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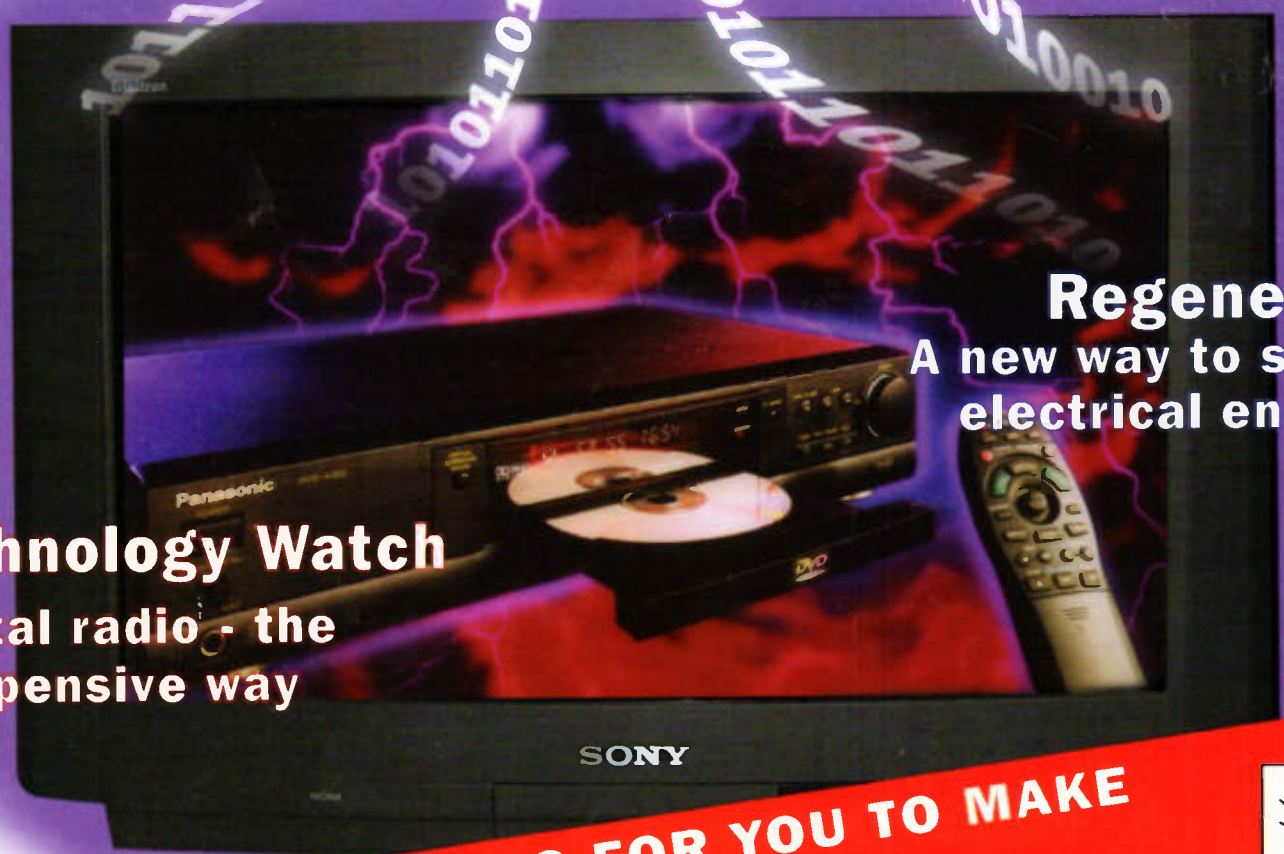

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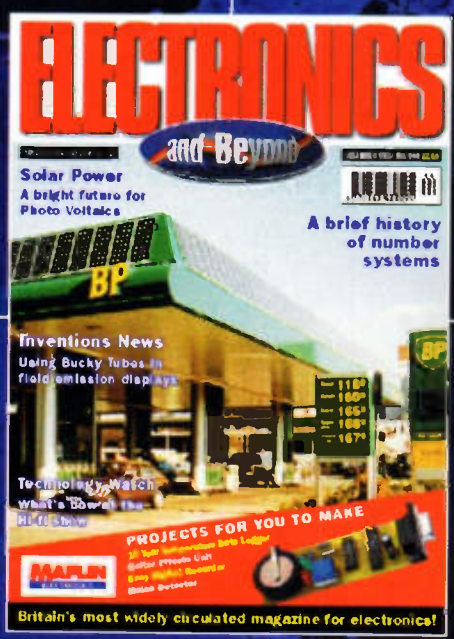

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ELECTRONICS and Beyond

February 2000 Vol. 20 No. 146

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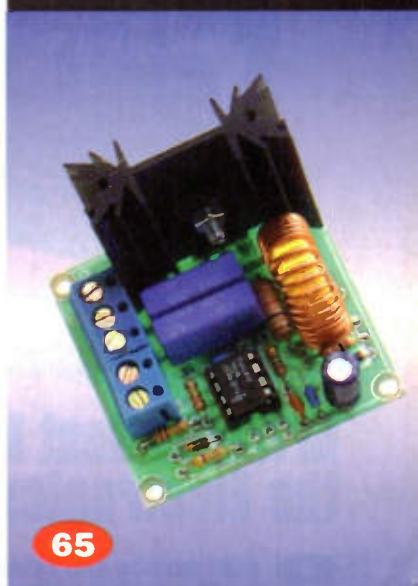

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ELECTRONICS and Beyond

The new Millennium is with us, and we are, hopefully, recovering from the extended festivities. If we were to offer a prediction for the new year then it would have to be the demise of the analogue 'world.' We have speculated in the past about the future of analogue, and present developments can only confirm our belief that the end is nigh. Already in Japan, Pioneer are selling the first recordable DVD video players, and we can expect to see them here later this year. So with CDs, MiniDisks and MP3, we must now be seeing the last days of analogue tape recordings, and the move towards solid state recording such as flash memory etc.

Within the next few years we must expect the end of analogue TV. If you need any proof, then read *Multimedia - Selection & Storage* by Reg Miles featured on page 20. Reg believes we may all be watching digital TV - whether we like-it-or-not! And if you think that going to the cinema in the future will still be an analogue experience, then you would be wrong, for celluloid is also heading for the same fate as tape. Hollywood will originate the 'film' - if we can still use that word - in a true digital format, compress and encrypt, and send via satellite link to receiving theatres. The programme will be stored in a mass storage system and then, via decompression/ decryption circuits, be convert back to a format that can be projected by electronic projection equipment. This system promises even better audio quality, plus the end of film blemishes, scratches etc. Remarkably, this is expected to bring about a 98% reduction in 'screening' cost compared to producing the celluloid film per year for each screen.

