turned hard on, causing gross distortion, oscillation, and is generally the bane of a tetrode's life! Without going into this in any great detail, suffice to say that it comes about where the anode becomes negative relative to the screen grid (Ed. - see Mike Bedford's series Valves in the 21st Century) . The screen then steals electrons, knocked from the anode by the cathode electron beam, that should normally be allowed to return to the anode and thence go to the external circuit. This can be serious in a high power valve; being merely wire, the screen grid's power handling threshold may be exceeded, causing it to melt.

The final output stage is shown in Figure 2. Loosely based on that for the Leak 50 (who remembers Leak?), valves V3 to V6 are organised into two paralleled, push-pull pairs, sharing a common output transformer T1. Two screen grids from each side share the same primary tap for that side. Resistors R9, R10, R12 & R13 are included to offset any screen current mismatch between the commoned grids, and also to provide a smoother transition from class A working (both sides conducting) to class B (one side cut off). The trade-off is a slight loss in gain.

Also quite important are C1 & C2, R11 & R14, Zobel networks intended to ensure that the transformer's primary impedance remains flat in the upper frequency band. Values should be chosen to ensure a flat frequency response in the HF range, followed by a roll-off beginning in the region of around 50 - 70kHz. You must avoid trying to aim for a wide bandwidth that encompasses the ultrasonic with the idea that this must be an improvement; it is not, it is actually detrimental.

If a signal generator and oscilloscope are available, this part of the finished amplifier can be checked out with a squarewave into a purely resistive 8Ω load; there should be a very small amount of overshoot on the leading edges followed by negligible ringing.

At the front end of Figure 2, R3 to R6 form the individual grid-leak resistors for V3 to V6. Values were selected to present the optimum load to the driver valve, V2. Again 'grid-stopper' resistors R1, R2, R7 & R8 must be included. In addition, these are augmented with RF chokes L1 to L4 to dissuade any particularly energetic radio nasties! Each should be located as near to pin 5 of its respective valve base socket as is possible, closely followed by the resistor. Note also that pin 1 of the KT88, identified as 'base shell' in the data, is an electrical screen that should be connected to chassis earth.

At the other end, a Zobel network comprising C4 & R15 is added across T1 secondary to offset the possible inductive increase of a speaker's voice coil impedance at high frequencies.

Dynamic Cathode Bias

The four items identified as 'Is1 - Is4' in Figure 2 represent a scheme used here to derive cathode bias for the four valves. Instead of using pure resistors of 600Ω each as per the application data, a much more dynamic approach is to employ a form of current source. This technique succeeds in maintaining an identical fixed current in each valve such that a balanced DC is preserved in the transformer primary - essential for the correct symmetry of low frequency waveforms - yet valves need not even be perfectly matched pairs.

Taken as one of four identical modules, a circuit diagram of the current generator is shown in Figure 3. TR1 & TR2 form a constant current source, where TR1 controls TR2 to maintain a voltage drop equal to its Vbe across the resistor chain R6 - R8. The total current is 88mA as supplied to the relevant KT88 cathode pin 8, via point 'A'. The actual cathode voltages will vary according to the characteristics of the individual valves (52V is the optimum level). In practice, this creates the equivalent negative bias for the signal grid.

This level is quite high, such that the heat dissipation of TR2 would be excessive if handling the voltage drop alone, requiring a large heatsink. Therefore resistor array R2 - R5 is added to take the brunt of this voltage drop. TR2 still needs a heatsink but this can more conveniently be a small PCB mounting type.

The whole module can be assembled onto a small square of plain stripboard, or all four combined on a strip in step and repeat fashion. Good ventilation is required; the centres of the resistor group R2 - R5 must be no less than 0.3 inches (placed at intervals of four stripboard holes) apart, and if the board is oriented vertically the resistors must be above TR2 and its heatsink, not below.

Finally, C1 is the AC bypass capacitor. Point 'B' connects to the 0VE line in Figure 2.

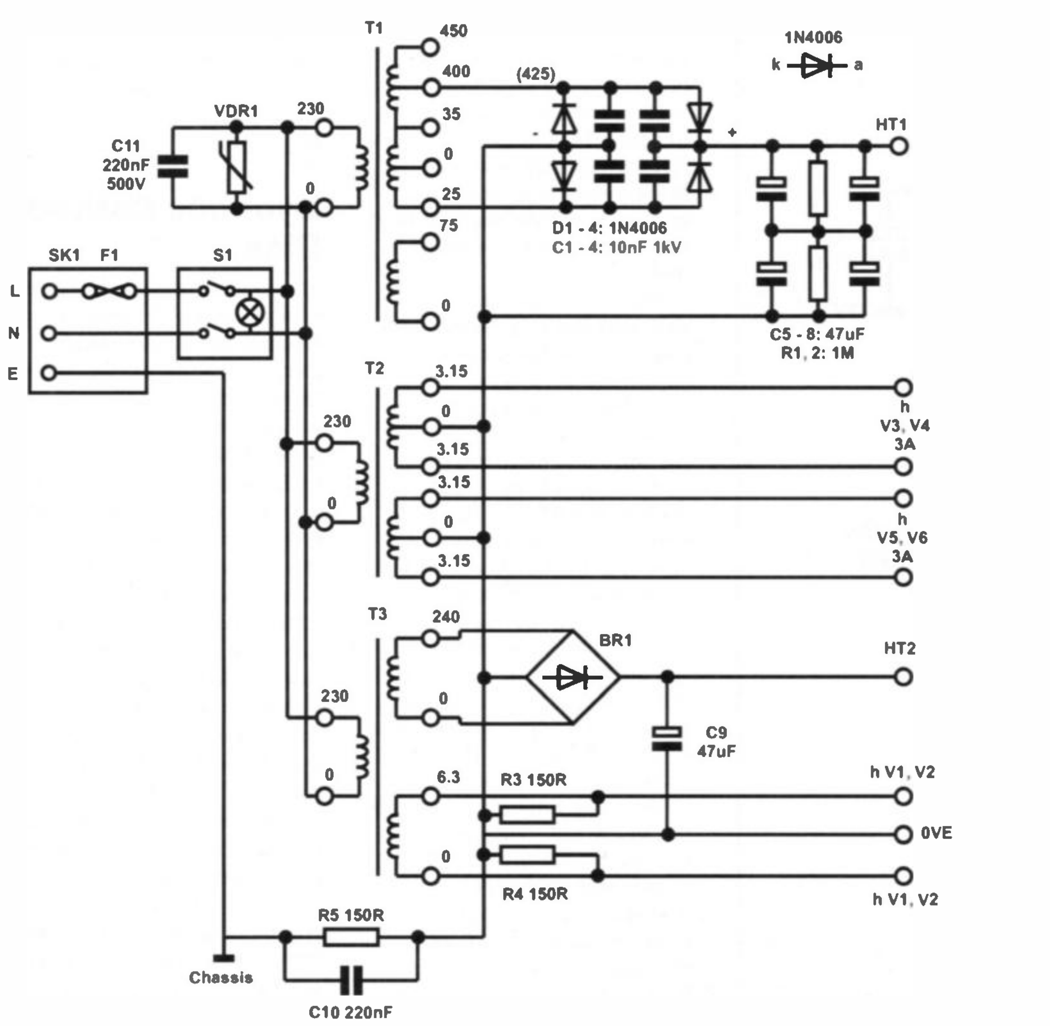


Figure 4. Power Supply Circuit

Power Supply

The power supply circuit for the 100W amplifier is shown in Figure 4. The 100W valve amplifier mains transformer, T1, only caters for the output stage and does not include heater windings. A number of useful taps in the secondary provide for various HT output levels, in the range 365, 400, 425, 450 and 475VAC. In this application 425V is used; if this is found insufficient it may be increased to 450VAC by selected the 0 and 450 taps.

The selected taps are rectified by D1 - D4, with noise suppression by C1 - C4. The final unloaded HT line is at a very level, up to 600VDC using the 425V taps (636V using 450), so it is imperative that rigorous safety practices are exercised!

This high level raises another problem in that it is not easy to find an electrolytic with a matching working voltage rating for the reservoir. This can be circumvented by the age-old technique of doubling capacitors in series, as in C5 - C8.

This neatly doubles the DC working for a single component, 450 V, to 900 V. To restore the full value of 47μF this chain must then be duplicated in parallel, hence four capacitors. R1 & R2 serve to stabilise the junctions at exactly half HT, well within the safe working limit of each component.

The entire capacity of T2, a heater transformer, is taken up by the four output valves. This means that further transformers are needed to provide heater and HT for the input and driver circuit, and the cheapest option is to use one of the general purpose valve transformers as T3. While a small amount of current for an HT line may be tapped from T1, there is again the problem of too high a voltage for the available electrolytics.

BR1 is a bridge rectifier (be sure to connect in correct polarity!), with C9 as the reservoir for the HT2 line. As the T3 heater winding is not centre-tapped, this is emulated by R3 & R4, producing a balanced heater feed.

All heater wires must be twisted pairs to minimise hum injection into sensitive parts of the circuit, and wire of the correct current rating must be selected. For V1 & V2 this can be 1A 'bell wire', but a separate loom of 3A hook-up wire must be used for each secondary of T2.

Resistor R5 separates true chassis earth from circuit earth to prevent what is called a 'hum loop' occurring, where both mains earth and the 0V screen of the input lead are connected at source; at no other point should either amplifier or PSU 0VE connect to chassis. C11 & VDR1 are mains noise suppressors, augmenting the filter in mains socket SK1. F1 must be 2A rated minimum to equal to total VA of the three transformers used, and the correctly colour-coded 6A wire and push-on connectors used for mains side wiring (see parts List) As an aside, in the event that you are as much of a traditionalist to consider including valve rectifiers (as had to be in the pre-silicon diode age), Figure 5 gives you an idea of what is involved! A single GZ34 is unable to provide all the necessary HT current, such that the power supply verges on becoming a separately encased item of equipment - which is, of course, what used to happen.

KT88 Mounting And Other Issues

Important: the KT88 may be mounted vertically or horizontally. Where mounted vertically, it is recommended that the centres should be no less than four inches apart, and that pins 4 and 8 of each valve of a pair are in line. Where mounted horizontally the same rules apply, plus no valve should be placed over another.

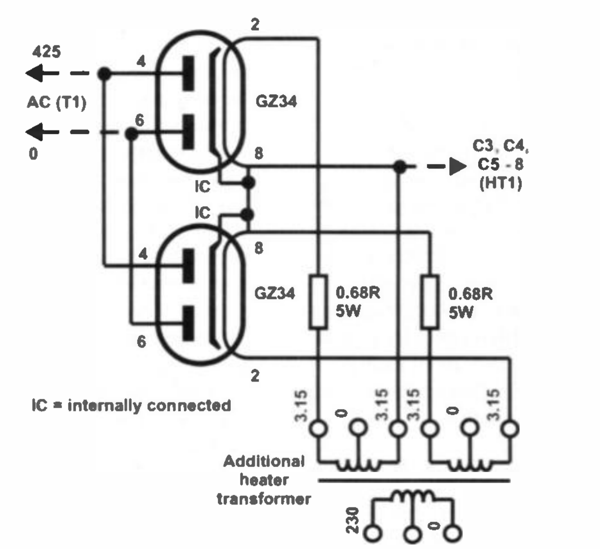


Figure 5. Valve rectifier arrangement

Therefore, if mounted vertically, four KT88's could be placed either in a square or in line; if mounted horizontally, only in a straight line.

It is beyond the scope of this article go into much detail concerning mechanical construction. Several components are specifically PCB mounting types, and these should be grouped on pieces of stripboard as sub-assemblies. Furthermore the transformers are large and heavy, and the total chassis area required for placing the biggest items is also large.

PROJECT PARTS LIST

KT88 CATHODE BIAS CURRENT GENERATORS (4 OFF - MONO) PARTS

RESISTORS			
R1,101,201,301	10k 0.6W 1% Metal Film	4	(M10K)
R2-5,102-105, 202-205,302-305	2k2 2W 1% Metal Film	16	(D2K2)
R6,106,206,306	6.8W 0.6W 1% Metal Film	4	(M6R8)
R7,8,107,108, 207,208,307,308	1W 0.6W 1% Metal Film	8	(M1R)
CAPACITORS			
C1,101,201,301	47µF 100V PC Electrolytic	4	(VH35Q)
SEMICONDUCTORS			
TR1,101,201,301	BC182L npn	1	(QB55K)
TR2,102,202,302	BD139 npn	1	(QF07H)
MISCELLANEOUS			
	Slotted Heatsink	4	(FL58N)
	Plain Stripboard	As req.d	(JP53H)
	Hook-Up Wire 3A Brown	As req.d	(FA28F)
	Hook-Up Wire 3A Black	As req.d	(FA26D)

PROJECT PARTS LIST

100W AMPLIFER POWER SUPPLY UNIT (MONO) PARTS

RESISTORS			
R1,2	1M 1% 2W Metal Film	2	(D1M)
R3-5	150W 0.6W 1% Metal Film	3	(M150R)
CAPACITORS			
C1-4	10nF 1000V Ceramic Disc	4	(JL04E)
C5-9	47µF 450V PC Electrolytic	5	(JL18U)
C10	220nF 250V Mylar	1	(WW83E)
C11	220nF 500V Polypropylene*	1	(FA22Y)
SEMICONDUCTORS			
D1-4	1N4006 Rectifier	4	(QL78K)
BR1	Bridge Rectifier W04	1	(AQ97F)
MISCELLANEOUS			
T1	100W Amplifier Mains Transformer	1	(PX88V)
T2	50VA Heater Transformer	1	(PX90X)
T3	50VA Valve Transformer	1	(XP27E)
SK1	Fused Mains Inlet/Filter Euro	1	(CT81C)
F1	Fuse 20mm 2A Type F	1 Pkt	(GG26D)
S1	Dual Rocker Neon Red	1	(KU99H)
VDR1	Suppressor 250VAC*	1	(HW13P)
	6A Wire Black	1m	(XR32K)
	6A Wire Brown	1m	(XR34M)
	6A Wire Blue	1m	(XR33L)
	Heat Resist Sleeving Red	1m	(BL70M)
	0.25in. Push-On Connector	1 Pkt	(HF10L)
	Insulating Cover (fits CT81C)	1	(JK67X)
	Mains Warning Label	1	(WH48C)
	HV Warning Label	1	(DM55K)
	Plain Stripboard	As req.d	(JP53H)

* connect across T1 primary

PROJECT PARTS LIST

100W POWER AMPLIFIER INPUT STAGE (MONO) PARTS

RESISTORS			
R1	33k 1W 1% Metal Film	1	(J33K)
R2	220k 2W 1% Metal Film	1	(D220K)
R3	4k7 0.6W 1% Metal Film	1	(M4K7)
R4	22k 0.6W 1% Metal Film	1	(M22K)
R5	1k 0.6W 1% Metal Film	1	(M1K)
R6	3k6 0.6W 1% Metal Film	1	(M3K6)
R7	330W 0.6W 1% Metal Film	1	(M330R)
R8,9	120k 2W 1% Metal Film	2	(D120K)
R10	18k 0.6W 1% Metal Film	1	(M18K)
R11	220W 0.6W 1% Metal Film	1	(M220R)
R12,13	680k 0.6W 1% Metal Film	2	(M680K)
R14,15	2k2 0.6W 1% Metal Film	2	(M2K2)
R16,18	100k 2W 1% Metal Film	2	(D100K)
R17	560W 0.6W 1% Metal Film	1	(M560R)
CAPACITORS			
C1,4,8,9	10nF 1000V Ceramic Disc	4	(JL04E)
C2,5	47µF 450V PC Electrolytic	2	(JL18U)
C3,10	100pF 1000V Ceramic Disc	2	(BX07H)
C6	220pF Polystyrene	1	(BX30H)
C7	47µF 63V PC Electrolytic	1	(VH34M)
C11-14	100nF 630V Audio Grade Polypropylene	4	(VM67U)
Valves			
V1	ECC82 Double Triode	1	(CR26D)
V2	ECC83 Double Triode	1	(CR27E)
MISCELLANEOUS			
L1	10H 10mA Choke PCB mount	1	(HW27E)
SK1	Gold Chassis Phono Socket Single (insulated mounting)	1	(JZ05F)
	Single Coax Cable	1m	(XR16S)
VR1	Pot Log 220k	1	(FW26D)
VB1,2	Valve Base B9A	2	(CR31J)
	Bell Wire Black	1 Pkt	(BL85G)
	Bell Wire Orange	1 Pkt	(BL90X)
	Hook-Up Wire 3A Brown	1 Pkt	(FA28F)
	Hook-Up Wire 3A Black	1 Pkt	(FA26D)
	6A Wire Black	1m	(XR32K)
	Heat Resistant Sleeving Red	1m	(BL70M)
	Plain Stripboard	As req.d	(JP53H)

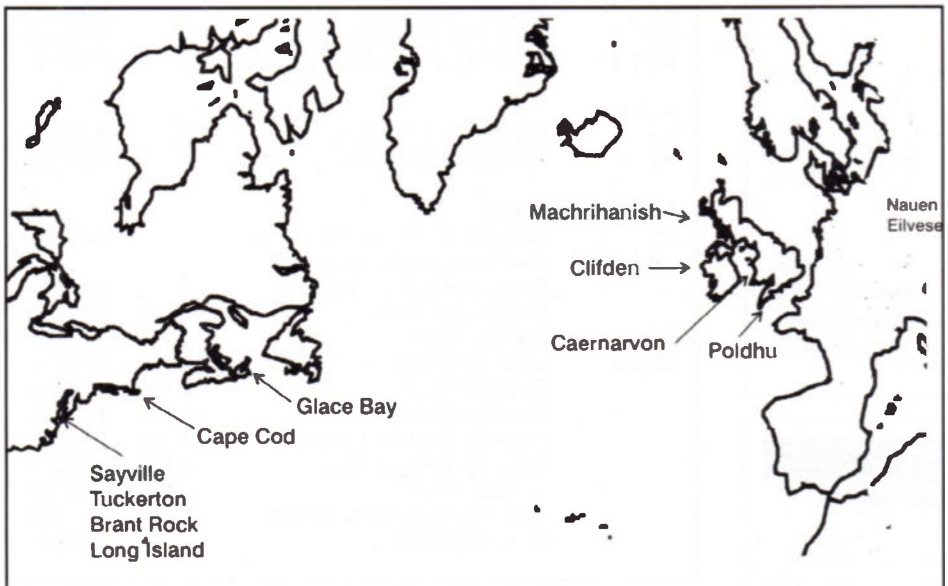
PROJECT PARTS LIST

100W POWER AMPLIFIER OUTPUT STAGE (MONO) PARTS

RESISTORS			
R1,2,7,8	10k 0.6W 1% Metal Film	4	(M10K)
R3-6	680k 0.6W 1% Metal Film	4	(M680K)
R9,10,12,13	220W 2W 1% Metal Film	4	(D220R)
R11,14	470W 2W 1% Metal Film	2	(D470R)
R15	10W 1W Carbon Film	1	(C10R)
CAPACITORS			
C1,2	1nF 1000V Ceramic Disc	2	(JL03D)
C3	1µF 500V Audio Grade Polypropylene	1	(KR78K)
C4	220nF 250V Mylar	1	(WW83E)
Valves			
V3-6	KT88 Power Output Beam Pentode	4	(AW79L)
MISCELLANEOUS			
L1-4	RF Choke 1mH	4	(WH47B)
T1	100W Amplifier Output Transformer	1	(PX91Y)
TB1	Gold Twin Terminal Posts 4mm	1	(JK24B)
VB3-6	Valve Base Octal	4	(CR30H)
	Bell Wire Black	As req.d	(BL85G)
	Bell Wire Orange	As req.d	(BL90X)
	Hook-Up Wire 3A Brown	As req.d	(FA28F)
	Hook-Up Wire 3A Black	As req.d	(FA26D)
	6A Wire Black	As req.d	(XR32K)
	Heat Resistant Sleeving Red	As req.d	(BL70M)
	Plain Stripboard	As req.d	(JP53H)

The Very LONG WAVES

In part 1, George Pickworth looks at the saga of the superstations from transoceanic telegraphy to signalling to submarines.



Map A. This shows the position of stations that figured in the very long wave transatlantic radio telegraph service.

Introduction

Superstations were originally constructed to provide a reliable transoceanic wireless telegraph system on waves between 6,000 and 25,000m long (50kHz to 12kHz). Indeed, the commercial superstations provided an attractive alternative to submarine cables from 1906 until around 1925 when they were made redundant by short wave systems. See Map A.

The name superstation was coined to emphasise their high power transmitters, typically in the order of hundreds of kW and enormous antenna structures needed to radiate very long waves. See Figure 1.

For the purpose of this study, the transmitter is the device that generates radio frequency (rf) current. Power is generally taken as input power to the transmitter. An installation comprising of a power supply, transmitter and antenna is referred to as a station.

The long range of the superstations can be attributed to a combination of high power transmitters and relatively low absorption of very long waves by the ionosphere 'D' region; this allowed for sufficient energy to reach the higher 'E' region from where it is reflected back to earth. See Figure 2. However, as the 'D' region largely disappears during darkness, transmitter power could generally be reduced at night.

Nonetheless, the reflected waves had to contain sufficient energy to activate distant receivers, which, prior to the amplifying triode valve, were passive devices where all the energy that produced an audible sound was derived from the incoming waves. Reception with passive receivers over transoceanic range was indeed a remarkable achievement.

The 'E' region is the lowest region that reflects radio waves so penetration of the ionosphere is minimal and the waves

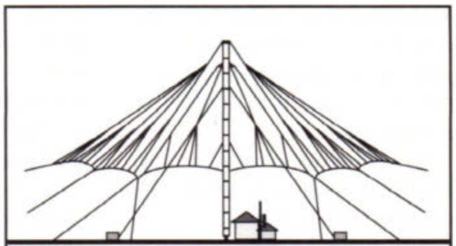


Figure 1. The Nauen antenna 1906 - this antenna was impressive when first built, but was replaced by a much larger 'T' type antenna. The umbrella was energised via the mast that rested on an insulated base.

propagate within a space about 100km high formed by the boundary with the 'E' region and earth. But it must be remembered that although the pioneers realised that the waves were being reflected from a layer high above earth, the ionosphere had yet to be discovered. The night-time effect was most puzzling and was not resolved until 1925.

Early in the history of the superstations it was discovered that range increased with increasing wavelengths. Moreover, the longer the waves the greater the reliability of communication. The inference is that absorption of very long waves by the ionospheric 'D' region decreases with increasing wavelength whilst reflection from the 'E' region is possibly enhanced. Therefore, it was advantageous to employ the longest waves that could be radiated with acceptable efficiency. Hence the enormous antenna structures.

But even the largest antenna structures were only a fraction of a wavelength long, see Figures 3 & 4, so radiation efficiency was poor. Fortunately, the relatively low attenuation of very long waves compensated in some measure for poor antenna efficiency.

Nonetheless, the longest waves that could be radiated with acceptable efficiency from feasible inverted 'L' or centre fed 'T' antennas was about 15,000m. For example,

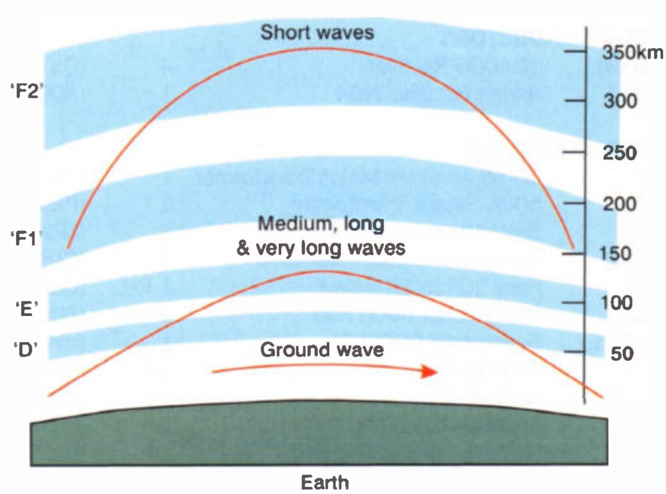


Figure 2. The ionosphere. This shows the paths of short and long waves. The waves are bent by refraction. A strong ionised 'D' region absorbs longer than about 100m but absorption declines with increasing wavelength. The 'D' region largely disappears at night. Compare this with propagation of extremely long waves of Figure 8.

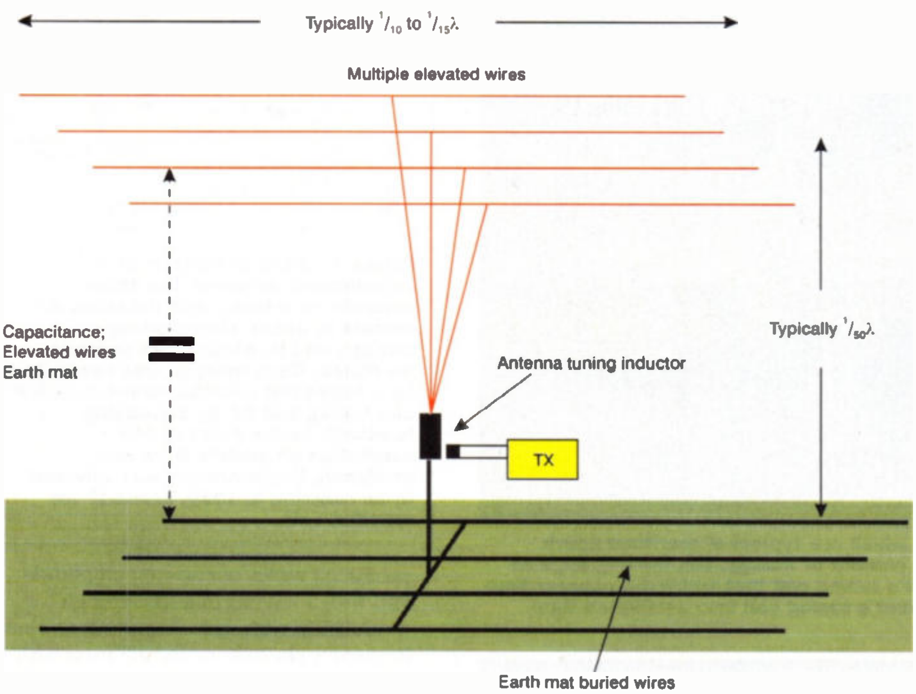


Figure 3. Top-loaded, very long wave antenna - essential a LC tuned circuit. Charging and discharging of the capacitor causes forward and reverse currents to flow thereby radiating energy. The antenna and tuning coil provide inductance. The elevated wires and mat provide capacitance. The system is brought into resonance by adjusting the antenna-tuning inductor. Multiple elevated wires increase capacitance with earth mat.

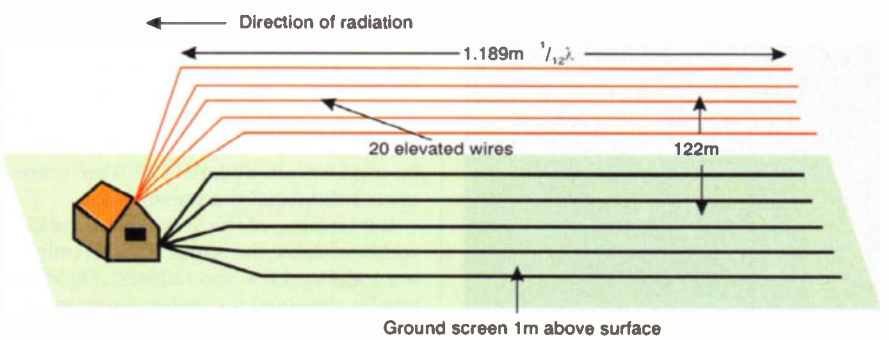


Figure 4. Marconi's Caernarvon inverted 'L' antenna - a similar one was employed at Clifden. The station occupied a strip of land 1,830 x 258m. Capacity 0.039μF; natural wavelength 5,400m; operational wavelength 14,000m; alignment 284°.

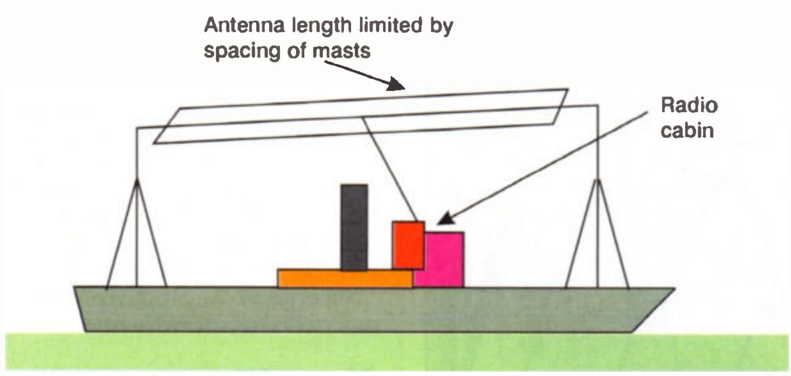


Figure 5. Ship antenna. Maritime wavelengths were set by space available for antennas. Small ships operated on 300m and used inverted 'L' antennas. Large ships, as shown, operated on 600m and used 'T' antennas. Using multi-wire antennas increased capacitance with deck.

the 1916 German station at Nauen near Berlin radiated waves 12,500m long, it employed a 'T' antenna with an overall length of 2,484m and a height of 260m. See Figure 3.

An inverted 'L' antenna was employed at Marconi's 1906 station at Clifden, Ireland that radiated waves 6,600m long.. The antenna extended over an area of 1.5km² whilst ancillary buildings, including those housing the boilers, steam turbines and 300kW generators, storage batteries and the transmitter capacitors, extended over a further 0.5km². With smoke belching from the chimneys, the complex was more like a factory site than a radio transmitting station. The Caernarvon station had a similar antenna - see Figure 4.

For comparison, maritime systems adopted a wavelength of 300m for small ships and 600m for large ships; this was set by the height and spacing of ships masts. See Figure 5. Small ship antennas were generally inverted 'L' which were directional from the end connected to the transmitter. Large ship antennas were centre-fed 'T' type, but as radiation was mainly from the vertical elements, directional effects were minimised. With regard to power, a maritime transmitter was typically rated at 1.0 to 1.5kW.

Only A Dozen

Although there were only about dozen or so commercial superstations operating worldwide at any one time, all shared a frequency band only 40kHz wide. The shortest useable wavelength was 5,000m (60kHz) and the longest that could be radiated with acceptable efficiency was 15,000m (20kHz). So, highly selective receivers were vital.

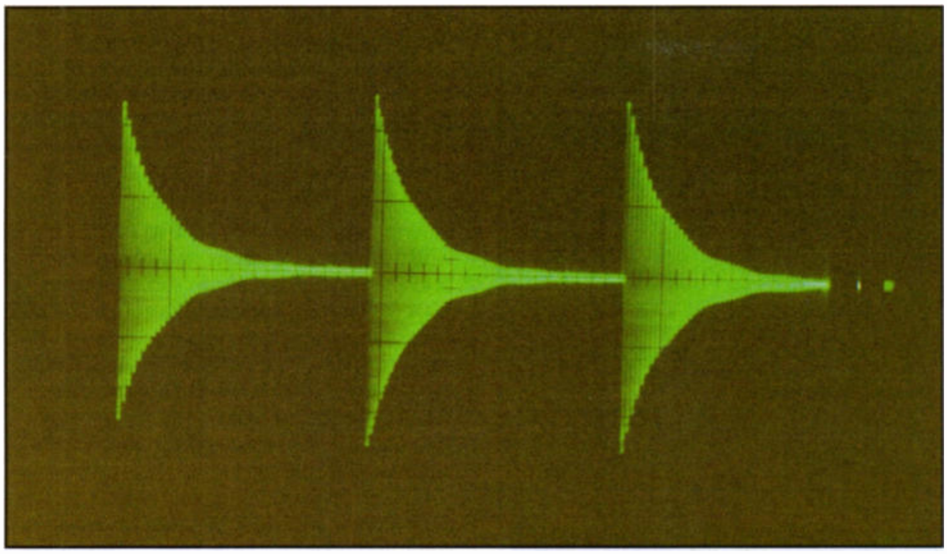
However, high selectivity was not possible with wave trains radiated by maritime spark transmitters. See Oscillogram A. The first wave of the train shocked the receiver tuner into oscillation at any frequency at which it happened to be tuned. Elaborate multi-stage tuners were developed to reduce shock excitation but with maritime systems high selectivity was neither necessary nor desirable.

High selectivity was only attainable by virtue of resonance with the receivers tuned circuit but this was only possible with continuous waves (CW) - see Oscillogram B. So, in addition to their high power and huge antenna structures, the superstations heralded CW transmissions and a new family of transmitters and detectors.

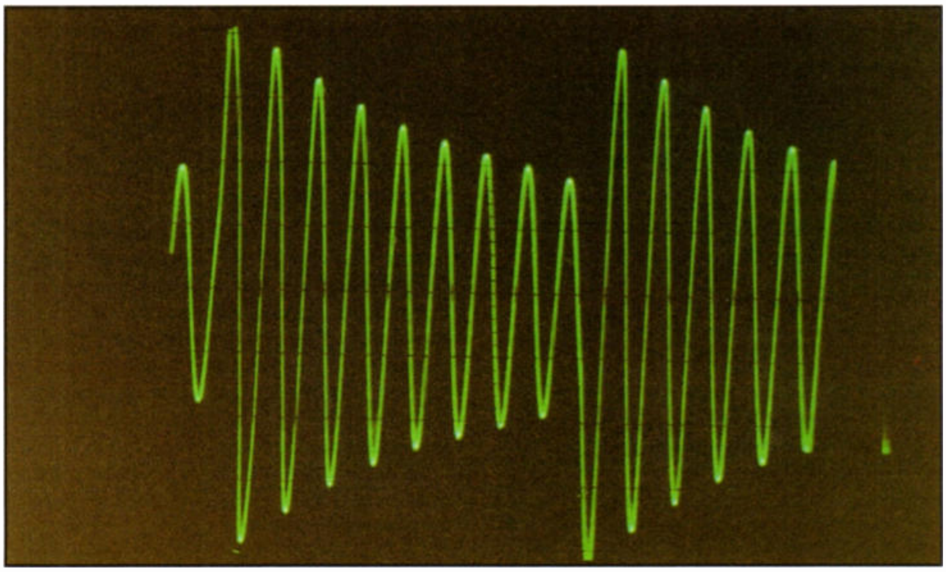
Transmitters

There was four basic methods of generating continuous waves:-

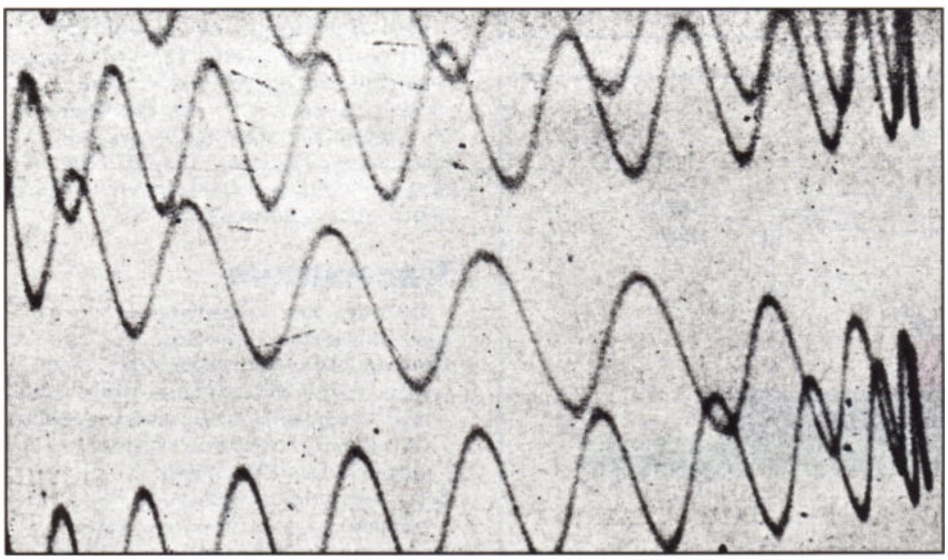
1. Marconi's system of employing a 'timed-spark' transmitter to generate wave trains that overlapped in phase so as to produce cw but they were not of constant amplitude. See Oscillogram C.
2. The quenched arc that produced continuous waves of more or less constant amplitude but waveform was poor. Moreover the system was temperamental.
3. Fessenden's high frequency alternator



Oscillogram A. Oscillogram showing wave trains, which are typical of maritime spark transmitters. Each train could pack an enormous amount of energy. The leading edge of each train induced a voltage pulse in the receiver's tuning coil that triggered coherer type detectors. The pulse also shock-excited the receiver's tuning coil into oscillation thus making sharp tuning possible.



Oscillogram B. A constant amplitude continuous wave produced by a very early valve type oscillator - frequency 69kHz. This is one of the earliest waveform images to be displayed by a 'cathode tube oscillograph.' It was produced by the French Military Wireless service in 1914, but was not made public until a few years after the First World War.



Oscillogram C. This is a continuous wave generated by wave trains overlapping in phase, and is a reproduction of the waves generated by Marconi's 1913 Caernarvon timed-spark transmitter. Note that although the waves are continuous they are not constant amplitude.

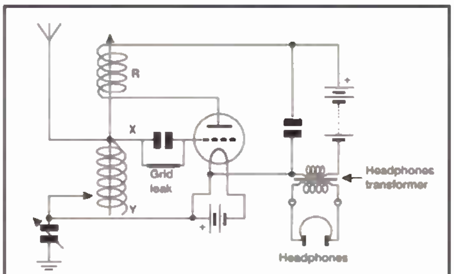


Figure 6. 1920 Schematic of a regenerative receiver. The valve behaves as a leaky grid detector. RF current in anode circuit passes through coil R, which gives positive feedback. Regeneration was controlled by a degree of coupling between coil R and tuning coil XY. By increasing feedback to the point of self oscillation an audible beat was produced. Regeneration was referred to as reaction in 1920, hence'R' for reaction coil.

produced waves of constant amplitude and with a waveform good enough for modulation with speech and music. High frequency alternators are still used with extremely long wave submarine signalling systems.

4. Valve type transmitters. These were the ultimate and produced waves of constant amplitude and near perfect waveform. See Oscilogram B.

Receivers

Whilst ubiquitous coherer type detectors were eminently suited to reception of wave trains they would not work with CW. Moreover, rectifier type detectors, including Fessenden's electrolytic detector and point contact carborundum detectors, could only be used with modulated CW. Wave trains in effect modulated the transmission.

But because of the very limited bandwidth available the super stations only unmodulated CW was radiated. Signalling was by chopping the transmission into short and long periods to represent the Morse code.

Detectors suitable for unmodulated CW included passive mechanical devices such as the 'Tikker' and 'Tone Wheel' that produced audio frequency (af) current directly from radio frequency (rf) current.

Fessenden's heterodyne receiver was claimed to be the most sensitive of pre-thermionic valve receivers. It used a small variable frequency alternator as the local oscillator.

However, around 1920, Armstrong developed his highly sensitive regenerative detector that employed a triode valve - see Figure 6. Unfortunately, it came too late to play a significant role with commercial very long wave superstations but it did enable signals from Marconi's Caernarvon station to be received in South Africa and Australia.

Superheterodyne receivers ultimately superseded regenerative receivers.

Short Waves

Regenerative receivers were found to be ideally suited to short wave reception. Indeed, amateurs using regenerative receivers and transmitters employing receiver type valves were able to attain

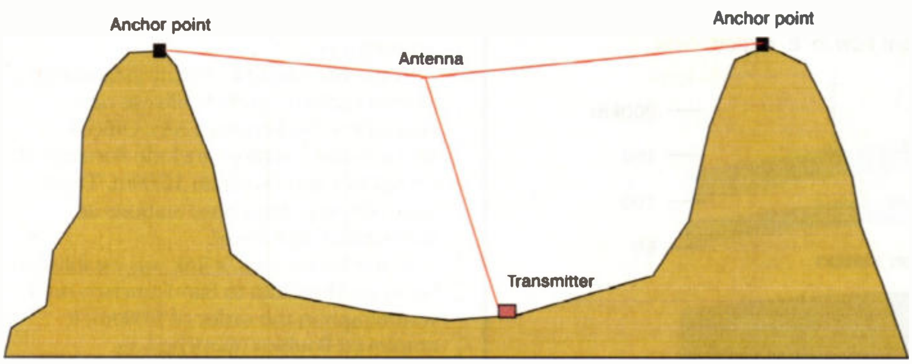


Figure 7. Mountain peak catenary antenna, as employed on pacific islands during WWII.

transatlantic range with power in the order of a few Watts. However, it was not until high power transmitter type valves were developed around 1923 that commercial exploitation of the short waves could start.

The obvious advantage of short waves was that available airspace was increased from a band 30kHz wide, with very long waves, to a band 10MHz wide - this is based on short waves extending from 5.0MHz to 15MHz. With early receivers, sensitivity fell off sharply above about 15MHz.

Short wave antennas could readily be made several wavelengths long and were therefore highly efficient radiators. Moreover, the cost of erection of short wave antenna was much less than that of the enormous very long wave structures. Last but far from least, communication with short wave systems and regenerative receivers needed to be only a fraction of the power necessary with the very long wave systems and passive receivers.

But, there was a down side. Signalling via short waves was not reliable as with very long waves. A simplified explanation is that unlike long waves that are reflected from the lower 'E' region, short waves are reflected from the highest 'F' regions. So, to reach the reflective region, short waves have to penetrate the ionosphere for about 250km where they are subjected to periodic and constant variations in the thickness and changing levels of ionisation - see Figure 2.

Therefore, it is understandable that the very long wave station at Caernarvon, Wales, continued to be used for transmission of government and strategic messages until 1925 when the new strategic station at Rugby was commissioned. It also transmitted facsimile news pictures and helped out with transoceanic telegraphy when ionospheric conditions interfered with short wave communications.