Finally, if you are someone who loves all this technology then Martin Pipe describes in a *Technology Watch Extra* how you can get DAB-quality radio reception 'on the cheap,' using a spare satellite receiver!

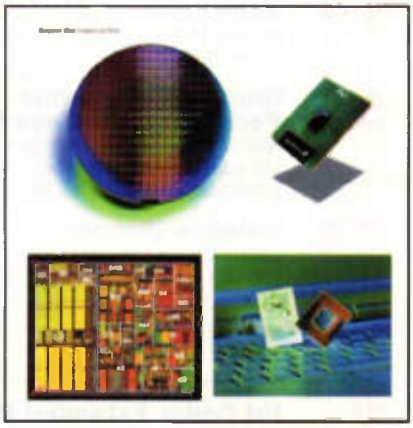
Congratulations to..

Trygve Andreassen of Norway who was the winner of our Edison 3 competition featured in issue 144.

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

Intel Introduces New Chipset for Pentium III



Intel has introduced a new chipset that optimises the performance of Intel Pentium III processor-based PCs targeted at the performance desktop market segment. The Intel 820 Chipset brings new features and capabilities to PC users including a faster processor system bus, superior memory capabilities and enhanced graphics functionality.

The Intel 820 Chipset supports Direct RDRAM memory technology and AGP 4x graphics support. Direct RDRAM memory provides the memory bandwidth necessary to obtain optimal performance from the fastest Intel Pentium III processors, delivering 1.6GB per second of maximum theoretical memory bandwidth - twice the peak memory bandwidth of 100MHz SDRAM systems.

Additionally, when used in conjunction with the Intel Pentium III processor and Direct RDRAM memory, AGP 4x technology delivers improved 3D graphics performance by allowing graphics controllers to access main memory at more than 1 GB per second – twice that of previous AGP platforms.

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

Contact: Intel,
Tel: (01793) 403000.

CacheFlow Integrates Caching Appliances with Filtering Software

CacheFlow has announced a solution designed to allow enterprises, educational institutions and Internet Service Providers (ISPs) to set and enforce Web-usage policies, boost Internet performance and save on wide area network (WAN) bandwidth costs.

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

Contact: CacheFlow,
Tel: (01753) 705175.

GSM Chip-Set Brings High-Speed Data Traffic to Cellphones

In advance of 3rd Generation (3G) mobile telecom systems, Philips is delivering mobile data technology that will enable high-speed data transfer over GSM phones.

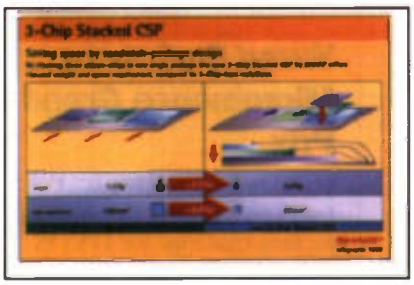
Philips GSM chipset, which is based on recently acquired VLSI Technology's OneC baseband controller, will be at the heart of a new generation of mobile phones that utilise the General Packet Radio Service (GPRS) for high speed data transfer.

GPRS will enable data to be transferred across the wireless domain at much faster rates, allowing improvement of several data communication applications, such as fax, e-mail and paging. It also represents the first step towards 3G.

For further details, <www.semiconductor.philips.com>.

Contact: Philips, Tel: +31 40 272 20 91.

Three Chips Stacked in One



Sharp has developed a three chip stacked package (CSP) aimed at the cellular telephone and the information and communications handheld terminal market.

The CSP uses thin silicon wafer layers and modified die and wire bonding. Three individual chips are arranged in a stacked structure within a single package with the result that products can be made lighter in weight and with reduced space requirements for mounting chip packages.

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

Contact: Sharp, Tel: (0800) 262 958.

Synaptics Announces Acquisition of Absolute Sensors

Synaptics has announced the acquisition of Absolute Sensors, based in Cambridge. The acquisition propels Synaptics toward its goal of expanding into the handheld information device market.

ASL, a spin-off of the Cambridge-based company Scientific Generics, brings its technological competencies in position sensing to Synaptics. ASL's technology, SPIRAL, uses a patented magnetically coupled technology to sense the position of a handheld pen. SPIRAL's high accuracy and noise immunity, combined with the benefits of being thin, lightweight, and requiring very little battery power, make the system an ideal solution for handheld device manufacturers.

The combination of ASL's SPIRAL technology with Synaptics' versatile capacitive touch sensing technology will enable manufacturers in numerous markets to develop advanced products that consumers can interact with intuitively and easily.

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

Contact: Absolute Sensors, Tel: (01223) 875220.

Digital Camera for the Weekend Warrior

Fuji has officially unveiled its DS-260 HD digital camera, a rugged mega-pixel model that protects its inner workings with a dust-proof, impact- and water-resistant outer shell. This tough exterior makes the DS-260 HD an ideal choice for outdoor enthusiasts who want to capture their images electronically.

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

Contact: Fuji, Tel: (01234) 218388.

NEWS BYTES

Iomega Unveils Digital Audio Strategy

Iomega has unveiled its broad digital audio strategy, to help music lovers access their favourite digital music anytime anywhere.

New digital music formats like MP3, portable music players and the Internet have created a tremendous opportunity for removable storage solutions. In disclosing its new strategy, Iomega announced its next ZipCD product and that Clik! drives will be featured in MP3 players from several manufacturers.

Zip, Jaz and Clik! disks also include a unique serialisation feature, which protects copyrighted music when used with the Windows Media Device Manager and Secure Digital Music Initiative (SDMI) devices and applications.

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

Contact: Iomega, Tel: (0800) 973194.

Intel Establishes Wireless Internet Technology Centre in Sweden

Intel has announced the formation of the Intel Wireless Competence Centre in Stockholm, a global centre of communications technology development commonly called 'Wireless Valley'.

The Intel Wireless Competence Centre will enable Intel and other industry leaders to develop technologies and products designed to provide business people and consumers with a wide range of new applications surrounding high-bandwidth, wireless Internet access.

Staffed by Internet, communications and PC platform experts, the Centre will serve as a resource for Intel's worldwide product groups and build upon Intel's strong synergies with other industry leaders. Intel formed the Bluetooth initiative in 1998 with Ericsson, Nokia, IBM and Toshiba after launching the successful Mobile Data Initiative in 1996.

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

Contact: Intel, Tel: (01793) 403000.

NEWS BYTES

Start-Up Informal Software Redefines the Desktop

A new start-up, Informal Software is poised to dramatically alter the way consumers and business professionals interact with PCs and the way they communicate and share information with others.