Submarines

It had been found that the fields of very long waves penetrated the oceans to a considerable depth and the longer the waves the deeper their fields penetrated the water.

Indeed, British submariners conducted trials with signalling to submerged submarines by very long waves radiated by the Portsmouth station during the First World War and no doubt it was from the results of these trials that the new strategic station at Rugby was constructed. As a result, the principal role of the very long waves shifted almost entirely to that of signalling to submarines submerged under the oceans.

During the Second World War and for a few years after, waves in the order of 15,000m were used for signalling to submarines but they required the antenna to be towed fairly close to the surface of the ocean. However, extremely long waves, i.e. about 100km long (3kHz) are required to signal to modern submarines at their operational depth.

Conventional antennas are virtually useless as radiators of extremely long waves so non-conventional antennas were developed. For now it is sufficient to say that operational antenna systems typically extend over 160km.[2]

The Earth Ionosphere Waveguide

When wavelength exceeds the distance between earth and the lower ionospheric regions (about 100km), the ionosphere forms the upper part of the waveguide whilst earth forms the lower part. Propagation is likened to waves travelling through a metallic waveguide.

In fact the cavity between earth and the lower boundary of the ionosphere is generally referred to as the earth/ionosphere waveguide. Propagation is as a vertical wavefront and electric field extending from earth and terminating in a complicated way within the ionosphere - see Figure 8.

The technology and use of ever increasing wavelengths was an evolutionary process so superstations have for the purpose of this study been categorised into three generations

First Generation 1906 To 1925

The North Atlantic service was most important (see Map A) and the first viable 'wireless' telegraphy link was Marconi's 1906 Clifden, Ireland to Glace Bay, Newfoundland on 6,600m (45kHz), distance 3,750km. Messages were relayed from Glace Bay to New York and Montreal. Clifden was linked to England by landlines and cable. The Clifden station employed a modified quenched arc transmitter.

In 1906 Fessenden's established his Brant Rock (USA)) link with Machrihanish, Scotland on 5,000m (60kHz), distance 5,000km. Fessenden used a high frequency alternator type transmitter based on the original work by Tesla. The waveform produced by the alternator was suitable for modulation by means a microphone inserted in the antenna lead.

On Christmas Eve, 1906, Fessenden broadcast from Brant Rock his rendering of Handel's Largo on the violin together with a Christmas message. The broadcast was heard with amazement not only by staff at Machrihanish but by wireless operators on ships employing Fessenden equipment crossing the Atlantic Ocean.

Marconi's Clifden station was replaced by the already mentioned Caernarvon station in 1913; this gave a direct link to Canada and the USA via New Brunswick and stations at Tuckerton, New Jersey and the New Radio Central Station, Long Island, USA. The original transmitter employed a

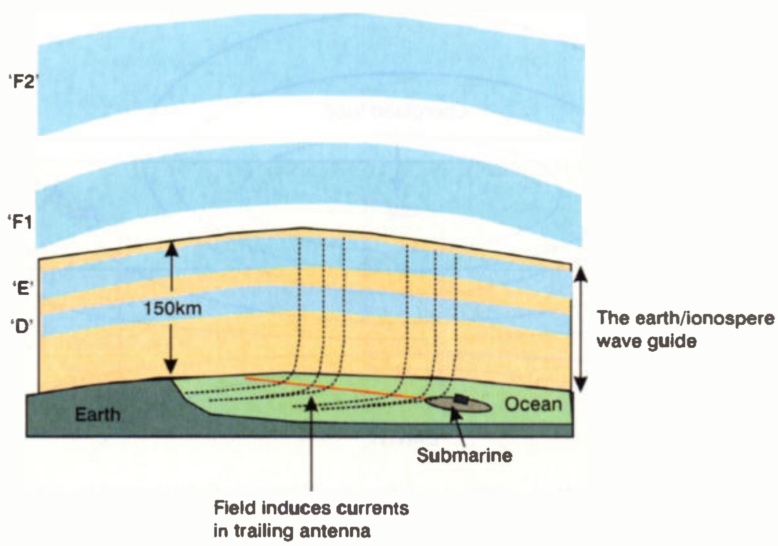


Figure 8. Representation of the earth/ionosphere waveguide. Extremely long waves propagate through the waveguide as a vertical waveguide. The electric field is vertical but bends to become almost horizontal in the ocean and near the surface of the earth. The magnetic field remains horizontal at 90° to the electric field - compare with Figure 2.

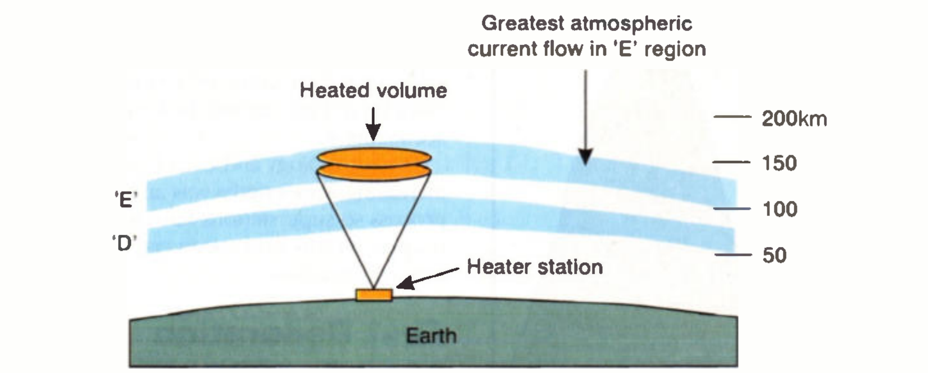


Figure 10. Peturbing ionospheric currents by means of a heating transmitter. Dynamo currents tend to be enhanced in the heated volume by concentrating current streamlines through this region. The changing current flow as the heater transmitter is switched on and off should be detected by induction devices on earth as changes in the dynamo-associated magnetic field.

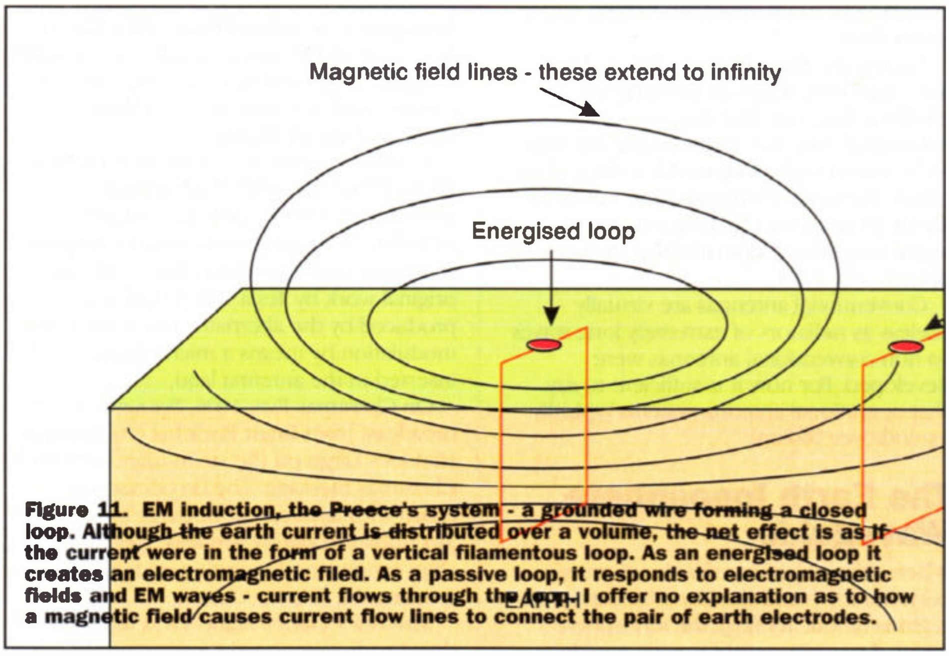


Figure 11. EM induction, the Preece's system - a grounded wire forming a closed loop. Although the earth current is distributed over a volume, the net effect is as if the current were in the form of a vertical filamentous loop. As an energised loop it creates an electromagnetic filed. As a passive loop, it responds to electromagnetic fields and EM waves - current flows through the loop. I offer no explanation as to how a magnetic field causes current flow lines to connect the pair of earth electrodes.

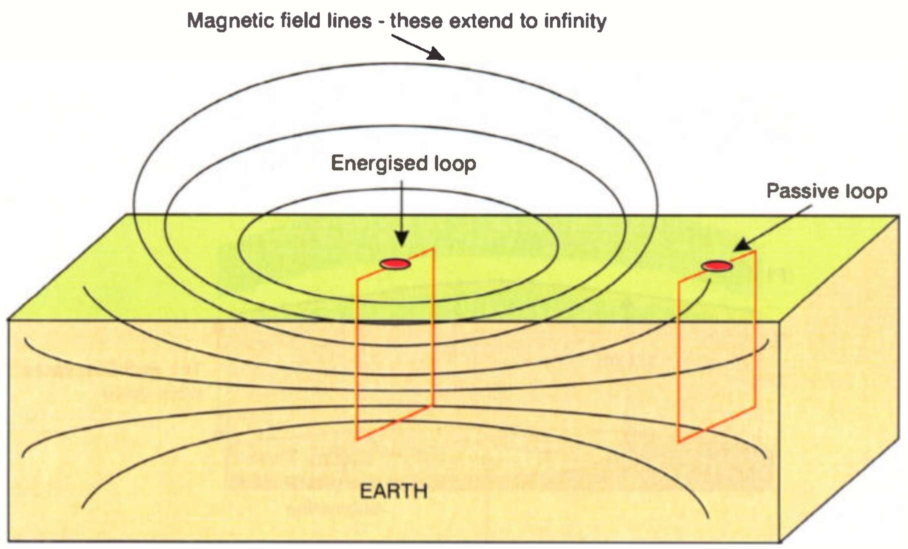


Figure 12. Preece's EM induction system - see also Figure 11. The energised loop produces a magnetic field of doughnut shape that extends through and above the earth. Some field lines cut the distant passive loop and induce a current.

timed spark, but was subsequently replaced by alternators and ultimately valved type transmitters.

In the meantime Germany established a link on 6,250m between Eilvese near Hanover to Tuckerton (USA). Official Wireless Press stations include Portsmouth on 5,000m and Lyons on 12,00m. There were also very long wave stations at Petrograd, Eiffel Tower.

In the Pacific area, a link was established between Honolulu to San Francisco on a wavelength in the order of 5,000m; it employed Poulsen quenched arc transmitters.

In 1919 the Caernarvon station sent the first signals directly to Australia and South Africa notwithstanding that the antennas were directional to North America; the waves apparently continued on a great circle path to Australia. With regard to South Africa, radiation must have been off the side of the antenna.

Indeed, in 1924 work actually started on construction of very long wave superstations in these countries to provide a two-way telegraph link but these were abandoned in favour of short wave systems.

Strategic

The hub of the German Imperial Wireless System was its strategic station at Nauen. MAP C. This station also transmitted official messages to German overseas embassies. Return messages from the USA were transmitted from Sayville (USA). The ultimate Nauen transmitter completed in 1916 employed a 6.0kHz alternator and frequency raisers that increased frequency to 24kHz (12,500m).

Nauen was also linked to a superstation at Kamina, Togoland that relayed messages to Windhoek, German South West Africa and to German East Africa. The allies captured the Kamina station early in WW1. Signals from Nauen were probably received directly by the German garrison at Tsinghau in China from where messages were relayed to German Far East territories. The allies closed Nauen directly after the armistice.

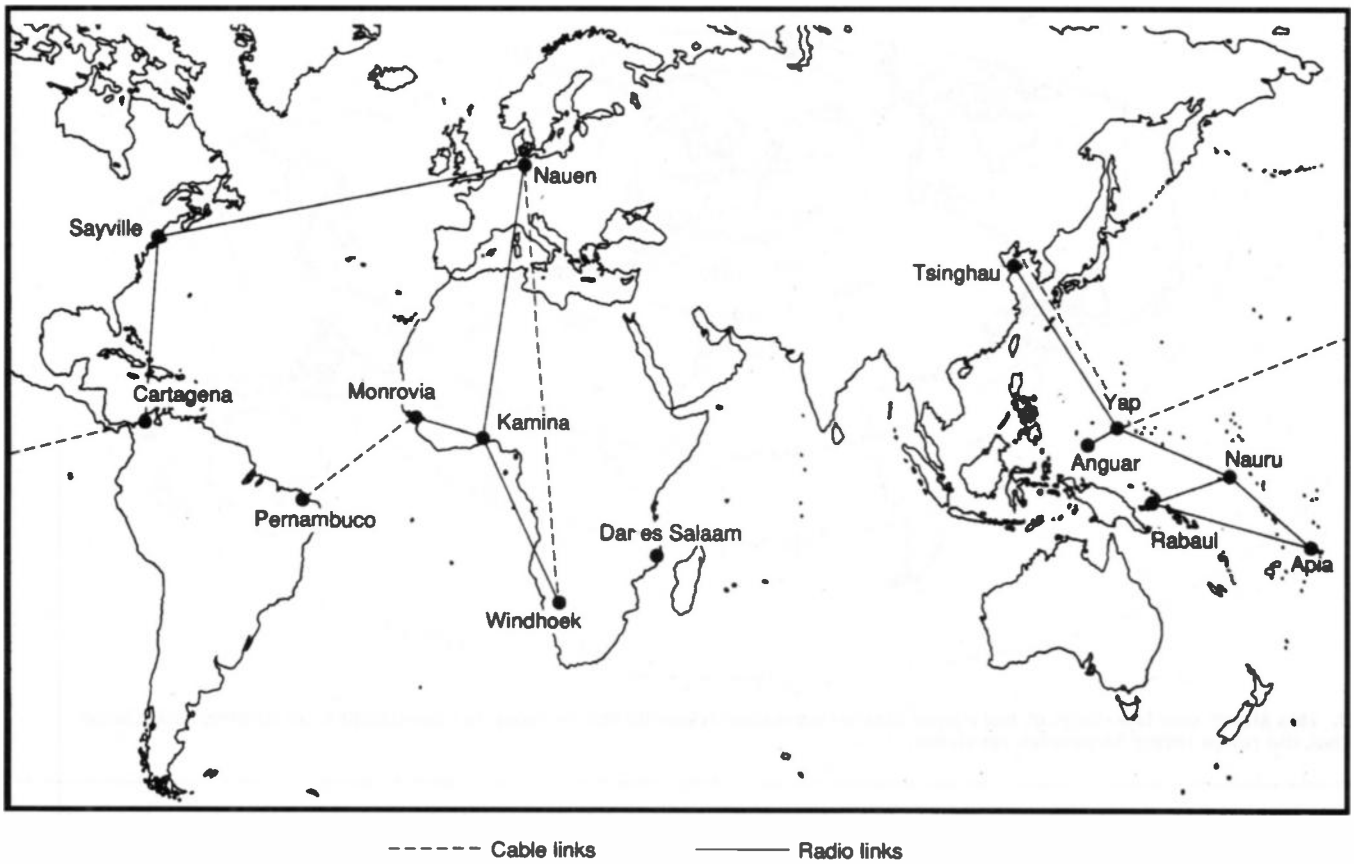
Europe to Africa links also included the Italian strategic link between Coltano and Massaua, which at that time was capital of Italian Eritrea.

In 1906 the Japanese built a new station at Funabashi presumably for signalling to their navy and forces occupying Manchuria after the Russo-Japanese war. I have no information on power or wavelength but from a description of its antenna it would probably be in the order of 6,000m. The philosophy of the Funabashi station seems to have been strategic and its evolution was similar to the Nauen station.

The earlier Funabashi station almost certainly played a role in the sinking of the Russian fleet in the Tsushima Straits in 1904; this would seem to be the first strategic employment of long waves and foreshadowed their role in future naval warfare.

National Security

During their reign, First Generation commercial wireless telegraph superstations



Map C. This shows the German Imperial wireless system 1914. Nauen could be received directly at Windhoek hence dotted line, and possibly at Tsinghau, but normal communication with the far east was via cable from Cartagena to Yap. Reception was with passive receivers.

provided governments with an insurance against possible interference with undersea cables during possible hostilities when the stations could be taken over by the authorities; indeed this was the case with the Caernarvon station during the First World War.

Nonetheless, Britain constructed a chain of medium range relay stations that covered much of the empire during the First World War but the country had to wait until the commissioning of the Rugby station in 1925 for a system comparable with the German Imperial System.

On the other hand, as we have seen, the Nauen station was constructed specifically as a strategic or national security transmitter. Shortly before the outbreak of WW1 the station transmitted instructions for German merchant ships to make for neutral ports. However, the limited range of maritime spark transmitters did not allow the ships to directly acknowledge receipt.

Immediately after the outbreak of WW1, the British cut all German submarine cables forcing the country to rely completely on the Nauen superstation for signaling to its overseas territories. So, the possession of a long range strategic station had been a wise decision.

Second Generation 1925 To Circa 1950

In 1925 Britain commissioned GBR at Rugby; this station radiated waves 18,750m long (16kHz) ostensibly to transmit signals simultaneously to all our overseas territories. But, unlike the inverted 'L' Caernarvon antenna GBR had a modified 'T' type antenna with the horizontal elements forming a figure of '8'. Radiation was principally from the vertical elements so it almost non-directional.

As overseas territories did not have super stations, return messages were transmitted via short wave beam stations. However, a two-way short wave, link with India via a beam station in the UK was also established.

The fact that the field of very long waves penetrated the oceans to an appreciable depth and could be detected by submarines towing underwater antennas was of enormous military and strategic importance. It is therefore reasonable to believe that GBR was a 'Q' station intended primarily for signalling to naval ships and particularly to submarines during an impending war. The fact that these new superstations could also be used for transmission of intercontinental strategic messages was a bonus.

Indeed, during the Second World War, GBR complemented by other British and particularly American superstations played a vital role in signaling to submarines in virtually every part of the globe. Second generation superstations used resonant top-loaded antennas similar to the Nauen antenna. Maximum useable wavelength was about 30,000m (10kHz). The US navy antenna at Cutler Marine was similar to Figure 3, and operated on 15kHz (20km). Height was given as 300m (0.15 wavelength) whilst the ground system covered 4.0km^2.

On the other hand the 'Jim Creek' antenna, Washington, was a catenary antenna suspended across a valley, and had an operating frequency of 12kHz. Catenary antennas were suspended between mountain peaks, especially in the Pacific area during WW2. Wavelength for some stations was given as long as 30,000m; that was about the limit with conventional antennas.

Audible

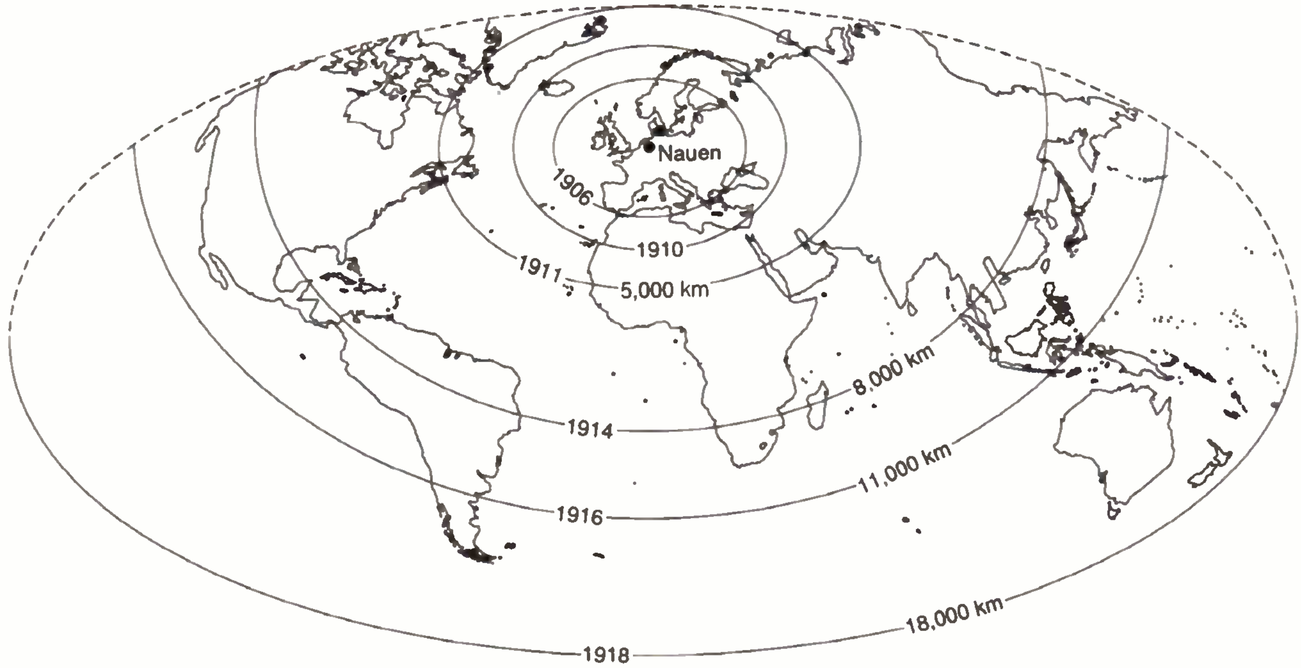
It must be appreciated that frequencies between about 30Hz and 15kHz fall into the audible range so currents induced in telephone lines can cause great interference. However, the interference problem was most pronounced with telephones having an earth return ringing system; this method is now obsolete.

Before the Second World War, as a schoolboy I could just hear GBR on 16kHz with a balanced armature loud speaker connected directly between an antenna and earth. The diaphragms of ordinary magnetic headphones could hardly respond to this frequency.

Third Generation 1960 To Present

Until more recent years it was not considered feasible to radiate energy as em waves at frequencies below 10kHz. Indeed, neither the SSIR nor the FCC made any allocations for frequencies below 10kHz.

Nonetheless, extremely long waves i.e. 3,000km long (100Hz) are necessary to signal to modern submarines at their operational depth. Moreover, total loss at 100Hz in seawater at 100m depth is only about 25dB whereas with waves 30,000m long (very long waves) it would be hundreds of decibels. Moreover, losses decrease further as wavelength is increased.



Map B. This shows how the range of the Nauen station increased following the increase in wavelength from 6,000m to 12,500m. note that the range refers to passive receivers.

So around 1960 Sanguine Project was initiated to study the feasibility of employing waves as long as 3,000km (100Hz). However, because of the problems involved in radiating waves 3,000km long it was decided to concentrate on waves 7500km (40Hz) and 3750km (80Hz) long.

It was calculated that with waves 7500km long the existing US navy antenna at Cutler Marine would radiate only 1.0W for 200MW delivered to the antenna. A new generation of antennas was therefore essential and their evolution is covered in future parts of this study.

For now it is sufficient to say that operational Sanguine antennas consisted of a number of elements forming grid 160km square. But, by feeding the X and Y elements out of phase, radiation could be steered over a wide angle. See Figure 9.

Nonetheless, at 40Hz the radiation of efficiency of the Sanguine antenna is very low but fortunately losses over path lengths of thousands of km are also very low because the wave guide effect confines nearly all the radiated power within the 100km above the earth. See Figure 7.

Experimental: Ultra Low Frequencies

It was known that wave generation and amplification processes occur spontaneously in the magnetosphere; it was therefore suggested that this effect might enable a frequency band between 0.5Hz and 1.0Hz to be used to signal to submarines. Data indicated that at 0.5Hz attenuation in seawater at a depth of 100m would be only 2.5dB. See Figure 8.

However, dynamo currents also flow naturally in lower ionosphere ('E') region so it was deemed more realistic to consider methods whereby these currents could be modulated rather than invoke the magnetosphere. It was envisaged that by modulating dynamo currents at frequencies in the order of 0.5 to 1.0Hz their changing magnetic field would be detectable by submarines fitted with suitable sensors at several hundred metres below the surface.

One of the more realistic methods of modulating dynamo current involved heating the 'E' region with powerful radio transmitters. Heating concentrates the current flow lines and thereby increases current flow and causes changes to the magnetic field.

Signalling would therefore be by magnetic fields rather than em waves. Indeed, if em waves do occur at 1.0Hz and I doubt it, the waves would be 300,000km long and wrap around the earth about eight times. Wavelength at these frequencies is therefore academic.

Remarkably, Tesla whose ideas and patents for 'wireless' transmission of electric power a 'wireless' world wide telegraph foreshadowed the discovery of the ionosphere, apparently installed radiant heaters directed towards the sky on the top of his Wardenclyffe tower!

EM Induction

To conclude this introduction, it is interesting to compare the Sanguine Project and particularly its antennas with pre-Hertzian systems pioneered by Sir W Preece and others; these employed earth loop antennas and em induction. Indeed, before the turn of the last century there were a number of proposals for a transatlantic signalling based on scaled up versions of Preece's system. See Figures 11 & 12.

Moreover, in 1913, Greenleaf Pickard conceived and patented a submarine signalling system that employed conductivity of the actual ocean water as the communications medium.

Next Month..

In part 2 we look at the evolution of the early superstations.

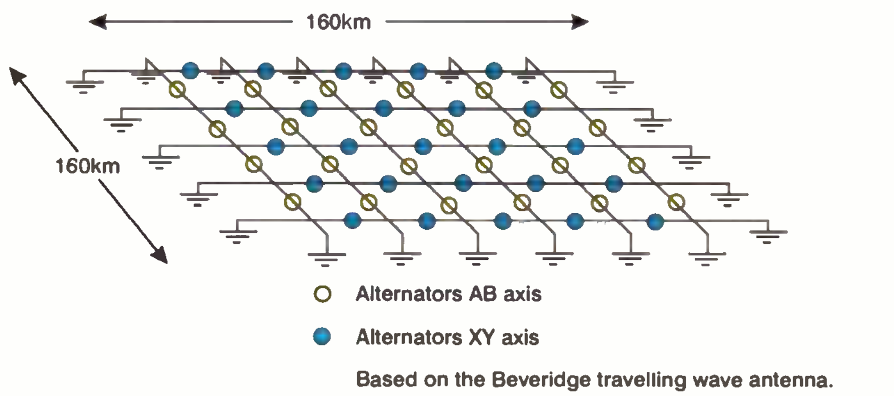
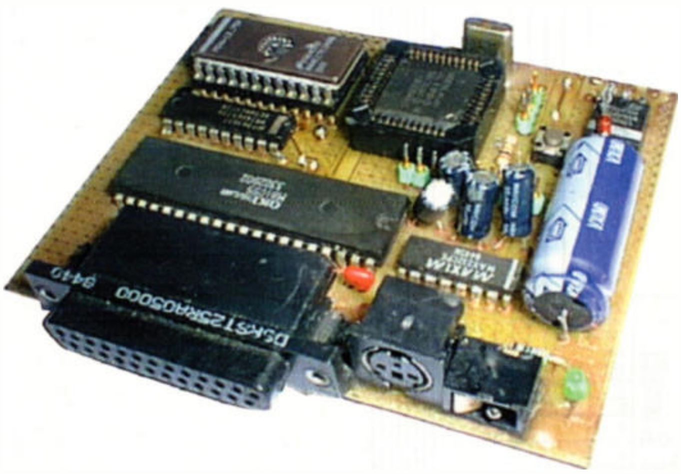


Figure 9. This represents an extremely long wave antenna, and is based on the Beveridge wave antenna. Alternators are spaced along the length of each element to maintain constant current as energy is radiated. Elements are insulated at crossover points. By energising AB and XY arrays in slightly different phase, radiation can be steered over a fairly wide range.

The 8031 SINGLE BOARD COMPUTER

R.Grodzik describes a compact and versatile computer



FEATURES

- PLCC 44-pin 8031 IC
- 8155 PIO 22 port lines
- RS232 interface
- Centronics printer port
- 2Kbyte eprom
- Small size 100 mm x 80 mm
- Collection of simple programs to drive SBC
- Single step and display 8031 registers on a PC
- EPROM emulator required for code development.

Introduction

Although the PIC range of microcontrollers now dominate in intelligent embedded applications, the 8031 8 bit controller has been in use for over 25 years and is still being used in new designs. Why is this so? Unlike conventional micro-processors, the 8031 has many on board peripherals including a UART/USART, two 16 bit timer/counters, an 8-bit bi-directional user port, half a page (128bytes) of scratchpad RAM, 16-bit address bus, 2 interrupt pins, and the ability to access 64 Kbytes of program data (ROM),and 64Kbytes of external read/write RAM. It is equipped with a Formidable instruction set which includes multiply, divide and decimal adjust instruction and a very large stack area so that recursive programs and maths routines can be easily accomplished. Try writing any complex maths routine or code conversion in PIC assembler and you'll see what I mean.

The 8031 uses conventional internal architecture having a main accumulator (A) register, a 'B' register for multiplication and division, together with a bank of 8 general purpose registers (r0 through r7). Approximately 20 special functional registers (SFR's) control the internal peripherals. The short programs listed in this article will hopefully explain how to use each peripheral including the RS232 interface, the printer and use port and high speed communications.

Code Development

For developing the code, the 'TASM' assembler was used and is available in the public domain on the Internet. A batch file - 'a.bat' assembles the ASCII source code as follows:

```
tasm -51 -b -fff try
```

(where try.asm is the filename of the source code)

Use lower case characters, since the source code will be erased otherwise! It is then a simple matter of downloading

SFR_3

The 8031's internal registers:

```
≥ B REGISTER                    F0H≥
≥ A REGISTER                    E0H≥
≥ PSW 'FLAGS'                   D0H≥
≥ IP INTERRUPT PRIORITY         B8H≥
≥ IE INTERRUPT ENABLE           A8H≥
≥ SBUF SERIAL PORT BUFFER       99H≥
≥ SCON SERIAL CONTROL           98H≥
≥ P1 USER PORT P 1              90H≥
≥ TH1 TIMER 1 HIGHBYTE          8DH≥
≥ TH0 TIMER 0 HIGHBYTE          8CH≥
≥ TL1 TIMER 1 LOWBYTE           8BH≥
≥ TL0 TIMER 0 LOWBYTE           8AH≥
≥ TMOD TIMER/COUNTER SEL        89H≥
≥ TCON TIMER CONTROL            88H≥
≥ PCON POWER/SPEED/IDLE         87H≥
≥ DPH POINTER HIGHBYTE          83H≥
≥ DPL POINTER LOWBYTE           82H≥
≥ SP STACK POINTER              81H≥
≥                               ≥
≥                               7FH≥
≥                               :   ≥
≥    BIT / BYTE                 :   ≥
≥ ADDRESSABLE REGISTERS         :   ≥
≥    GENERAL PURPOSE            :   ≥
≥                               :   ≥
≥                               20H≥
≥                               1FH≥
≥ BANK 3 R0 - R7                    ≥
≥                               18H≥
≥                               17H≥
≥ BANK 2 R0 - R7                    ≥
≥                               10H≥
≥                               0FH≥
≥ BANK 1 R0 - R7                    ≥
≥                               08H≥
≥ REGISTER R7                   07H≥
≥ REGISTER R6                   06H≥
≥ REGISTER R5                   05H≥
≥ REGISTER R4                   04H≥
≥ REGISTER R3                   03H≥
≥ REGISTER R2                   02H≥
≥ REGISTER R1                   01H≥
≥ REGISTER R0                   00H≥
```

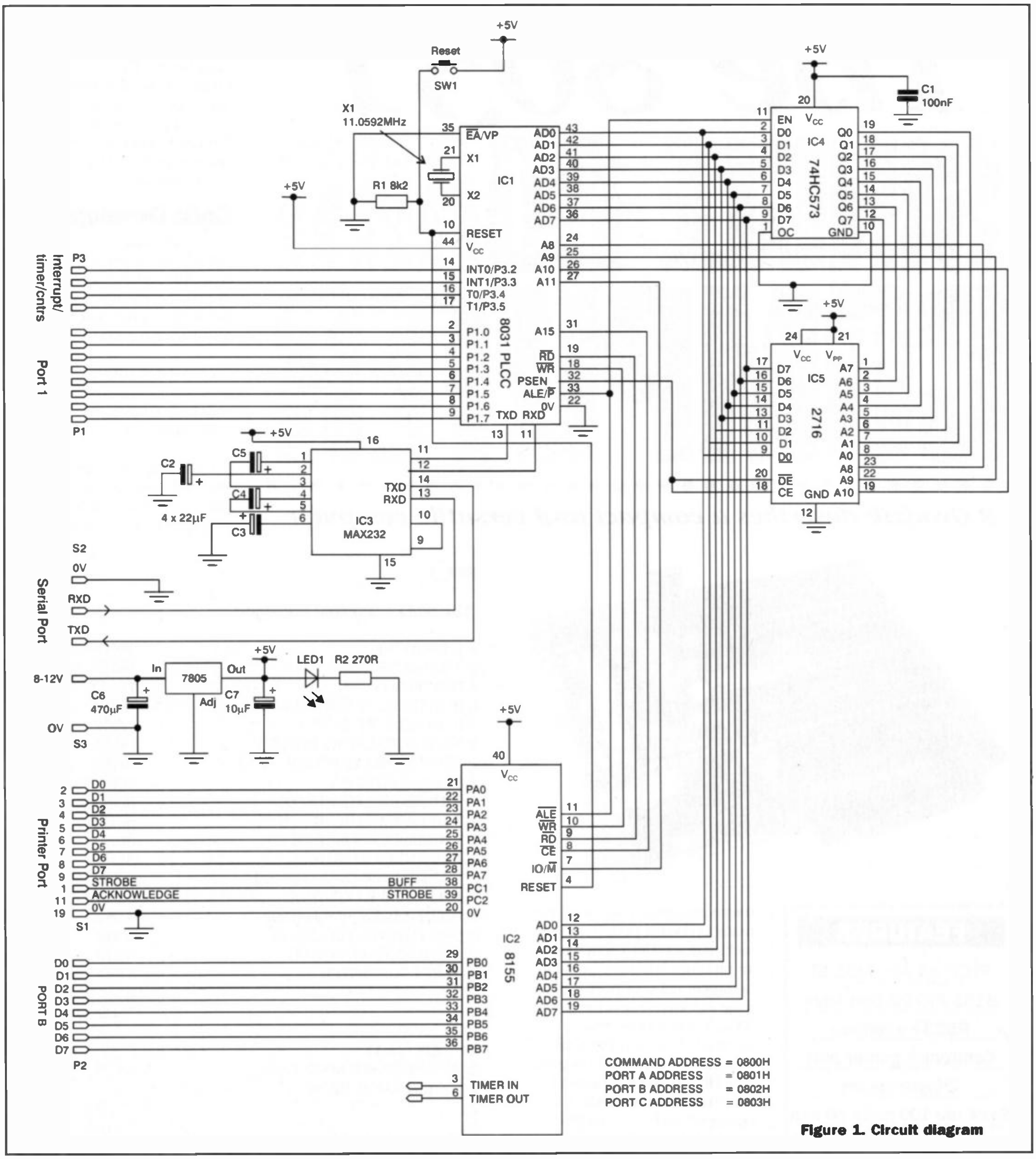


Figure 1. Circuit diagram

the filename OBJ code from the PC via an EPROM emulator to the 8031 SBC. All source code examples used in this article, together with the list and object files are included on the author's web page:

http://members.netscape online.co.uk/dgrodzik

Construction

The 8031 SBC is constructed on a single sided PCB with a couple of wire links. Note that a 0V ground plane has been used to reduce the effects of E.M. transmission. Most of the components are available from the usual sources with the exception of the 81C55 PIO, and the 80C31 PLCC package obtainable from Farnell or R.S. Components. Current consumption is low since CMOS components are used throughout and a heatsink for the 7805 (500mA rating) is not required, providing the input DC voltage does not exceed 8 or 9V. The 8031 possesses a 'sleep mode' during which the processor control lines adopt a high impedance state and all activity ceases, reducing power consumption to a couple of milliamps.0.1" header pins are provided for connections to the various port lines, and for the attachment of a logic probe which will be indispensable in checking for the functionality of the newly constructed board.

Architecture

The 8031 SBC adopts a conventional micro-processor type architecture with a lower order Multiplexed data/address bus. The 74HC573 octal latch demultiplexing to produce a 16-bit address bus (a0 through a15) and an 8-bit data bus (d0 through d7). A 2Kbyte wide EPROM area (27C16) contains the user code and is addressed via the PSEN (program select enable line) of the 8031.For external peripheral accesses, the read (RD) and write (WR) lines are active - the PSEN line remains high. The 81C55 PIO with 256 bytes of internal RAM is selected via the chip enable

(CE) and the input/output (IO/M) line, a high on this line selects one of three ports- A B or C. Port A of the PIO is used for the centronics printer interface to which a standard PC printer cable may be attached with no modification. A serial communications facility is provided by the 8031 - pins txd and rxd interface directly with the MAX232 RS232 voltage convertor. Finally a bidirectional user port is provide by the 8031 (port P1). Note that these port lines (P1.0 thru P1.7) need buffers to light LEDS etc. since they cannot provide a large source current. The same applies to the PIO port B and C port lines.

Programming

The power of the 8031 lies in the fact that it is bit addressable, unlike conventional microprocessors whose 8-bit registers are byte addressable. This means that a single port pin can be set, cleared or complemented. The 8031 contains a 256 byte high internal 8-bit block, divided in half - the bottom range (addresses 20H to 80H)are general purposes 1-bit registers organised in byte wide addresses. The lowest address range (00H to 1FH) contain four banks of identical registers (R0 through R7) which are switchable and on which many instructions operate, so that the programmer doesn't have to rely on a single accumulator for complex manipulations. The upper half of the 256 byte block (see diagram SFR_3) contains the 'Special Function Registers' or SFRs which define the operation of the 8031's internal peripherals. Each of the SFRs are dedicated to a particular function, e.g. The SCON SFR configures the USART, and the description of each SFR will be described in subsequent programming examples.

Some of the SFR's have been given a different name adapted by most microprocessor manufacturers and will be mentioned now.

PSW - The Program Status Word is equivalent to the normal Flag register - the condition of the bit flags dependent on the results of instructions.

SP - The Stack Pointer used in PUSH POP and calling subroutines, is initialised to address 8 and grows upwards into the stack which is shared by the bit addressable lower block of internal memory.

DPH and DPL - Data Pointer high and low, form together a 16-bit address pointer for reading and writing to external memory.

The above SFRs have one address allocated to the 8 bit wide register. Each SFR contains 8 bits, each having a bit address, so for example. The user port P1 (SFR address 90H) individual bit addresses are from 90H to 97H i.e. address 97H corresponding to the most significant bit position (P1.7).

In common with most micro-processors, the 8031 has several interrupt vectors as follows:

- Reset at address 0000H - This is the first address placed on the address bus by the 8031 on powerup or reset, and accesses the first opcode in external ROM.
- INT0 - An active low interrupt input pin causes the program counter to vector to address 03H
- INT1 - An active low interrupt input pin causes the program counter to vector to address 13H Both pins may be used as conventional IO port pins.(addresses B2,B3)
- T0 -This pin has a dual fuction. It can act as a counter input for a 16 bit counter or may be used as a bidirectional IO pin. Whenever Timer 0 times out i.e. rolls over from FFFFH to 0000), the processor vectors to address 0BH
- T1 -This pin has a dual function. It can act as a counter input for a 16 bit counter or may be used as a bidirectional IO pin. Whenever Timer 1 times out, the processor vectors to address 1BH.

The serial interrupt vector occurs at address 23H whenever a byte is received or transmitted to/from the serial buffer, providing the interrupt mechanism has been enabled.

The use of an 'equate' table in the programming examples means that the address of a particular SFR or a 8031 pin does not need to be calculated by the reader, since the actual name of the pin is used as the OPERAND. For example the instruction:

```
CLR P3.4
```

will clear the T0 pin (clear to logic low)

Continued next month

Creating the ARTIFICIAL EYE

Douglas Clarkson looks at some of the remarkable developments in this field.

Introduction

The concept of the artificial retina became established in the 1960's. What characterises work now, perhaps, is that across a number of research groups working in this field, clinical trials of devices if not already being undertaken are planned within a year or two.

While developments with arrays of photodetectors and software algorithms to process the data produced by them tend to be fairly rapid, the process of integrating these technologies into a complex biological environment - namely the eye - is the major factor now determining the rate of progress. Also, new surgical techniques in ophthalmology, and also now in brain surgery, require to be developed.

It is quite clear that current approaches for development of 'artificial retinas' fall a very great way short of replicating the visual 'intelligence' of the human retina. Work carried out by Carver Mead in the USA during the mid 1980's, primarily in the context of neural network developments acknowledged the broad range of sensory functions that were undertaken by cells in the retinal structure. (It is interesting to relate that carver Mead has just announced the development of the 'Foveon' VLSI image capture system that takes a 48Mbyte 4000 x 4000 pixel Photoshop file without any interpolation.)

In the sensory process, for example, some cells would detect motion while some cells would be sensitive to the local average light intensity so that the higher cortical levels did not have to 'think' about the structure of the image that was being projected. In terms of selective evolution, the retinas of frogs are designed to 'see' insects and little else.

A large part of the image processing has therefore been undertaken before the nerve impulses pass into the optic nerve. Also, the surprising thing about the human retina is that its image processing function changes with different levels of light, so that rod and cones can 'pool' their signals at low light levels yet while exhibiting a more singular identity at higher levels. The basic structure of the retina is indicated in Figure 1.

The current level of visual stimulation of the retina, optic nerve and also of cortical stimulation in present 'artificial retina' projects are therefore seeking only to replicate the most basic of visual functions. Even a visual field of an array of 10 by 10 dots would be seen as a great step forwards. The development of the work of artificial retinas and early work with direct electrical stimulation of retinal surface reveals in many ways the absolute miracle of normal vision, and in particular the spatial mapping of points on the retina to points in our perceived visual field.

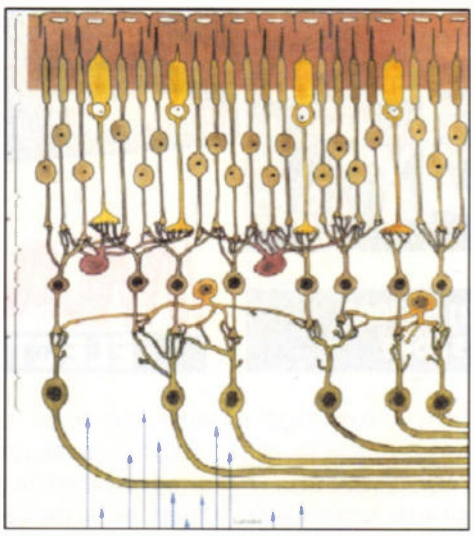


Figure 1: Basic structure of the retina. As light enters the retina structure, it has to first pass through the outer layer of cells to interact with the photoreceptors. Nerve impulses then travel outwards from the photoreceptors to pass along the layer of ganglion cells towards the junction at the optic nerve.

Previous Clinical Experience - Cochlear Implants

There is of course a very close parallel with cochlear implants, where externally received sound is translated into a sequence of electrical stimulation on a multicomponent electrode that is inserted inside a patient's cochlea. In this way, with the nerve endings still intact within the cochlea, the processed signals are designed to mimic the normal response of the cochlea. The actual signal boundary between the external sound detection/processing and the inner stimulation system is in fact inductive so that 'no wires show'. This also has the benefit of reducing problems of cross infection and wearer acceptance, especially when most recipients are children. The external signal detection system is shown in Photo 1.

The success of the artificial cochlea, however, is quite remarkable in that most implants have around six to twelve discrete electrodes, showing that there is massive redundancy in provision of nerve cells for the very basics of auditory perception.

The challenge of 'wiring into the retina' has some obvious similarities with that of the cochlea. The most immediate problem, however, is that of the complexity of vision. While in the cochlea there may be around several million nerve cells that link and communicate to the auditory nerve, in the retina this number expands to about 120 million rods and cones. In the process of signal processing, bipolar cells and then ganglion cells translate the photoreceptors

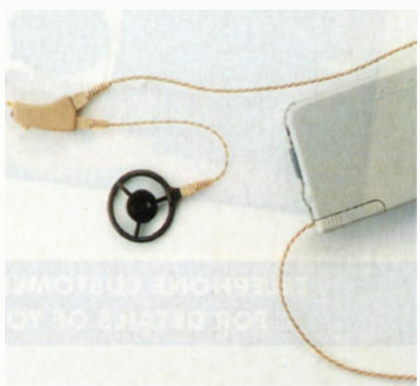


Photo 1: External stimulation system for Cochlear Implant. Streams of nerve impulses are coupled into the receiver coil that in turn drives the implant electrodes in the cochlea.

signals for onwards transmission to the optic nerve which alone carries around one million nerve fibres to the brain's visual cortex.

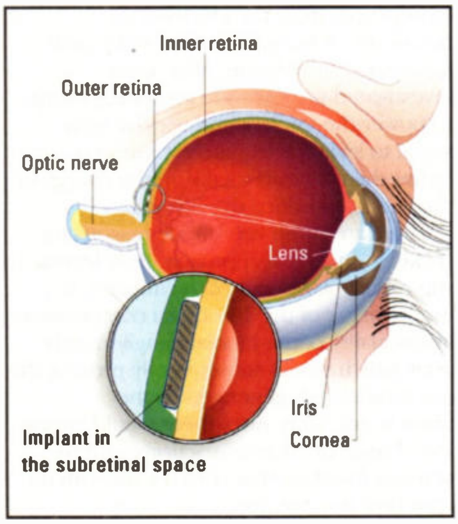
While there has been continued interest in direct implantation to the visual cortex via the brain, most current programmes of 'artificial vision' design propose to use interfacing across retinal based structures - with stimulation across areas of retina where rods and cones have atrophied but nerve cell connections are in place. This is principally because the spatial mapping on the retinal surface is better preserved than on the exposed surface of the visual cortex in the brain. There will always be some requirement for direct brain implant systems since patients may have no viable retinal structures available for retinal implant. Recently, there has been developments in the field of direct stimulation of the optic nerve so on this basis the range of competing ideas has increased.

The approach of direct stimulation to nerve cells that are still active on the retinal surface has a distinct advantage in terms of maintaining the direct 'one to one' mapping between point of physical light stimulation and point of perception of signal within the patient's visual field. It is anticipated, for example, that if an array of photodetectors was presented on the retinal surface with the letter E, then this would in fact be the pattern seen by the patient as dots of light on a dark background.

What seems to be emerging in 'artificial retina' research is a process of developing solutions against a backdrop of patient histories and conditions. Solutions would seem to be more readily available in the form of retinal implants for patients where loss of cone and rod cells due to conditions such as retinosa pigmentosa and macular degeneration leaves essentially nerve cell functions intact. It is quite obvious - as with the process of cochlear implant - that the ultimate success of such procedures is dependent on the skill of the surgeon.

North Carolina State University/John Hopkins University Team

Initial analysis by Dr Mark Humayun and Dr Eugene de Juan of John Hopkins University



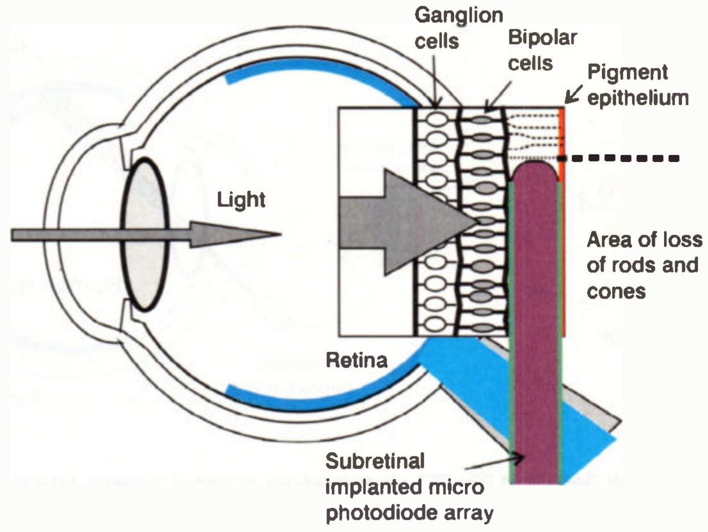


Figure 2: Process of sub retinal implantation where the retinal implant is placed in the gap previously occupied by photoreceptors. Using this method, the stimulus signals will still be processed by the intermediate layer of nerve/ganglion cells.

on preserved human eyes subject to retinosa pigmentosa revealed that while indeed there was a near total absence of photoreceptors as expected, there still remained between 30% and 80% of other retinal carriers intact. This work was undertaken out of curiosity about being able to provide treatments for such degenerative diseases. It was necessary, however, to test ideas out on a patient to see if the remaining nerve and ganglion cells were still functioning.

In September 1992, initial stimulation studies were undertaken with a probe placed in contact with a patient's retina. When the probe was activated, the patient did indeed see a dot of light. This was later repeated in another patient where three distinct spots of light could be produced from three separate probes with an edge to edge separation of about 300 microns. The anxiety had been that electrical stimulation of the retinal surface could have stimulated much larger areas and thus not provided any useful ability to relay spatial information. The work indicated that such highly localised electrical stimulation did in fact produce a correspondingly localised visual signal.

Subsequent clinical investigations allowed testing with arrays of increasing complexity. In 1996 a five by five array was tested and the patient was able to distinguish fairly well basic shapes produced using the grid pattern. The success of these clinical experiments has provided the necessary impetus to encourage other groups to develop their own specific solutions to the artificial retina problem.

This led scientists to speculate that appropriate electrical stimulation of these signal pathways could provide a means of restoring the basics of vision. Work in developing an artificial retina in association with the Dr Mark Humayun and Dr Eugene de Juan is centred round the activities of Dr. Wentai Liu, professor of electrical engineering at North Carolina State University and Elliot McGucken, originally a doctoral student at UNCCH.

Designs for this particular installation appear to show the implant directly against the exterior of the ganglion cell interface (epiretinal), so that light has to travel into the implant and electrical signals appear on the opposite surface. This is in contrast to the German MPDA project. Here the implant is planned to be inserted in the area where photoreceptors have been destroyed by disease, and where the 'contact' surface has both to serve as the sensitive area of light and also the surface for derived signal contact with the nerve cells.

Options exist for supplying power to the implant by means of a laser attached to a pair of glasses. It has been difficult, however, to the attract funds to undertake the research and applications to National Science Foundation and National Institutes of Health proved initially unsuccessful though some funding has latterly been provided by the NSF. There is caution in anticipating the degree of vision that such developments may make possible. But it has to be remembered that for the totally blind, even a small component of vision is a major advancement.

Developments in Germany

In Germany two separate consortia 'MPD-Array' and 'EPI-RET' are active. The EPI-RET consortium consists of 14 partners and is co-ordinated by the main development centres in Bonn and Duisburg. The 'MPDA' consortium is chiefly based at the University of Tubingen. The German Federal Research Ministry (BMBF) - to the tune of $10 million - will fund both groups over a five years period.

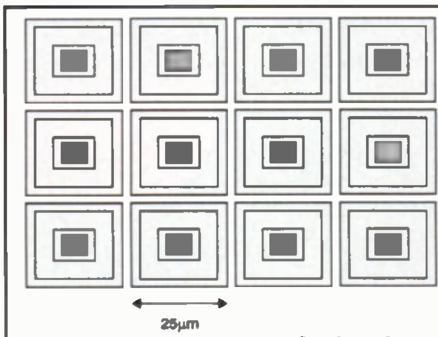


Figure 3: General design of sub retinal silicon array. The surface in contact with nerve/ganglion cells is required to convert light into electrical signals and communicate these signals into the nerve pathways.

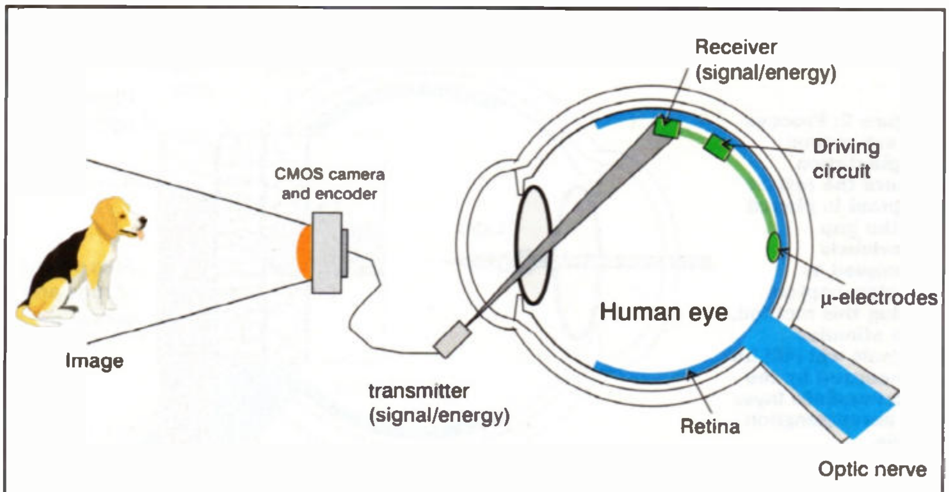


Figure 4: Design of EPI-RET system where external camera data is transmitted optically and electrode array transfers data to retinal surface.

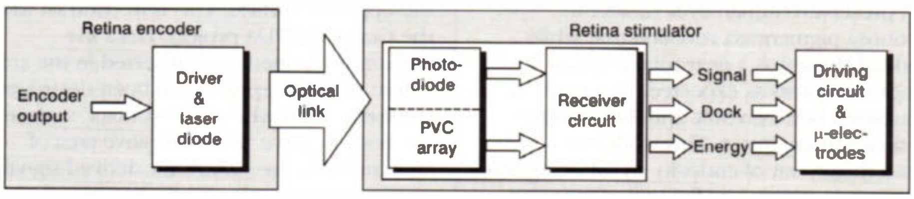


Figure 5: Block diagram of function of EPI-RET system.

The MPD-Array Group

In this approach it is intended to implant a layer of photoreceptors into the subretinal space as shown in Figure 2, and for the remaining nerve cells to be stimulated by the process of light incident on the photodetectors.

One major consortium based at the University Eye Hospital at Tubingen, Germany is actively pursuing the technique - described as 'subretinal implanted micro electrode array' - or MPDA. The film is inserted into the layer previously occupied by rods and cones. Light incident on the retina actually has to pass through the layers of ganglion and bipolar cells to reach the photosensitive layer. Also, the nerve impulses travel out along the layer between the ganglion cells and the vitreous of the eye to the optic nerve.

One immediate problem of such an implant is that it should be as thin as possible. Relatively thick structures tend to cause atrophy of the structures on either side. The use of thin flexible foils will allow contours of the retinal interface structure to be followed without creating localised areas of increased contact pressures. Also, there is the need for assistance with biocompatability of the surface structure - so that a lattice structure is desirable - allowing fluids to circulate across the boundary where the film implant is inserted.

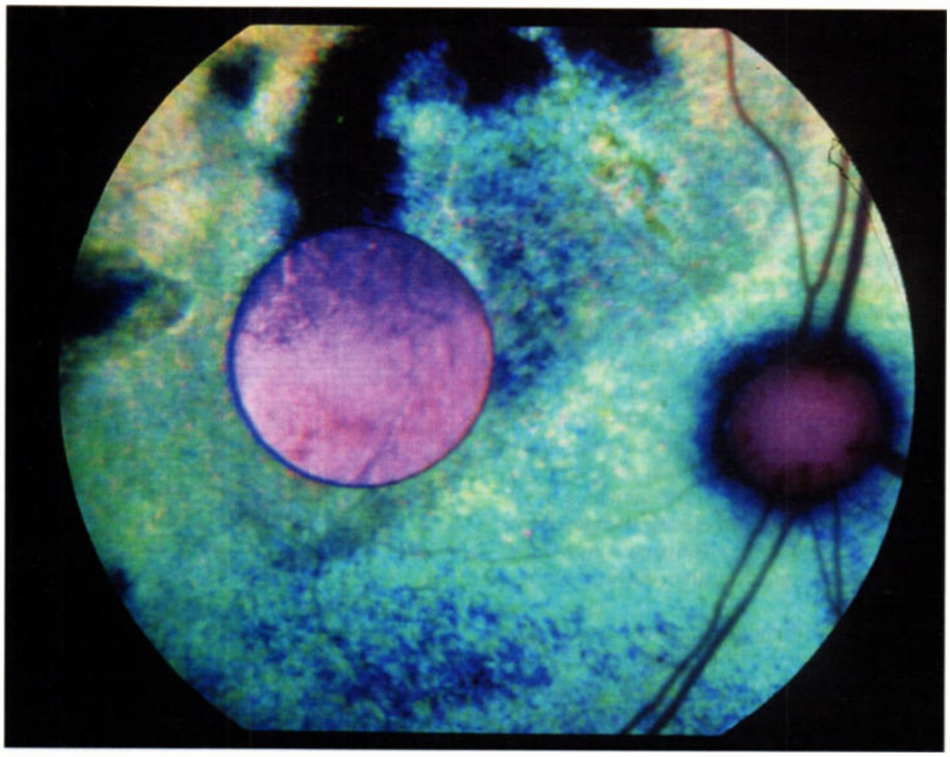
The fabrication of the prototype artificial retina has been undertaken by the Institute of Micro-Electronics at Stuttgart and consists of a disk some 3 mm in diameter with a total of 7600 microelectrodes arranged in a checkerboard like distribution. The total disc thickness is 50 microns and each discrete electrode occupies an area of 20 microns by 20 microns. Figure 3 indicates the general design of the array elements. Each photoelement requires having a stimulation electrode to contact the layer of bipolar cells. Typically these are some 8 x 8µm in size and are fabricated in either gold, iridium or titanium nitride. The actual array surface consists of silicon oxide that is permeable to light and also electrically isolating.

Second generation devices have alternate patterns of positively and negatively charging photoreceptor elements in order to allow adjacent nerve endings to be either positively or negatively charged. This should allow stimulation of bipolar cells sensitive to 'light on' and 'light off' conditions. In a further modification of this design, crystalline silicon is being embedded in soft plastic fabrics or nets in order to allow unhampered flow of essential cell nutrients within the retina structure.

One of the key issues of successful signal generation is the close contact of nerve cells to the implant interface. At distances greater than one micron, current tends to dissipate into the surrounding tissue and not along nerve cell pathways. One approach to improve nerve cell connection is to coat the surface of the MPDA with specialist protein molecules (poly-L-lysine) which in turn establishes a pattern for nerve cell attachment. Such technologies, moreover, are bound to have application across many areas - for example in spinal injury treatments where external nerve conduction is under development and perhaps even further in the future direct nerve to nerve repair processes.

While there is growing confidence of the ability of photodiode detectors to establish nerve conduction, it is anticipated that the levels of light from normal vision processes - of the order 1 to 5,000cd/m^2 - are not sufficient to initiate nerve conduction. Solutions will require further development to improve either the efficiency of detection, or increase the level of retinal light signal stimulation. Also being investigated is to provide additional energy to power the implant and use the light signal to switch adequate excitation pulses rather than depend totally on the energy of the light to produce the signals.

There are some very subtle reasons for seeking to use this approach. By selecting a sub retinal placement of the implant, use can be made of the 100:1 data compression functionality of the bipolar/ganglion cells array which would subsequently process the electrical signals generated by the photelectric array. Also, there would appear less chance of adverse reactions with the vitreous interface that could occur with the epiretinal implant approach.



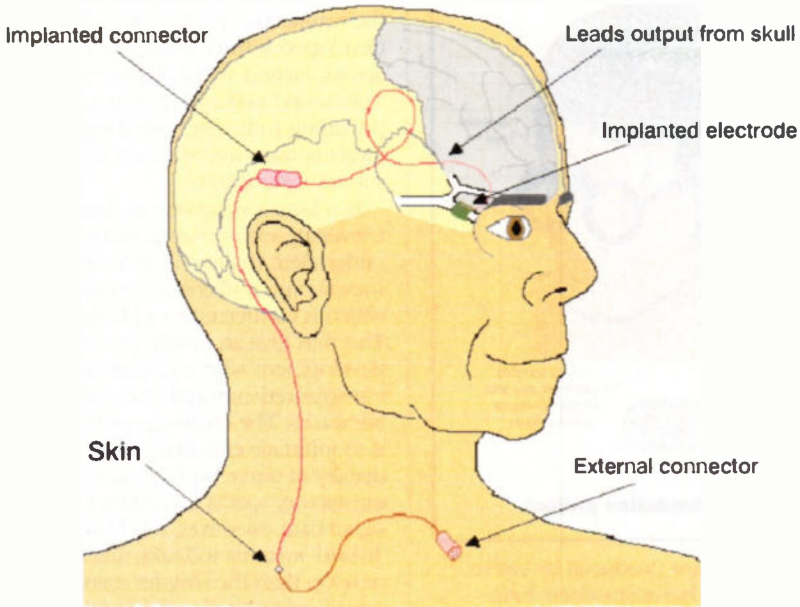


Figure 6: Unique implant system of optic nerve stimulation method as developed by a team at the Neural Rehabilitation Engineering Laboratory in Belgium

The EPI-RET System

The EPI-RET approach is summarised in Figure 4 where an external camera system translates images into digital format for mapping to the implant at the ganglion cells interface. It is intended to match the visual input to appropriate ganglion stimulation through use of neural network adaption of the processing network. This solution is therefore seeking to relay an array of derived and processed signals rather than the directly driven signals in one to one correspondence as with the conventional retina. The function of the system is indicated in Figure 5.

It is interesting to relate, also, how the very rapid march of optical data transmission is being applied to develop solutions for the artificial retina. It is proposed to use a CMOS camera to capture data which is then encoded digitally and transmitted using optical decoding at a rate currently of 1Mbytes/sec. Part of this signal is also a light beam which is converted to electrical power to power the implanted electronic assemblies. Up to 5mW of power is supplied to drive the electronics in this way. The implanted electrode array impacts directly onto the ganglion cell interface. The material used in the receiver array is that of GaAs in order to achieve high conversion efficiencies - of the order of 23% at a wavelength of 800nm. It is estimated that efficiencies can be further increased to 31% by encapsulating the cell array within a biocompatible anti-reflection coating. This implies that the total optical input power into the eye will be of the order of 15mW.

There would appear to be scope for transmitting data at least up to rates of 1Gbits/s, so there is future scope for transmitting and decoding more complex image data. A system of neural networks in the image processing system will allow training of the system to provide optimum visual perception.

Optobionics: Dr Alan Chow of Wilmer Eye Institute, USA.

The Optobionics Corporation in the USA, is essentially developing a stand alone 'Artificial Silicon Retina" - some 3mm in diameters, around 25(m thick and contains more than 7000 microphotodiodes. Clinical trials are expected to begin during 2000.

Dr Chow's design has a high level of spatial resolution and is simple in that it doesn't require image coupling or a power source. It is designed to be positioned in the sub retinal space

- similar to that of the MPDA array group in Germany. Dr Chow's confidence in the sub retinal site selection relates to using the ganglion/nerve cells in place to process/amplify the input signals. If this approach works, it offers the simplest approach to retinal implant technology.

The MIT/Harvard Team

A separate team involving John Wyatt, professor of electrical engineering at MIT and Joseph Rizzo, a neuro-ophthalmologist at Harvard Medical School, is also active in developing artificial retina systems. From initial beginnings in 1988, the final system design is developing where an initial camera image mounted on a pair of glasses is projected to a retinal implant and with

power being provided by a laser beam. The implant would be in 'epiretinal' position with photodetector area facing outwards towards the pupil and the electrode surface in direct contact with the ganglion cell interface. Wyatt is hopeful of modulating signal levels to create various shades of grey. Initially it is planned to implement a 10 by 10 grid array.

Optic Nerve Stimulation - University Catholique de Lovain

A team at the Neural Rehabilitation Engineering Laboratory in Belgium has successfully implemented an optic nerve stimulation system based on a patient implanted on February 5th 1998.

Figure 6 shows the system of interconnection used, where a special electrode is placed in contact with the optic nerve of the patient's right eye and connections fed within the brain to an external connector linked to image processing systems.

Initial work has proved the validity of stimulating broadly throughout the visual field. According to initial reports, thousands of 'phosphenes' are created when vision is excited and simple pattern discrimination is possible. Changing the stimulating conditions can alter the nature of the perceived visual field. The electrode is essentially providing a single channel of signal stimulation. While the project is researching ways and means into restoring lost vision, it is also providing a marvellous insight into the mechanisms of our vision processes.

The actual final 'concept' product is indicated in Figure 7. Here the artificial 'eye,' as a CCD camera, transmits data to an external processor which in turn transmits 'under the skin' to a stimulator device, which is in turn directly connected to the spiral cuff electrode on the optic nerve. This mode of operation has similarities with the mechanism of implementing cochlear implants.

The project is very dependent on the role of trial patients in assessing the various modes of image processing of the images and driving of the pulse trains. The project is funded under an Esprit project and has numerous European partners, although none in the UK. The workers in this project are clearly delighted with the progress of their project. There is a very real chance of significant additional progress being made as R&D across a wide European spectrum becomes applied to the problem.

Brain Implant Systems

It is interesting to reflect that it was initially work undertaken in the UK by G. S. Brindley that began research in this field. An important initial milestone was the implantation of 80 surface electrodes connected to 80 radio receivers in 1967 of a blind 52-year-old patient.

The main aim of such projects appears to have been to improve patient mobility - to provide some small element of interacting in a visual context with their surroundings. The actual process of installing an electrode array on the visual cortex using modern implant materials is not considered a major surgical procedure.

The work on direct brain implantation/ stimulation using directly connected electrodes developed out of routine neurosurgery procedures where patients were undergoing neurosurgery on their occipital lobe under local anaesthesia to

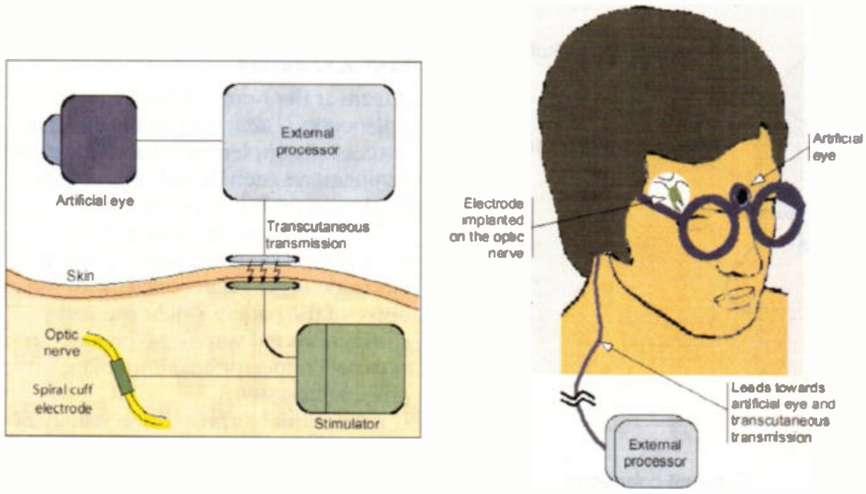


Figure 7: Final 'concept' product of the Belgian optic nerve stimulation project.

remove tumours and other lesions. Starting in the period 1970-1972, the visual cortex of three blind volunteers was stimulated for a few days after surgery by means of in situ wound drains. This work indicated the value of installing permanent electrodes and subsequently a total of eight volunteers were implanted with permanent electrodes. Implantations were mainly undertaken in the University of Western Ontario, London, Canada and with two procedures being undertaken at the Columbia-Presbyterian Medical Center in New York City.

There has been recent publicity in connection with a 62-year-old patient whose initial implant was undertaken in 1978. The nature of the research has been essentially to process the TV camera image into a suitable pattern for direct detection by the implanted visual cortex electrode array. The present system, which has successfully afforded the patient some element of object recognition, is effectively a fifth generation version using state-of-the-art image processing software which has only recently become available.

The electrode system resembles an 8 x 8 rectangular array and is directly located on the mesial surface of the right occipital lobe. The fine platinum electrodes, which form each electrode site, are 1 mm in diameter. A separate ground plane is established around the electrode array site in order to provide an additional measure of electrical safety.

Stimulation of each electrode produces up to four closely spaced 'phosphenes' or dots of light. Seen in a spatial mapping context, the stimulation appears to produce dots of light in an area 8 x 3 inches at arms length. Also, this mapping has been essentially stable over the last two decades. Such maps produced by earlier volunteers and other researchers have tended to produce larger, more two-dimensional maps. It is likely that future implant systems will include additional 256 surface electrodes to increase the resolution of the system. In general terms it is estimated that an array of 256 electrodes based on 3mm centre separation is possible for each visual lobe. There are also additional sites for stimulation of visual association cortex though such placements would be more difficult to use due to more complex spatial mapping patterns.

Other Developments

Work at the Moran laboratories in Applied Vision and Neural Sciences is also developing direct cortical implants. One device, which has been developed, is a silicon electrode array in a 10 x 10 design with electrodes 1.5mm long, and separated by 0.4mm. The transcranial interconnect may be by direct link, or through radio frequency signalling. The use of radio frequency link would reduce problems of infection during the lifetime of the implant and would even provide in the longer term the provision of a second 'intelligent' interface inside the brain. Included in the electronic architecture is a means of improving mapping of image field to cortical stimulation pattern.

Researchers at Stanford University have recently developed a new synthetic cell membrane that will adhere to both living cell and semiconductor surfaces, and will enhance the efficiency of retinal implant devices.

The field of artificial retinas is developing in a wider context of developments of image projection systems. So called VRD technology, indicated in Figure 8, is being developed where an 'image' in the form of a scanned point of light is scanned across the retina. This technology is being developed with potential wide application across current visual display requirements. This would perhaps provide a means of providing sufficient optical signal level for direct stimulation of either an epiretinal or sub retinal implant.

In a Japanese project at Nagoya University, experimental work has been undertaken to grow animal nerve cells (newt) onto a silicon array of 64 elements which is connected to a photodiode array. This may give an insight into future lines of development where patient nerve cells are transplanted/cultured onto silicon interfaces. The challenge of this approach is to interface effectively with the high density of nerve bundles and provide satisfactory spatial co-ordination of the signal data. However, it is likely that such 'hybrid' systems will take much longer to develop than the simpler epiretinal/ subretinal implant techniques.

Summary

In terms of predicting when retinal implants may be offered as a routine, - funds permitting - some operators are indicating as soon as 2010. But what we are witnessing is the development of the new field of Neurotechnology. While the developments so far described have been in relation to visual systems, this technology can be applied to numerous sensory/neurological problems where it is required to interface electrical signals to various layers/interfaces of the body's complex sensory system.

Further Reading

The development of subretinal microphotodiodes for replacement of degenerative photoreceptors, E. Zrenner et al, Ophthalmic Research, 1997;29,269-280

Visual sensations produced by optic nerve stimulation using an implanted self-sizing spiral cuff electrode, C. Veraart et al, Brain Research 1998, Nov 30; 813(1):181-6

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Retinal Implant News in Bonn with links to other sites http://www.nero.uni-bonn.de/ri/retina-en.html

Japanese site with links to other groups. http://www.cmplx.cse.nagoya-u.ac.jp/research/retina/

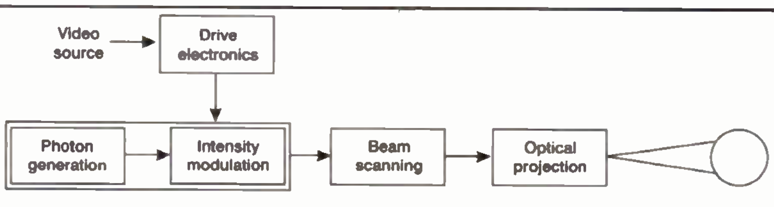
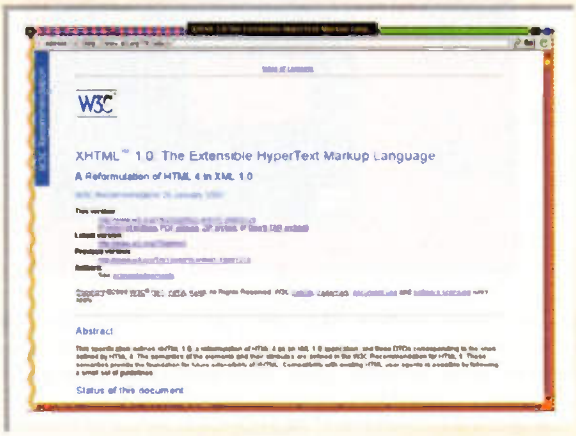


Figure 8: Example of VRD technology where image is scanned on the retina to give the appearance of 'live image'. This technology may allow stand alone retinal implants to stimulate retinal nerve pathways successfully.

XHTML



While the whole world knows what HTML - hypertext markup language - the language of the World Wide Web is all about, not so many of us are aware of XHTML. However, it's something that we need to be aware of, if only because it's the language of the World Wide Web of the future. Where HTML has ruled the roost since the WWW's inception around ten years or so back, it appears that its limitations have been reached.

Effectively, HTML is not good at handling large chunks of data. Modern Web pages - particularly those of e-commerce and high-usage sites - need to be able to manipulate data rather better than they can with only HTML. Enter XML - extensible markup language - which is a language that allows a means whereby data can be manipulated easily. The problem so far is that an ordinary HTML Web browser like Communicator or Outlook Express is only able to deal with HTML pages. To date, to view XML pages requires a different browser. XHTML, on the other hand, is a hybrid of the two markup languages, which provides a bridge between both. If a page is constructed using XHTML, then an ordinary Web browser can view it. Put another way, ordinary Web browsers can view both ordinary HTML pages, and not-so-ordinary XHTML pages.

To the end-user therefore, there will be little change. They'll be able to surf anywhere on the World Wide Web and view either HTML or XHTML generated pages. Few people will even realise there is a difference. Which is the whole point, of course. XHTML sets the course for the XML-based future of the Web, while HTML will continue to exist exactly as it stands for many years to come.

The World Wide Web Consortium, which has recently set the XHTML 1.0 specification, has information about it, at: **<http://www.w3.org/TR/xhtml1/>**.

Graphics Too

As anyone who has ever tried to print off some Web pages will be able to testify, the quality of printed Web page graphics - while maybe looking great on screen - leaves a lot to be desired. Usually, graphics printed from a Web browser will be jaggy, and suffer from a bitty appearance on paper. Images like these are bitmapped, which means they are comprised of dots.

The problem is essentially the same as that which the printing industry came up across at the onset of the desktop publishing revolution back in 1984. Screen resolution is typically 72 dots per inch (dpi), while high-quality printed resolution needs to be at least 300dpi. It is possible just to increase the resolution of a graphic, so that it prints out better, but that entails larger file sizes (each doubling of resolution represents a quadrupling of file size). On the Internet this means that images take longer to download and display too, so is not acceptable.

In the print industry, the problem was overcome by using vector graphic files (usually based on the PostScript format), which comprise textual descriptions of images rather than individual dots. Also, because they do comprise textual descriptions, the images are actually scalable. This means they can be printed out (by a PostScript printer) to give high-quality prints at any size.

To date it's not been possible to generate vector graphics for Web use for two reasons. First there has to be a standard which all Web browser manufacturers agree on. Second, HTML doesn't support any form of vector graphics. However, now that XML (which does support vector graphics) has been integrated with HTML in the new XHTML specification (see the previous story), and as all modern Web browsers will support XHTML, both these reasons have been countered. All that is required is the file format.

That file format is SVG (scalable vector graphics). It is a text-only collection of XML commands (similar to the PostScript language, in fact), which can be viewed by current versions of ordinary Web browsers as long as they have an SVG plug-in. Next-generations of Web browsers will incorporate SVG integrally.

Adobe, one of the companies involved in defining the SVG standard, has released beta versions of SVG plug-ins for some of its products and some Web browsers. Adobe's Web page at **<http://www.adobe.com/web/features/svg/>** gives details.

BT on the Cheap

British Telecom's BT Internet service has recently announced an update to its service, whereby users can get unmetered evening access (in addition to the existing unmetered weekend access) to the Internet at a reduced monthly rate. The service is now offering free weekend access (from 12pm Friday night, to 12pm Sunday night) along with free weekday evening access (from 6pm to 12pm), for the fee of £9.99 a month. Sounds almost too good to be true so where's the catch?

Rapster

The Napster revolution, featuring thousands of sites worldwide, brimming full of downloadable MP3 music files continues unabated. Rapster is a new Macintosh version of a client that allows anyone to access Napster servers, then search for and download files in a chosen format. It's available for free download, from: **<http://www.macnews.com.br/overcaster/rapster.html>**.

Free Bug Check

If you're a Pipex Dial user (business or consumer) then you should take up the Pipex offer of free virus checking software. The software is part of an agreement between Pipex and Symantec, to offer all of its Internet customers a copy of Symantec's Norton AntiVirus solution for free. All you have to do is download the software from the Pipex Web site, or get it from the latest CD-ROM of the Pipex Dial software (Pipex Dial 6). It's available for both Windows and Mac. Updates to virus definitions files will be available as soon as they are produced, also downloadable from the Pipex Web site, at: **<http://www.dial.pipex.com/>**, or direct from Symantec, at: **<http://www.symantec.com>**.

AOL Announces Anywhere Mobile Internet Strategy

AOL at <www.aol.co.uk> has announced its AOL Anywhere mobile Internet strategy to extend its service to a range of next-generation WAP, SMS and GPRS wireless devices by later this year.

To maintain its leadership as an estimated one-third of Europeans access the Internet via mobile phones by 2004, AOL Europe announced a series of agreements to ensure its Mobile Portals are compatible with current SMS and WAP protocols and handsets, as well as next-generation General Packet Radio Service (GPRS).

GPRS technology allows 'always-on' service at up to ten times the speed of current mobile devices. The agreements include:

- Strategic partnerships with Nokia and Ericsson for the development and trial of AOL Europe mobile services based on the partners' Wireless Application Protocol (WAP) solutions;
- A strategic alliance with RTS Wireless for trials of its WAP gateway, as well as SMS (Short Messaging Service) Alert Messaging and e-mail by phone using RTS Wireless' Advantage system;
- Active participation in the WAP Forum, the industry association that has developed the de-facto world standard for fast and easy delivery of information and telephony services on digital mobile phones and other wireless terminals.

E-Commerce Lags in Europe

A Forrester Research survey of 17,000 households in Germany, France, Sweden, the Netherlands and the UK at <www.forrester.com>, indicates that less than 10% of respondents were interested in shopping online.

In Sweden, where e-commerce was most popular, 14% of households were connected to the Web and 7% had ordered goods. At the other end of the scale, only 7% of French households were linked to the Internet, and only 2% had bought anything.

Rothschild Leads £10million Investment in Star Internet

Star Technology at <www.star.net.uk> has raised £10 million to provide funds for ambitious expansion plans. The investor group is led by Nat Rothschild, Lord Rothschild's son and includes RIT Capital Partners and Lord Weinstock.

Nat Rothschild and David Morrison, on behalf of the investor group, have joined the board of Star.

Star Technology Group includes Star Internet, the award-winning business-only ISP, and Starlabs, an application service provider (ASP) offering e-mail management services to other ISPs both in the UK and abroad.

Starlabs' main product is the recently launched Virus Control Centre, which is a centralised virus scanning service capable of scanning tens of millions of emails every day using three virus scanning packages, with no discernible impact on delivery times.

In the first quarter of next year the Starlabs offering will be extended to include additional content filtering services including anti-spamming, content security and auto-compression.

WIPO Service Tackles Cyber-squatting Cases

Eighty-nine cases have been filed with the cyber-squatting arbitration service run by the World Intellectual Property Organisation (WIPO) at <www.wipo.org> since its inception in December last year.

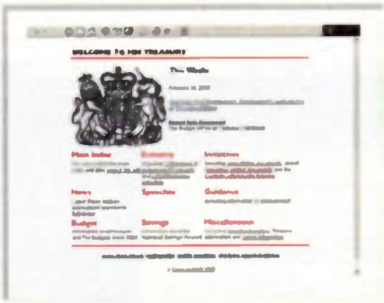
The WIPO was established to protect brand or personal names on behalf of their owners on the Web.

The organisation has the power to force domain name registrars to hand over URLs unless an arbitrated decision is challenged in court.

Recent disputes include <dior.org>, <easyjet.net>, <worldcup2002.com>, <jpmorgan.org>, <microsoft.org>, <alaskaairlines.org> and <dodialfayed.com>.

The mandatory dispute resolution system has seen a jump in cases from one filed in December to 60 filed in February.

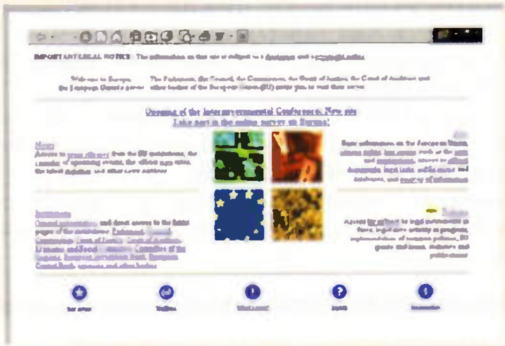
Chancellor Seeks to Slash Internet Costs in the UK



Chancellor Gordon Brown at <www.treasury.gov.uk> says he plans to cut the cost of Internet use in half by 2002, largely through opening up British Telecom's local loop - the wires that run into homes and businesses - to greater competition.

The UK telecommunications regulator Oftel had earlier agreed to a plan for opening up the local loop by July 1, 2001, but Brown says he's convinced Oftel that the date should be moved forward. Currently in the UK, less than one in five people have Internet access, compared with one in two in the US.

Internet Sales Dispute Resolution System Planned



The European Commission at <europa.eu.int> is planning an EU-wide system for resolving consumer complaints about goods purchased over the Internet. The European extra-judicial network, as it will be called, will involve setting up a series of clearinghouses in EU countries.

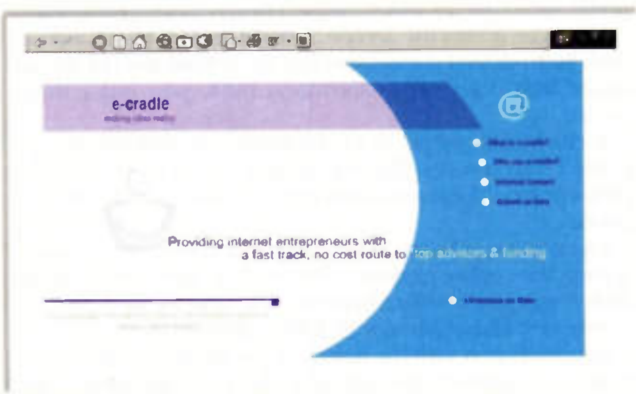
The clearing houses will collect information on the complaint and pass it on to industry regulators and to settlement authorities for specific industries. The tribunal that renders final judgment will be based in the producer's country, meaning that the consumer will have a better chance of seeing legal action carried out, enforced by a local court

Alliance Defines Palm Standard

IBM, Nokia, Lotus, Motorola, Palm, and Starfish Software have formed an alliance to develop an open universal standard that would make it easy for users of handheld computers to exchange calendars, e-mail, to-do lists and other data among different devices and different operating systems.

The group is called SyncML at <www.syncml.org>, and the synchronisation protocol that it is set to develop will be based on XML, the extensible markup language which is itself based on the HTML computer language used for presenting Web pages.

e-cradle Venture Catalysts Launch



e-cradle has been set-up in response to a demand for specialist help in the UK for IT, internet and e-commerce start-ups.