Informal Software's first software product, enotate software, turns stylus-based devices, such as 3Com's PalmPilot, into an indispensable tool for everyday computing by turning it into a direct, real-time extension to the PC.

With enotate, Informal Software is allowing users to annotate text, sketch ideas and draw directly onto their PC just as they would with the traditional pen and paper.

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

Contact: Informal, Tel: +1 408 727 0351.

Lucent Technologies' Researchers Announce World's Fastest DSP

Twenty years after inventing the world's first single-chip digital signal processor, researchers at Lucent Technologies' Bell Labs have developed the world's fastest DSP operating at one volt.

DSPs are the key semiconductor engines driving today's cellular phones, high-speed modems and other communications and electronics devices.

The Bell Labs chips operate at 100MHz - the fastest processing speed of any industry DSP technology using only one volt of power. The DSPs were made with equipment available in today's manufacturing facilities. Potential applications include enabling smaller and lighter cellular phones with extended battery life.

The technology also could be instrumental in packet voice and data transport over wireless phones, higher-speed Internet surfing and video applications, as well as digital audio broadcasts.

Typically, system-on-a-chip (SoC) technology combines on a single silicon chip, a number of components that formerly had to be implemented on separate chips. The approach enables substantial reductions in cost, power consumption and size of integrated circuits.

For further details, check: <www.bell-labs.com>.

Contact: Lucent, Tel: +1 732 957 3870.

Compaq has Designs on Internet Appliance Market

The iPaq is an Internet appliance from Compaq that provides the right features for Internet-based computing while still supporting mainstream personal productivity applications.

In addition, Compaq has announced a new initiative to deliver the Internet destination for the business-to-employee market. This Web site destination will provide supporting services and content offered by American Express, CMGI, Intel, Microsoft and Siebel.

With its small, sleek, innovative industrial design, one-touch Internet access and simple configuration choices, Compaq iPaq is the first business computer specifically designed for companies moving toward an Internet-based computing model.

The future of Internet-based commercial computing is the rapid movement of business processes and operations to the Internet. What is now required are products and services that can take full advantage of the Internet by providing access to its content and services at any time and from any location.

Compaq will continue to expand the scope of Internet products and deliver the devices, appliances and services required for Internet-based commercial computing.

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

Contact: Compaq, Tel: (0845) 2704222.

Berkeley Transistor Breaks Barrier for Chip Integration

Engineers at the University of California (UC) Berkeley have created a new type of semiconductor transistor so small that a single computer chip can hold 400 times more of the devices than ever before.

Details of the prototype transistor, called FinFET, will be presented for the first time at the International Electronic Devices Meeting in Washington in December.

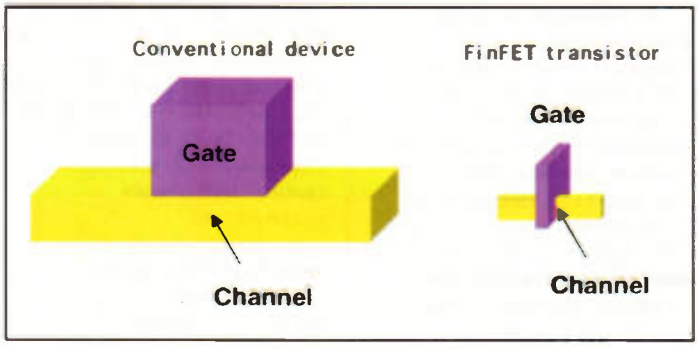
The breakthrough is due to a change in the design of the transistor 'gate', or switch, that controls the flow of current in the electronic devices. Typically, this gate is a flat conductor that controls only one side of the passage through which current flows in a transistor.

This design is limited because it cannot turn off the current flow when the gate is much shorter than its present length.

The new UC Berkeley design uses a fork-shaped prong that straddles both sides of the current channel. This improves control and reduces current leakage so that the gate, and thus the transistor, can be made much smaller.

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

Contact: UC Berkeley, Tel: +1 510 642 6000.



Young Engineers Micromouse Grand Prix

Young Engineers has joined forces with the IEE to create an exciting challenge for 11 to 18 year olds – The Micromouse Grand Prix 2000.

Teams of up to four have been invited to build and race their own robot cable of finding its own way around a course at high speed to take place in a series of race days in 2000.

Entrants to the challenge will have specialist support via the Internet through the Young Engineers Web site at <www.youngeng.org> for chassis, electronics, steering control, digital and programmable technology.

The Race Days will take place in March 2000 with five eliminator events to be held in Birmingham, Glasgow, Swansea, Stevenage and London. A winner for each category for team and individual will race through to the IEE Micromouse Grand Prix 2000 in July.

For further details, check: <www.youngeng.org> or <www.iee.org.uk>.

Contact: IEE, Tel: (0171) 7240 1871.

Cambridge Silicon Radio Makes Bluetooth link

Cambridge Silicon Radio (CSR) has successfully demonstrated a short-range, 2.4GHz radio link using pure CMOS implementation of the radio frequency circuits. The use of pure CMOS for such a 2.4GHz radio represents a major step forward in the drive to low cost wireless communications systems such as Bluetooth.

It allows specialised, more expensive radio frequency IC technologies to be replaced with the mainstream standard CMOS integrated circuit processes, allowing very low cost implementations of digital radio communications.

The successful demonstration builds on CSR's Bluetooth version 1.0 compliant baseband design and marks a major milestone on the path to CSR's goal of supplying customers with its single-chip BlueCore 01 radio and baseband in the first quarter of the year 2000.

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

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

Pocket Watch is Set for a World Record Sale Price

Patek Phillipe's Graves Supercomplication timepiece was expected to set a world record sale price over £3 million when auctioned at the beginning of December at Sotheby's in New York. Commissioned in 1925 for £10,000 by Henry Graves, a New York bank magnate, the watch took eight years to complete and is considered the most complicated timepiece ever produced without the aid of a computer.

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

Contact: Sothey's, Tel: (0171) 293 5000.

DigitalThink Conquers Parking Challenges

Steve Zahm and Umberto Milletti, two of DigitalThink's three co-founders, have found a creative solution to avoid parking problems. They are among the first wave of users of the electric scooter, a modified skateboard with motorcycle-like handles and a battery-powered motor, to shuttle between their company's offices.

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

Contact: DigitalThink, Tel: +1 415 625 4000.

Sound-Activated Personal Robot Unveiled by Probotics

A compact personal robot that responds to sound has been launched by Probotics. With a string of claps, the Cye-sr robot can be directed to carry coffee and donuts to the dining room or to vacuum the carpet, using its optional wagon or vacuum attachments.