Here, 'time to market' and experienced advice are key critical success factors for businesses that succeed in what is a very competitive market.

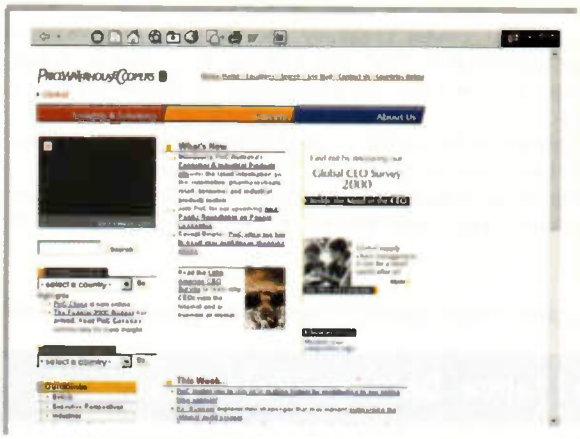
e-cradle will provide budding 'n-trepreneurs' and 'clicks and mortar' start-ups with a fast-track, no 'up-front-cost' route to top advisors with seed funding contacts.

The organisations involved in the project have assembled a senior-level team to review proposals and ideas put forward, within days of receipt. Depending on the quality of the submission, they aim to have a 'yes' or 'no' decision back on the idea, again within days.

They will then work together with the entrepreneur to arrange start-up and second phase funding, making introductions to venture capital providers and corporate finance sources as appropriate. The service will be fast, comprehensive and confidential.

e-cradle will be organised around its Web site at <www.e-cradle.co.uk>. Here anyone will be able to post a request to review an idea and arrange a meeting 'of minds'. The e-cradle team will be able to help formulate proposals and improve plans for venture capital.

Internet Start-ups Hit Jackpot



Internet companies raised almost £12.5 billion in venture funding last year - more than five times the £2.2 billion invested in 1998, according to PricewaterhouseCoopers at <www.pwcglobal.com>.

In fact, Internet-related businesses accounted for more than half of all 1999 venture investments, and analysts predict the trend will continue in 2000.

However, this year the focus will shift away from business-to-consumer ventures like Carsdirect.com or Webvan Group, and toward business-to-business start-ups.

Students Trading MP3s With Napster Clogging Networks

Several universities have blocked their networks' access to Napster software at <www.napster.com>, which lets users share MP3 music files, because the program was consuming too much bandwidth.

Napster opens MP3 files on users' hard drives to searches and downloads by other users, and the program can make hundreds of thousands of files available.

With hundreds of students at a campus each sending and receiving dozens of MP3s at the same time, bandwidth quickly disappears.

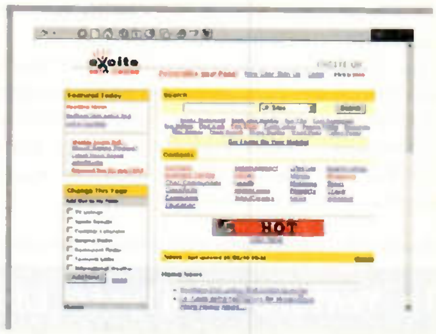
Sky Opens Internet Sports Shop

British Sky Broadcasting at <www.sky.co.uk> has revealed plans to launch a sports shop on the Internet. The venture will mark Sky's first major stand-alone e-commerce initiative.

The new shop will include key icon sports already prominently covered by Sky TV; these include football, cricket, golf and rugby. Visitors will be able to browse and buy a range of sporting goods including clothes and equipment relating to a wide variety of sports.

Sky says that its expertise and passion for sport will be reflected in the new online store, which will be available to its 8 million UK customers across multiple platforms. Recent announcements have clearly outlined Sky's commitment to Internet content delivery and mobile commerce via WAP enabled phones.

Excite Launches Personalised WAP Service



Excite at <www.excite.co.uk> has launched Excite Mobile, the first WAP service in the UK to be offered by a major UK Web portal, with content which can be tailored to user preferences.

Users can access the service at <mobile.excite.co.uk> on their WAP-enabled phones and can go to <www.excite.co.uk> on the Web to get more information and to personalise their service.

Excite Mobile will act as a complementary platform to Excite's Web services, allowing users to access their personalised information from either a computer or a WAP phone.

Excite users only need to register once to access the same service from either platform. No other UK WAP service offers such a seamless interface between WAP and the Web. The service is available through all WAP enabled platforms.

In conjunction with the launch of Excite Mobile, Excite has announced partnerships with BT Cellnet and Vodafone. Under these agreements, Excite Mobile will be prominently featured on the carriers' newly launched WAP networks. Excite is in the process of negotiating a number of additional deals for the roll out of Excite Mobile across Europe.

Yahoo Secures WAP Deal with Siemens

Siemens and Yahoo have joined forces to provide easy access to WAP services for Siemens phone and companion users. The agreement also includes the development of equivalent services by Siemens and Yahoo! Asia.

Siemens plans to build direct access to WAP content from Yahoo!, a leading global Internet company, into all upcoming products including S35i, C35i and IC35.

At `<wap.siemens.yahoo.com>`, Siemens' customers in Europe and Asia will have quick and easy access to content in 10 different language versions from localised Yahoo! sites.

The first versions will be available in April, in English and German, and all remaining versions are scheduled to be completed by mid-year.

Dow Jones And Excite@Home Form Work.com

Excite@Home and Dow Jones have formed Work.com at `<www.work.com>`, which will be developed a premier business portal.

Work.com will focus on the burgeoning business-to-business market and build a leading business portal designed primarily for the needs of small and medium-sized business Internet users.

The start-up will leverage the portal experience of Excite and the business content of Dow Jones and The Wall Street Journal.

Phone.Com Acquires Paragon for WAP Synchronisation

Phone.com at `<www.phone.com>` a provider of mobile Internet is to acquire Paragon Software at `<www.paragonsoftware.com>` for approximately £300 million in stock. Headquartered in Newbury, United Kingdom, Paragon Software is a pioneer of synchronisation technology allowing PC-based personal information to be easily transferred to mobile devices.

Paragon Software's product, FoneSync, enables users of PC and Internet-based personal organisers such as Microsoft Outlook, Lotus Notes, and Excite@Home to download and synchronise contact information to over 240 digital mobile phones from 20 major manufacturers including Alcatel, Ericsson, Nokia, Panasonic, Philips, Samsung, Sanyo, Siemens, and Sony.

WhoMakesIt.com Portal Provides Access to Component Industry

WhoMakesIt.Com, the electronic industry's first Web portal designed to provide direct access to product information from manufacturers for electronic component industry professionals, has gone live at `<www.whomakesit.com>`.

The portal allows the user to search for components by specifying multiple parameters; prioritise key product attributes; compare product information from multiple manufacturers; and then link directly to the location on the manufacturer's Web site where the specific information resides.

Oracle Spin-Off First with Consumer Wireless Portal

Oracle has announced the formation of OracleMobile.com, a wholly owned subsidiary, offering the first comprehensive consumer wireless Internet portal.

The portal, available immediately at `<www.oramobile.com>`, is based on Oracle's Portal-to-Go technology platform and offers personalised business and lifestyle services free of charge.

The most popular Internet content and commerce services are teaming with OracleMobile.com, including AllSites.com, Amazon.com, Astrology.com, eBay, E*TRADE, Hollywood.com, KDFC, Lottery.com, MapQuest.com, OpenTable.com, Sabre, Sabre BTS, Travelocity.com, ScreamingMedia, SmarTraveler, SnoCountry, SysTran Software, The Weather Channel, UPS, Waiter.com, and ZAGAT.com.

The OracleMobile.com service can be accessed from Web-enabled wireless devices, such as Web-phones, and two-way pagers.

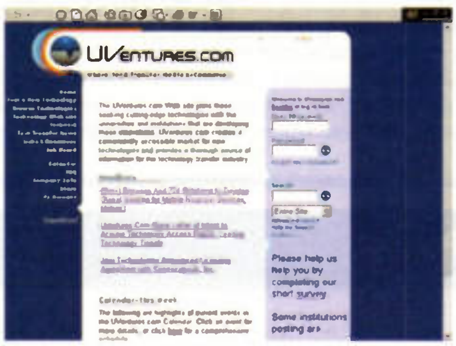
According to the Gartner Group, more than one billion mobile devices will be in use by 2003. In less than two years, virtually all new mobile devices being sold are expected to be Web-enabled.

Zing Set to Integrate PictureIQ Technology into Site

Zing at <www.zing.com> and PictureIQ at <www.pictureiq.com> have announced that Zing has agreed to integrate PictureIQ technology within its photo community site. This will build upon Zing's services to provide an additional set of powerful image editing, enhancement, and creativity tools.

By early second quarter, the PictureIQ technology will be integrated into Zing.com to enable users to perform high-quality edits and enhancements to their photos, with additional creative and special effect capabilities to be rolled out over time. The capabilities can be used with any Web browser, without the need for any additional software or downloaded plug-ins.

UVentures.com Launches Release 2.0



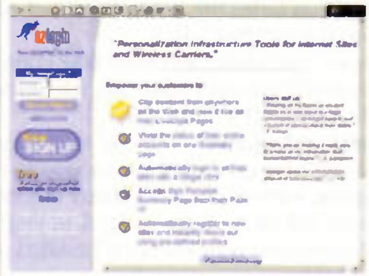
UVentures.com at <www.uventures.com>, the largest Internet portal for newly developed technologies available directly from top universities and government labs, has announced the release of new navigation and content features.

The site's enhanced capabilities make it quicker and easier for prospective private sector businesses to search and access rich data from the site's more than 2,500 technology listings.

As the one-stop online resource for the technology transfer community, Uventures.com helps reduce the search process, which can ordinarily take six months to a year, by as much as 80%.

The site's new features offer a tremendous wealth of information, including links to relevant technology transfer industry resources and access to e-mail discussion groups for technology licensing professionals.

ezlogin.com Announces Support for 2,500 Sites

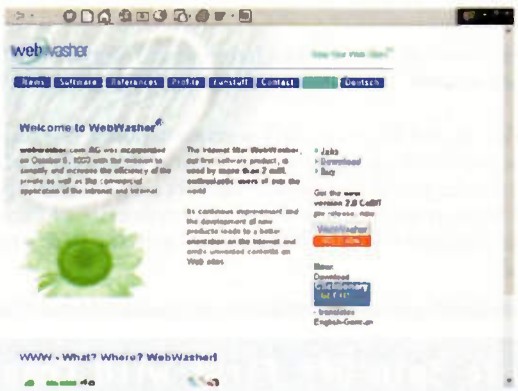


ezlogin.com at <www.ezlogin.com> has announced that its suite of personalisation infrastructure tools now provides automated access to personal content at more than 2,500 financial, shopping, general information, email, chat and other Web sites.

These tools are available for use by Internet destination sites to provide their online customers with OneClick access to personal accounts as well as the ability to view a summary of their personal account information on a single Web page.

With ezlogin.com's comprehensive site directory, Internet sites allow their online customers to create highly personalised start pages, which contain direct links to their online accounts and frequently visited sites.

WebWasher.com Keeps Clean with Version 2.0



webwasher.com at <www.webwasher.com> has announced immediate worldwide availability of Version 2.0 of WebWasher, the premier filtering software that blocks unwanted information from computer Web screens. The new release of WebWasher includes an improved user interface, automatic installation feature and new filtering mechanism.

First launched in Germany in January 1999, WebWasher has dramatically improved the Web surfing experience of more than 2 million users worldwide. With WebWasher installed on a PC or proxy server, undesired Web page content, such as banner ads, JavaScript objects or animated graphics, is blocked from loading to the Web browser. This accelerates download time and creates dramatic network efficiency in both the network and consumer environment.

By limiting the download of undesired content, WebWasher can boost the performance of mobile laptop users and legacy computer systems, thereby enabling employees to surf the Web more efficiently. According to Webwasher.com the application saves up to 45% of network bandwidth when deployed as an enterprise-wide infrastructure tool.

Earjam.com and EMusic.com Team for Premier Music Catalogue

MP3 distributor Earjam.com at <www.earjam.com> has announced a comprehensive partnership with EMusic.com at <www.emimusic.com>, the Internet's leading seller of downloadable music. Via Earjam.com's Internet Music Player (IMP) music fans worldwide will be able to preview, purchase and download over 75,000 MP3 music tracks

Earjam.com's new IMP software provides music fans with a direct connection to the music and artists they like, while making it easy to find, download, play and burn music off the Net.

The Earjam IMP is the world's first free universal Player/Burner that solves the problem of conflicting music file formats, security measures and hardware standards, by supporting all popular formats and hardware devices.

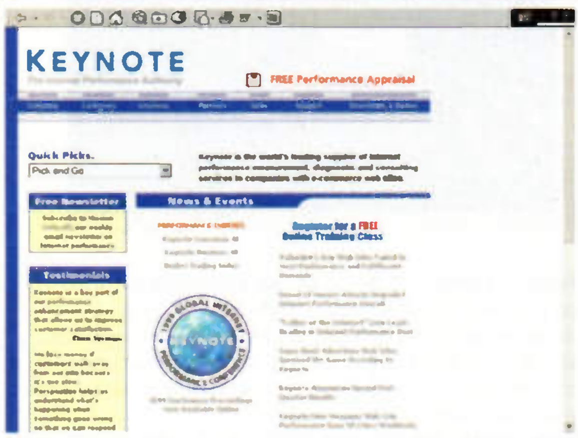
Users can play MP3s, Windows Media files, audio CDs, plus over a dozen additional formats, and transfer their music to popular devices such as the Diamond RIO and Creative Nomad, as well as burn CDs they can play in any standard CD player.

The Earjam IMP automatically handles all downloading, ripping, unlocking and transcoding, without requiring any user interaction or technical knowledge. The consumer simply selects the music they want and sends it to the desired device.

The Earjam IMP also makes it simple for music fans to find the music they like, using Earjam's patent-pending Audiobot technology that spiders across the Web using user-defined preference filters. Music links, including graphics, video and descriptive text are then delivered directly to the user's desktop, to preview, buy, download and burn.

The Earjam Audiobot secure communication layer acts as a conduit between consumer's preferences and Internet content, enabling artists to reach out to their existing and new fans, while completely protecting the consumer's anonymity.

Denial of Service Attacks Degraded Internet Performance



The performance of the Internet overall degraded by as much as 26.8% during business hours due to denial of service attacks on major Web sites during the week of 7 February, according to measurements taken by Keynote at <www.keynote.com>.

Overall Internet performance for users accessing Web sites degraded slightly on Monday, February 7 and Tuesday, February 8 compared to performance on the same day the previous week.

Average performance on Wednesday, February 9 degraded by 26.8%, attributable in part to increased traffic on the Web looking for news and other information about the attacks, as well as to the increased traffic and congestion generated by the attacks themselves.

Keynote's data verifies that performance deterioration was widespread for users around the Internet and affected many Web sites that were not direct targets of the attacks.

Zap.Com Unveils the ZapBox Web Application

Zap.Com at <www.zap.com> has unveiled the ZapBox, a new Web application for Internet users and advertisers on the forthcoming ZapNetwork. According to the company, the ZapBox gives users portal-like functionality enabling them to search the Web and access current news, sports scores, weather and other information directly on their favorite ZapNetwork sites rather than leaving those sites for a large portal.

The ZapBox, an interactive and customisable frame within each page of every site of the ZapNetwork is currently deployed on four Internet sites: Word at <www.word.com>, Charged at <www.charged.com>, Pixeltime at <www.pixeltime.com> and Zap.Com's homepage at <www.zap.com>.

A demo of the ZapBox can be viewed at either the Zap.Com homepage or at <www.zap.com/ZapBoxdemo.html>.

According to the Zap.com, the ZapBox will be located on every page of the sites that join the ZapNetwork. As users move from one ZapNetwork site to another, their ZapBox preferences follow them, offering them the same functionality and customised settings of full-featured portal sites. The ZapBox offers news, sports scores, and weather wrapped around a space for advertising.

Nokia Launches Interactive Owner's Manual

Nokia, the world's leading mobile phone supplier, launches a new Web site designed to provide fast, easy access on how to use the powerful features available on any of Nokia's mobile phones.

<www.nokiahowto.com> provides an easy three-step process to enable users to select a particular feature from any Nokia phone that they would like to learn more about. The user can read a description and the steps required to use a phone feature with the ability to click on each step for a demonstration.

GartnerGroup Forecasts Business-to-Business E-Commerce to Reach £5Trillion in 2004

Gartner analysts claim that business-to-business (B2B) e-commerce will grow at aggressive rates through 2004, causing fundamental changes to the way businesses do business with each other.

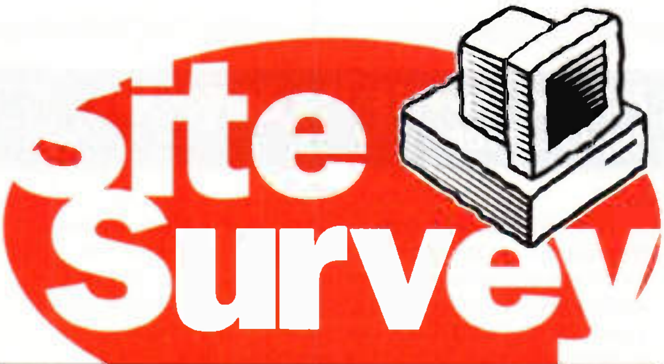
The worldwide B2B market is forecast to grow from £90 billion in 1999 to £5 trillion in 2004. By 2004, B2B e-commerce will represent 7% of the forecasted £65 trillion total global sales transactions.

The catalyst for B2B e-commerce is e-market maker activity. E-market makers are projected to facilitate £1.7 trillion e-commerce sales transactions in 2004, representing 37% of the overall B2B market, and 2.6% of forecasted worldwide sales transactions.

An e-market maker is an organisation that develops a B2B, Internet-based, e-marketplace of buyers and sellers within a particular industry, geographic region or affinity group.

GartnerGroup analysts said e-market makers will have a critical but subtle impact on transactions that flow through brick and mortars' sell-side initiatives. These sell-side initiatives are defined as including extranets, B2B Web storefronts, EDI and flat file transfer over the Internet, and related e-commerce activity allowing a seller to leverage the IP network as a channel to its buyers.

The worldwide B2B market is poised for explosive growth as the market is projected to reach £250 billion in 2000 followed by £595 billion in 2001. In 2002, the market will increase to £1.4 trillion, and at the end of 2003 worldwide B2B revenue is forecast to reach £2.5 trillion.



The months destinations

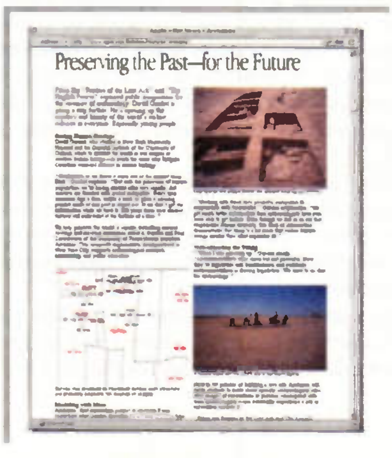
Destinations of the Month

Tackling death online and coupling it with an ecommerce site could feel tacky if it wasn't handled correctly. However, hats off to the Funeral Shop, with its Web site at: `<http://www.funeralshop.co.uk/>`, where you can buy coffins, caskets, headstones, flowers and so on, all from a very tasteful interface. It has been set up by a number of funeral directors in the North-West of the country, but it can supply products to anywhere. The service also says it can help you with pet funerals, as well as those of loved ones of the human kind.

If you missed the Lottery when you were away on holidays (or simply fell asleep during last week's really, really exciting Red Alert and failed to wake up in time) and want to check to see if you won, the National Lottery has a page, at:

`<http://www.national-lottery.co.uk/game/search.html>` where you can enter your numbers and search to see.

Finally, for the more high-brow reader who has been watching Time Team on Channel 4, and has have been intrigued as to how computers are being used more and more in archaeology these days, take a look at Apple's news item, at: `<http://www.apple.com/hotnews/features/archaeos/>`. Here you'll see how easy it is to integrate Macs into archaeological sites. The story also tells of the newly launched Archaeos organisation, which has been set up to support research, scholarships and education.



Valves in the 21ST CENTURY

PART 5

In this last part Mike Bedford presents a potpourri of valve related topics.

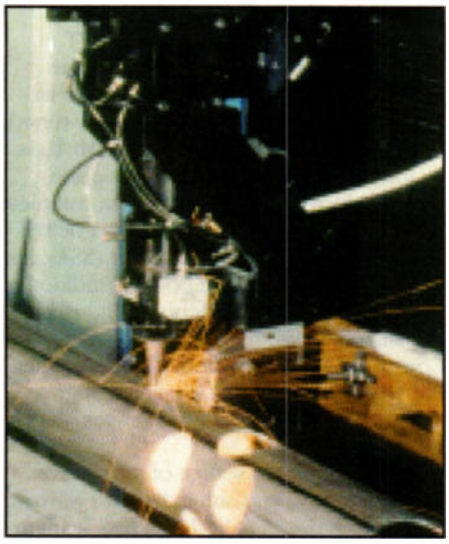
This is the last article in our series on valves on the 21st century and is slightly different from the first four articles. Each of the earlier articles took a topic which was largely self-contained but this month we're going to present a potpourri of valve-related topics. Basically, if it didn't conveniently fit into any of the first four articles you'll find it here. And with that short introduction let's jump straight into out first subject.

RF Revisited

Actually, despite what I've just said, the first type of valve we're going to take a look at would have fitted very well into last month's article. The only reason it wasn't covered there is that space didn't permit. For completeness, therefore, we'll start off by looking at another common special type of valve that was designed for high frequency RF applications - the travelling wave tube or TWT. You may also come across the mnemonics TWA (travelling wave amplifier) and TWTA (travelling wave tube amplifier), but all refer to what I've referred to as the TWT. If you like to pigeon hole things, then this type of valve fits nicely alongside the other specialist UHF and microwave valves, namely the klystron, the inductive output tube (IOT) and the magnetron, all of which we investigated last month.

Figure 43 is a representation of a TWT and you'll notice that an electron beam is generated in an electron gun, in much the same way as in the klystron or the IOT. Electron guns differ slightly from one type of device to another and the electron gun in the TWT is much more akin to that in the klystron than in the IOT, i.e. it doesn't have a grid to intensity modulate the beam at the RF frequency. When the electron beam leaves the gun it passes along a glass tube inside which a helical coil of wire is wound for its complete length. The signal to be amplified is coupled into the wire coil close to the electron gun. Clearly this signal will travel down the wire of the coil at close to the velocity of light but the axial velocity of the signal along the tube will be much slower, the actual speed depending on the pitch of the coil. In practice, the coil is designed such that the axial velocity of the signal down the tube is similar to the velocity of the electron beam. Under these conditions an interaction between the signal and the electron beam takes place and this results in a velocity modulation of the beam and hence electron bunching - as in the klystron - and wave amplification. In practice, the amplification factor is roughly proportional to the axial distance along the tube. Magnets are placed along the length of the tube to ensure that the electron beam remains focussed and is not attracted to the positive helix. The amplified signal is extracted from the coil at the far end by using a suitable coupling. One other essential element of a TWT is the attenuator, a cylinder of lossy material that surrounds the centre portion of the tube. Without this, the amplified signal would pass back along the helix to the input resulting in unwanted oscillation.

Typically, a TWT can provide amplification of 40dB. The available power rating is much lower than that of the klystron - up to a few kilowatts is achievable compared to tens of megawatts with a klystron. There are, however, other advantages that compensate for this lack of power and make the TWT especially suitable in certain applications. One advantage is size and weight - a device with an output power of tens or hundreds of watts may weigh less than a pound. And unlike klystrons and IOTs, which have a quite modest bandwidth, TWTs with a bandwidth of an octave or more at microwave frequencies are available. TWTs are used, typically, for satellite communications and for radar. The fact that the MTBF (mean time between failures) could well be fifteen years is particularly attractive for use on-board spacecraft. Due to their high bandwidth TWTs are particularly suitable for applications where it may be necessary to change the operating frequency on a regular basis. Tuning magnetrons, klystrons and IOTs is more difficult and can only be carried out over a fairly narrow band of frequencies.



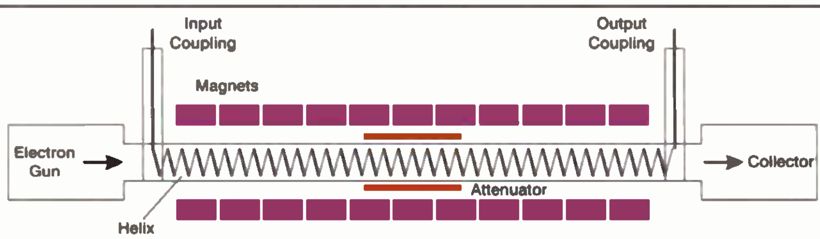


Figure 43. Travelling Wave Tube

Yet More High Frequency Valves

Klystrons, IOTs, magnetrons, TWTs - there seems to be no end to the different ways UHF and microwave signals can be generated and amplified - are just the valve alternatives for high frequency applications. If this series also covered solid-state devices there would be plenty of others to look at. However, our coverage so far doesn't even cover all the specialised valves that have been designed for high frequency RF applications. If you're not a UHF or microwave enthusiast, though, a detailed coverage of the full range will start to get a bit tedious. You'll be glad to hear, therefore, that we're not going to take a look at any of the others in the same detail. However, if you do have in interest in the top end of the RF spectrum here are brief details of some of the other valve types so that you can research them further. The first two are reasonably well established, not that this implies that they are no longer enjoying further development. The remaining ones, though, are very much the subject of leading-edge research, even though some commercial products are available.

The crossed field amplifier (CFA) is a high efficiency, compact amplifier that is operated at a relatively low-voltage. These characteristics make it attractive for lightweight portable and airborne systems. The CFA operates rather like a magnetron except that an input signal is applied to the anode where, in the presence of the rotating electron stream, it experiences amplification through most of one rotation before it is extracted into an output wave-guide.

The backward wave oscillator (BWO) is similar to the TWT except that it's designed to oscillate rather than amplify. This is achieved firstly by the omission of the attenuator that is present on the TWT specifically to prevent it oscillating. The BWO also has just the one connection to the helix - the output - and is voltage-tuned.

The microwave power module (MPM) is an interesting combination of valve and semiconductor technologies. It's a complete microwave amplifier that includes a helix TWT, a solid-state driver amplifier (SSA), and a high-density electronic power conditioner (EPC). All three components are housed in a small, compact, lightweight package. Compared to the traditional TWT amplifier, the MPM is significantly smaller, lighter, more efficient, and has a greater signal-to-noise ratio.

The gyrotron is a source of microwave, millimetre wave and sub-millimetre wave radiation. It uses a helical electron beam in a high magnetic field to generate radiation by stimulated emission at the electron cyclotron frequency. It can produce power levels above 100kW continuous or 1MW pulsed at 100GHz with efficiency of 50% or above.

The Free Electron Laser (FEL) generates tuneable, coherent, high power radiation, currently ranging from the microwave region through the infrared to the to visible spectrum with the possibility of ultraviolet and x-rays in the future. It has the optical properties characteristic of conventional lasers such as high spatial coherence and a near diffraction limited radiation beam. However, it differs from an ordinary laser in that it uses a relativistic electron beam as its lasing medium.

Cathode Ray Tubes

Most of the applications of valves we've seen in this series can't exactly be described as common or garden. We looked at audio amplification a couple of months ago but it has to be admitted that few people are willing to pay many thousands of pounds for an audiophile valve amplifier. And the applications we investigated last month are even more specialised - broadcasting, satellite communications, radar, industrial inductive and dielectric heating, radiotherapy and particle physics research. But it would be wrong to believe that valves don't also find their way into ordinary household appliances even in this era of semiconductors. In fact we made passing reference to one such applications last month. If you were to take your microwave oven to pieces, not that I suggest you do that, you'll find a magnetron inside. And whereas you might not recognise it as a valve - certainly it's very different in its operation and appearance from a conventional gridded valve - it is, nevertheless, a special type of valve which is particularly suited to the generation of microwave energy. But this isn't the limit of household valve applications and this brings us to our next topic. You might think that the use of valves in TV receivers died out in the 60s or 70s and whereas it's certainly true that TVs no longer use valves as amplifiers or oscillators, the vast majority still rely on valve technology. Virtually all TVs and the majority of PC monitors contain an important component that the layman won't even recognise as a valve. That component is, of course, the cathode ray tube or the CRT.

To many people the continuing dominance of the CRT is rather surprising, after all, the crystal ball gazers have been telling us for decades that the future of screens was flat. But despite these predictions, and despite the availability of flat solid-state alternatives, the CRT does remain the component of choice for TVs and PCs. The much vaunted TV which you would hang on a wall like a picture has failed to materialise and, except for laptops, flat screen displays for PCs are only starting to appear and are much more expensive than monitors based on CRTs. No doubt many readers, even confirmed transistor-philes, will already know all about CRTs because, as I've already mentioned, many people don't really consider them as a valve. If you come into this category I trust you'll excuse this recap because no treatment of valves in the 21st century can be complete without a brief look at the CRT.

Figure 44 shows the component parts of a typical monochrome CRT. An electron beam is generated in an electron gun (just for a change) and this accelerates towards a glass screen, the inside of which has been coated with a mixture of rare earth oxides called a phosphor. When the focussed electron beam hits this fluorescent coating a dot of light is produced but if the electron beam can be made to scan the entire surface of the screen at a sufficiently high speed, the whole screen will appear to be illuminated. The electron beam is directed to a particular part of the screen using two sets of field coils that can generate horizontal and vertical magnetic fields. The circuitry driving these coils causes the electron beam to scan the screen in the familiar raster pattern of horizontal lines progressing down the screen. Now let's take a more detailed look at the operation of the electron gun (Figure 45) to see how this allows a picture to be built up on the screen. Unlike most of the electron guns we've looked at, the gun in a CRT has a grid between the cathode and the

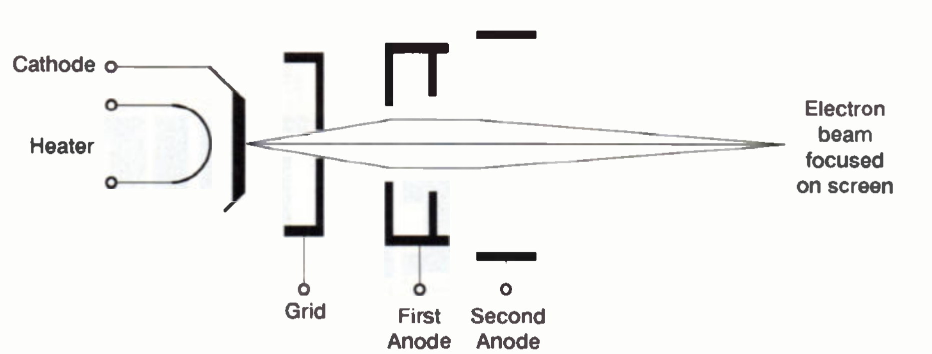


Figure 45.

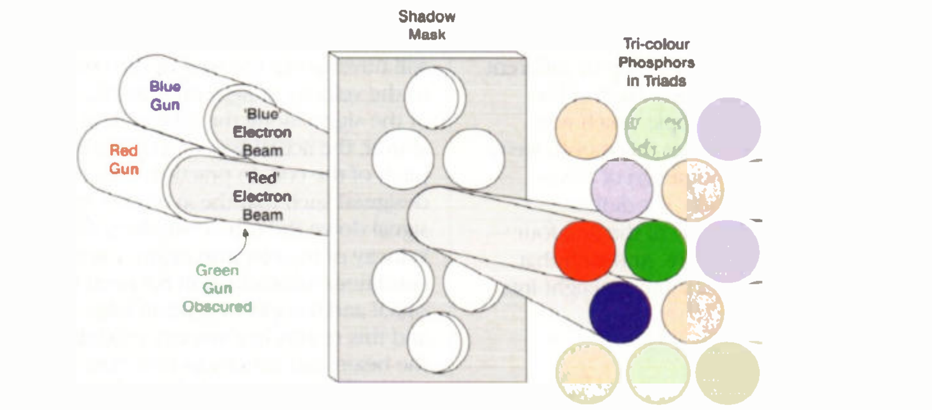


Figure 46. Shadowmask tube

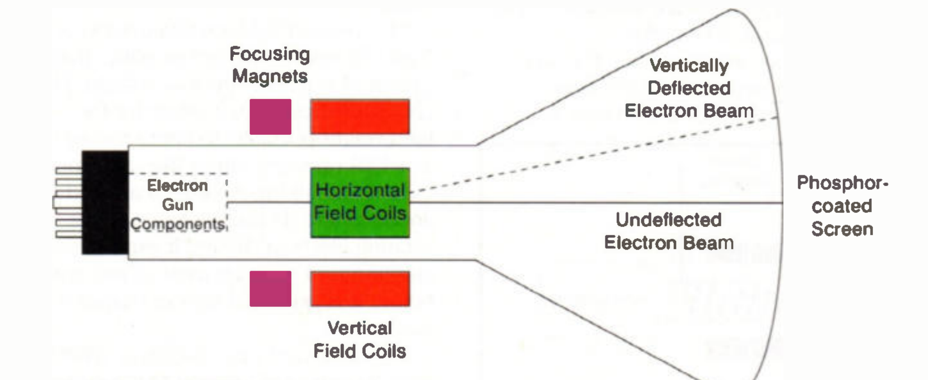


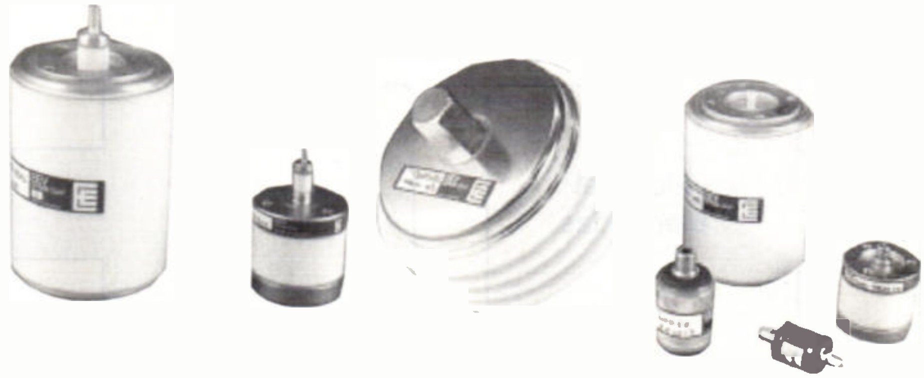
Figure 44. Typical CRT arrangement

first anode, which operates in exactly the same way as the grid in a conventional triode. It therefore allows the intensity of the beam to be controlled. So by applying a signal to this grid as the electron beam is being scanned across the surface of the screen, the intensity light spot produced at each part of the screen can be controlled. Clearly this permits an image to be built up on the screen. The two anodes are shaped so as to act as electrostatic lenses and thereby focus the electron beam into a small dot on the screen.

This is a standard monochrome CRT and these principles are extended in the colour CRT. Now instead of a single electron gun there are three, one for each of the primary colours, red, green and blue. We still only have a single pair of field coils, though, so in operation, three modulated electron beams scan the surface of the tube together -or almost. Although the scanning circuitry directs all three beams to the same part of the tube, a so-called shadow mask, placed just behind the front surface of the tube, actually causes the three beams to hit the tube at slightly different positions. This is possible because of the slightly different angles at which the three beams arrive at the shadow mask. The other difference between a monochrome and a colour CRT is that instead of a phosphor which will emit white light, three separate phosphors, which will generate red, green and blue light, are used. These are deposited onto the surface of the screen in triads such that each electron beam, which is projected through the shadow mask, can only land on the areas of the screen at which the appropriate phosphor has been deposited. This is undoubtedly an explanation that becomes very much clearer with a picture so if you've had difficulty visualising all of this, take a look at Figure 46.

Gas-filled Valves

The field of valve technology is often referred to as vacuum electronics. And last month, in justification for calling magnetrons and klystrons valves, despite the obvious differences from gridded valves, I suggested that a common feature of all valves is that they involve the flow of electrons through a vacuum. The phrase gas-filled valves may, therefore, seem to be a



contradiction in terms and I have to admit to a degree of wooliness in my terminology. Perhaps some people won't acknowledge that these devices are genuinely valves, therefore, but in my opinion the similarities are sufficient to justify their inclusion. Of course, if we take this line of argument too far we'd end up including X-ray tubes, discharge tubes such as neon lamps and even fluorescent tubes. However, since these types of gas-filled tubes are pretty much stand-alone devices as opposed to components in electronic circuits, I think I can make a reasonable case for ignoring them in this series of articles. Turning to genuine gas-filled valves, though, we've already come across one valve of this type. Back in the first article of the series we touched on the voltage stabiliser tubes which were used in valve-based power supplies. And yes, voltage stabilisers had gas-filled rather than evacuated envelopes. The reason that we only looked briefly at voltage stabilisers is that this is a series on valves in the 21st century yet voltage stabiliser valves are now very rarely used. By way of contrast, some of the other types of gas-filled valve which we're about to look at are still used very widely, albeit only in specialist applications.

The Hydrogen Thyratron

The hydrogen thyratron is a switching device capable of holding off high voltages, perhaps as high as 100kV, and switching several thousand amps when triggered. Thyratrons feature a very fast rise time and a rapid recovery time thereby allowing a repetition rate of up to 100kHz. From the name you might reasonably expect hydrogen thyratrons to be filled with hydrogen and, whereas this is true of some, others are actually filled with deuterium, a variant of hydrogen with an extra neutron in its nucleus. The hydrogen type of thyratron has a shorter recovery time whereas the deuterium-filled variant features a higher voltage hold-off. Schematic symbols for two common types of thyratrons are shown as Figure 47. You'll notice that these are the same as the symbols for ordinary triodes and tetrodes except for the black dot which indicates that the devices are gas-filled. Despite this similarity, note that different names, specifically the auxiliary grid (G1) and the control grid (G2), rather than the control grid and the screen grid refer to the grids in the tetrode, as they would be in a standard tetrode. And as we'll see later, the additional grid on the tetrode-type thyratron has been added for a very different reason from the screen grid on a standard vacuum tetrode.

Initially, we will look at the basic triode type of thyratron before moving on to the tetrode type. When an anode potential is applied and the grid is held at the cathode potential the thyratron is switched off and no current flows. By applying a positive potential, of the order of a few hundred volts to the grid, a discharge is set up and current flows between the cathode and the anode. Except for the somewhat different grid potentials, this really isn't too different from the operation of a standard vacuum triode. However, once the thyratron has been switched on, if the grid is returned to the cathode potential the flow of current between the cathode and the anode continues. To turn the thyratron off, the

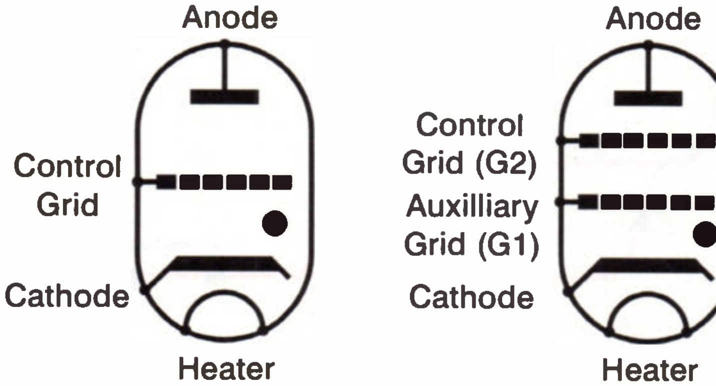


Figure 47. The common types of Thyratron

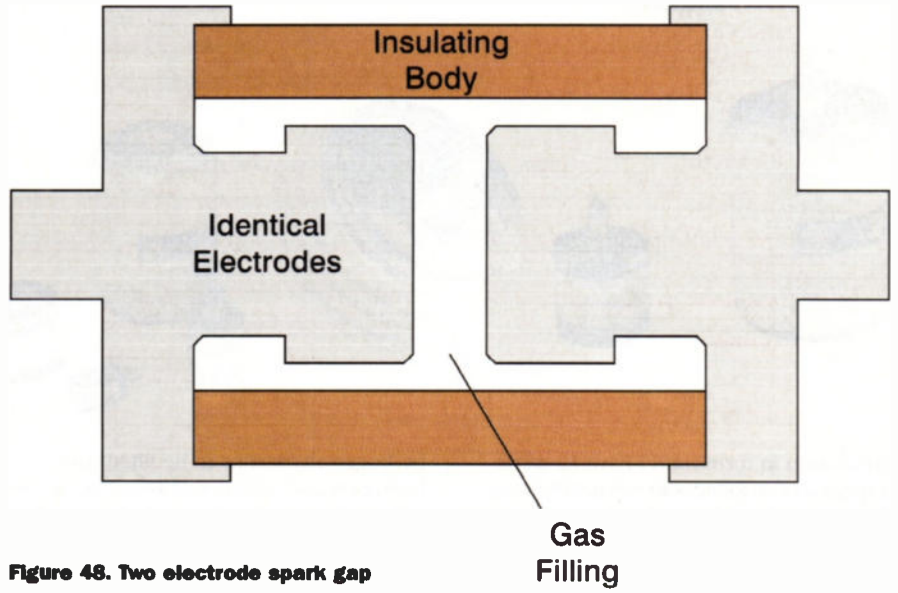


Figure 48. Two electrode spark gap

anode voltage has to be removed. Clearly this is very different from the way a conventional triode works, in fact the thyratron can be thought of as the valve equivalent of the solid-state thyristor. Turning now to the tetrode-type thyratron, a positive voltage is applied to the auxiliary grid first of all and this causes pre-ionisation of the gas in the area between that grid and the cathode. Switching the device on is then achieved by applying a positive potential to the control grid, just as with the triode-type thyratron. However, the pre-ionisation causes a faster switch on time and various other benefits compared to the single-gridded thyratron.