Cye-sr is programmed to respond to claps. After one clap, Cye-sr beeps to let you know you've got its attention. To send Cye-sr to a destination, clap to indicate where you'd like it to go. For example, use two claps to send it to the kitchen, three claps to send it to the living room and one clap to come back to its home base (charger).

Cye-sr can also be navigated using the mouse on the PC, which is linked to the robot via wireless communications.

The compact Cye-sr (16 x 10 x 5in.) comes in yellow, orange and black/neon green. Its 9lb rectangular body has two spiky wheels, which enable it to move around any room at a speed of three feet per second.

Available immediately via the Probotics Web site, Cye-sr costs around £500. An optional wagon attachment sells for £55.

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

Contact: Personal Robotics, Tel: +1 412 322 6005.

NEWS BYTES

Sharp Unveils Worlds Lightest Notebook

Sharp has unveiled the latest model in the Actius line of notebook computers, the Actius PC-A800. The PC-A800, housed in a durable magnesium alloy case, features an advanced 13.3in. XGA active matrix LCD display, a 366MHz Mobile Pentium II processor and a standard modular CD-ROM drive that can be swapped with a floppy drive.

Measuring just over one inch thick and weighing only 4.7lbs, the PC-A800 marks Sharp's first entry into the thin and light notebook category and is the lightest notebook with a 13.3in. display and an integrated swappable CD-ROM drive.

For further details, check: <www.sharp.co.uk>.
Contact: Sharp, Tel: (0800) 262 958.

Iobjects Unveils Portable Digital Stereo Reference Platform

Interactive Objects has developed a portable stereo reference platform. This platform provides a solution for digital audio integration into a variety of consumer electronics systems, computer peripherals, portable audio players or home stereo systems. The reference platform consists of the minimum amount of hardware and firmware needed for a full-featured digital audio playback system and is designed to adapt to technological changes over time.

For further details, check: <www.iobjects.com>.
Contact: Interactive Objects, Tel: +1 425 653 5505.

Sony and Palm Collaborate on Joint Development

Palm Computing and Sony are collaborating to create a platform for handheld consumer electronics products with audio-visual functionality. Under the terms of the agreement, Sony licenses the Palm OS operating system and Palm Computing commits to supporting Sony's Memory Stick storage and data exchange technology as part of the Palm Computing platform.

For further details, check: <www.palm.com>.
Contact: Palm Computing, Tel: (0171) 365 9820.

NEWS BYTES

Transistor Design From Lucent's Labs May Turn Silicon World on End

Using a revolutionary design, researchers at Lucent Technologies' Bell Labs have produced the world's smallest transistor using equipment available in today's manufacturing facilities. This new design may help silicon chips continue their march toward smaller and smaller dimensions, and it has the potential added benefit of nearly doubling the processing speeds of some chips.

The 50nm transistor - roughly 2,000 times smaller than the width of a human hair - is known as a 'vertical' transistor because all of its components are built on top of a silicon wafer and its current flows vertically. In today's conventional transistors, which typically measure 180nm, the current flows horizontally and the transistors are formed within the wafer itself.

For further details, check: <www.bell-labs.com>.
Contact: Lucent,
Tel: +1 732 957 3870.

Forrester Acquires Fletcher

Forrester Research has acquired Fletcher Research creating the leading Internet analyst house in Europe. Founded in 1997, Fletcher Research delivers its research and analysis through a combination of expert knowledge of the UK's new media industry, cutting-edge analytical and modeling techniques, and high-quality data.

For further details, check: <www.fletcherresearch.co.uk>.
Contact: Fletcher Research,
Tel: (0171) 631 0202.

National Semiconductor Announces Linux Support for Geode WebPAD

National Semiconductor has announced that Infomatec will port its custom Linux-based operating system to the National Geode WebPAD platform - a complete hardware and software reference design for a wireless Internet personal access device (PAD).

National's Geode WebPAD platform is a reference design for a wireless PAD that is optimised for Internet browsing. Weighing less than three pounds, the WebPAD tablet is about the size of a standard 8.5in. x 11in. paper notebook and features a simple touch-screen that encourages user interaction.
For further details, check: <www.national.com>.
Contact: National Semiconductor,
Tel: (01475) 633733..

Sony Discam Camcorder Enables Instant Random Access

Sony's latest digital video recorder is a disc-based digital device with video capture and editing capabilities all in the same unit. The MiniDisc (MD) Discam digital camcorder (DCM-M1), takes advantage of MD technology to give consumers the versatility and convenience of instant random access.

The MD Discam camcorder records up to 20 minutes of video, up to 4,500 still images in MPEG2 file format, and more than four hours (260 minutes) of recorded audio with three digital still images in Interview Mode. The image quality of MD Discam video delivers more than 400 lines of horizontal resolution.

MD Discam camcorder uses MD Data 2 media, called MD View (MMD-650A), which was developed to handle the high capacity video storage needs of the MD Discam camcorder. It holds 650MB of audio/video re-writable data. Building on its developments in magneto-optical technology, Sony designed MD View to expand the benefits of the MiniDisc format to a visual medium for the first time.

Although not the same format, MD View and MiniDisc audio media share the benefits of instant random access playback, quick and easy editing and digital recording.

Scene Shuffle editing with the MD Discam camcorder is easy and intuitive. Users no longer have to rewind or fast forward movies with Scene Shuffle, because it lets them do on-the-spot editing. On-screen controls let users play, copy, move, trim, or erase scenes at the touch of the stylus to the screen.

Changing the order of scenes, erasing, copying and more can be accomplished in seconds. An index window on the LCD screen shows the starting image of each scene to let users mark each video segment for editing.

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

BT and Microsoft to Develop Wireless Internet

BT and Microsoft have announced an agreement to combine efforts in developing world-leading mobile internet and multimedia applications and equipment, which will lead rapidly to new types of service with broad customer appeal.

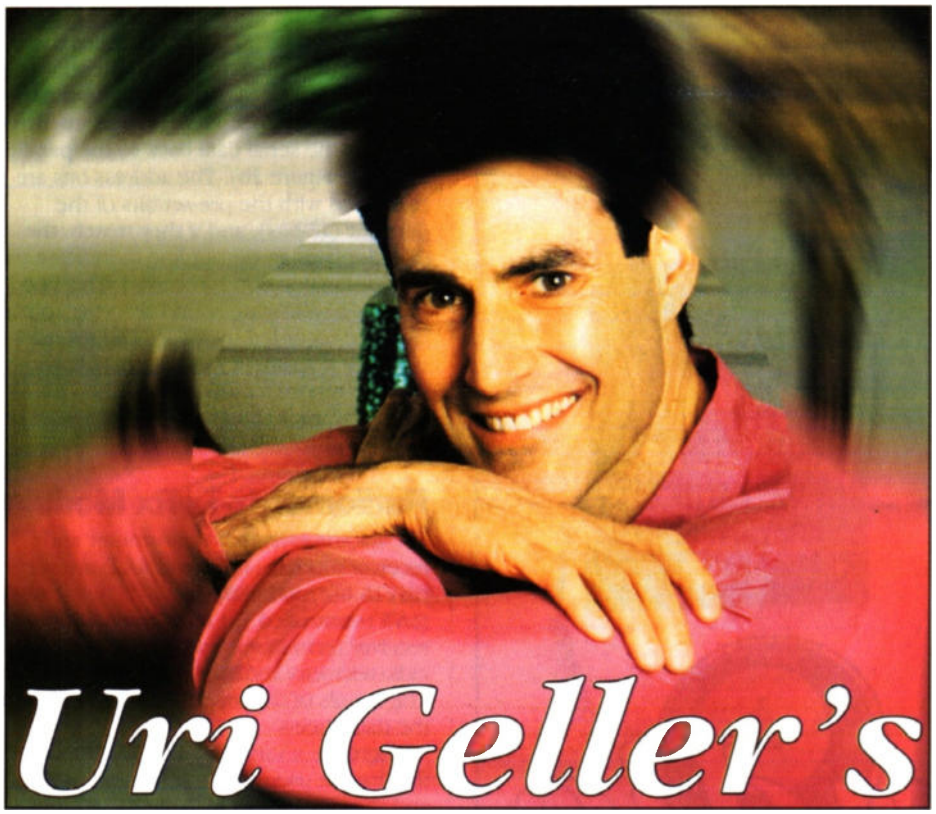
The two companies have begun the most extensive and ambitious trial of wireless Internet services ever, involving four of the companies' corporate customers – the BBC, Credit Suisse First Boston, KPMG and Nortel Networks - and business partner Telenor Mobil.

The trial, starting this month, builds on a BT and Microsoft agreement announced earlier this year to develop Internet, Intranet and corporate data services for mobile customers around the world. It will involve about 1,000 mobile phone users in the UK and Norway.

Some of the tests will evaluate services that allow users to send and receive e-mail as well as access in real-time their Microsoft Exchange-based calendaring, address list, personalised Web content and online information services from their mobile phones over established radio interfaces.

In support of this initiative, BT and Microsoft have signed development agreements with France-based Sagem SA and South Korea-based Samsung Electronics, two of the world's leading mobile equipment manufacturers. Both companies have developed Web browser mobile phone equipment for use in the trial.

For further details, check: <www.bt.com>.
Contact: BT, Tel: (0800) 309080.



Uri Geller's EXTENDED REALITY

Let There Be Light

The other day I dropped in on a friend of mine who helps me now and then with research for my books and columns. It was a dull, overcast day and as we had some papers to shuffle, he asked me to come into the kitchen. "The light's better in there," he said.

It certainly was. When I walked into the small room, I thought at first I was in a conservatory. Yet there was no glass roof, just two fourfoot fluorescent tubes in the centre of the ceiling. They looked different, somehow, and as my friend soon explained, they were indeed different.

"Just a minute," he said "I'll go and get the file". (He has files on everything under the sun). While I waited, I looked at the rows of postcards on the wall. The colours really jumped off the wall at me. The bowl of fruit on the sideboard might have come straight out of a painting by Cezanne, their greens and reds were so vivid.

The fills, I noticed was labeled 'F.S. Light' This, I learned stood for Full Spectrum, and what was different about it was that its tube was coated in a special way so as to make the light coming from it very similar to natural daylight.

"It certainly fools the birds he said," "if I leave the door open when it's on, they fly in here all the time, thinking they're still outdoors."

I went home with a pile of photocopies and brochures from the DuroTest company in the U.S.A., who make the tubes, and Full Spectrum Lighting Ltd (for their address, see the end of this page) who import them into the United Kingdom. I was amazed by what I learned about a type of lighting I had vaguely beard of without quite knowing what it was, and confusing it with those sunlamps that give you an artificial tan, which I had never bean tempted to try when I feel like getting a suntan. I get it from the source!

I discovered that there are three different ways of measuring light:

- Colour Temperature (CT). This refers to the relative amounts of red (warm) and blue (cool) in the light. Natural daylight is rated at about 5500 degrees Kelvin.
- Colour Rendition Index (CRI). The scale by which colour rendition accuracy is measured against that of daylight, which is rated at CRI 100.
- Spectral Curve the proportion of each of the colours that make up the visible light spectrum.

Some of the tubes you buy in the shops have a CT as low as 2100 and a CRI of 54, while their spectral curve looks nothing at all like that of the sun, often having large peaks in the orange and yellow bands and almost no ultraviolet at all. (No wonder so many people hate fluorescent light!) The DuroTest products have the same CT as day-light, a CRI of 100 also the same, and a spectral curve that comes very close except for having slightly less red and blue.

A good deal of research has been done into the positive effects of FS light on plants, animals and of course people from newborn babies to residents of a retirement home. Its benefits have been shown to be considerable:

Hospitals use it for the early detection and treatment of jaundice in babies - thereby saving them from possible mental and physical retardation and even cerebral palsy.

In a carefully controlled test carried out at Cornell University, it was found that it helped improve student's visual acuity and made them less likely to feel tired after working for four hours non-stop.

Male turkeys kept under the light have retained their sexual potency while another group housed in 'cool-white' light lost theirs. I wonder if this has implications for office workers who spend all day in unnatural light?

Puffins at a zoo in New York bred for the first time after four years soon after FS light was installed.

It has proved invaluable for sufferers of Seasonal Affective Disorder (SAD), a severe form of depression that hits people in winter and is thought to be caused by overproduction of the melatonin hormone. It can he suppressed by light, and FSL supplies a wide range of light boxes to cheer people up in the dark months.

I could give dozens more examples, but the general picture is quite clear: FS light does you good and a good deal of other kinds of light don't do you any good at all. It's only natural, when you remember that humans evolved for thousands of years with no artificial light at all except various kids of fire, lamps and torches. Electric light is barely a century old.

As early as 1970, when fluorescent lamps had only been on the mass market for about 20 years, a report published by the Massachusetts Institute of Technology stated, prophetically, that the effect of this was:

"...of potentially far greater significance biologically, since their spectra differ markedly from that of the sun. But after eons of conditioning to the natural star, could man's body adapt to the spectra and colours of the new glass ones?"