Cold Cathode Devices

The hydrogen thyratron is just one of many high current switching devices. Most feature a gas filling of some sort but, intriguingly, many don't have heated cathodes - the thyratron is rather unusual in this respect. With these devices, referred to as cold cathode valves, the voltage gradient between the cathode and the anode is sufficient to initiate a discharge even at a low temperature. The spark gap is an example of a cold cathode device. The construction is extremely simple as Figure 48 shows. The device is simply a gas-filled cylinder with an electrode at each end. Note that these are just two electrodes - there's no concept of the cathode and the anode here. And the purpose of a spark gap is very simple too - whenever the potential between the two electrodes exceeds some threshold it will switch on and start to conduct. This, of course, is the potential at which ionisation takes place and a discharge is established. Figure 49 shows how the volt drop across the spark gap varies with current as discharge is established maintained and terminated. Normal conduction is in the area labelled 'arc discharge' at which a very high current can flow with a very low volt drop across the gap. Once the device has switched on, though, it will remain in this state even if the potential is reduced below the turn-on

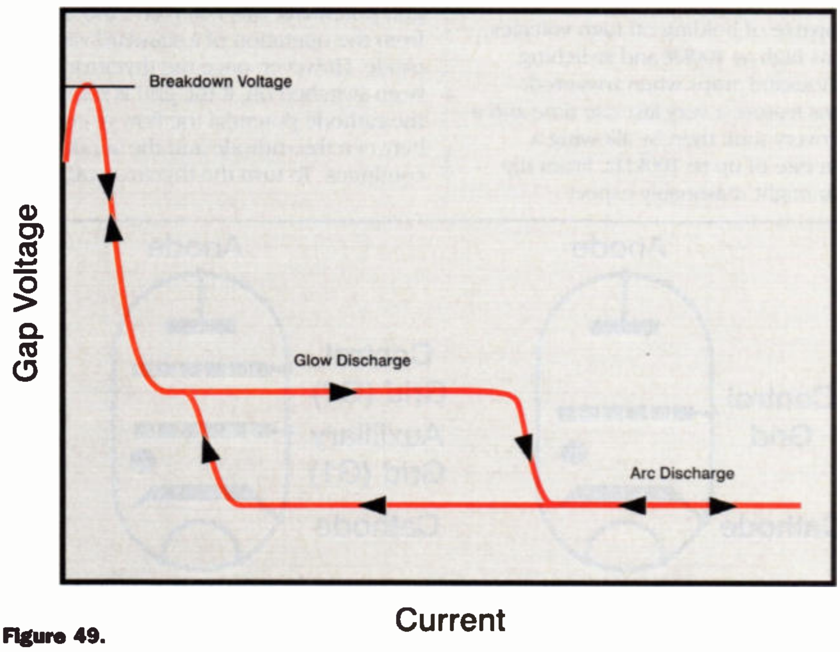


Figure 49.

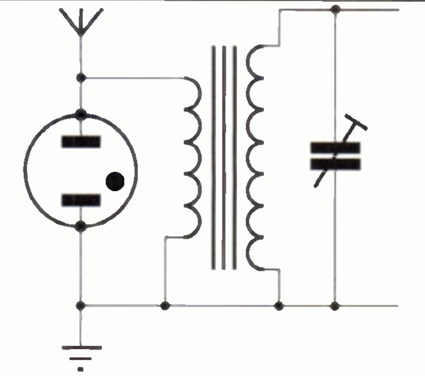


Figure 50. Spark gap front end

potential. In other words, a spark gap has considerable hysteresis. There is also a three-terminal spark gap that can be thought of as a cold-cathode, gas-filled triode. Here the device is switched on by pulsing the trigger electrode, even when the potential between the other two electrodes is well below the normal turn-on threshold.

Given the high hold-off voltages and the very high switching current of some of these devices, it's not hard to see why they still offer an attractive alternative to solid-state devices. But what types of applications require devices with these sorts of switching characteristics? First of all the simple two-electrode spark gap and a common application here is protection of sensitive circuitry from high voltage transients. Figure 50 shows how a spark gap could be used to protect a radio receiver front end from damage due to lightning. Three-terminal spark gaps can be used for triggering lasers although thyratrons are more commonly used in this application, especially at high pulse repetition rates. Thyratrons are also used to switch UHF and microwave devices such as klystrons, IOTs and magnetrons in pulse radar applications and they're also used, in a crowbar circuit, to provide protection for IOTs. High-energy physics research is another major application for thyratrons.

Contact

If you have an industrial need for TWTs, large hydrogen thyratrons or spark gaps, point your browser at **www.marconitech.com** or call Marconi Applied Technologies on 01245 493493.

Hands On

If this series has sparked an interest in valve technology and you'd like to delve further, trying your hand at something practical would be a good next step. This series has concentrated on the theory and looked at applications but valve constructional articles are by no means rare, even though valves are coming up to their hundredth birthday and a solid-state alternative has been available for more than half of that time. This magazine in particular publishes valve-based projects on a fairly regular basis and back issues are available if you've missed out on some of our earlier projects. In fact this includes a design for a 100W amplifier.

Valves in Migs and Patriots?

There's a tale, probably apocryphal, of a Soviet Mig fighter, together with its pilot, which was captured by the American military in the latter years of the Cold War. The American scientists who therefore had the opportunity to investigate Soviet technology were somewhat amused to discover that the on-board electronic equipment was based largely on valves. And this could well be true, the USSR did lag well behind the USA in the adoption of solid-state techniques. According to the tale, though, when questioned about this, the pilot indicated that rather than this being evidence of the impoverished state of Soviet technology, this was a well thought-out policy. In the event of a nuclear explosion, when the electronic equipment on-board American fighters would be wiped out by an electromagnetic pulse (EMP), the Soviet valve-based equipment would continue to operate correctly. But what has this to do with valves in the 21st century, even if the tale does have an element of truth to it? Well, the answer is that, according to further uncollaborated reports, the Patriot missile, which is still used by western powers, also contains valve circuitry for exactly the same reason. If any readers are able to collaborate these tales, do let us know, I'm sure that other readers would be interested.

And finally on the suitability of valves for protection against EMPs... Whatever the truth or otherwise of the suggestion that valves are still used in Mig fighters and Patriot missiles, the vast majority of military electronics is now solid-state. It's interesting to note, therefore, that one of the special types of valves we've looked at in this article is used to protect sensitive electronic equipment from the effects of an EMP. It has been estimated that a single one-megaton nuclear detonation above the North Sea would seriously damage unprotected equipment throughout the UK and across much of Europe. Electronic circuitry connected to EMP energy-collectors such as antennas, cables and pipes would be especially vulnerable. Transient protectors such as gas-filled spark gaps are available for use with antennas, mains supplies and data cables and can protect critical equipment from the effect of repeated EMP energy bursts.

Whatever Happened to the Nixie Tube?

Even if you were sceptical at the start of this series, I trust that you'll now recognise that valves remain important, even in the 21st century. And their application is often in leading edge areas such as digital TV transmission, particle physics research and satellite communication. This isn't to say, though, that every classification of valve that has ever been invented is still finding application today. Many special types of valve did fall by the wayside as solid state alternatives appeared. This is a series on valves on the 21st century so it's not appropriate to cover these obsolete valve types in any detail. But, it would be interesting, nevertheless, to have a brief round-up of some of the more interesting, if not bizarre, types of valve which fell by the wayside and never made it into the 21st century.

So what of the Nixie tube? This was one of a number of valve-based devices which were used in numerical displays and which have now been completely superseded by 7-segment LED or LCD displays. Figure 51 is an exploded view of a Nixie tube. It shows that the tube was neon-filled with a transparent mesh anode and one cathode for each of the digits 0 to 9. When a potential of around 200V was applied between the anode and any of the cathodes, the neon gas in the vicinity of the cathode would glow orange. Since the cathodes were in the shape of the numerical digits, this caused a glow in the shape of the required digit. Interestingly, the Nixie tube's successor, the valve-based fluorescent display tube (VFD), is still with us today.

I won't bore you with describing the internal construction of the magic eye indicator but a quick look at what it did would be interesting. Magic eye indicator tubes were a special type of valve that produced a green eye-like display. They were used as tuning indicators on early radio receivers. When the receiver was off-tune, a shadow would obscure a segment of the eye. As it was tuned in the green fluorescence started to fill in the shadow until, when the receiver was properly tuned, the shadow was gone completely. Similar devices were also used as level indicators in some early reel-to-reel tape recorders.

So the list of vacuum devices which, like the Nixie tube, have been replaced by solid-state alternatives or, like the magic eye indicator, were novelty products of a particular era goes on. If space permitted we could also talk about vacuum noise diodes, electron multipliers, photo-multipliers, valve-based versions of light-sensitive devices or even the vidicon, the most recent of a series of vacuum devices which were used in television cameras prior to the adoption of CCDs. I do have to acknowledge, though, that a full coverage of these valves would be more appropriate to a history book than an article on valves in the 21st century.

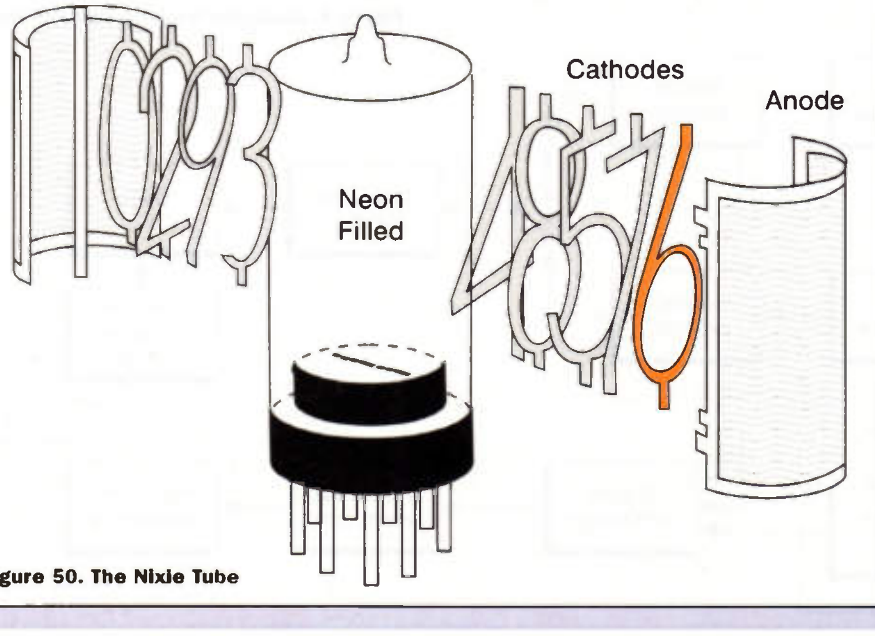


Figure 50. The Nixie Tube

An Electrifying CENTURY

THE RISE OF ELECTRONICS 1900 - 2000

In the final part of this series about the 20th Century, Gregg Grant brings us up to the present time and discusses the Photonic Future.

Introduction

The last quarter of the present century has proved to be a period when electronics conquered almost all other technical and scientific disciplines. From aeronautics to zone refining, there is virtually no profession or specialisation that does not rely on electronic devices of one type or another.

An astonishing variety of transducers convert pressure, fluid flow, pitch and yaw, temperature and other parameters into analogue or digital form for analysis, study, graphical interpretation or comparison against other standard readings. Equally, some measurements are fed, via a communications network, to some distant location for analysis or comparison by a computer, or network of computers.

Over the last 25 years, new components and systems have been invented and developed with the same panache and speed that has characterised the electronics industry throughout the century. Some of the more important of these achievements are outlined in Table 1. Of all these advances however, the one device that continued to forge ahead, increasingly dominating almost all activities on the planet, was the computer.

Computers Everywhere

By 1977, the Apple Corporation had introduced their Apple II machine, the first PC to become available assembled, and ready to roll, 'across the counter' as it were.

It was an immediate marketing success and at this time '. . there were at least thirty personal computer companies, including Apple, IMSAI, Commodore, Vector Graphic, Heathkit, Cromemco, Radio-Shack, North Star and MITS' 1 in that corner of California that would come to be known as Silicon Valley.

The micro-computer was now 20 times faster than ENIAC, possessed a far larger memory, was thousands of times more reliable, consumed the power used by a light bulb as opposed to that swallowed up by a hovercraft and - every bit as important - had only 1/30,000th of ENIAC's volume!

The technology behind computer advances was already spreading throughout electronics, with startling results. Small became not only beautiful, but also universal. With smallness came mobility and with the latter came new sources of power, new techniques of testing and measuring equipment parameters and more universal methods of communication. Nowhere are these developments more obvious than in the new storage batteries, automatic test equipment and the mobile phone.

Equipment for a New Age

Prior to the integrated circuit and digital electronics '. . the testing of electronic appliances was just a case of measuring a few independent analogue measurand parameters, such as voltage and current amplitude, frequency and time relationships etc., at a small number of points.' [2]

Today, matters are very different. Figures 1 and 2 illustrate the changes in equipment design and ergonomics over the last quarter of a century.

Figure 3 traces the stage by stage development of instrumentation from the relative simplicity of the early measuring analysers to the complex investigative and measuring situation facing electronics engineers presently.

Analogue oscilloscopes had a number of limitations, one of which was their penchant for

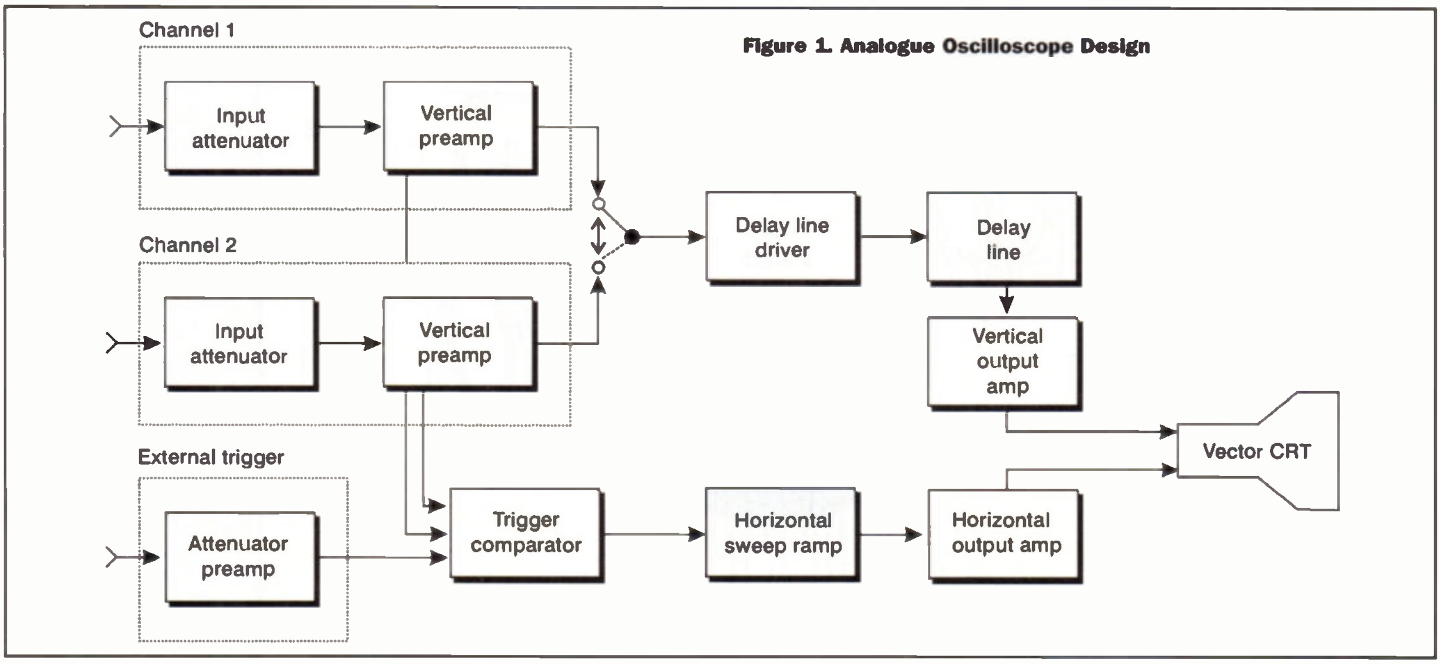


Figure 1. Analogue Oscilloscope Design

Component/System	Inventor/Discoverer	Date
4096-bit RAM.	Fairchild Corporation. (USA).	1975.
Laser printer.	IBM. (USA).	1975.
Spread Spectrum Communications.	R.C. Dixon et al. (USA).	1976.
16,384-bit RAM.	Intel Corporation. (USA).	1976.
Magnetic Imaging Resonance (MRI).	G. Houndsfield, EMI. (UK).	1977.
Fluorescence-Activated Display (FLAD).	Institute for Applied Solid-State Physics, Freiburg, Gemany.	1977.
Laser Optical Recording System (CD).	Philips, Netherlands.	1978.
Optical Metal Insulator . Silicon Thyristor (OMIST)	A.G. Nassibian, R.B. Calligaro . (Australia) and J.G. Simmonds (Canada)	1978.
Satellite Echo-Cancelling Circuit.	Bell Laboratories (USA).	1979.
Seven Colour Ink-Jet Printer.	Siemens, Germany.	1979.
256 K-bit Dynamic RAM.	NEC-Toshiba Electrical Communications Labs. (Japan).	1980.
Fibre Optic Submarine Cable.	Standard Telephone & Cables. (UK).	1980.
MS-DOS Operating System.	W. Gates, Microsoft Corporation. (USA).	1981.
Plane Polarised Light Optical Fibre.	T. Suganuma, Hitachi. (Japan).	1981.
Fission Track Auto-Radiography. (FTA).	Atomic Energy Research Establishment (AERE), Harwell. (UK).	1982
Camcorder.	Sony Research. (Japan).	1982.
'LISA' computer brings the Mouse and pull-down menus to the PC.	Apple Corporation. (USA).	1983
PC-XT becomes the first PC with a hard-disk drive built-in. Stores 10 Mbits of information.	IBM. (USA).	1983.
Digital Optical Disk.	ATG. (France).	1984.
CD-ROM.	Philips. (Netherlands).	1985.
Windows Software.	Microsoft Corporation. (USA).	1985.
Scanning Tunnel Microscope.	Heinrich Rohrer & Gerd Binnig. IBM. Germany.	1986.
32-bit Integrated Circuit. (IC).	Intel Corporation. (USA).	1986.
Advance Programme Control of Video Recorders.	Matsushita Corporation. (Japan).	1987.
Digital Audio broadcasting (DAB).	European Project Group. (Eureka 147).	1987.
McIntosh II and SE models become the most powerful PCS available to the general public.	Apple Corporation. (USA).	1987.
Personal System 2 group of PCs introduced. They give 3.5 in. disk drives & enhanced graphics. They also enable interconnection between computers.	IBM. (USA).	1987.
Fibre Optic Transatlantic Cable. (TAT-8).	AT&T (USA): BTI (UK) and DGT (France).	1988.
Video Walkman.	Sony Corporation. (Japan).	1988.
Very High Density Diskette.	(Floptical Disk).Insite Peripherals. (USA).	1991.
Photonic Crystal.Eli Yablonovitch.	Bellcore Research. (USA).	1991
VHS Bitstream Recorder.	Hitachi Corporation, (Japan) & Thomson, (USA).	1995
Glass Fibre Laser.	Seng Tiong Ho et al, Northwestern University. (USA).	1995
Surface Flat Integrated Circuit.	IBM & Cornell university. (USA).	1996.
Direct Laser Writing.	Mikroelektronik Centre. Lyngby, Denmark.	1996.

Table 1: Electronic Component and System Developments 1975-2000

lagging behind the triggering event. Another problem was that their measurements were dependent on the accuracy of their horizontal ramp generators. Finally, their architecture made their integration into an automatic testing facility - for example a Built-In Test Equipment, or BITE arrangement - difficult at best.

In digital oscilloscopes however, an analogue-to-digital, (A-to-D), converter system based on thick film technology and integrated circuitry takes a ' . . snapshot of the input signal . . [which] . . can be compared against various calibrated voltage reference levels to produce an encoded digital representation of the initially sampled analogue voltage level.' The result of this repetitive process - of the order of hundreds of thousands of times per second - is a time representation, in the digital domain, of the original analogue input. Consequently, such a measurement can be stored for use later in a computer memory.

The benefits of such a system are firstly a more reliable and efficient display system, with the need for chop, or alternate, facilities a thing of the past. Moreover, multibeam oscilloscopes are no longer necessary either and 'connecting a digital oscilloscope to a personal computer or workstation, by means of an industry standard interface, made automated test equipment possible' ' Figure 2 is an illustration of the latest concepts in digital oscilloscope architecture.

Today, mobility and portability is all. Test equipment, laptop computers, mobile phones and camcorders must all be capable of functioning anywhere on earth and - very often - above it too. This has become possible thanks to advances in one of the oldest of the electrical technologies - batteries.

For the past three decades, the Nickel-Cadmium, or NiCd, battery handled man's portable power requirements. Sturdy though it was, the NiCd cell had its drawbacks, not the least of which was firstly its weight - in relation to the power it delivered - and secondly its susceptibility to Memory Effect. This meant that NiCd batteries lost their capacity to fully recharge if they had been repeatedly discharged and then recharged before they were fully drained.

All of the above came under even more pressure with the advent of the portable, lightweight electronic equipment already touched on. Consequently, the battery industry had a commercial incentive to develop portable power sources to match the new equipment and systems. The solution was the Lithium-Ion, or Li-ion, battery.

Some 35% lighter in weight than their Ni-Cd predecessors with the same discharge capacity, the Li-ion cell is also 30% smaller in size. Their performance too is no less impressive. Where a Ni-Cd battery provides between 40 and 60Wh/kg, Li-ion batteries deliver some 100Wh/kg.

Above all, in today's environmentally sensitive climate, Li-ion batteries once again have an advantage: they don't contain Cadmium! The latter of course is a toxic metal, which has a considerable environmental impact, particularly in terms of its disposal.

The market for Li-ion batteries - which were introduced by the Sony Corporation in the early 1990s - increased seven-fold in the two years between 1995 and 1997. Presently, demand continues to outstrip supply, since everything from satellites to whole communications systems are now being designed with Li-ion power supplies in mind.

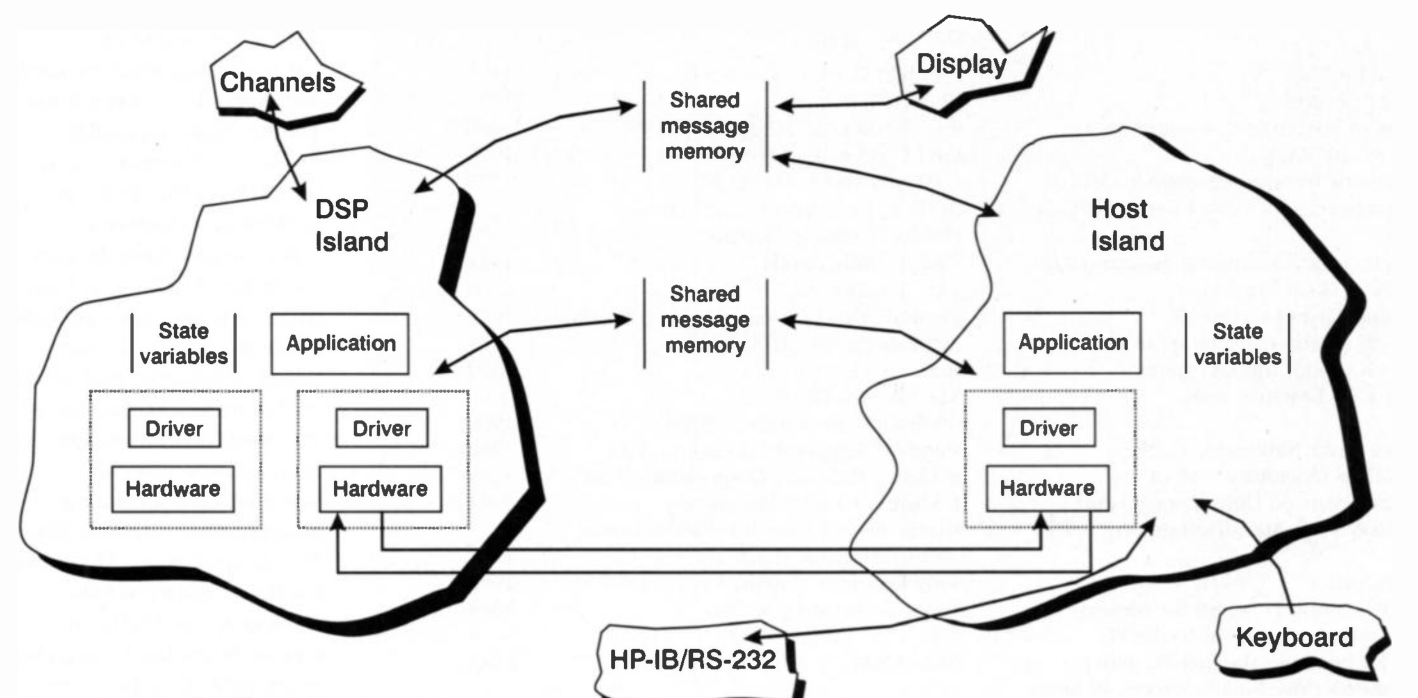


Figure 2. Digital Oscilloscope artitechture

The Global Positioning System

In the 1950s, the American electronics engineer Ivan Getting thought that if a system of satellites were placed in orbit above the earth such that a minimum of four were always in view to a ground receiver, it would be possible to determine the receiver's position in three dimensions. You would, in short, have a system similar to the LORAN system, developed in 1942 at the Massachusetts Institute of Technology, (MIT).

A life fellow of the IEEE, Getting's concept attracted the attention of the American Department of Defence, (DOD), who approved a massive US$10 billion development and deployment programme. In 1978, the DOD launched the first of 18 Global Positioning System, (GPS), satellites, the intention being that the programme would be up and running by 1987. The tragedy of the 'Challenger' shuttle disaster however, and the launch problems resulting from it, delayed full GPS deployment until 1993.

The DOD undoubtedly thought that, apart from itself, the Western Alliance defence community and the civil aviation industry, few others would be remotely interested in this elaborate navigation system. Once again - as with the ARPAnet earlier - the military had sadly miscalculated. Walkers, ramblers, sailors, glider pilots, orienteering sportsmen, mountaineers and other outdoor activity enthusiasts worldwide all took to the system to such an extent that, by the mid-1990s, they had almost elbowed its military applications to the sidelines!

Indeed, as the century draws to a close, the GPS market has grown by 40% and by next year, GPS business will have reached US$10 billion, which was the cost of the system initially! And of this increasingly powerful business market, it's reckoned that the military portion will be less than 10%!

Moreover, as with much else in the electronics world, GPS devices are getting smaller all the time. Presently the Japanese Casio Corporation has produced a watch that can give its owner latitude and longitude anywhere on the planet. Weighing in at a mere 148 grams, this watch is some 60% lighter than the existing GPS hand-held receiving devices and its lithium battery provides 10 hours of constant use, amounting to 600 separate GPS readings.

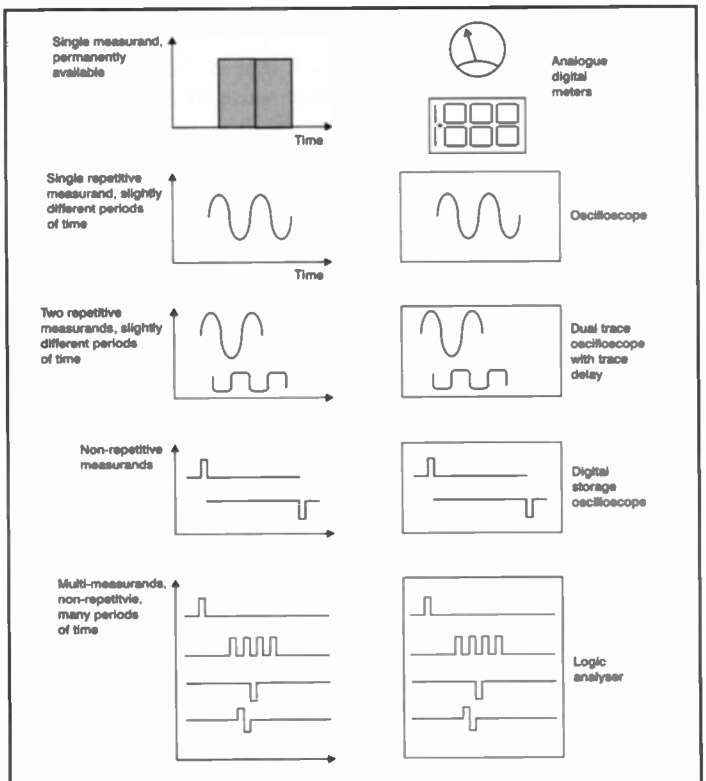


Figure 3.

The Multi-Media Mélange

The earliest form of multi-media of course was the 'Talkies' and Newsreel shorts of the late 1920s - briefly examined in Part Two - combining as they did, sound and vision in one unified whole. By the middle to late 1930s Television (TV) had arrived, and multimedia - albeit it in a basic form - had entered the home.

Multimedia is the concept of a system which can combine text with audio, video and still images to create an interactive application. In a looser sense, it is frequently applied to any communications system involving more than one medium.

This linkage between speech, text, illustrations and moving images only came about through the invention of the CD-ROM and far speedier PCs. Where the latter were concerned, multimedia really began with the Microsoft Corporation's Windows 3.1 system. This simple, user-friendly, front-end to DOS was controlled by a mouse and possessed all the functions and tools needed to get off the ground, with multimedia built in as standard.

Multimedia systems are now

in widespread use in encyclopaedias and other educational products as well as in promotional material such as exhibitions, demonstrations and - of course - in computer games. More recently, another entertainment area has been subject to multimedia principles - leisure photography.

Japan's Sony Corporation has developed a camera that uses a floppy disk as opposed to film. The individual simply inserts a standard, 3.5-inch floppy into the camera, points at his or her subject-matter and clicks! The image captured, the photographer then transfers the floppy to his or her PC, where the photographic image can be adjusted to suit individual taste and then printed out.

Undoubtedly the ultimate multimedia training aid is the Flight Simulator, whose software modules - contained within the broken line - and hardware interface elements are illustrated in Figure 4.

With Local Area and Long Distance networks using Asynchronous Transfer Mode, (ATM), technology with a transmission capacity in excess of 160Mbits/second, media units are packaged and sent - via file servers and routing switches - to other terminals, locations and distant sites. Consequently, the future of multimedia is assured, and there is little doubt that '. . most applications will eventually embed multimedia in help keys, and that software manuals will be entertaining, interactive guides distributed on CD-ROM, instead of bound books.' [5]

In fact, we are more than half way there already. Timothy Garrand's Writing for Multimedia for example is a well-written, profusely illustrated and carefully tabulated guide to the subject - with a CD-ROM version, in its own envelope, inside the back cover!

This is reminiscent of the last decade of the fifteenth century when another new technological product - Gutenberg's printed book - elbowed its way in among the parchment rolls, vying for the buying public's attention.

Exit the Electron

Sometime in this new century - within, I suspect, the opening 20 years - the fundamental particle of electricity will be replaced by the photon, the fundamental particle of light. Indeed the groundwork for this change is already under way.

In 1994, the development of optical amplifiers made long distance fibre optic links not only possible but economically viable. Three years later Wavelength Division Multiplex, (WDM), links were also proven to be financially worthwhile.

WDM works through combining multiple optical signals into a single fibre and transmitting each signal on a different wavelength. The main reason for this approach is simple: public demand. It has been estimated that, in the next century, the demand for bandwidth could be some 500% more than it is at present.

Currently, electronic scientists and research engineers at Hewlett Packard take the view that fibre can provide a bandwidth of - wait for it - 25THz, or Terahertz. Indeed beyond the year 2000, electronics engineers may have to come to terms with a new language in order to understand photonic networks.

In an information sheet dealing with such networks, Hewlett Packard state that '. . the most popular components used to build photonic networks include laser diodes: most are either FP (Fabry-Perot) or DFB (Distributed Feedback).' [6] Other components include planar Grating and Bragg Grating filters, Isolators, Circulators and Photo Detectors. Such networks will provide many new technical an managerial challenges in the next century.

Probably, the greatest challenge of all will come not from the networks themselves, but from the sheer volume of information that will pour from them. In the final article in this series, I'll look at this problem which - like the so-called Millennium Bug - has been growing for some time.

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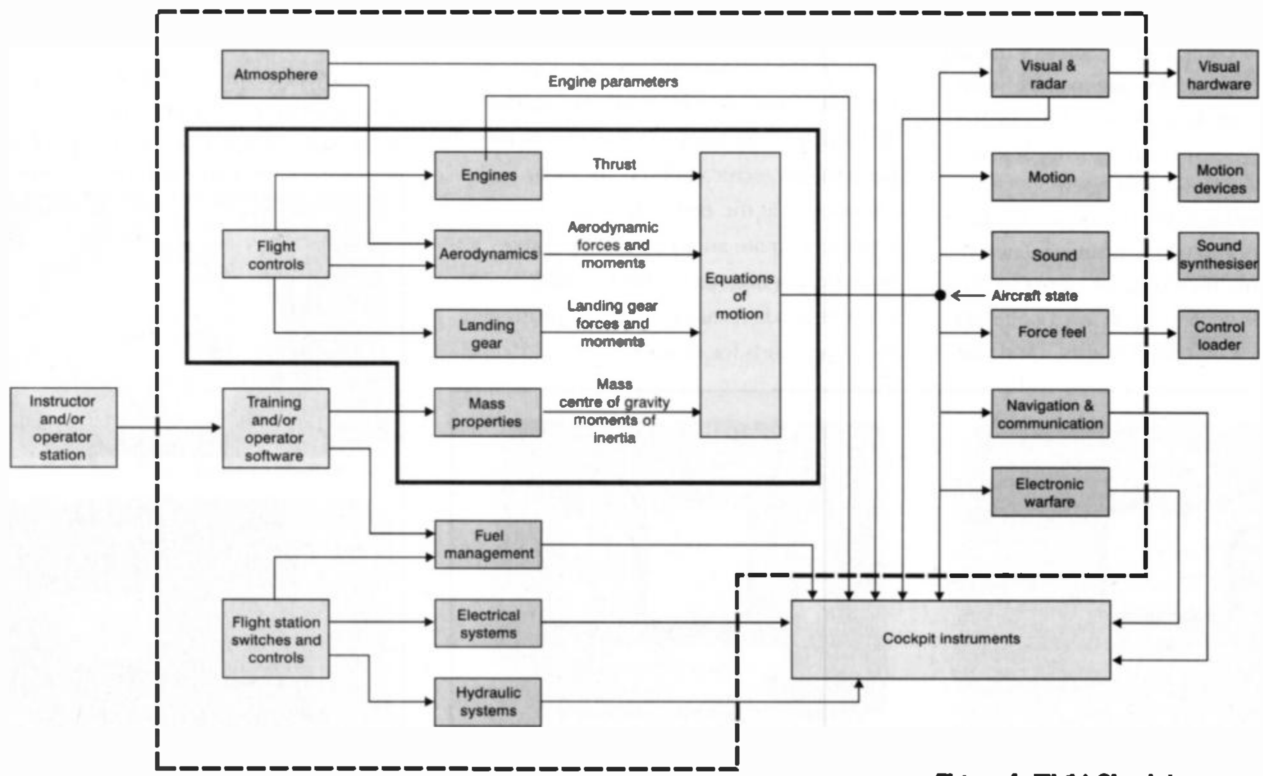


Figure 4. Flight Simulator

TECHNOLOGY WATCH

With Martin Pipe

Not so long ago, Linux - a PC version of the operating system Unix - was considered to be 'anoraks-only'. It was powerful, open, configurable and reliable but extremely user-unfriendly. The original software was written by Finnish programmer Linus Torvalds (hence the name) around ten years ago. Other programmers kept in touch with Torvalds over the Internet, and contributed to the operating system's development. Today, Linux (www.linux.org) is seen as a major threat by vendors of other operating systems, not least because it is freely-downloadable. Indeed, most of the applications are also given away free - in this respect, Linux is seen as true to the original spirit of the Internet. Commercial distributions of Linux span several CD-ROMs and include just about every program you're likely to need, yet are cheaper to purchase than Windows '98 on its own.

Today, major companies - such as Compaq - are offering Web servers pre-installed with Linux. Many organisations and individuals who host Internet sites are moving across to Linux, largely because of its open architecture and stability (Linux servers have been known not to crash during the two years - or more - they've been running). The fact that it's far cheaper than Microsoft's NT Server is merely an added bonus. The front-end (notably the X-Windows GUI) and installation process are becoming more user-friendly, and an increasing number of ordinary PC owners are hence opting for Linux nowadays. Microsoft is only too aware of this, as leaked internal documents published on the Internet (www.opensource.org) have shown. The competition represented by Linux is forcing Microsoft to innovate again. In other words, Linux is - ironically enough - benefitting Windows devotees...

So what is Mr. Torvalds up to these days? In the last ten years, he's made software companies of Microsoft's stature sit up and take notice. Now it's the turn of corporate microprocessor giants like Intel and AMD. Torvalds now works as a software engineer for Transmeta (www.transmeta.com) - a Californian company that, over the last five years, has been developing a new kind of Pentium-class x86-compatible microprocessor. Despite the development time - and an expenditure of over $100m - Transmeta's 200 employees were able to keep things secret until the chip was announced at the end of January. This represents quite an achievement in the hype-ridden high-tech world, in which non-existent products are extensively promoted to attract funds for development.

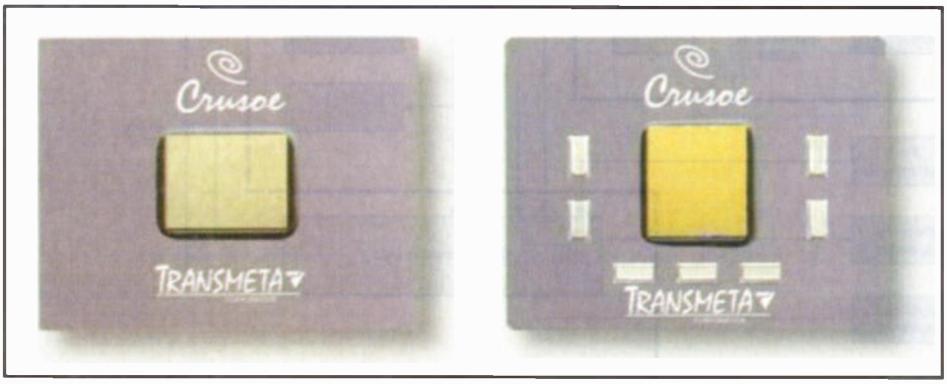
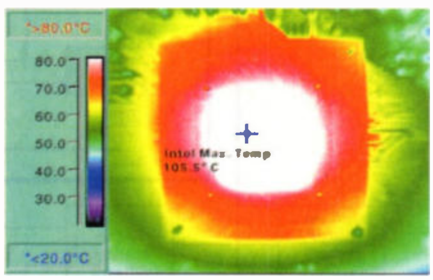


Figure 1. Crusoe Chip - TMS3120 on the left, TM5400 on the right.

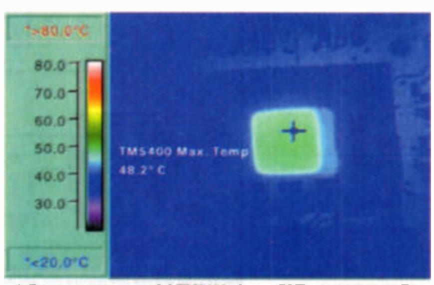
Crusoe

The Crusoe (as in Robinson) is intended to form the basis of mobile 'internet computers'. Many see these as replacements for the 'modemed' desktop PC. Lest we forget, wired phones are increasingly being replaced by cellular ones now that the cost of ownership is falling. Transmeta believes that we'll see a broad range of portable Internet computers, ranging from Web pads to ultra-light notebooks. The company believes that performance levels should match, or at least be close to, what desktop PC owners are used to. Current PDAs are limited in computing power - typical models are roughly equivalent to a 33MHz 486SX or thereabouts - and cannot run the types of Internet software taken for granted by 'tethered' users, such as streaming multimedia playback.

Power consumption was the first major issue that had to be addressed. To this end, Crusoe (www.crusoe.com) consumes a mere 2W of power at full pelt - a fifth of what Intel's currently-best processor needs. As a result, a Crusoe-based laptop will be



A Pentium III processor plays a DVD at 108° C (221° F).



A Crusoe processor model TM5400 plays a DVD at 48° C (118° F).