The answer seems pretty clear no, it couldn't.

(FSL, Lincoln Road, Cressex Business Park, High Wycombe, Bucks, HP12 3FX. Tel 01494 526051 or 448727).

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**

MESSAGE PLAYER

Dr Pei An describes audio message player system based on the Radiometrix 418MHz transmitter/receiver modules.

This article describes a remotely controlled audio message player system that consists of at least one remote control handset and at least one audio message player. On each handset, there is a push to make button. The audio message player allows users to record an audio message, e.g. speech, which can be replayed after the button on the handset is pressed. The system is illustrated in Figure 1. The operating distance is approximately 70m inside buildings and approximately 300m over open ground.

The system can be can be configured for many different applications. For example, in a doorbell application, you could have one remote control handset mounted outside a house and a number of message players in different rooms inside the house. If the remote control is activated, the recorded audio message will be played simultaneous in different rooms.

The system utilises the FM radio transmitter and receiver modules (TX2 RX2) from Radiometrix Limited. The transmitter is type-approved to the Radiocommunications Authority specification MPT 1340 for use in the UK and in Europe, so avoids the need to submit the project for final approval.

How It Works

Inside a remote control handset, the encoder (HT-12E) converts the 12-bit parallel data into a serial data form. All the 12-bits are treated as address. The serial data is fed into a TX2 transmitter to FM modulate the 418MHz (or 433MHz) radio frequency carrier. Figure 2a shows the principle of the remote controller.

Inside the message player, a FM radio receiver module, RX2, demodulates the radio signal picked up by the antenna. The demodulated serial data is fed into the serial-to-parallel decoder (HT-12F), which converts the serial data back to the parallel data (see Figure 2b). The address bits are compared with the pre-set bits of the decoder (12-bits), and if they match, the decoder flags an output line to indicate that a valid transmission is received. This line triggers a solid state sound recorder to play back the recorded message. The sound recorder is a simple module that allows users to record a message and then play it back. The audio message is stored in its on-board non-volatile memory.

Radiometrix Tx/Rx Modules

The Radiometrix radio transmitter and receiver modules (TX2 and RX2) are very easy to use, and make use of acoustic wave (SAW) controlled FM radio transmitter and receiver techniques, specially designed for radio telemetry and tele-command applications. The details of the modules are described in the data sheets[1]

There are a variety of TX2/RX2 modules that can be used with the present project, and they are shown in Table 1.

Table 1 Variants of TX2/RX2 radio link modules

Parameters	Description
Frequencies	418.00 MHz for UK use 433.92 MHz for European use
Supply voltages	5V (4-6V for TX2 and RX2) 3V (2.2V to 4V for TX2, 3 to 4V for RX2)
RX data rate	-A: 7kHz baseband BW, slow data up to 14 kbps -F: 20kHz baseband BW, fast data up to 40 kbps

Transmitter Module, TX2

The pin functions of the transmitter are given in Figure 3a. For the +5V and 433 MHz version, the operation voltage ranges from 4 to 6V DC. The typical current consumption is about 10mA at 5V. For the +3V and 433MHz version, the operation

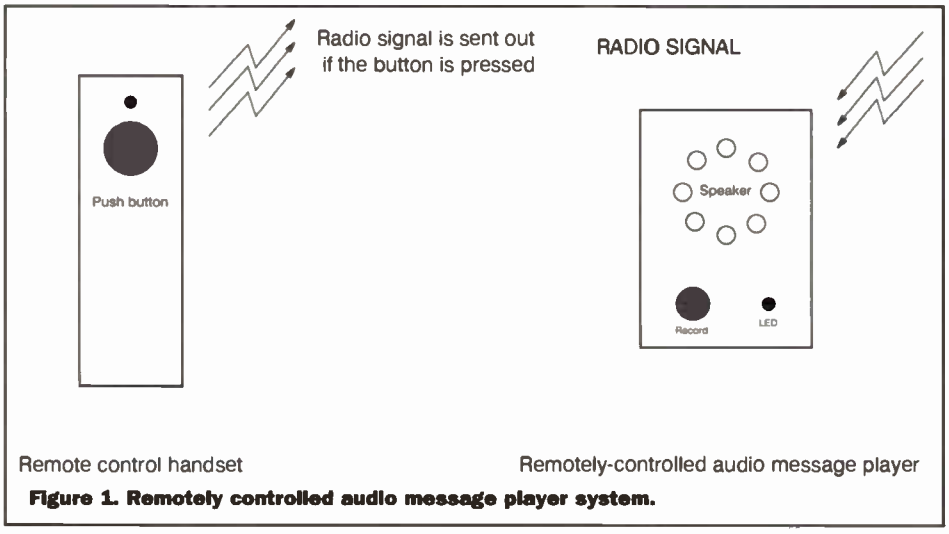
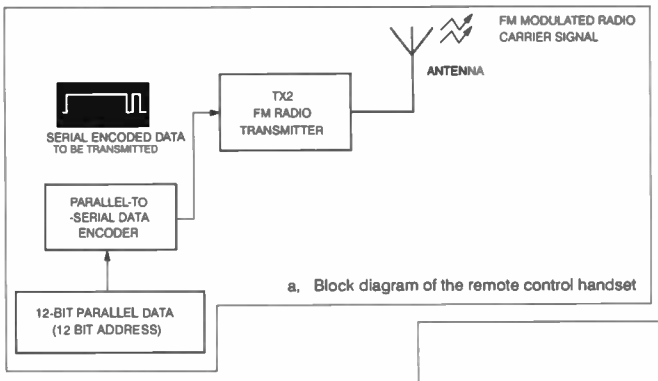


Figure 1. Remotely controlled audio message player system.



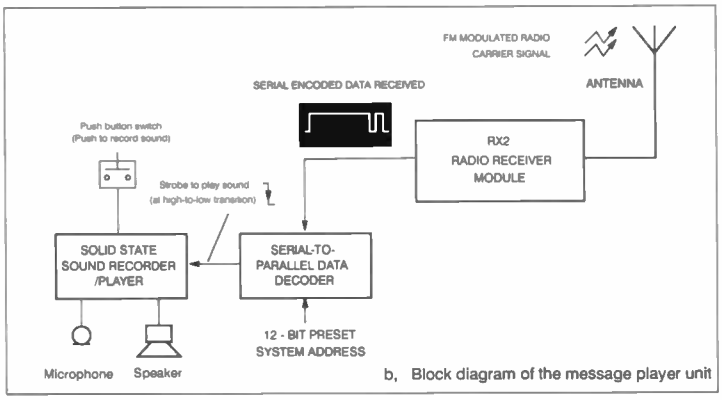


Figure 2. Block diagram of the system.

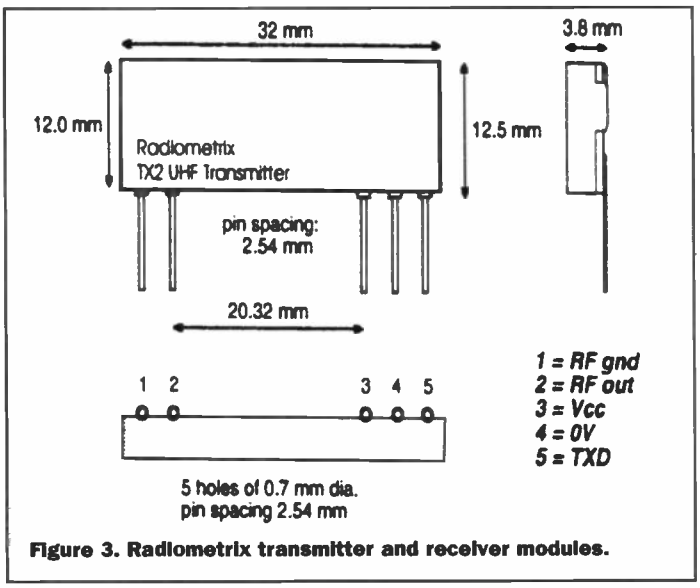


Figure 3. Radiometrix transmitter and receiver modules.

voltage is between 2.2V to 4V DC with a typical current consumption of 6mA at 3V. Digital data to be sent (which should be a CMOS logic level at the same power supply voltage) is fed into Pin 5. An antenna is connected to Pin 2. The block diagram of the module is given in Figure 4a. There are three possible variations to the transmitter antenna - the helical type, the loop type and the whip type (see Figure 5). The helical antenna is very compact but needs to be optimised for the exact wavelength in use. The loop antenna consists of a loop of PCB track, which is tuned by a variable capacitor. The whip-type antenna can be a length of wire, a rod, PCB track or various combinations of all three. Figure 5 shows how the antennas are constructed and compares their performances.

The Receiver Module, RX2

The pin functions of the receiver are shown in Figure 3b. For the +5V version, the operating voltage range is from 4 to 6V DC with a typical current consumption of 13mA at 5V. For the +3V version, the operating voltage is between 3.0 to 4.0V DC with a typical current consumption of 13mA at 3.5V. The digital output signal appears at Pin 7 (RXD), and is at COMS logic level. Pin 3 is the Carrier Detect output, and may be used to drive an external pnp transistor to obtain a logic level carrier detect signal. If not used, it should be connected to +5V. The block diagram of the receiver is shown in Figure 4b. Any of the antenna previously described in the transmitter section can be used with the receiver.

Encoder, HT-12E

The HT-12E and HT-12F are CMOS LSI encoder and decoder ICs that are designed for transmitting and receiving digital code. They have a wide range of operating voltage from 2.4V up to 12V with a typical stand-by current of 1μA. An on-board oscillator is provided in the ICs and requires only one external 5% resistor. The Pin-out and pin functions are shown in Figure 6, with typical applications for the devices given in Figure 7. Details of the operation of the ICs are given at the end.[2]

The HT-12E encodes a 12-bit of parallel data into a serial data which is transmitted upon receipt of a low-going signal at the Transmit Enable pin (-TE, Pin 14). The 12 bits of data consist of 8 bits of address (A0 to A7 connected to Pin 1 to Pin 8) and 4 bits of data (D0 to D3 connected to Pin 10 to Pin 13. The external oscillator

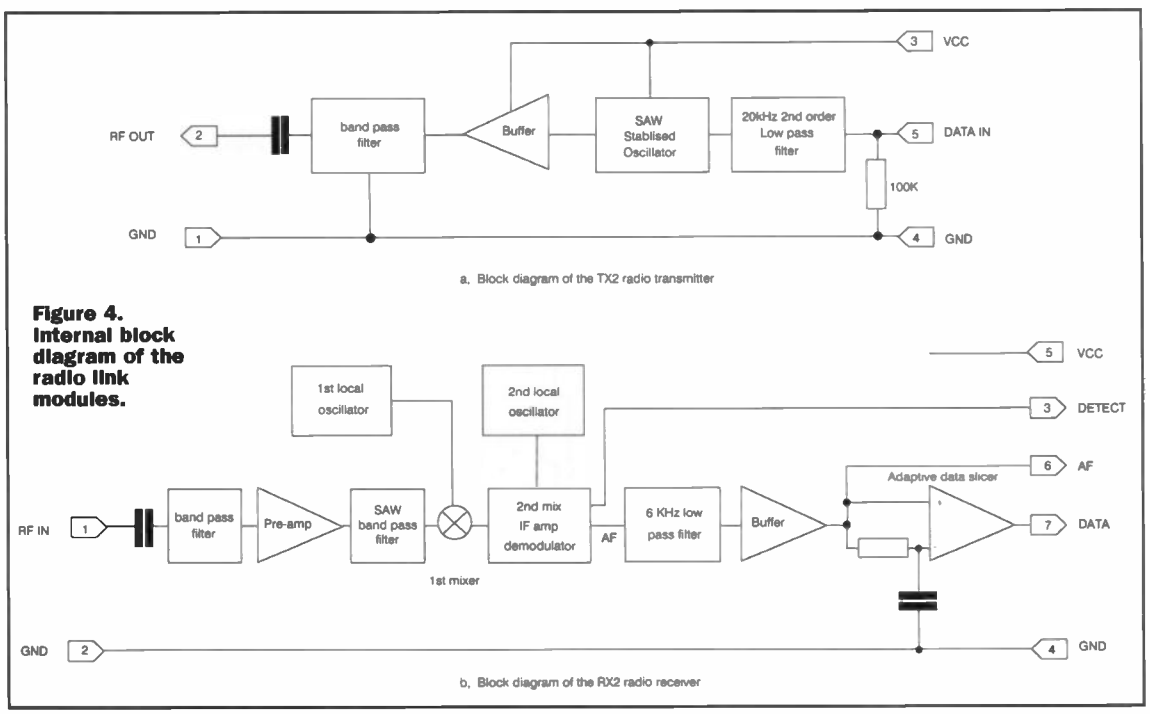
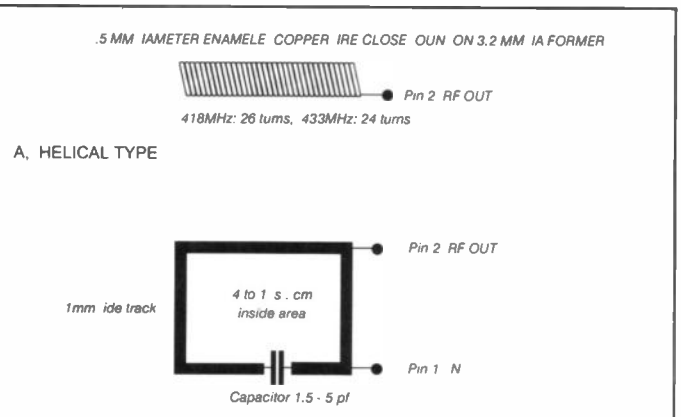


Figure 4. Internal block diagram of the radio link modules.