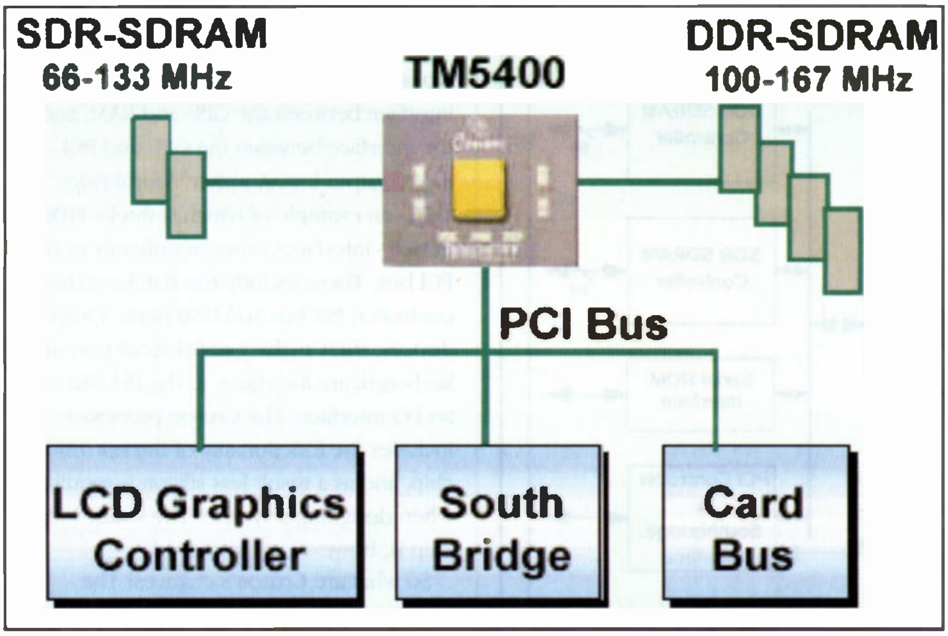


Figure 2. Simplified hardware design block diagram

able to run all day on a single charge. Because it consumes less energy, the processor generates less heat. As a result, there is no need for fans - which themselves eat up battery power - or cumbersome and heavy heatsinks. Very important if you're trying to make a portable computer, in other words. Smaller batteries can be specified, and there's no need to integrate sizeable chunks of aluminum into your product's case design. Power consumption is driven down by some interesting technology. Transmeta has developed a power management system, known as LongRun. Here, the processor continuously monitors the demands on the processor, and dynamically picks just the right clock speed (and hence power consumption) needed to run the application, so that no power is wasted. There's also a 'deep sleep' mode, in which Crusoe might consume as little as 8mW. Transmeta claims that LongRun can reduce overall power consumption by almost 30%. Since the switching happens so quickly, it is not noticeable to the user.

Other processors run at a fixed operating speed, needlessly wasting battery life. Some 'mobile' versions of existing designs regulate their power consumption by rapidly alternating between running the processor at full speed and (in effect) turning the processor off. Different performance levels can be obtained by varying the on/off ratio (the 'duty cycle'). However, with this approach, the processor may be shut off just when a time-critical application needs it. This can result in glitches, such as dropped frames during movie playback, that are perceptible (and annoying) to a user. On which subject, LongRun also provides a solution for today's strenuous multimedia applications. Transmeta claims that it is possible to design a light-weight mobile PC that plays a DVD movie for three hours or more. Reproduced elsewhere in these pages are thermal imaging views of a conventional processor and Crusoe, both running DVD playback applications.

RISC

The CEO of Transmeta is David Ditzel, who previously enjoyed careers with SPARC Labs, AT&T and Sun Microsystems. In 1980, he wrote a seminal paper that defined the principles of RISC (Reduced Instruction-Set Computing). RISC techniques are now employed - to one extent or another - in the microprocessor designs of many vendors, including Intel, Advanced RISC Machines (ARM) and Hitachi. The Crusoe's CMOS-fabricated VLIW (Very Long Instruction Word) core - is itself based on RISC techniques. Transmeta claims that it has eliminated around three-quarters of the transistors that would be required in an all-hardware design of similar performance. VLIW is a CPU architecture in which the processor executes long instruction words (128-bit 'molecules') each consisting of several instructions (in the case of Crusoe, up to four of these 'atoms') per clock cycle.

Unlike traditional superscalar (multiple instructions per clock cycle) processors, a VLIW does not need to analyze whether instructions can be executed in parallel, since the molecule already explicitly encodes that information. This reduces hardware cost and enables higher processor speeds. The hardware only form part of the story, though. Clever software techniques, partially developed by Torvalds, are employed to provide x86 emulation. This 'code morphing' translates the x86 instructions into Transmeta's proprietary ones, before passing them to the VLIW hardware engine. As far as the applications and operating system are concerned, it's an Intel (or code-compatible) processor in the guts of the hardware. In theory, different code-morphing software could emulate other types of processor.

Crusoe - Two Versions

There are two versions of the Crusoe. The lower-cost ($89) TM3120, which runs at 400MHz, is optimised for a specially-developed mobile version of Linux - hence Torvalds' involvement. A big draw of Mobile Linux is that it can be stored in solid-state

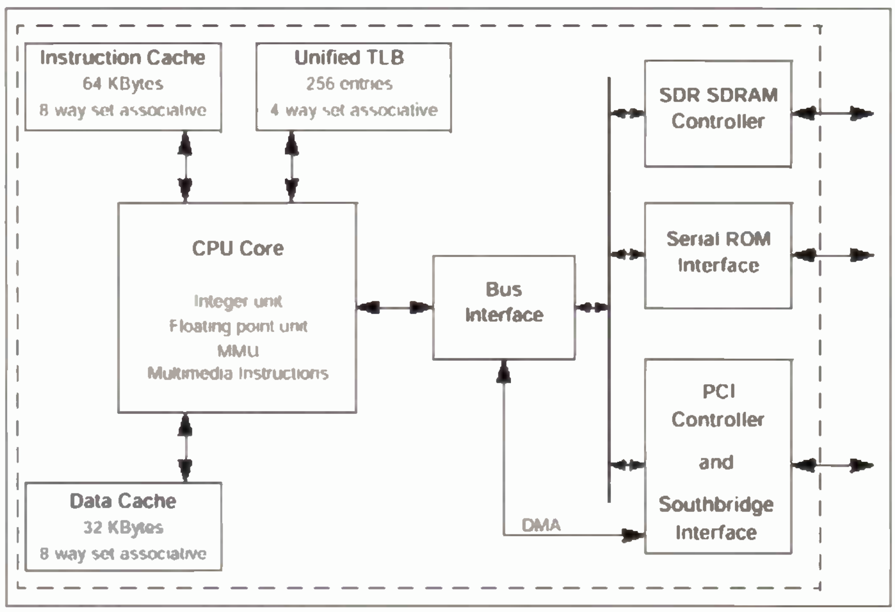


Figure 3. TM3120 Architecture.

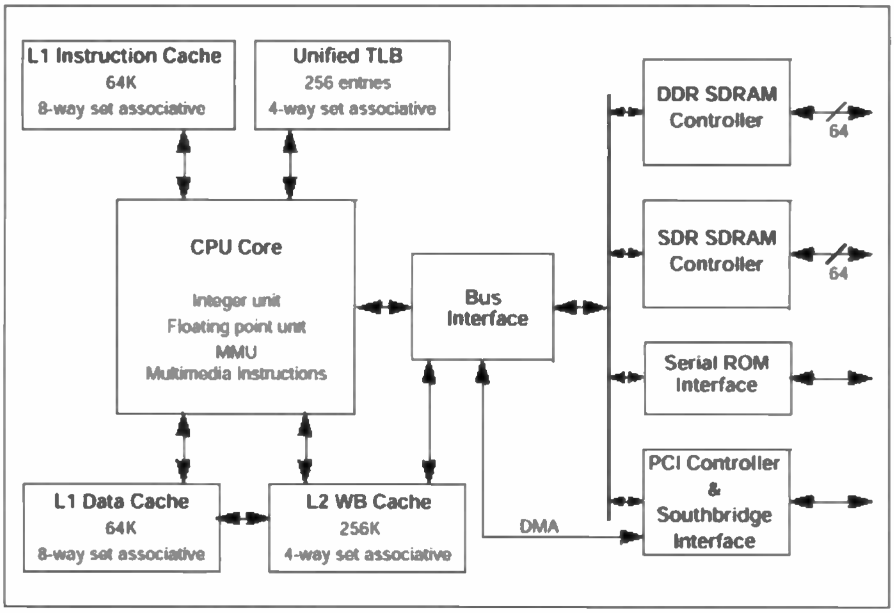


Figure 4. TM5400 Architecture.

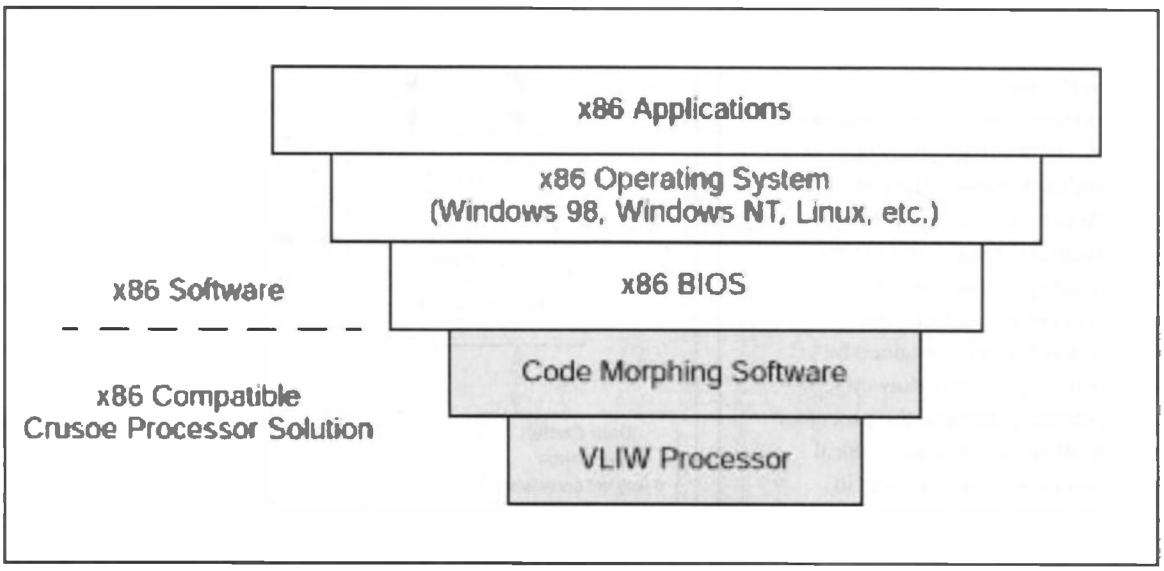
flash ROM, thus removing the need for an expensive and fragile hard disk drive. A faster (700MHz) version of the chip - the TM5400 - is aimed at fully-blown Microsoft Windows 9x/NT/2000 devices, such as laptops. x86-compatibility is, of course, critically important here. Windows aside, one only has to think of all the browsers (and plug-ins) that exist in only x86 form (in a perfect world, they would be written in JavaScript, but that's another story!).The 700MHz TM5400 version of the Crusoe, which includes the aforementioned LongRun technology, sells for $329. It's said to have a performance equivalent to that of a 500MHz Pentium III. That said, the Pentium III's SIMD instruction set is not yet supported.

Slower - and cheaper - devices are also available. A 333MHz TM3120 sells for $65, while a 500MHz TM5400 can be acquired for $119. The chips are, according to Transmeta, already available to system builders. Licensees currently include Diamond/S3 (the graphics chipset people) and IBM. The company believes that we'll begin to see commercial Crusoe-based products by the summer. Prototypes of a Crusoe-based notebook PC and palmtop PDA have been demonstrated - we can also expect to see mobile computers with built-in cellular hardware - remember that data-friendly communications technologies like GPRS and G3/UMTS are only around the corner.

Although less expensive devices of similar performance are available from other manufacturers, one has to factor in the cost of beefier power supplies, heatsinks, fans and so on. What's more, both devices integrate some of the other functionality required by PCs. Modern PC motherboards contain two chips that handle certain hardware tasks. The 'northbridge' chip - typified by Intel's 430TX/HX, contains the interface between the CPU and RAM, and the interface between the CPU and PCI input/output bus. Another 'southbridge' chip - an example of which is Intel's PIIXx device - interfaces other peripherals to the PCI bus. These include the IDE hard disk controller, ISA bus and USB ports. Other devices, such as the parallel/serial port and keyboard, are interfaces to the ISA bus via an I/O interface. The Crusoe processor includes the functionality of the northbridge chip, and as a result less silicon is required when designing a system. The southbridge chip is, however, still required.

So what are Crusoe's chances? The problem is that Transmeta is a new entrant into the market, and it's got to convince system builders of the long-term reliability and stability of its largely-untried technology. What's more, it doesn't make its own chips. That said, the IBM connection is a reassuring one. In addition, software bugs are cheaper to rectify than hardware ones - instead of opening up their machines and replacing components (as Pentium users, affected by the notorious floating-point bug, had to), a patch can be obtained from a web site or via e-mail, and installed on the errant system. Then there's the established competition. Intel and its ilk are, no doubt, working on more efficient versions of its existing products. Interestingly enough, Intel - and, ironically enough, IBM - have strong relationships with Cambridge-based design house ARM. The latter company, which also relies on licensing its designs to third parties for manufacture, already sells powerful processors of low energy consumption. These are built into popular PDA devices from Psion, and fully-blown

Figure 5. Code software hierarchy



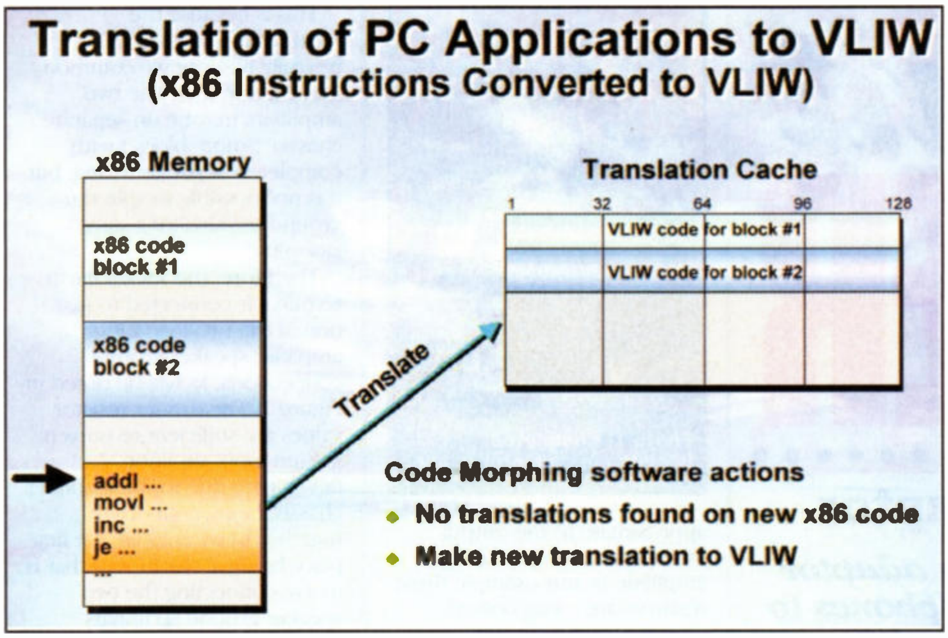


Figure 6. Code tanslation process.

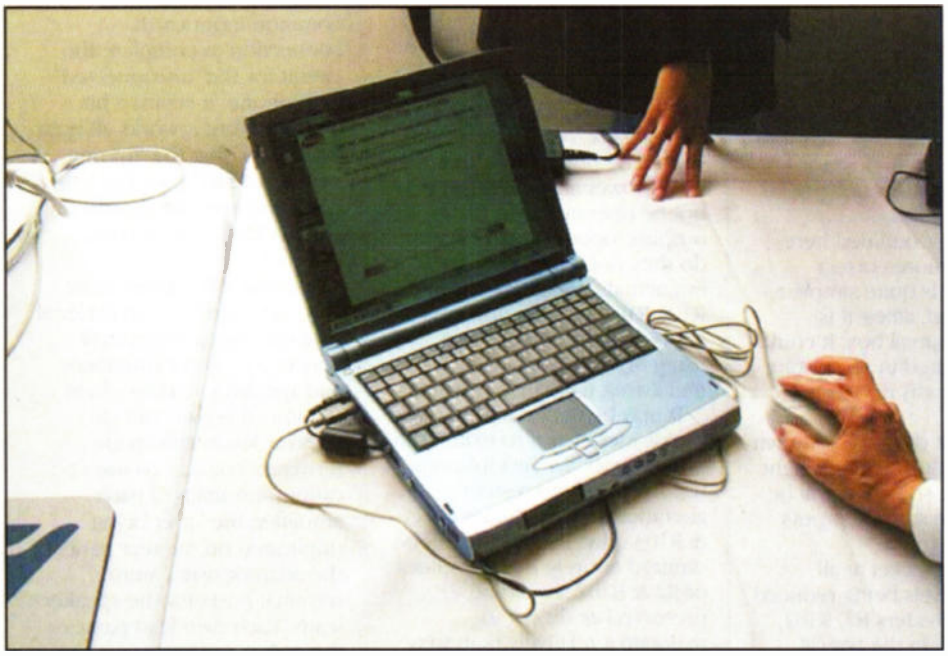


Figure 7. Crusoe powered notebook.

Figure 8. Quanta Crusoe-powered 'WebPad.'

desktop computers like the Acorn RISC PC. ARM, in a quick-fire press release issued just after Crusoe's launch, stated that Transmeta is targetting 'very different markets'. Personally speaking, I'm not quite sure about that. One thing's for sure. The increased competition is, as with Linux, good news for us consumers.

Specification	
Clock Frequency:	333-400MHz
Level 1 Cache:	96Kb
Level 2 Cache:	0Kb
Memory:	SDRAM (66 to 133MHz)
Upgrade Memory:	N/A
Deep sleep mode:	20mW
Northbridge:	Integrated
Package:	474-pin BGA
Sample Availability:	Now
Production:	Now

Table 1. TM3120 Specification

Specification	
Clock Frequency:	500-700MHz
Level 1 Cache:	128Kb
Level 2 Cache:	256Kb
Memory:	SDRAM (100 to 166MHz)
Upgrade Memory:	SDRAM (66 to 133MHz)
Deep sleep mode:	8mW
Northbridge:	Integrated
Package:	474-pin BGA
Sample Availability:	Now
Production:	Mid-2000

Table 2. TM5400 Specification

Specifications of Quanta prototype Crusoe-powered 'WebPad'

- Textbook size with a 10.4 inch LCD display
- USB, 11Mb/sec Wireless Internet connection and hard disk
- Touch-screen user interface
- One handed design
- Long battery life (8-10 hours)
- Based on mobile Linux
- Designed for web surfing, portable multimedia, electronic book applications, streaming audio/video and productivity
- Expected to launch mid-year

Table 3. Specifications of Quanta prototype Crusoe-powered 'WebPad'

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

Circuit MAKER

Headphones Adaptor

Mike Holmes describes an adaptor for connecting stereo headphones to a valve audio power amplifier

With the possible exception of some overly expensive 'Hi-Fi' examples, most audio valve power amplifiers, even 'original' commercially manufactured ones, do not have the facility for driving headphones. The use of headphones becomes desirable where you may want to use the system but not disturb the neighbours (on late nights, for example).

This raises a problem - while speakers can be disconnected from a conventionally designed solid state amplifier and substituted with headphones easily, it cannot be done so simply with the valve amplifier. This is because the optimum output load for the amplifier must be maintained at all times.

Furthermore it cannot be assumed that the headphones will have the same 8W impedance (typical), indeed several modern designs are 'high impedance' types, possibly including an integral volume control. In any case it is unlikely - indeed, undesirable for several reasons - that you would want to connect the 'phones directly to the amplifiers even if they were the correct impedance. The fact that (a), the output may be too loud, possibly damaging both headphones and ears, and (b), that it would make any low level noise more clearly audible, are just too reasons why this is not a good idea.

The project outlined here describes a more correct approach. It is quite simple to construct and, albeit it is housed in a small box, it could be incorporated in an existing amplifier chassis if there is room.

The circuit diagram is shown in Figure 1. Both left and right channels are shown. It will be seen that the stereo outputs are available to the headphones socket at all times, the levels being reduced by resistor dividers R2, R102, and R3, R103 in the typical fashion.

Note, however, that switch S1, used to silence the loudspeakers when not required, is actually a double-pole changeover type, because it is necessary to redirect the amplifiers' outputs to 'dummy load' resistors R1, R101, the values of which must

Photo 1. Completed headphones adaptor in use.

approximate to the output impedance required by each amplifier. In this example these resistors are metal bodied, chassis mounting types selected for a maximum power dissipation of 25W (compatible with push-pull EL34 or KT66 output pairs, e.g. Millennium 420, 'Trident' etc.).

For higher powers higher rated types should be used (up to 100W are available). It should be pointed out that valve power amplifiers must not be operated with their outputs 'open circuit'; not only do they not sound very good but actual damage may result! R1 & R101 must be attached to the box base (or a chassis) using M3 hardware, the metalwork forming a heatsink.

It may be necessary to adjust the divider chains to match the sensitivity of the headphones used. If so, try to restrict alterations to the values of R3 & R103 only. They may even be omitted entirely, but the values of R2 & R102 should be preserved as shown to maintain a relatively high value in each headphone circuit.

This is because the headphones socket, SK1, typically has a single common ground terminal. The two amplifiers may be on separate chassis' ('monoblocs') with completely separate wiring, but it is not possible to split the ground terminal of a stereo jack plug!

Therefore, the socket earth terminal is connected to just one of the two incoming amplifier speaker ground connections, as will be noted in Figure 1. The divider resistor values are sufficient to prevent a 'hum loop' situation developing due to the amplifier chassis' being connected together in two places, the first place being at the input - that is to say, connecting the two speaker ground terminals together directly must be avoided.

It then falls to the existing, common input earth connection to complete the circuit for the 'unconnected' headphone. It seems a bit confusing but it works all right. Note, also, that the 'tip ring' contact of SK1 is for the left-hand channel, the second ring contact for the right-hand channel.

The example shown here was constructed as an external 'add-on', being connected between a pair of amplifiers and speakers in 'daisy chain' fashion. Two pairs of twin speaker leads with spade terminals connect to the output terminals of each amplifier, the latter being duplicated on the rear panel of the adaptor using 4mm terminal posts for the speaker leads. Each twin lead passes through a 4mm grommet in the box rear panel.

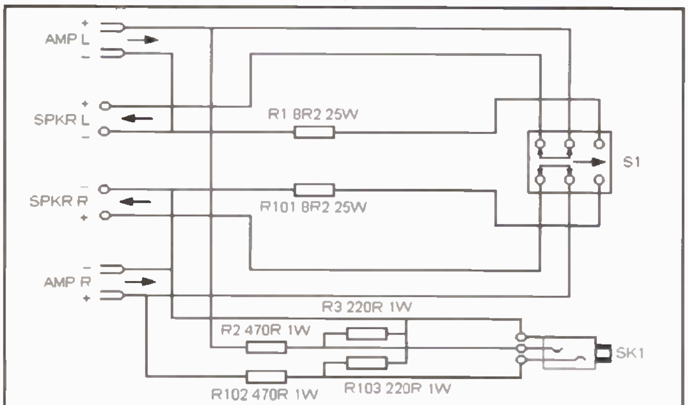


Figure 1. Headphones adaptor circuit diagram.

PROJECT PARTS LIST

VALVE POWER AMPLIFIER HEADPHONES ADAPTOR PARTS

RESISTORS			
R1,101	8R2 25W Wire Wound, metal body	2	(P8R2)
R2,102	470R 1W 5% Carbon	2	(C470R)
R3,103	220R 1W 5% Carbon	2	(C220R)
MISCELLANEOUS			
S1	Toggle Switch DPDT 2A 250V w/Plate	1	(FH39N)
SK1	6.3mm Stereo Jack Socket w/Bezel	1	(BW79L)
TB1,3	Terminal Post 4mm Red	2	(HF07H)
TB2,4	Terminal Post 4mm Black	2	(HF02C)
Or:	Gold Twin Terminal Posts 4mm	2	(JK24B)
	Aluminium Box AB11 4 x 2.5 x 2in	1	(LF12N)
	Hook-Up Wire 3A Brown	1 Pkt	(FA28F)
	Hook-Up Wire 3A Black	1 Pkt	(FA26D)
	Std Grommet 4.0mm	1 Pkt	(JX64U)
	M3 x 10mm Bolt	1 Pkt	(JY22Y)
	M3 Nut	1 Pkt	(JD61R)
	M3 Shakeproof Washers	1 Pkt	(BF44X)
	Twin Speaker Cable	As req.d	(XS47B)
	6mm Spade Terminals	1 Pkt	(JH63T)

COMMENT

by Keith Brindley

British Telecom is making moves towards offering lower priced Internet access for its customers. As of March 1st this year, its BT Internet customers were all able to surf the Internet for a total of 78 hours a week absolutely free of telephone charges. From 6pm to midnight each weekday, and from midnight on Friday night to midnight on Sunday night, customers can dial up using a free 0800 telephone number to the BT Internet service. As such times fall directly in the bands that most home Internet users actually want to get on the Internet, this would probably mean a good deal. Plus, an increase in free access times and a fall in subscription price too - down from £11.75 to £9.99 a month - it sounds a very good deal. However, there's more to it than meets the eye.

To date in the UK, Internet service providers have provided access to the Internet in one of three main payment methods - all directly associated with the amount of time users actually use the Internet. First is the traditional paid for access. Users pay a monthly flat-fee, and dial up using a standard telephone number. Pipex Dial, Demon, and even BT Internet provide this sort of service. Second is the variable fee (the more you use it, the more you pay) access, with a limited rate telephone charge (usually 1p a minute at any time of day or night). AOL and ntl's PC Internet are good examples. Third method is the free Internet access, using standard rate telephone calls. Freeserve, freebeeb, Netscape Online, Free4All are all examples of these service types.

Choosing which method to use depends on how much you use the Internet. If you don't use it much at all (say only for the odd email) then the cheapest by far is the third method, as you pay nothing for access and only a little for telephone calls. If you use it more regularly however, then the second method is invariably cheaper, as the small monthly fee is more than adequately offset by cheaper telephone call charges. Interestingly, at no time does the first method prove to be cheapest, as these types of service argue that the service is invariably better quality (that is, faster, and rarely do you find a busy line) than the other types, so worth the expense for certain customers.

BT Internet first made the move to allow free access at certain times sometime last year, with free weekend calls, but this new move to have free weekday evening calls too actually tips the balance for services of the first method. Interestingly, BT is introducing another Internet service, BT Surftime, giving the same sorts of unmetered access but in various configuration options. First, for a standard line rental of £9.26 a month, users get all Internet access calls at 1p a minute (or less at evening and weekend). Second, for the line rental plus £5.99 a month, evening and weekend access is free. Third, is full free Internet access for an extra £19.99 a month over and above the line rental. So, for around £30 a month anyone can have full, unmetered Internet access. Maybe it's a case of one of BT's hands not knowing what the other's doing, but whatever the reason it probably heralds the start of a new age of Internet access.

All this alone would be good news for Internet users, if it wasn't for a couple of other news items in the same week that BT announced BT Surftime. First, AltaVista (the search engine people) announced its unmetered Internet access service, which for a £30 connection fee, and a yearly £10 subscription, will be available in the next three months. Second, ntl (the cable telephone and television company) announced its unmetered Internet access service, at £9.25 a month, which will start on April 17. Both of these services will be available throughout the UK.

These services effectively beat BT's services hands-down. AltaVista's relies on users dialling an 0800 telephone number from an existing telephone, so requires that you still pay BT a line rental of £9.26. However, ntl's service can be used by both ntl telephone users or BT telephone users. If you're a BT telephone user you have an adaptor box that routes all your telephone calls onto ntl's network, so you still need to pay BT's line rental, although you can opt to use BT's light user rental (around £10 a quarter). If you're an ntl user (so don't use BT at all), however, the free Internet access service is available under the standard ntl line rental (£9.25 for either a single telephone line and a handful of cable television channels, or two telephone lines).

There are causes and effects for everything that happens in the communications world, of course, as there are elsewhere. February's announcements of BT's much reduced profits in its third quarter (a fall of some 24% down to £650 million) meant that BT's share price fell just as drastically. Later that month the Chancellor of the Exchequer's and Oftel's requested that BT bring forward the dates of unbundling the local loop, so bringing share prices down even further with the expectance of even cheaper Internet access. It's not beyond the grounds of scepticism to say that maybe this new BT Internet pricing policy is simply BT's attempt to regain the higher ground and pump the share prices back upwards.

On the other hand, AltaVista and ntl have rather stolen BT's thunder, with unmetered Internet access services that are significantly cheaper than BT's. It's just possible that BT will have to think again regarding Internet access costs. BT Internet and BT Surftime, on the face of it, form significant improvements over the Internet access services BT previously offered, but in the light of these other services they are probably still not good enough.

In the end, whether or not BT shareowners find a light at the end of the dark tunnel they're currently in remains to be seen. But, for the moment at least, it's the nation's customers, not just shareholders, that are happy. And this means that all Internet users can be pleased. Any one of these services is infinitely better than any existing Internet access service, and - put together - they all mean that there's a lot more to come too.

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

RESEARCH NEWS

by Dr Chris Lavers

Microtechnology, Integrated Chips and Miniature Microsystems

For several decades now silicon transistors have become smaller and smaller, allowing the fabrication of tiny but powerful semiconductor chips. These microchips have led to countless miniature inventions such as mobile phones, laptop computers, and modern CD music systems. Incredibly the performance of such systems has improved over 30,000 times over the last 30 years.

There are two particular key ingredients that helped fuel the modern computer revolution originally started by Charles Babbage (1791-1871). Babbage was a brilliant British mathematician who planned a mechanical calculating machine, but failed to complete the construction because the Government refused the financial support recommended by the Royal Society. Incidentally, a working model of his original computer sat in a little Totnes Museum in Devon for a number of years. The first crucial component was the stored program concept. Every computer since the late 1940's has followed this model, which prescribes a processor for numerical processing and a memory for storing programs, data and date. Hence in the early days the limit on memory forced programmers to forgo the full four digits of the year, e.g. 1940 to replace it with the binary equivalent of 40, which is much smaller. However, the misrepresentation created no problem, as everyone knew it was 1940 anyway, yet triggering the countdown to Y2K almost without notice! I somehow suspect that the number of people who have written 1999 on a cheque in the New Year or after writing 00 have somehow felt that this wasn't right far outweighs any computer errors. Who said that only computers have a Y2K problem? Anyway the advantages of such stored program systems is that they can be modified to perform a number of tasks flexibly.

The second key ingredient was the invention during the late 1940's, spurred on by the Second World War, was the transistor, demonstrated in 1948 by John Bardeen, Walter Brittain and William Shockley of Bell Labs in the USA. These silicon switches were much smaller than existing bulky vacuum tubes, which often glowed red hot in circuits of their day. As such, transistors enabled the creation of smaller, faster, and not insignificantly cheaper, electronics. Not inconsequential fallout from this is that electronics was now able to pass into the hands of the 'layman.' He could test ideas with actual electronics systems and components leading to an explosion in electronics design and creating the next generation of electronics designers, entering the domain previously held by only a handful of big developmental research laboratories.

However, it may be argued that the flame that lit the fuse was the Cold War period, culminating in the Apollo Space Program and the Race to land a man on the Moon. The old story of the US needing to miniaturise its systems in order to place them on a less powerful launch vehicle than the Russian's had is undoubtedly true - to a degree. However, the pace of commercial development in integrated chips would probably have taken place by the mid 1970's anyway.

Mass Production

Meanwhile, the development of the Intel 4004 chip, the first mass-produced device to be built on a single silicon chip no larger than a pea, led to its being named the microprocessor.

Fabrication of different silicon devices takes a variety on a theme of heating the raw silicon and forming it into a disk and adding chemical dopants, and then heating the doped silicon in an oven. Heat helps diffuse the relevant dopants in the right areas to form conductors, insulators and transistors. The trend over the last couple of decades has been to cheaper, smaller and faster chips. The more chips made per wafer the less expensive they are. Unfortunately the larger the wafer or chip the more likely they are to contain flaws in fabrication. It is only recently that computer giants like IBM have gone over to 300mm wafer size production with more stringent requirements on dust particle size which are like huge mountains on the scale of the device features. Since the 1970's Random Access Memory (RAM) on a chip has grown fourfold every three years, but memory speed has not kept pace at the same rate.

The techniques used in creating very small computer memory devices has also led to the possibility of machining devices at a much smaller level. In the past decade there have been numerous successful demonstrations of microactuators and micromechanical parts using IC-based micromaching technology to produce miniature motion systems. Microsystems will contribute to 21st century society in at least three key areas:

1. Wider distribution and access to information,
2. Ensuring a lifestyle in the home heavily reliant on microsystems and,
3. Improvements in medical diagnostics and treatment.

Three fundamental benefits of the technology will be Miniaturisation, Multiplicity and the integration of Microelectronics. Multiplicity, combined with Miniaturisation and Microelectronics with communication between the different components, will be like an army of ants in a colony, who work together in a coordinated fashion to complete seemingly impossibly large tasks, will be powerful tools for change.

Intelligent Machines

On the horizon are machines with high levels of intelligence, incorporating all the necessary functions of sensing, decision making and movement. An intelligent machine may have several closed-loop microsystems embedded in it. Sensors will gather detailed information from the external environment, integrated circuits will process the information, and microactuators will respond virtually instantaneously.

Machines may even be composed of several different microsystems in order to mimic behaviour of living organisms, or so called biomimetics. Microactuators are on the micron size scale, the same size as cells and large macromolecules such as DNA. Future medical techniques may require microsystems that could detect individual molecules in the body, perhaps sent to capture and destroy cells infected with the HIV virus, actually curing rather than arresting the progress of this terrible illness.

A microactuator is the key device for microsystems to perform physical functions. While sensors and electronics are well established technically, the study of microactuators is still in its infancy. Because of scaling considerations, the electromagnetic force, which is most commonly used in full size actuators, may not be the only possibility for microactuators. Many microactuators utilise other principles, such as electrostatic force, piezoelectric force, memory shape alloys, and thermal expansion.

The limitations of traditional integrated circuit based fabrication only permits flat structures and micromotors, or overhangs from the edge of a wafer. Hence it is difficult to realise various functions only by changing the shape of the machine. In addition, wiring will be very difficult if all the control signals are externally applied to each element of a microsystem. However, integrated circuit based fabrication methods allow the fabrication of complex systems composed of large numbers of smaller micromechanisms. A complicated micromachine composed of many parts can be fabricated using this approach. Fabrication including, deposition, photolithography and etching allows micromachines to be fabricated.

One problem for the future lies in the fact that photolithographic methods are now reaching serious fundamental limits. If the problem is not resolved soon the progress of previous decades will grind to a halt. In photolithography, light or ultra violet radiation is used to transfer circuit patterns from a chromium-covered template onto the surface of a silicon chip. The technique now allows routine design of chip features between 0.3-0.35μm wide. Making features half as wide would yield transistors four times smaller, since the device is essentially 2-dimensional, but light waves are just too big. Thus the drive within several companies is to investigate X-rays instead. Other possibilities include using the electron beam used to write the 'master' template to instead write the silicon wafers. Unfortunately electron beam writing is painfully slow when compared with current rates of device manufacture. Another significant downside is the rising cost of building your average semiconductor manufacturing plant. At between one to two billion US dollars, these complexes now cost 1000 times more than they did 30 years ago. If the costs rise in accordance with Moore's Law as well, semiconductor equipment will double in price as the minimum feature size is doubled, causing the price of manufacture to gradually squeeze out the number of manufacturing plants. Perhaps in the future there will be a single factory producing the worlds entire microprocessing output! And of course without competition the rapid pace of technological improvement will also probably slow down. Quite how a global market which is very much based on continued global growth, particularly in the high-technology e-commerce sector, will be affected is unclear.

The use of quantum dots, molecular arrays that allow individual electrons to be trapped, and molecular computing will have to wait to a future issue. Certainly quantum dots could be used in a binary register to record the presence or absence of a single electron as either a 1 or 0 respectively. Unfortunately on the scale of the very small quantum-mechanical effects begin to disrupt their function. Logic components hold their 1 or 0 value less reliably because the position of a single electron become hard to specify (Heisenberg's Uncertainty Principle).

Micromechanical Systems

The first micromechanical systems were made from silicon using techniques borrowed from microchip manufacture. Silicon has several attractive features, it is stronger than steel but is as light as Aluminium with a high sensitivity to stress and temperature and can be coated with a variety of materials. This ability to pattern the silicon's surface was soon transferred to bulk micromachining, which allowed 3D structures to be built for the first time. Microsystems technology was revolutionised in the early 1980's when researchers at the Institute for Microstructure techniques in Karlsruhe, Germany, introduced a method to make micromechanical systems from metal. This technique, now known as LIGA (from LIthographie, Galvanoformung and Abformung), allows both metal parts and entire microsystems to be produced. The technique allows X-ray lithography to form a structure in a polymer layer and then deposit metal into the patterned layer to form the component. LIGA allows hard wearing micromechanical parts to be formed. Metal parts can be replicated on a vast scale from a single substrate, significantly reducing costs. Unfortunately LIGA is a complex fabrication process, and access to synchrotron X-ray radiation, prevents small to medium sized companies having an opening into the market.

The Georgia Institute of Technology in Atlanta, and the Ecole Polytechnique Federale Lausanne eliminated the need for synchrotron radiation by using semiconductor lithographic equipment. Although not as good as LIGA, costs are 20 times cheaper, which is attractive to any company in any business. Currently there are twenty or more microstructure based businesses in Silicon Valley alone, including IBM, HP, Xerox and Perkin Elmer amongst them. In LIGA a substrate is coated first with a metallic layer and then a polymer resist. The pattern of the component is defined in the polymer by shining radiation through a mask. The exposed areas of the polymer are dissolved away with chemicals, leaving the shape of the part in the polymer layer. This shape is then filled with a metal using electrochemical techniques and the rest of the polymer layer removed.

Things are advancing so rapidly that in 1998 researchers at Sandia National Laboratories in Albuquerque, New Mexico, developed a tiny gearing system for making a microengine three million times more powerful using a gear. The 3,000,000:1 gear ratio uses six identical transmission systems, each with two dual-level gears crafted one on top of the other. The two gears operate at a ratio of 3:1 and 4:1 providing an overall gear ratio of 12:1. A coupling gear is needed to add more gear sets, and the Sandia team used an intermeshing set of 29 gears. The complete transmission system occupies an area of less than a millimetre square! One application of these tiny micromachines could be as near-invisible locks in doors or anywhere where access may need to be restricted.

Applications

Promising applications of microactuators and microsystems for the near future will be in magnetic and optical heads, optics, ink jet printers, the handling of human cells and macromolecules as well as improvements in Scanning Tunnelling Microscopes and Atomic Force Microscopes.

Miniature Microscopes

For over a decade scientists have used Scanning probe microscopes to manipulate and form images with individual atoms. One of the most widely encountered is the Atomic Force Microscope, or AFM.

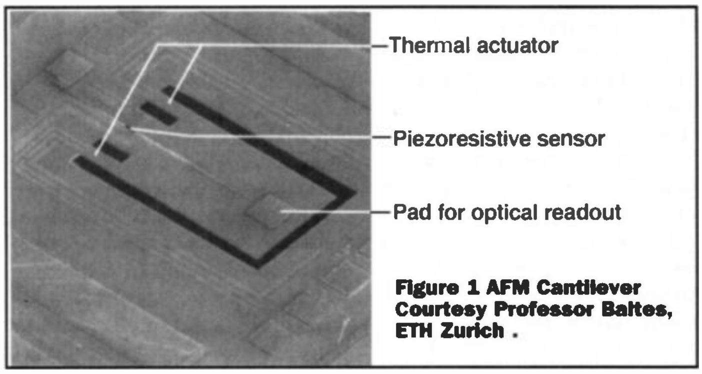


Figure 1 AFM Cantilever Courtesy Professor Baltes, ETH Zurich .

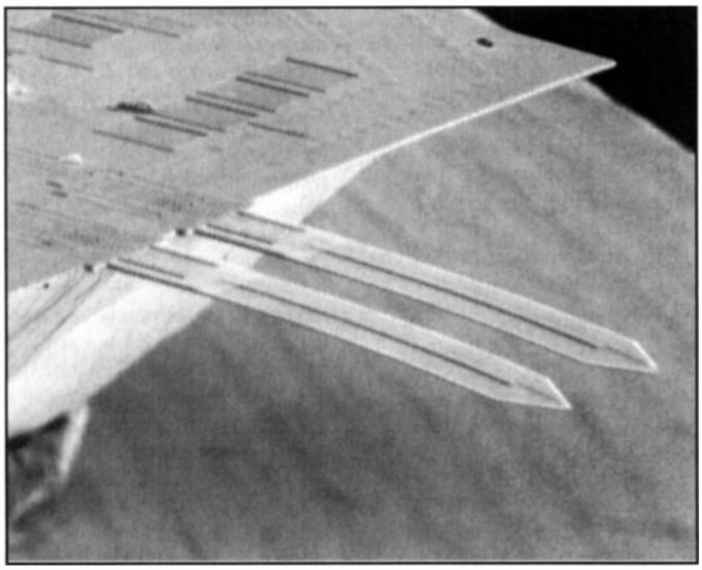


Figure 2 SEM of piezoresistive AFM chip. Courtesy Professor Baltes ETH Zurich.

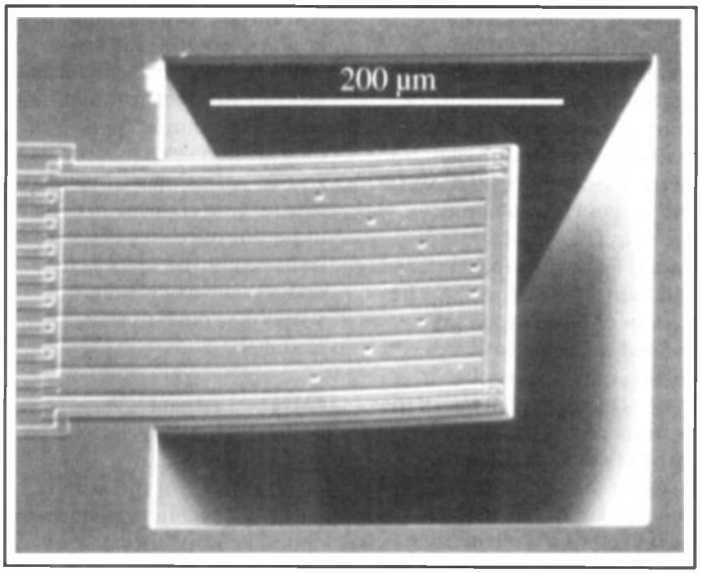


Figure 3 Test structure for measuring conductivities of thin films. Courtesy Professor Baltes ETH Zurich.

Exciting work in Professor Henry Baltes Department of Physical Electronics Laboratory at the Ecole Polytechnique Federale de Zurich in Switzerland have pioneered many areas of microtechnology, including developing groups of AFM cantilevers with an electrothermal actuator and a piezoresistive deflection sensor to work in parallel (Figure 1).

AFM's and STM's could be used to stored and read digital data, so that a million million bits of information could fit onto a square centimetre chip. An STM has a needle-shaped probe with a tip consisting of a single atom. Current that 'tunnels' from the tip to an adjacent conductive surface can move small groups of atoms, either to create holes or pile up mounds on the silicon chip. Holes and mounds correspond to the zeroes and ones necessary to store digital data. Only beams and motors a few tens of microns across, could move the STM quickly and accurately enough to make such data storage on a chip practical. Figure 2 shows a stunning Zurich SEM image of a fabricated piezoresistive AFM chip. The cantilever length is 300μm with a thickness of 3μm. In a dynamic mode a resolution of better than 20 Angstroms was recorded!

Smart Homes

Microsystems will play a major role in information collection, and distribution. Small microsystems will find themselves in all kinds of traditional systems: furniture, monitoring the chemical composition of water in a kettle and then perhaps balancing it, monitoring the temperature in a coffee cup and then cooling it. Embedded chips in the walls and windows will give you details about the stresses on your buildings. And a room could be equipped with microsystems to ensure that humidity, air flow, sound and temperature are maintained at a constant level, also embedded in the walls. Professor Baltes group has already developed a micromachined test structure to measure heat capacities and thermal conductivities of thin films (Figure 3). Passive anechoic tiles already exist, adaptive control offers interesting features. A microsystem will detect conditions in the room using its temperature sensor, humidity sensor, air-flow sensor, infrared sensor, and microphone. Electronic circuits in the system determine the appropriate response based on signals from other local microsystems. The system would also possess microminiaturised arrays of heaters, ventilators, lamps and speakers, which can all be adjusted. The benefits of such microsystems lie in their ability to fail gracefully, as the vast number of individual components, will fail only a few at a time, for which the system can adjust its overall output distribution. Currently a single fan in a room, which fails, leaves the whole room without any air-conditioning at all. Scientists at Bell Labs announced in May last year that they had fabricated the three key components needed for a single chip radio. Workers at Bell's Lucent Technologies used surface micromachining to create a tiny pyramid-shaped microphone and a micron-sized inductor coil and a very small radio-frequency filter. A single chip radio for example would be small enough to be integrated into a wristwatch or millions of them built into the walls for true surround sound. Micromachine pressure pads could also be designed in the floors of a house to detect burglars. Micromachines could perhaps be programmed to repair damaged surfaces and household items at the atomic level!

Information Networks

Microsystems are already indispensable for the future infrastructure for the rapidly expanding global internet community. Such components should include optical matrix switches for optical fibre networks, high speed modulators for optical communications, displays based on movable mirrors, data storage devices, optical disk drives, and input/output devices for virtual reality and computing. Nanolasers, less than a hundredth the thickness of the human hair will have myriad applications in optical computers making much more efficient usage of the photons they produce. For some lasers only one photon in 10,000 is used, the rest are wasted in the form of heat. Nanolasers in a microring where a tiny laser beam is split and can travel in opposite directions around the ring act as a microminiature fibre optic ring gyroscope for inertial guidance systems.

A laser application in medicine is the suggested biocavity laser, where a thin layer of human tissue is incorporated into the device itself. The composition, size and shape of the cells will result in a unique spectral signature or personal spectrometer, allowing doctors to detect dangerous antibodies and diseased tissue, all in a handheld device.

Microsystems for Science

Microsystem technology can supply unique tools for scientific and medical research. The typical dimensions of biological objects are about 1-20μm for cells and nanometres in thickness by microns in length for macromolecules. Manipulation of individual molecules has many exiting possibilities.

Currently pinning down the strain of a pathogen during an outbreak such as E. coli is depressingly time-consuming. The bacteria are first grown on Agar to produce enough for testing and then infected with viruses that attack specific strains. If one virus kills the bacteria then microbiologists have a good idea of what they are up against. The identity is then confirmed using enzymes to cut the bacterium's DNA and copy the fragments. These DNA fragments after electrophoresis, leave a characteristic pattern, a fingerprint that may be compared with the fingerprints of known strains. The market for DNA multipliers has already been estimated at over one billion units a year.

Research groups worldwide are rising to the challenge of shrinking laboratories onto tiny

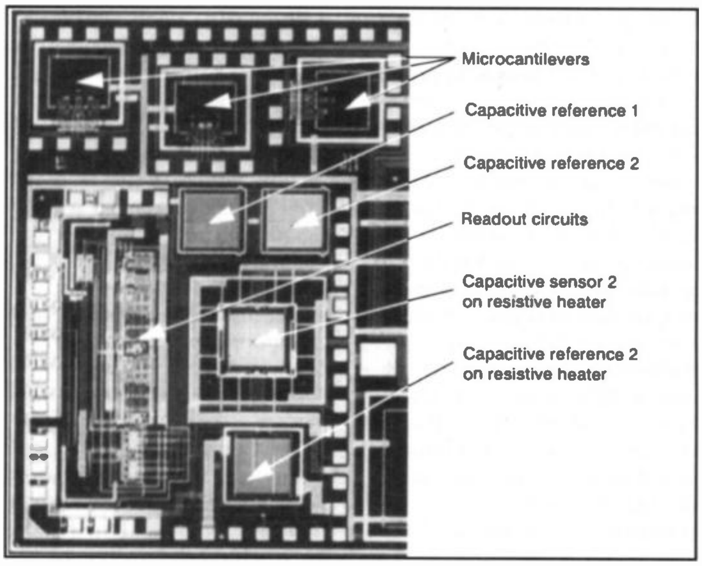


Figure 4 Experimental micronose chip with on chip sensors, references and readout, multiplexing circuitry. Courtesy Professor Baltes ETH Zurich.

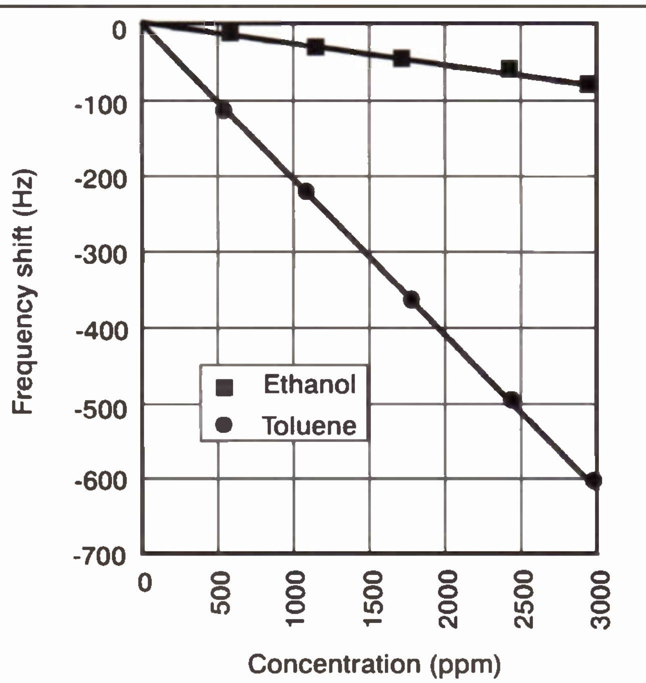


Figure 5 Sensitivity of Chemical sensor to ethanol and toluene vapour. Courtesy Professor Baltes ETH Zurich.

Figure 6 JPL Pasedena/Hughes miniaturised gyroscope for space stabilisation. Courtesy NASA.

squares of silicon or glass to speed up the detection and identification of bacteria. Researchers at the Institute of Molecular and Biomolecular Electronics at the University of Wales, Bangor, led by Dr Ron Pethig are developing IC devices to move different cell types around their chips. A 100kHz electric field will move E. coli one way and Micrococcus lysodeikticus the other, hence discriminating between the two. Bangor is not alone, as several other consortiums, such as Yorkshire Water with Siemens and the University sector are trying to create disposable sensing chips for monitoring the water supply system and the infrastructure to transmit a signal if there is a problem. Again Professor Baltes group have demonstrated a chemical microsensor with an amplifier integrated on one chip, and an electronic micronose for monitoring volatile organic compounds (Figure 4). Results of similar systems such as a micromachined chemical sensor for monitoring toluene and ethanol sampled on times of only 20ms are extremely promising (Figure 5). A CMOS resonant beam gas sensor with integrated preamplifier for the detection of volatile organic compounds (VOC) was developed by D. Lange, C. Hagleitner and O. Brand using 0.8μm processing, measuring ethanol down to 500ppm and toluene at 100ppm. The VOC is detected as a shift in frequency of the 380kHz frequency beam.

A pocket calculator size microchemical laboratory could create drugs, perform DNA testing to detect aqueous pathogens or convert chemicals into electrical energy more efficiently than current conventional batteries.

Microsystems for Automobiles and Aerospace Applications

Size and weight are probably the most important limitations for aircraft and spacecraft particularly. Microsystems can be utilised to reduce the size and weight of apparatus with the same functions as conventional systems. Airbag for cars have been looked at in a recent Research News, and Analog Device, a Massachusetts-based company that manufactures a micromachined acceleration sensor that triggers the release of an airbag, has sold upwards of a million sensors in the past few years. One day, a microsystem equipped with microsensors for space observation, processors, antennae, microrockets and controllers could be fabricated on a substrate and launched, making a 'flying wafer'!

Aircraft design may be drastically changed by the use of controlled microsystems. The initial size of vortices of air is in the order of a few tens of micrometers. Therefore if arrays of microsystems which can detect and destroy the vortex are embedded on the aircraft skin, it may be possible to significantly reduce aerodynamic drag. Microsystems offer a potential alternative to a flapping wing, as well as microinertial guidance components such as gyroscopes (Figure 6). The newly developed JPL/Hughes microgyro with an expected space lifetime of 15 years is only 4 x 4 mm and weighs less than a gram! In addition, accelerometers, and micron scale Magnetometers are being developed for satellite operations. Indeed workers at Lviv Polytechnical State University in the Ukraine have produced a whole series of magnetic microsensors operable over a temperature range of 4.2 to 350K, and a magnetic field range of 10' to 15T with a sensitivity of 10mV/T, and operational currents of only 10mA (Figure 7). Even mobile robots or flying robots have been suggested which could be

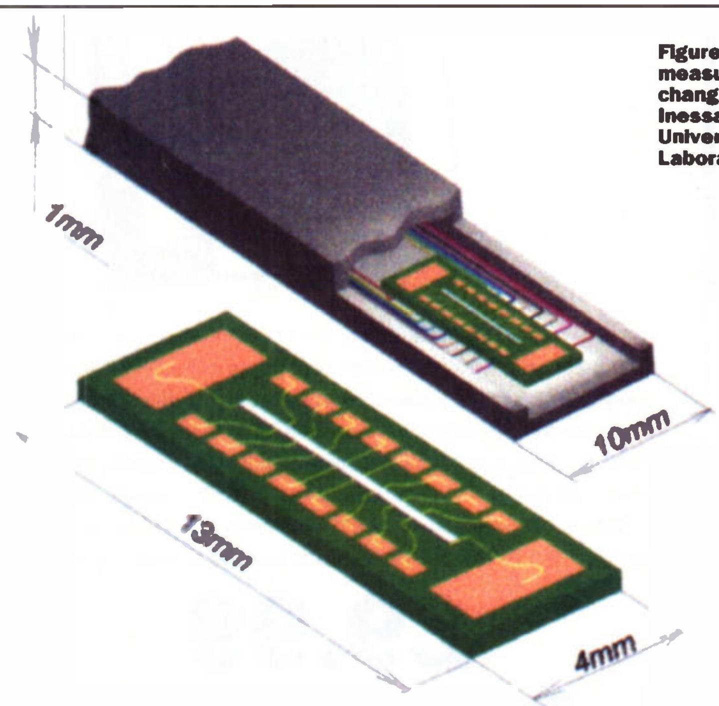


Figure 7 Multisensor for measuring magnetic field changes. Courtesy Bolshakova Inessa, Lviv Polytechnical State University, Test Magnetic Laboratory.

only a few grammes in weight and possibly used to gather aerial information cheaply and sometimes secretly!

Microsystems in Surgery

Metal microstructures could also be used in medical applications, particularly when it is important to localise and minimise tissue damage. Tiny metal cutters just 200μm wide could be used in microsurgery, while tools for endoscopy on a micron scale could revolutionise this relatively non-invasive medical procedure.

Many thin film materials could be used in potential chemical and medical sensors, from metals to polymers, Langmuir-Blodgett films and molecular crystals. Potential areas include the controlled release of glucose for diabetes patients or the controlled drug release in the brain of patients with chronic pain, activated in the microsystem by recognition of specific body fluid analytes. Potential microsystems could be used to 'scavenge' the body for harmful agents causing problems such as the furring of arteries. It might be possible to design micromachines that could travel the blood system of the body seeking out HIV viruses in the body and then destroying them or removing them from the bloodstream. Even microdialysis and artificial sense organs such as cochlea implants have been suggested as well as artificial eyes.

Micronscale to Nanoscale Technology

The ultimate drive of all of this micromachining must clearly be to control the device scale right down at the level of the individual atom. Professor Richard Feynman was probably the first person to seriously raise the idea of moving individual atoms around at will in 1959. One of the current leaders in the race towards nanoscale systems is Eric Drexler author of 'Engines of Creation', who believes that soon people will be able to handle the fundamental molecules and atoms of matter and rearrange them to form entirely new patterns in true 3 Dimensions. The concept is to send instructions to the equivalent of a tool making machine which will arrange the atoms and molecules the way you want, to make a computer, medical device, or even a Sunday roast. The guts of his engine of creation are so called assemblers. An assembler is a molecular machine that can build anything, including itself, with the complexity of a living cell. All living cells use electronics the size of single molecules. The molecular electronics within living organisms and the biosensing revolution may be the gateway to practical large-scale nanoscale systems. Simple materials rearranged differently such as carbon from common humble yet soft graphite into hard and durable diamond offer incredibly strong materials for buildings or aircraft built from diamond, or diamond-like materials. In fact if the 20th Century is remembered as the silicon age, the 21st might just be remembered as the diamond age.

Devices such as micromotors and microactuators have been proven. It is now necessary to demonstrate real microsystems composed of mechanical and electrical elements. For example a micromotor is useful only when driven at a controlled speed. The design method and integrated fabrication technology of microsystems is now being established. Microsystems will have a profound impact on future society. It is necessary to continue and enhance research activities across previous subject domains. The commercial uptake of microsystems based on nanotechnology is really the next step.

Solar Pictures

For those who particularly enjoyed the auroral pictures in issue 147 you may be interested to know that further beautiful colour photographs of the aurora are available for viewing or may be purchased by contacting: jcurtis@gi.alaska.edu or Jan Curtis, PO Box 83482 Fairbanks, Alaska, USA 99708-3482.

Software HINTS & TIPS

by Mike Bedford

If you don't have a separate drawing package, you can produce some pretty smart sketches using Word 97.

No doubt you put tables in your documents but are you really making the most of MS Word's table drawing facilities?

Tables are an integral part of word processed documents, especially if your documents are technical in nature. And whereas you probably know how to create and edit a table, you might not be making full use of all the features available in Word 97. Much of what we'll see are features that you can manage without. However, by knowing about and making use of more of the functions available in Word you'll be able to create more professional looking results.

The Basics

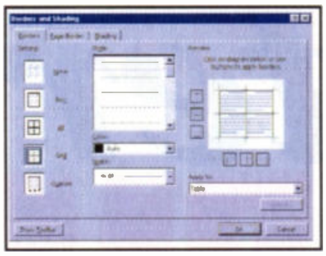
Many of you will already know this but to make sure we're all starting at the same point, let's briefly recap on how to create a basic table.

From the Table menu select Insert Table... and then, on the Insert Table dialogue box which is displayed, fill in the number or rows (horizontal) and columns (vertical) before clicking on OK. Alternatively - and this is easier - click on the Insert Table icon on the standard toolbar, hold down the mouse button and drag the pointer to create a table of the required size. A basic table like the one shown below is created. Now, all you have to do is to click into each of the cells in turn and enter the required text.

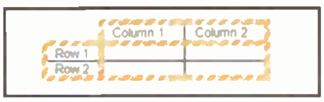
Borders

The standard table, which is created as described above, has thin lines separating each of the cells. Sometimes, though, you'll want a table without these lines or perhaps you'll want thicker lines around the edge and, perhaps, to separate off the row and column headings from the rest of the table. Select the whole table and then select Format > Borders and Shading... > Borders. The Borders dialogue box, shown here, is displayed.

The left-hand portion allows you to pick some standard formatting options but for more flexibility, you'll need to use the centre and right-hand portions. As you click on lines in the Preview area, those lines will alternately disappear and appear. When they appear,



they'll reflect the style, colour and width specified in the centre portion of the dialogue box. Note, though, that if you selected the whole table, this interface will only allow you to alter the appearance of the outer lines, all the inner vertical lines or all the inner horizontal lines. To alter just some of the internal lines - to rule off the column and row headings with a thick line, for example - you'd need to select just part of the table before selecting Format > Borders and Shading... > etc. Try it out and all will become clear. Here's an example of a table with some rather more interesting rulings.



Perhaps this isn't the most tastefully designed table imaginable but at least it hints at the sorts of things that can be done this way. Another interesting (and rather more tasteful) way to format a table is to use a combination of borders and shading. Here's an example of the sort of thing I have in mind - you should easily be able to figure out how to do this now:

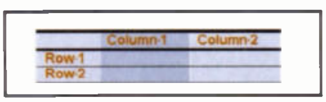
Sizing Cells

You may have noticed that all the columns are of the same width and all the rows of the same height when you first create a table. You may also have noticed that the left-hand column in the two previous examples has been made narrower. Re-sizing columns, and perhaps rows, is something you'll often need to do so let's take a look at the methods available to do this. First of all it can be done manually. To do this, move the pointer over any of the horizontal or vertical dividing lines in the table. The pointer will change shape. When this happens, hold down the left mouse button and drag. Note that when you change the width of a column this way, you specify and exact width. When you specify the height of a row, though, you are specifying a minimum height. If necessary, the actual height will increase automatically if the amount of text you enter into a cell in that row exceeds the space available.

If you want to size the column width or the row height more accurately, select the row or column in question and select Table > Cell Height and Width... The Cell Height and Width dialogue box will be displayed and should be reasonably intuitive. And finally on cell re-sizing, if you get it all wrong and want to return to the standard formatting, in which all the columns and all the rows are the same width and height respectively, this is easily achieved. Simply use the Distribute Rows Evenly or Distribute Columns Evenly options in the Table menu.

Formatting

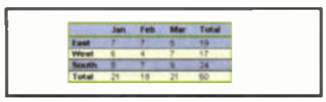
Although paragraph and font formatting are by no means



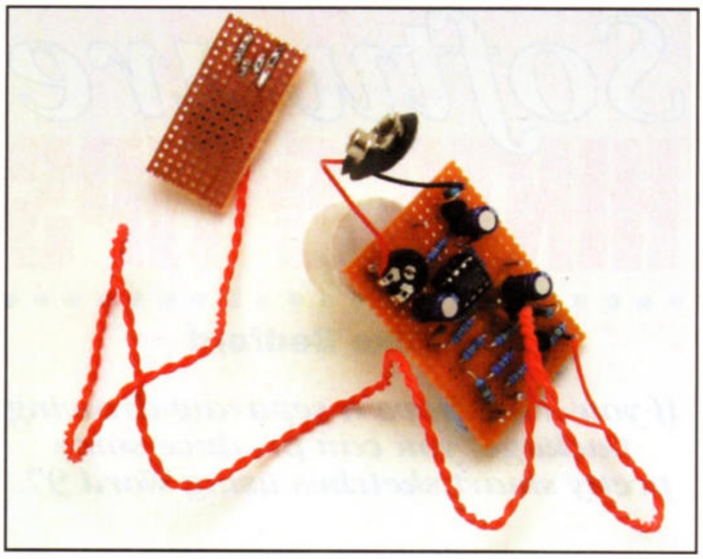
specific to tables, these are aspects you need to think about in order to produce eye-catching tables. For example, if your standard paragraph style has an indentation on the first line it will probably be unsuitable for use in tables. In fact, it would be a good idea to create a paragraph style specifically for use in tables. In addition to making sure there's no first line indentation, you might want a slight space before and after so that the text isn't too close to the lines which divide the rows. You might also choose to use a different font. If you use Times New Roman for most of your text, for example, you might find that a simple sans serif font like Arial would be suitable for use in tables. Also, consider using a different text style for row and column headings - you could use bold or italicised text or perhaps a slightly larger point size for the headings than you used for the main table text.

We've seen how to format tables manually and whereas it's good to know how to do all this, there's also an automatic method. Obviously you don't get as many options this way but it is a good method of generating some very professional looking tables very quickly and easily. First of all, create a basic table in the usual way and enter the text into the cells paying no attention whatsoever to the formatting. Now select Tables > Table Auto Format... and play around with the options provided. You'll soon get the hang of it and be producing tables like the one shown here.

Well that's all we have space for but it's certainly not all there is to know about tables. Other things to try out are merging cells (select two cells in one row and select Merge Cells from the Table menu), Split Cells..., also in the Table menu, and converting non-tabular text (perhaps sent to you in an e-mail) into a tabular form. This latter option, which



you'll also find in the Table menu, allows you to convert text, separated by commas, tabs or another specified character, into a table. Each comma, tab or other character forces a new column and each new paragraph forces a new row.



Water ALARM

Gavin Cheeseman describes a simple water alarm with audible and visual indication plus an alarm time-out.

Introduction

This article describes a simple project that can provide an audible or visual indication when a set of conductive probes come into contact with water. The circuit can be used in many applications from detecting when it is raining to indicating when a specific water level is reached in a container. A timeout is provided so that the alarm does not continue to sound until the battery goes flat!

The circuit effectively works by detecting whether there is a conductive path between a set of probes. When there is no water present the current flow between the probes is negligible, but when water bridges the gap between the two contacts the effective resistance drops and a small current is passed. The circuit detects the current flow and triggers a buzzer. Alternatively, the circuit can be arranged so that the alarm triggers when there is no water present, for example to show that the water in a container has fallen below a certain level.

Circuit Description

Figure 1 shows the circuit diagram of the Water Alarm. Darlington transistors TR1 and TR2 together with associated components effectively form a Schmitt trigger circuit (a switch with hysteresis). This helps to ensure a clean switching action. The Darlington devices exhibit high gain and therefore only a comparatively small base current is required to turn the transistor on. Normally, when the alarm is in standby condition terminals P3 and P4 are connected together (either directly or indirectly). TR1 is switched on by the current flowing in its base and TR2 is turned off. As a result, a logic high state is present at the collector of TR2. In an alarm condition, current ceases to flow in the base of TR1, and the voltage at the collector rises switching on TR2. This produces a logic low condition at the collector of TR2.

IC1 is a simple timer based around the TS555 low power timer IC. The timer prevents the alarm from sounding continuously. Normally the output of the timer on IC1 pin 3 is low. When the alarm is triggered the collector of TR2 switches low applying a pulse to the trigger input of IC1 via capacitor C2. The timer is triggered and IC1 pin 3 switches high. This in turn switches on output transistor TR3. IC1 pin 3 remains high for a period determined by the values of C5, R10 and VR1 after which the IC reverts to its previous state. Terminal P5 may be connected to 0V to reset the timer before the end of the timeout period if required. TR3 is used to drive a small piezo buzzer.

Construction

The circuit may be built on matrix board with or without copper strips. Although the component layout is not critical the usual common sense rules should be adhered to. Make all connections between components as short as possible and use a DIL socket for IC1. Capacitor C3 should be positioned close to IC1 and C6 and C7 should be close to P6 and TR3.

Both for safety and functionality reasons please ensure that all relevant components are connected observing the correct polarity. Semiconductor pin designations are shown in Figure 2. The buzzer may be soldered directly to the circuit board or wired externally. The polarity of the buzzer is marked on the case of the component. The positive terminal connects to P6 and the negative terminal connects to P7.

Power supply

The circuit is designed to operate from a 9V or 12V battery. Please do not forget the fuse as this helps to minimise the damage in the event of a short circuit. This is particularly important if a lead-acid, NiCad or other high capacity battery is used. Battery life will vary considerably depending on the type of battery used and how often the alarm sounds. When in standby condition the alarm consumes less than 0.5mA but when the buzzer is sounding, this increases to a few tens of mA.

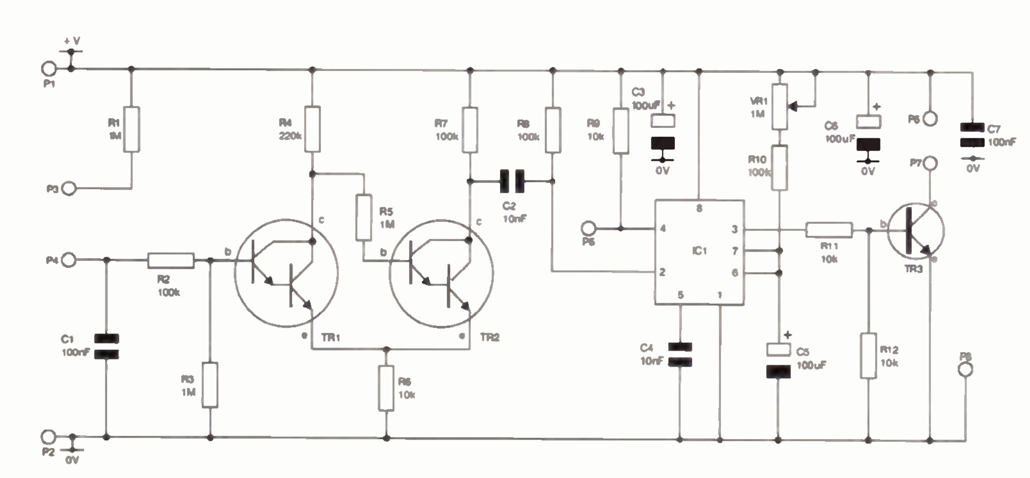


Figure 1. Circuit Diagram.

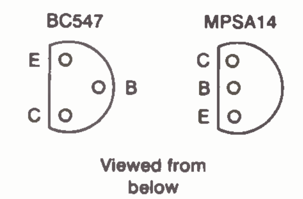


Figure 2. Semiconductor pin designations.

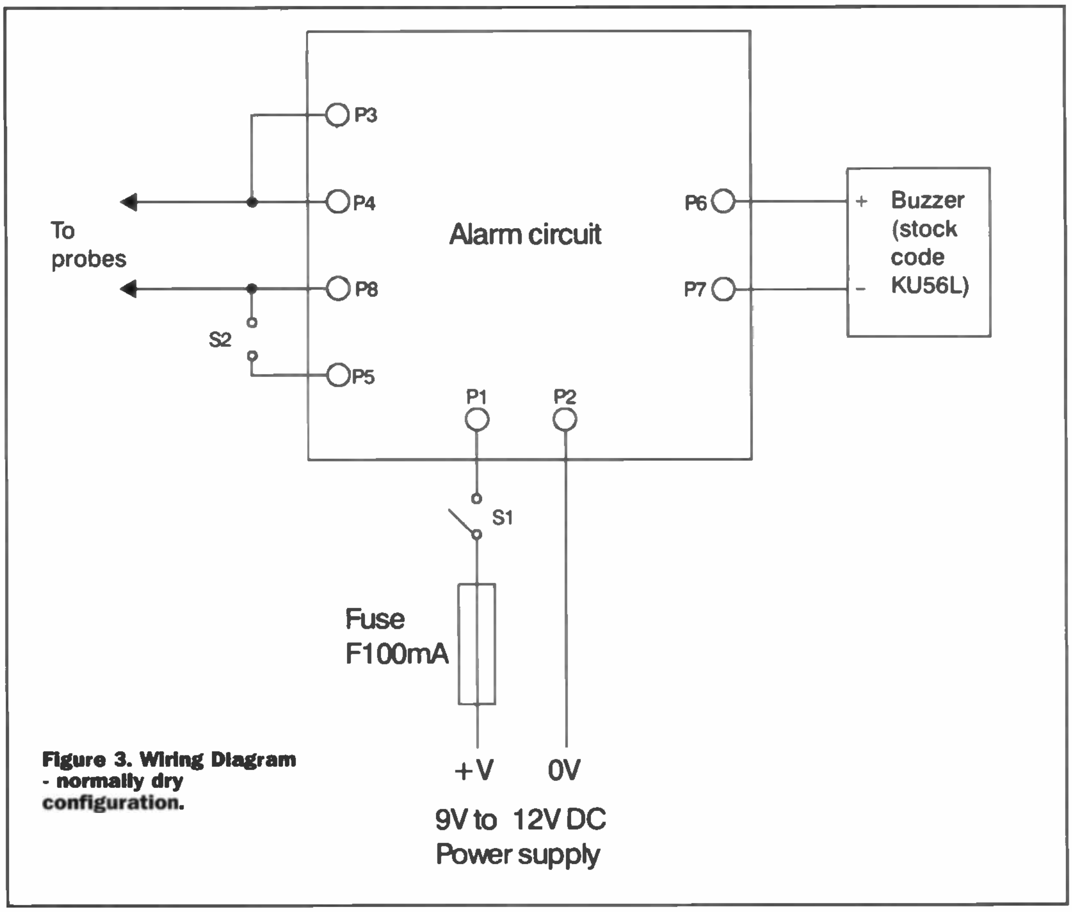


Figure 3. Wiring Diagram - normally dry configuration.

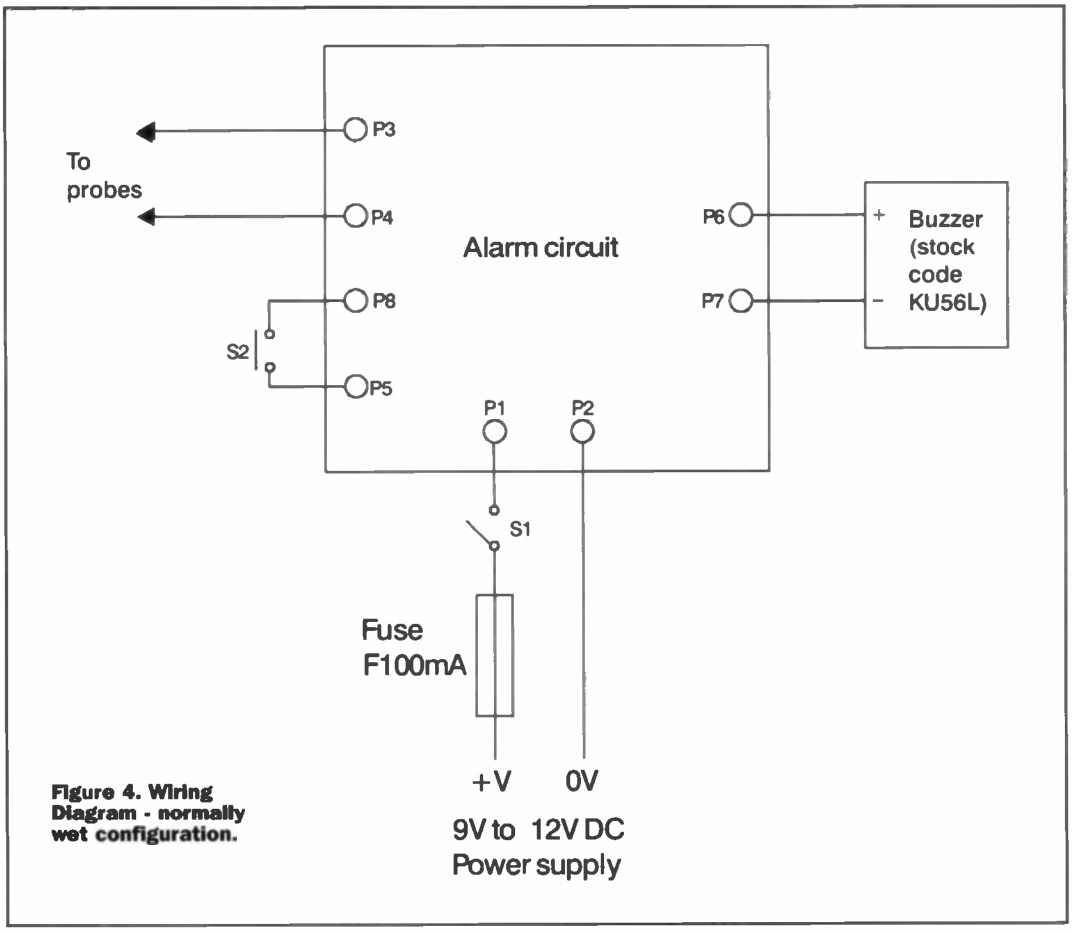


Figure 4. Wiring Diagram - normally wet configuration.

Testing

The test procedure is relatively straightforward and does not require the use of specialised test gear. However, a multimeter is useful for checking the current consumption and for measuring voltage levels in the circuit to confirm that it is operating correctly.

The circuit can be used in one of two modes either to trigger the alarm in the presence of water (normally dry) or in the absence of water (normally wet). The mode is determined by the connection configuration. The wiring arrangement shown in Figure 3 triggers the alarm when the probes are immersed in water and the following test procedure is based on this arrangement. Short lengths of wire or test clip leads may be used in place of probes for testing purposes.

Set variable resistor VR1 to the minimum resistance position and ensure that terminal P4 is disconnected from P8. Apply power to the circuit. When power is first applied to the circuit the alarm may sound. Should this be the case, please wait for the alarm to time out before continuing. After the timeout is complete, the alarm should remain silent until a trigger condition occurs. Connect terminal P4 to P8 momentarily. The alarm should sound for a short period and then silence. Adjust VR1 to maximum resistance. Retrigger the alarm by connecting P4 to P8. This time the timeout period should be considerably extended. Setting VR1 between minimum and maximum resistance should result in intermediate timeout periods. When the alarm is sounding, momentarily press S2. This should reset the timer circuit and the buzzer should stop sounding until the circuit is retriggered.

When the alarm is wired in the normally wet configuration as shown in Figure 4, the test procedure is similar but in this case the probe leads are connected together in standby condition and an open circuit condition triggers the alarm.

Probes

The probes consist of two electrically conductive contacts that will pass a current when immersed in water. In their most basic form, the probes may simply consist of two pieces of wire; however, in practice the arrangement used depends on the specific application. For example, if the alarm is required to trigger when only small drops of water are present it is necessary to make sure that the water will contact both probes to a sufficient extent to form a current path. It is not necessary to mount each probe separately; for example, the contacts may be two separate tracks on the same piece of circuit board. A simple probe arrangement suited to normally dry applications may be produced by connecting the probe inputs to alternate strips

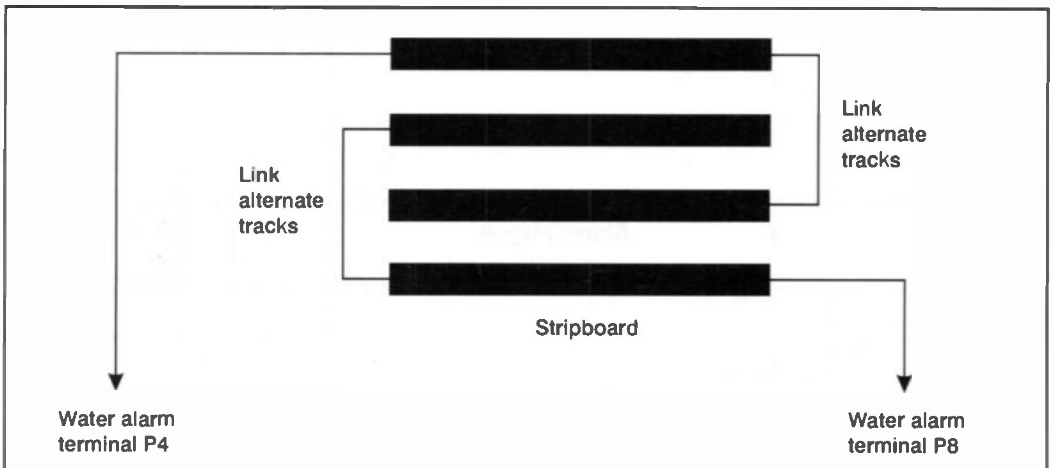


Figure 5. Simple probe arrangement for normally dry applications using matrix board.

on a small piece of strip board. This arrangement is illustrated in Figure 5. It is useful if the probes are resistant to corrosion particularly if they are going to be regularly exposed to water.

Arrangements such as that illustrated may tend to corrode but are simple and cheap to construct and are generally acceptable where the probe is dry for most of the time. The circuit input is relatively high resistance and a small amount of corrosion at the probe contacts will probably not prevent the alarm from working. The strip board may be replaced when its useful life has expired as long as it is in an accessible position. In cases where access is not so easy it is probably worth using a more corrosion resistant material. This consideration is even more important for normally wet applications.

Important Note

The unit should not be used with drinking water or in any situation where hazardous pollution may occur as a result of the probes being immersed in the water. The circuit is only suitable for use with water and should not be used with any other liquid. The alarm should not, of course, be used in safety critical applications in case unexpected failure should occur.

Housing

Once tested, the circuit board may be installed in a suitable plastic housing. The size and shape of the enclosure is not critical as long as it is large enough to house the circuit board, battery etc. All parts of the circuit with the exception of the probe assembly should be protected from moisture and must remain dry at all times. It will be necessary to drill suitable holes in the housing to fit the switches and to allow the sound from the buzzer to escape. It may also be useful to drill a small hole to facilitate easy access to VR1.

Using the Alarm

As mentioned there are two ways in which the alarm can be used. When configured as shown in Figure 3 the unit will sound when the resistance between the probes falls low enough to trigger the circuit. This occurs when water is present as long as the probes are sufficiently close together. In this mode the circuit can be used to provide an alert if an area becomes flooded or to indicate that it is raining heavily. The probes must be positioned so that they come into contact with the water when the required alarm condition is present. In some situations it may be useful to partially enclose the probe assembly so that it is protected from condensation and other forms of moisture that could result in unwanted false triggering.

Of course, it is important to check the state of the battery from time to time to ensure that it has sufficient charge. Probably the simplest way to do this is to simulate an alarm condition by momentarily connecting the probe leads together. If the output from the sounder is weak, the battery may well need replacing. If required a push to make switch may be connected between terminals P4 and P8. The operation of the unit may then be checked regularly by pressing the switch.

When the alternative configuration is used as shown in Figure 4, the alarm remains silent whilst the probes are immersed in water (i.e. when there is a low resistance between the probes). If the probes become dry interrupting the flow of current the alarm sounds until the timeout period has elapsed. A typical application for the circuit in this mode is to indicate when the water in a container falls below a set level (where the probes are positioned).

Independent of which mode is used, once the timeout period has elapsed the buzzer should stop sounding. If the condition at the probes returns to normal, the alarm is effectively reset and is ready to respond to a further alarm condition. So, for example, if the alarm is set up to trigger when rain falls on the probes, it is not necessary to reset the circuit manually after it sounds in order for it to trigger next time it rains. When the probes become dry the circuit will automatically reset.

If an optical indication of an alarm condition is required in place of or in addition to the buzzer, an LED with a suitable series resistor may be connected between terminals P6 and P7. This is illustrated in Figure 6.

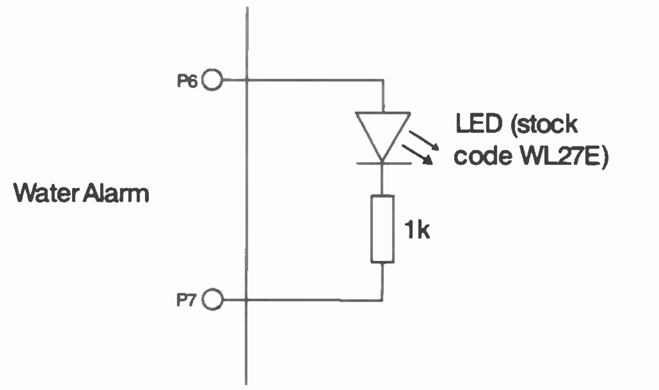


Figure 6. Connecting an LED.

PROJECT PARTS LIST

RESISTORS:			
R1, 3, 5	1M	3	M1M
R2, 7, 8, 10	100k	4	M100K
R4	220k	1	M220K
R6, 9, 11, 12	10k	4	M10K
VR1	Hor Encl Preset 1M	1	UH09K
CAPACITORS			
C1, 7	Minidisc 0.1?F 16V	2	YR75S
C2, 4	Ceramic 10000pF	2	WX77J
C3, 5, 6	GenElect 100?F 16V	3	AT40T
SEMICONDUCTORS			
TR1, 2	MPSA14	2	QH60Q
TR3	BC547	1	QQ14Q
IC1	TS555CN	1	RA76H
MISCELLANEOUS			
	DIL Socket 8-Pin	1	BL17T
P1-8	Pin 2145	8 pins	FL24B
S1	SPST Ultra Min Tggle	1	FH97F
S2	Red Push to Make Sw	1	FH59P
	DC Piezo Buzzer	1	KU56L
	20mm QB 100mA 10pk	1 fuse	GJ72P

FET Principles & CIRCUITS

PART 4

Ray Marston looks at practical VMOS power FET circuits in this final episode of this 4-part series.

Part 1 of this series explained (amongst other things) the basic operating principles of those enhancement-mode power-FET devices known as VFETs or VMOS. This final episode of the series takes a deeper look at these devices and shows practical ways of using them.

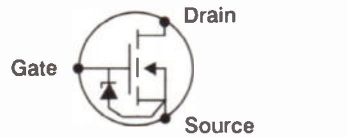


Figure 1. Symbol of Siliconix VMOS power FET with integral zener diode gate protection.

Device type number	P_{TOT} (max) (W)	I_D (max) (A)	V_{DS} (max) (V)	V_{GS} (max) (V)	V_{TH} (min-max) (V)	g_M (typ) (mmho)	C_{IN} (max) (pF)	f_T (typ) (MHz)
VN10KM	1	0.5	60	5	0.3 - 2.5	200	48	-
VN1010	1	0.5	100	15	2V max	200	48	-
VN48AF	12.5	2	40	15	0.8 - 2	250	50	600
VN66AF	12.5	2	60	15	0.8 - 2	250	50	600
VN88AF	12.5	2	80	15	0.8 - 2	250	50	600

Figure 2. Major parameters of five popular n-channel Siliconix VMOS power FETs.

STATIC

Max drain-to-source voltage..........60V
Max drain-to-gate voltage..........60V
Max continuous drain current..........2A
Max pulsed drain current..........3A

Max continuous forward gate current..........2mA
Max pulsed forward gate current..........100mA
Max continuous reverse gate current..........100mA
Max reverse gate-to-source (zener) voltage..........15V

Max dissipation at 25°C case temperature..........15W
Gate threshold voltage ....0.8V min, 2A typ.
Zero-gate-voltage drain current at 25°C..........10μA max
On-state drain current at V_{GS} = 10V..........1A min, 2A typ.
Temperature operating and storage range.......-40 to 150°C

Dynamic

Forward transconductance (typical)..........250mmho
Input capacitance (typical)..........50pF
Reverse transfer capacitance (typical)..........10pF
Common-source output capacitance (typical)..........50pF

Typical switching times, 25V supply, 23Ω load 0-10V gate drive from a 50Ω source:
Turn-on..........2ns
Rise time..........2ns
Turn-off delay..........2ns
Fall time..........2ns

Figure 4. Major static and dynamic characteristics of the VN66AF.

A VMOS Introduction

A VFET can, for most practical purposes, be simply regarded as a high-power version of a conventional enhancement-mode MOSFET. The specific form of VFET construction shown in Figure 17 in Part 1 of this series was pioneered by Siliconix in the mid-1970s, and the devices using this construction are marketed under the trade name 'VMOS power FETs' (Vertically-structured Metal-Oxide Silicon power Field-Effect Transistors). This 'VMOS' name is traditionally associated with the V-shaped groove formed in the structure of the original (1976) versions of the device.

Siliconix VMOS power FETs are probably the best known type of VFETs. They are available as n-channel devices only, and usually incorporate an integral zener diode, which gives the gate a high degree of protection against accidental damage. Figure 1 shows the standard symbol used to represent such a device, and Figure 2 lists the main characteristics of five of the most popular members of the VMOS family. Note in particular the very high maximum operating frequencies of these devices.

Other well-known families of 'Vertically-structured' power MOSFETS are those produced by Hitachi, Supertex, and Ferranti, etc. Some of these V-type power MOSFETs are available in both n-channel and p-channel versions and are useful in various high-performance complementary audio power amplifier applications.

The VN66AF

The best way to get to know VMOS is to actually 'play' with it, and the readily available Siliconix VN66AF is ideal for this purpose. It is normally housed in a TO202-style plastic-with-metal-tab package with the outline and pin connections shown in Figure 3.

Figure 4 lists the major static and dynamic characteristics of the VN66AF. Points to note here are that the input (gate-to-source) signal must not exceed the unit's 15V zener rating, and that the device has a typical dynamic input capacitance of 50pF. This capacitance dictates the dynamic input impedance of the VN66AF; the static input impedance is of the order of a million megohms.

Figures 5 and 6 show the VN66AF's typical output and saturation characteristics. Note the following specific points from these graphs.

1. The device passes negligible drain current until the gate voltage reaches a threshold value of about 1V. Then, the drain current increases non-linearity as the gate is varied up to about 4V, at which point the drain current value is about 400mA; the device has a square-law transfer characteristic below 400mA.
2. The device has a highly linear transfer characteristic above 400mA (4V on the gate) and thus offers good results as a low-distortion class-A power amplifier.
3. The drain current is controlled almost entirely by the gate voltage and is almost independent of the drain voltage so long as the device is not saturated. A point not shown in the diagram is that, for a given value of gate voltage, the drain current has a negative temperature coefficient of

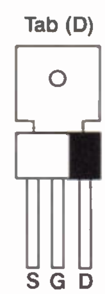


Figure 3. Outline and pin connections of the TO202-cased VN66AF power FET.

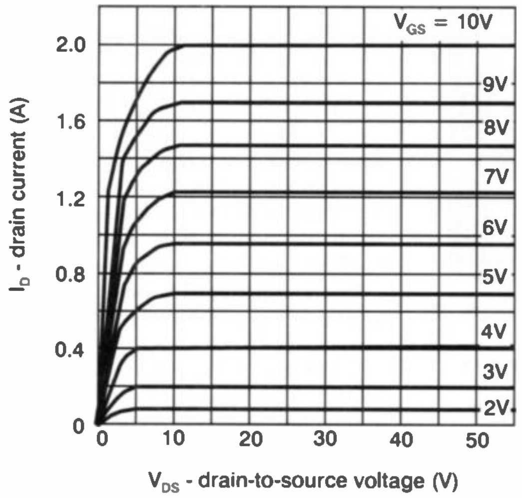


Figure 5. Typical output characteristics of the VN66AF.

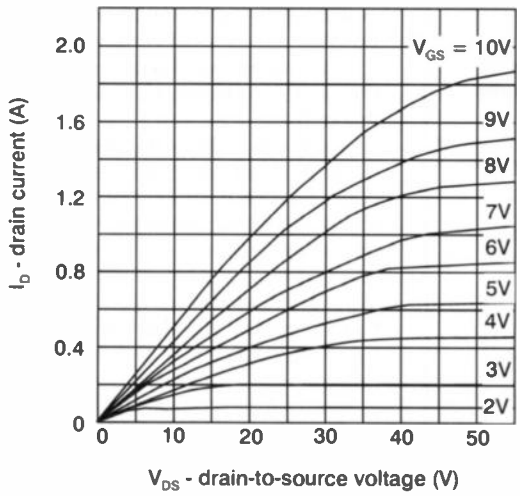


Figure 6. Typical saturation characteristics of the VN66AF

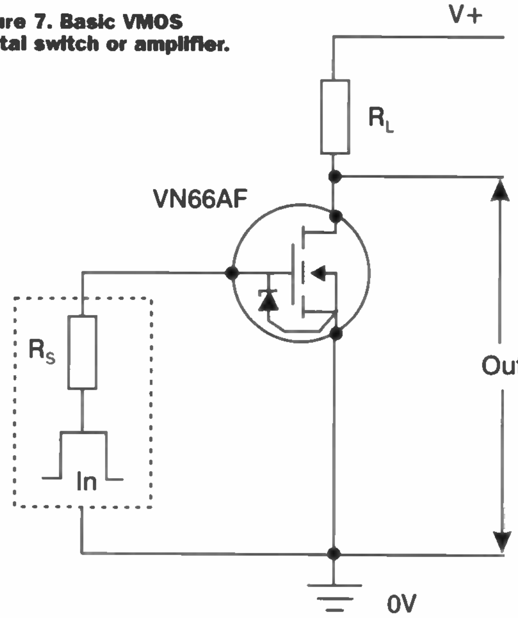


Figure 7. Basic VMOS digital switch or amplifier.

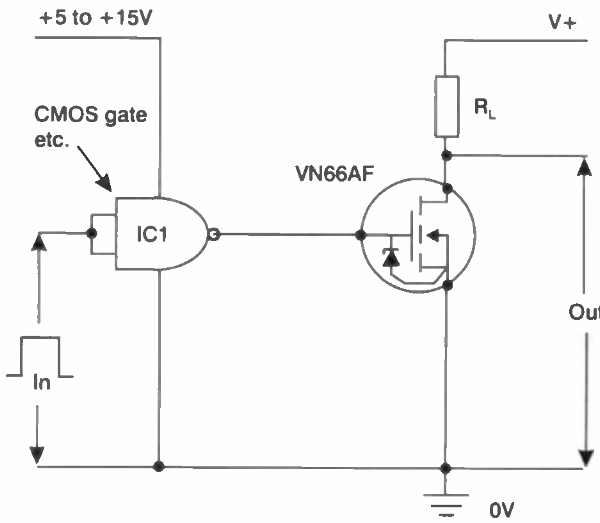


Figure 8. Methods of driving VMOS from CMOS.

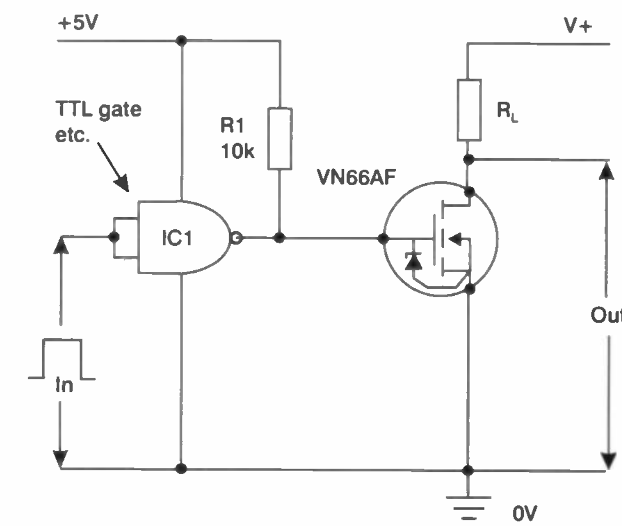


Figure 9. Method of driving VMOS from TTL.

about 0.7% per °C, so that the drain current decreases as temperature rises. This characteristic gives a fair degree of protection against thermal runaway.

4. When the device is saturated (switched fully on) the drain-to-source path acts as an almost pure resistance with a value controlled by the gate voltage. The resistance is typically 2R0 when 10V is on the gate, and 10R when 2V is on the gate. The device's 'off' resistance is in the order of megohms. These features make the device highly suitable for use as a low-distortion high-speed analogue power switch.

Digital Circuits

VMOS can be used in a wide variety of digital and analogue applications. It is delightfully easy to use in digital switching and amplifying applications; Figure 7 shows the basic connections. The load is wired between the drain and the positive supply rail, and the digital input signal is fed directly to the gate terminal. Switch-off occurs when the input goes below the gate threshold value (typically about 1.2V). Unless saturation occurs, the drain ON current is determined by the peak amplitude of the gate signal, as shown in Figure 5. In most digital applications the ON current should be chosen to ensure saturation.

The static input impedance of VMOS is virtually infinite, so zero drive power is needed to maintain the VN66AF in the ON or OFF state. However, drive power is needed to switch the device from one state to the other; this power is absorbed in charging or discharging the 50pF input capacitance of the VN66AF.

The rise and fall times of the output of the Figure 7 circuit are (assuming zero input rise and fall times) determined by the source impedance of the input signal, by the input capacitance and forward transconductance of the VMOS device, and by the value of R_L. If R_L is large compared to R_S, the VN66AF gives rise and fall times of roughly 0.11ns per

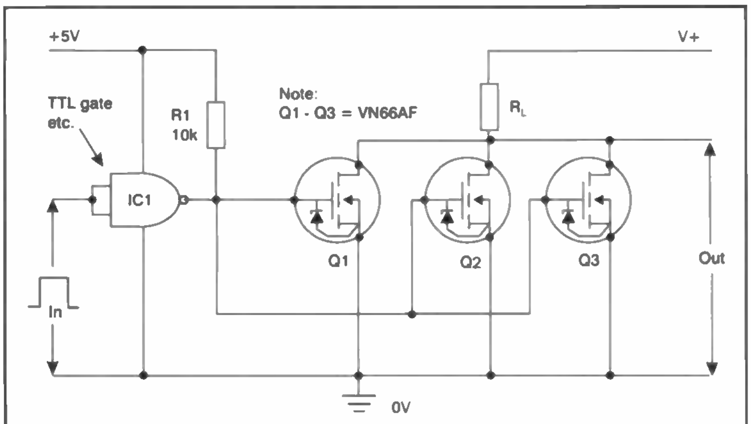


Figure 10. Method of boosting the output of Figure 9 by driving three VN66AFs in parallel.

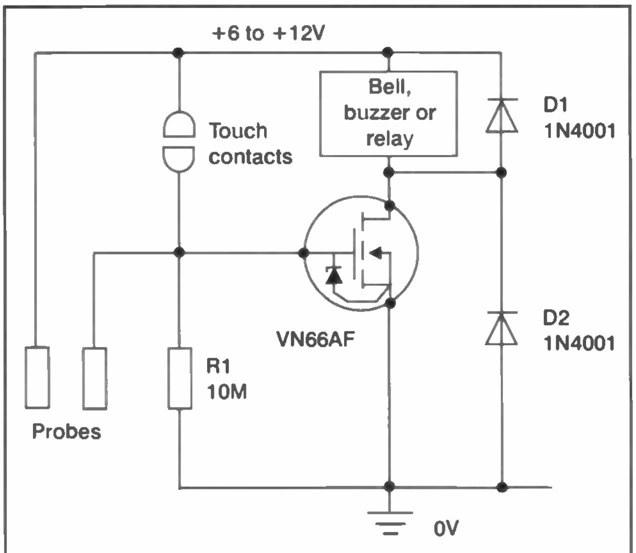


Figure 12. Water- or touch-activated power switch.

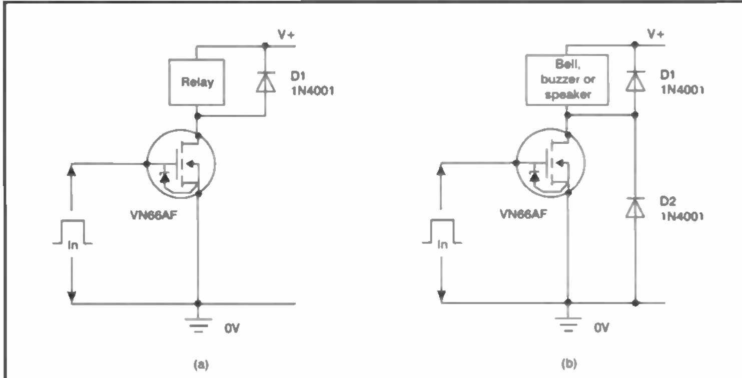


Figure 11. If inductive loads such as relays (a) or bells, buzzers or speakers (b) are used in digital switching circuits, protection diodes must be wired as shown.

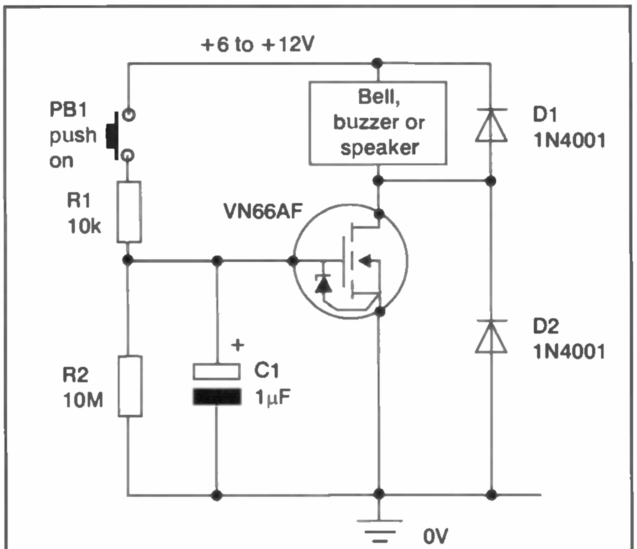


Figure 13. Delayed-turn-off power switch.

Ohm of R_S value. Thus, a 100R source impedance gives a 11ns rise or fall time. If R_L is not large compared to R_S, these times may be considerably changed.

A point to note when driving the VN66AF in digital applications is that its Zener forward and reverse ratings must never be exceeded. Also, because of the very high frequency response of VMOS, the device is prone to unwanted oscillations if its circuitry is poorly designed. Gate leads should be kept short, or be protected with a ferrite bead or a small resistor in series with the gate.

VMOS can be interfaced directly to the output of a CMOS IC, as shown in Figure 8. Output rise and fall times of about 60ns can be expected, due to the limited output currents available from a single CMOS gate, etc. Rise and fall times can be reduced by driving the VMOS from a number of CMOS gates wired in parallel, or by using a special high-current driver.

VMOS can be interfaced to the output of TTL by using a pull-up resistor on the TTL output, as shown in Figure 9. The 5V TTL output of this circuit is sufficient to drive 600mA through a single VN66AF. Higher output currents can be obtained either by wiring a level-shifter stage between the TTL output and the VMOS input, or by wiring a number of VMOS devices in parallel, as shown in Figure 10.

When using VMOS in digital switching applications, note that if inductive drain loads such as relays, self-interrupting bells or buzzers, or moving-coil speakers are used, clamping diodes must be connected as shown in Figure 11, to damp inductive back-emfs and thus protect the VMOS device against damage.

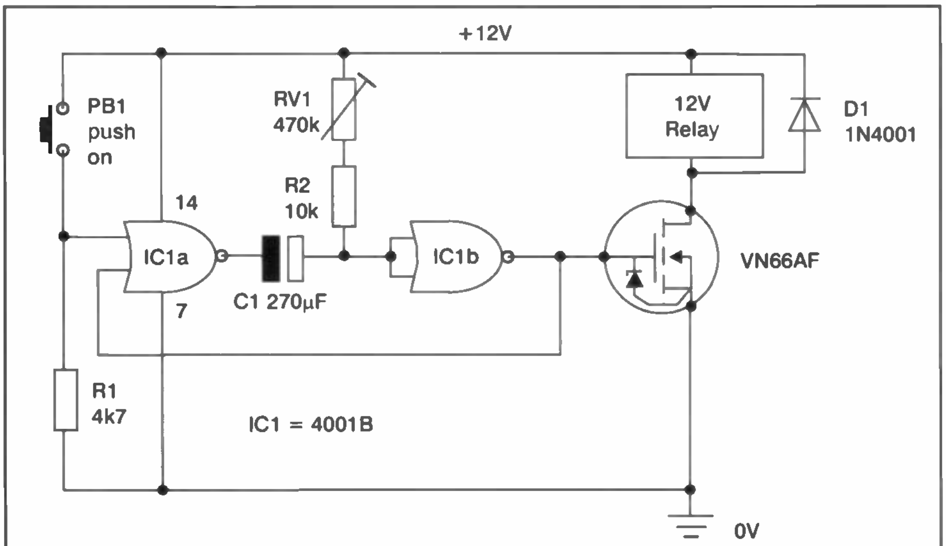


Figure 14. Simple relay-output timer circuit.

Some Digital Designs

Figures 12 to 15 show a few simple but useful digital applications of the VN66AF. The water, or touch-activated power switch of Figure 12 could not be simpler. When the touch contacts and water probes are open, zero volts are on the gate of the VN66AF, so the device passes zero current. When a resistance (zero to tens of megohms) is placed across the contacts (by contact with skin resistance) or probes (by water contact), a substantial gate voltage is developed by potential divider action and the VN66AF passes a high drain current, thus activating the bell, buzzer or relay.

In the manually activated delayed-turn-off circuit of Figure 13, C1 charges rapidly via

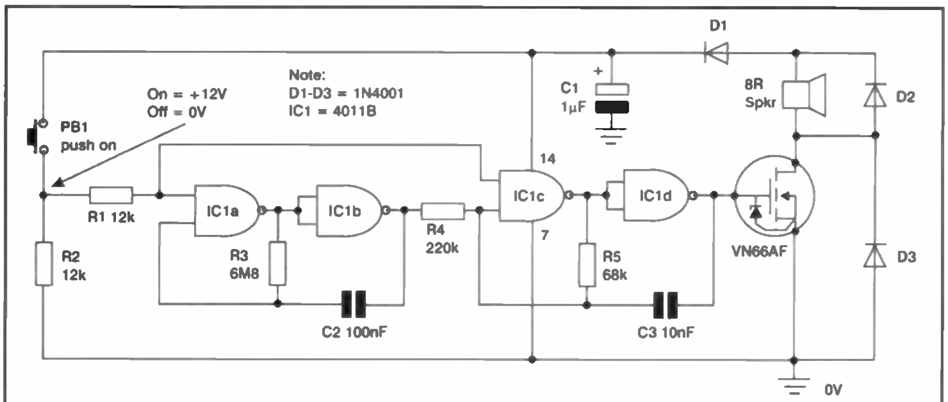


Figure 15. Warble-tone 6 watt alarm.

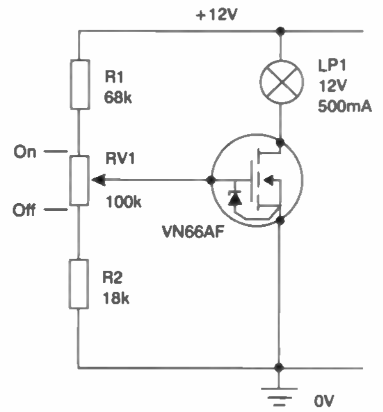


Figure 16. Simple DC lamp dimmer.

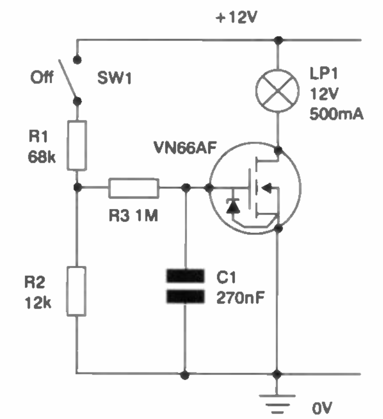


Figure 17. Soft-start lamp switch.

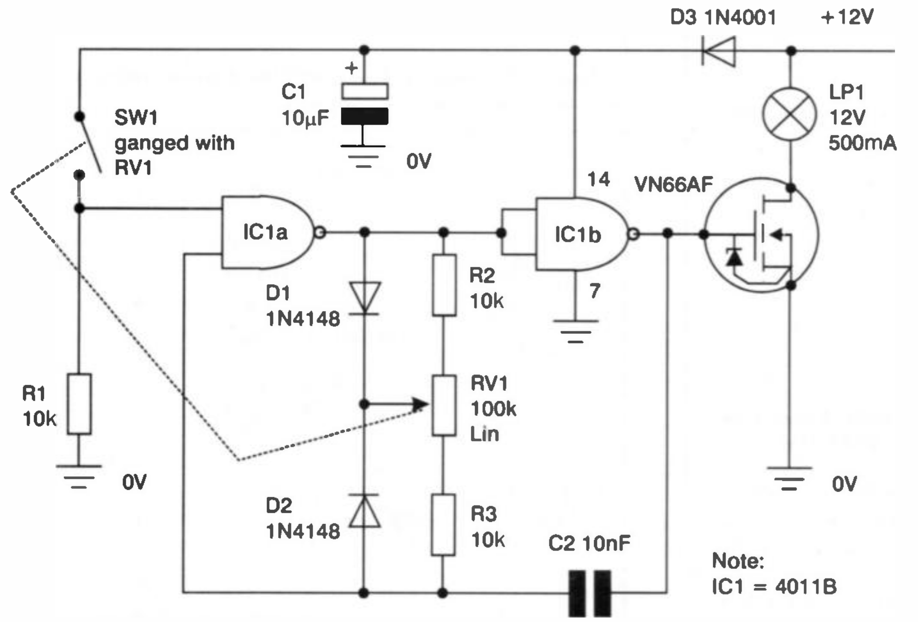


Figure 18. High-efficiency DC lamp dimmer.

R1 when push-button switch PB1 is closed, and discharges slowly via R2 when PB1 is open. The load thus activates as soon as PB1 is closed, but does not deactivate until some tens of seconds after PB1 is released.

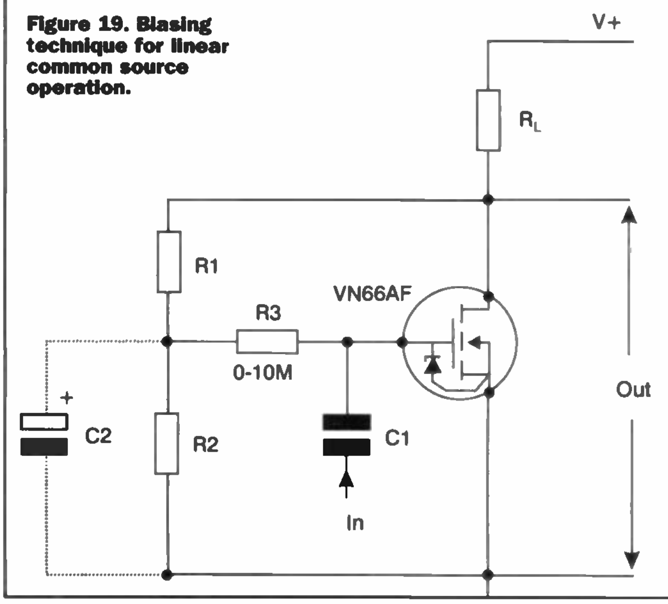
In the simple relay-output timer circuit of Figure 14, the VMOS device is driven by the output of a manually triggered monostable or one-shot multivibrator designed around two gates of a 4001B CMOS IC. The relay turns on as soon as PB1 is closed, and then turns off automatically again some pre-set 'delay time' later. The delay is variable from a few seconds to a few minutes via RV1.

Finally, Figure 15 shows the practical circuit of an inexpensive but very impressive alarm-call generator that produces a 'dee-dah' sound like that of a British police car siren. The alarm can be turned on by closing PB1 or be feeding a 'high' voltage to the R1-R2 junction. The circuit uses an 8R0 speaker and generates roughly 6W of output power.

DC Lamp Controllers

Figures 16 to 18 show three simple but useful DC lamp controller circuits that can

Figure 19. Biasing technique for linear common source operation.



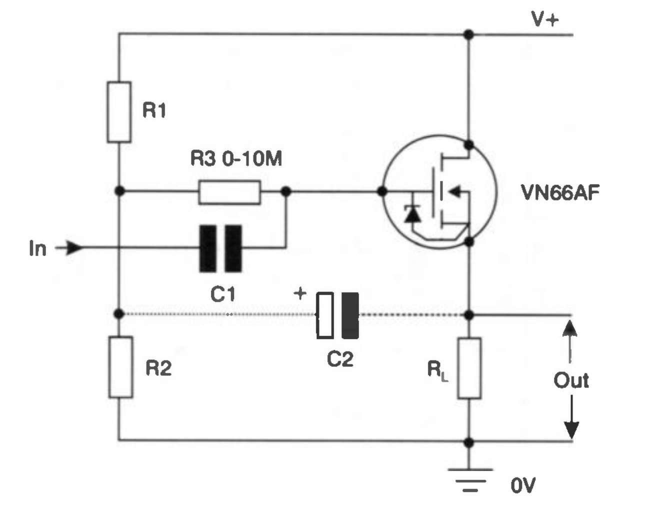


Figure 20. Biasing techniques for linear common drain (voltage follower) operation.

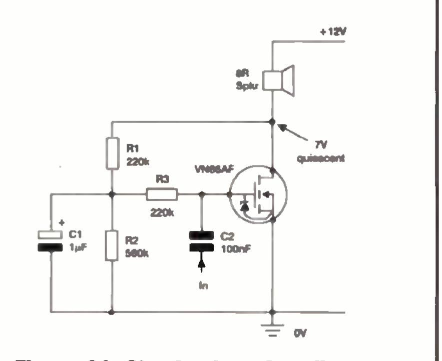


Figure 21. Simple class-A audio power amplifier gives 1% THD at 1W.

be used to control the brilliance of any 12V lamp with a power rating of up to 6W. A VMOS power FET can, for many purposes, be regarded as a voltage controlled constant-current generator; thus, in Figure 16, the VMOS drain current (and thus the lamp brightness) is directly controlled by the variable voltage of RV1's slider. The circuit thus functions as a manual lamp dimmer.

The Figure 17 circuit is a simple modification of the above design, the action being such that the lamp turns on slowly when the switch is closed as C1 charges up via R3, and turns off slowly when the switch is opened as C1 discharges via R3.

The Figure 18 circuit is an efficient 'digital' lamp dimmer that controls the lamp brilliance without causing significant power loss across the VMOS device. The two 4011B CMOS gates form an astable multivibrator with a mark/space ratio that is fully variable from 10:1 to 1:10 via RV1. Its output is fed to the VN66AF gate, and enables the mean lamp brightness to be varied from virtually fully-off to fully-on. In this circuit the VMOS device is alternately switched fully on and fully off, so power losses are negligible.

Linear Circuits

VMOS power FETs can, when suitably biased, easily be used in either the common source or common drain (voltage follower) linear modes. The voltage gain in the common source mode is equal to the product of R_L and the device's gm or forward transconductance. In the case of the VN66AF, this gives a voltage gain of 0.25 per ohm of R_L value, i.e., a gain of x4 with a 16R load, or x25 with a 100R load. The voltage gain in the common drain mode is slightly less than unity.

A VMOS power FET can be biased into the linear common source mode by using the standard enhancement-mode MOSFET biasing technique shown in Figure 19. Here, the R1-R2 potential divider is wired in the drain-to-gate negative feedback loop and sets the quiescent drain voltage at roughly half-supply value, so that maximal signal level swings can be accommodated before clipping occurs.

When, in the Figure 19 circuit, R3 has a value of zero ohms, the circuit exhibits an input impedance that, because of the ac negative feedback effects, is roughly equal to the parallel values of R1 and R2 divided by the circuit's voltage gain (R_L x gm). If R3 has a finite value, the input impedance is slightly less than the R3 value, unless ac feedback-decoupling capacitor C2 is fitted in place, in which case the input impedance is slightly greater than the R3 value.

Figure 20 shows how to bias the VN66AF for common drain (voltage follower) operation. Potential divider R1-R2 sets the VMOS gate at a quiescent value slightly greater than half-supply voltage. When the R3 value is zero, the circuit input impedance is equal to the parallel values of R1 and R2. When the R3 value is finite, the input impedance equals the R3 value plus the parallel R1-R2 values. The input impedance can be raised to a value many times greater than R3 by adding the C2 'bootstrap' capacitor to the circuit.

Finally, Figure 21 shows a practical example of a VMOS linear application. The circuit is wired as a class-A power amplifier that, because of the excellent linearity of the VN66AF, gives remarkably little distortion for so simple a design. The VN66AF must be mounted on a good heat sink in this application. When the design is used with a purely resistive 8R0 load, the amplifier bandwidth extends up to 10MHz.

Diary Dates

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

March 2000

6 to 9 March. Electrex 2000 - International Electrotechnical Exhibition, NEC Birmingham. Tel: (01483) 222 888.

9 to 10 March. Softworld in Accounting & Finance, Olympia, London. Tel: (0181) 541 5040.

14 to 16 March. Service Management Europe, NEC Birmingham. Tel: (0208) 232 1600.

29 to 30 March. Softworld Supply Chain, NEC Birmingham. Tel: (0208) 541 5040

April 2000

30 March to 1 April. Apple Expo - Apple Platform Show, Olympia, London. Tel: (0171) 904 9388.

4 to 5 April. Electronic Design Solutions, NEC Birmingham. Tel: (0181) 910 7934.

4 to 6 April. NEPCON - Electronics & Semiconductors, NEC Birmingham. Tel: (0208) 910 7910.

10 to 13 April. Automation & Robotics, NEC Birmingham. Tel: (01737) 768 611.

10 to 14 April. Engineering Lasers, NEC Birmingham. Tel: (01737) 768 611.

11 to 13 April. Infosecurity - Info Security & Network Management, Olympia, London. Tel: (0208) 910 7910.

18 to 19 April. Government Computing Conference & Exhibition, Business Design Centre, London. Tel: (0207) 608 0900.

18 to 20 April. WebCom 2000 - Corporate Intranet Technology, Olympia, London. Tel: (0208) 742 2828.

28 to 30 April. PC@Home+Internet 4All, Earls Court, London. Tel: (01895) 630 288.

May 2000

9 to 10 May. Dealer Expo and Channel Expo, NEC Birmingham. Tel: (01923) 676 867.

23 to 25 May. Internet World Conference and Exhibition, Earls Court, London. Tel: (0208) 232 1600.

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?

City Attitude Will Kill UK Manufacturing

Quantum Electronics, a leading UK company has is accused hi-tech financiers of short-sightedness in clamouring to back sexy dot com start-ups but failing to see the potential of the country's electronics design and production businesses - many of whom are fuelling Britain's technology fortunes.

Financiers are on the brink of initiating a boom-bust cycle in hi-tech as many of Britain's non-dot com companies are being ignored as investment propositions, Quantum says.

Quantum is a remarkable company. It is a solid UK hi-tech company that makes things. More than that, it is profitable, with sales of £15 million, and is growing at 30% per annum.

The company operates from a purpose-built 60,000 square foot facility in Newport, South Wales and manufactures electronics products on behalf of customers such as Johnson & Johnson and PerkinElmer.

But it isn't sexy. It isn't developing intellectual property which is the vogue in the electronics sector and it certainly isn't a glittery dot com.

By comparison, Internet companies such as amazon.com and qxl.com that have little in the way of infrastructure and certainly don't have a product that can be touched or felt can float and achieve spectacular valuations. Yet it would be financial suicide for a manufacturing company such as Quantum to pursue such a strategy.

Quantum can't claim that it will enjoy hyper-growth in the future. It can't claim that massive high margin opportunities lie around the corner. All it has to show is steady, sustainable growth over its eight year trading history. But unfortunately, steady double digit growth just doesn't excite the city.

"It's a sad fact that the City doesn't recognise the value of a company that produces goods for the business to business market. This naive approach on the part of financiers will ultimately kill manufacturing in the UK," said Mark Woodiwiss, managing director, Quantum.

The Quantum management team can only look on in awe at the market success of these Internet start-ups and the floatation of companies such as microprocessor manufacturer ARM.

Manufacturing companies that have gone public have traditionally been valued on the basis of a multiple one or two times of sales revenue.

Such calculations are of course simplistic at best. In reality more than a dozen factors contribute to the valuation of a company including its cash position, profitability and potential revenues over the medium term.

But here's the real irony. Quantum is the virtual manufacturing arm, and as such, a key enabler, for more than half a dozen fast growing electronics start-ups such as Equiinet, Flexion and Virtual Access.

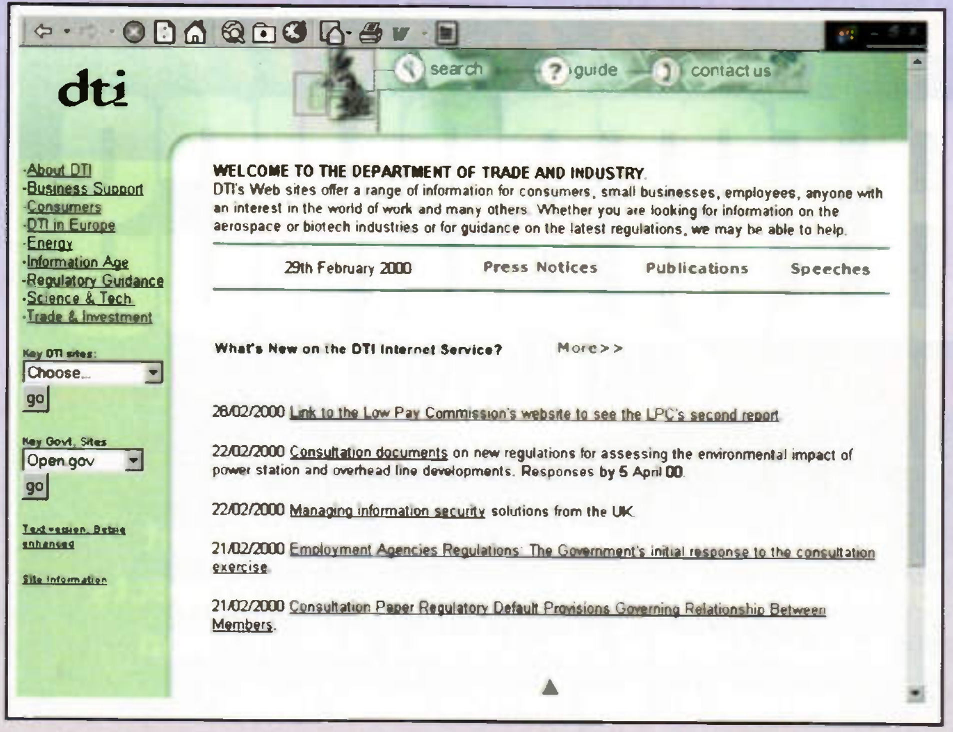
For further details, check: `<www.quantum-electronics.co.uk>`.

Contact: Quantum Electronics, Tel: (01633) 654600.

Competitive e-Europe depends on Strong Digital Public Service

BBC Director General Greg Dyke has told a Brussels audience that he believes that strong European public service broadcasters, including the BBC, will be vital to counter the danger of US domination of European electronic media and e-commerce.

In a speech on his first working day as



director general on 31 January to an audience in Brussels, Dyke said publicly funded broadcasters are the backbone of Europe's strong television industry and have a special role to play in creating a digitally literate Europe.

Dyke urged the swift introduction of a regulatory framework for open access to the new digital technology. It was necessary to safeguard its benefits for Europe as a whole, he told an invited audience of MEPs, European Commissioners, decision-makers and media executives.

"Already it is a scandal that digital television is fast developing as the only major new technology where closed, proprietary standards can be used to deny consumers real choice," said Dyke.

Digital Nation

Dyke said, " I am aware of arriving at the BBC at an extraordinary moment. The digital revolution is upon us."

26% of people in UK were now using the Internet, with many more expected to join them this year. Two and a half million UK households have switched to digital television.

Digital radio is up and running in Germany, Portugal, Sweden and the UK. Mobile phones can receive news in at least four out of the 15 member states.

"The economic significance of this - especially to Europe - cannot be over-estimated," said Dyke. AOLs record-breaking merger with Time Warner will almost certainly herald others as multi-media companies consolidate.

"Will Europe grab the opportunity to be one of the leaders in the communications revolution or are we all seriously in danger of being dwarfed by American domination," said Dyke.

Need for Regulation

Dyke urged the EU to press ahead with the right regulatory framework for digital television, for the benefit of Europe's economy. In Britain, two existing digital platforms, ONdigital and Sky each operate their own systems.

"Unless you want to buy two set top boxes you have to choose between one system or the other. Because there is no agreement or requirement for interoperability between the systems, if you subsequently change your mind and want to swap digital systems - say from Sky satellite to ONdigital - you need to get yet another set top box. It doesn't take a degree in economics to realise that this will dramatically slow down the take-up of digital."

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

Contact: BBC, Tel: (0870) 010 0222.

Hewitt Confirms Start Date for 3G Mobile License Auction

Patricia Hewitt, Minister for E-commerce and Small Business has confirmed that the 3G mobile auction will start in early March.

Ms Hewitt said, "Early licensing certainty for 3G mobile is essential if the UK is remain at the forefront of the global telecommunications market. This will be the first spectrum auction in the UK and the first auction for 3G mobile spectrum in Europe."

"The Government is delivering on its commitments to begin the auction this financial year and to introduce measures to attract one or more new entrants. The increased competition and innovation in the mobile market that this will bring is good news for the UK economy and for consumers. It will be an important contribution to the Government's aim of making the UK the best place in the world to conduct e-commerce," said Hewitt.

"With thirteen high quality bidders participating I look forward to a competitive auction. The progress of the auction will be published round by round on the auction Web site," said Hewitt.

The Government will auction five licences for blocks of spectrum for 3G services. The four existing operators, BT, One2One Personal Communications Limited, Orange 3G Limited, Vodafone Limited may not bid for the licence with the largest amount of spectrum which is reserved for a new entrant to the UK mobile telecoms market.

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

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

New Legislation for Digital Age

New measures to keep the UK at the forefront of the digital age will be unveiled later this year, Trade and Industry Secretary Stephen Byers and Culture Secretary Chris Smith announced at the end of February.

A White Paper will put forward proposals for reforming telecommunications and broadcasting regulation to take account of the convergence of the communications industries.

The White Paper will build on proposals published in the Regulating Communications, The Way Ahead report, in June last year and will take account of the European Commission's proposals for reforming the European Union's regulatory framework for communications.

Stephen Byers, Secretary of State for Trade and Industry said, "As we move into the twenty-first century and the digital age, we need to ensure that regulations covering the converging broadcasting, telecommunications and information technology industries are flexible and effective, foster competitive markets, and ensure the UK remains a world leader in providing communications services."

Chris Smith, Secretary of State for Culture, Media and Sport said, "The Government's aim is to promote the global competitiveness of our media and communications industries, as well as protect the interests of the consumer. The White Paper will be broad in scope, covering areas such as future regulation of broadcast content, media ownership rules, and the role of public service broadcasting."

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

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

Project Ratings
Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering, side cutters, pliers, wire strippers, and screwdriver). Test gear not required and no setting-up needed.

Easy to build, but not suitable for absolute beginners. Some test gear (e.g. multimeter) may be required, and may also need setting-up or testing.

Average. Some skill in construction or more extensive setting-up required.

Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.

Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

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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.

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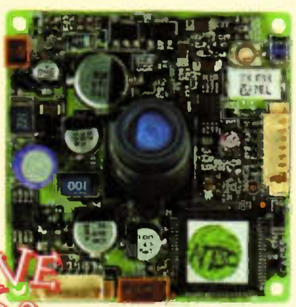

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