Antenna performance chart	Helical	Loop	Whip
ULTIMATE PERFORMANCE	√√	√	√√√
Ease of set-up	√√	√	√√√
Size	√√√	√√	√
Immunity to proximity de-tuning	√√	√√√	√

Figure 5. Suitable antenna designs.

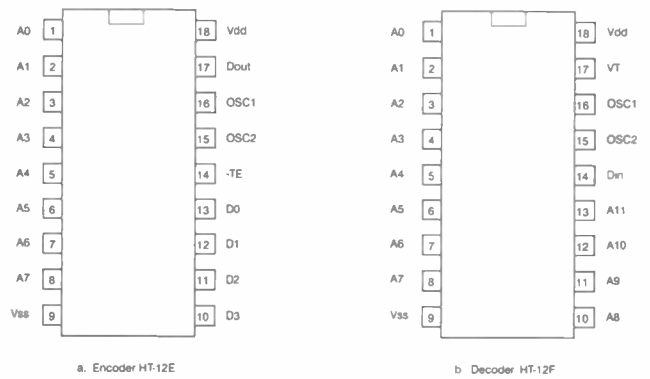


Figure 6. Pin-out diagrams for HT-12 ICs.

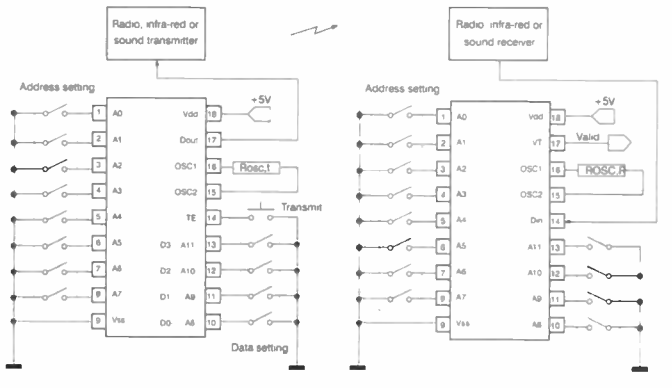


Figure 7. Typical HT-12 applications.

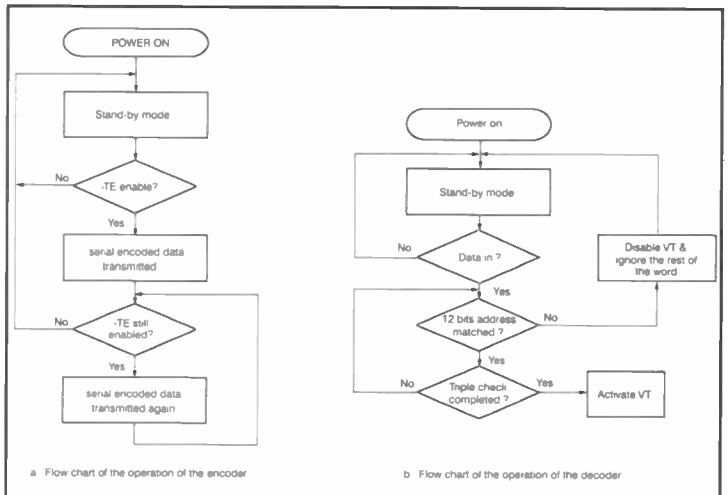


Figure 8. encoder/decoder operational flow chart.

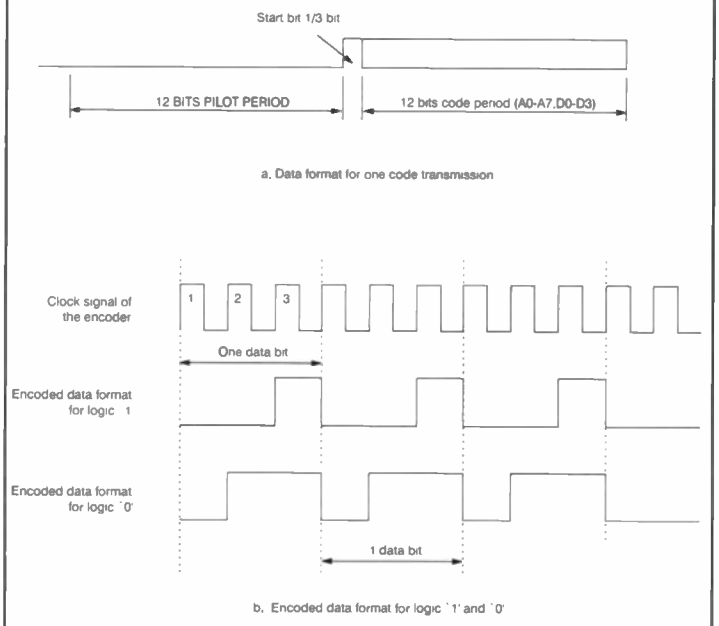


Figure 9. Encoded serial data format.

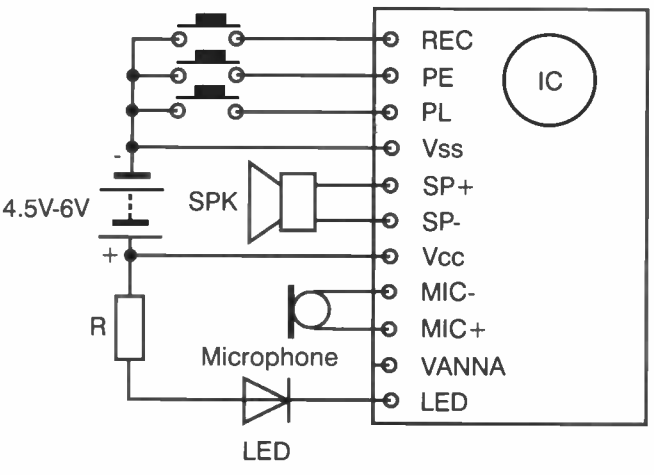


Figure 10. Typical connection of the QX-RD1 module.

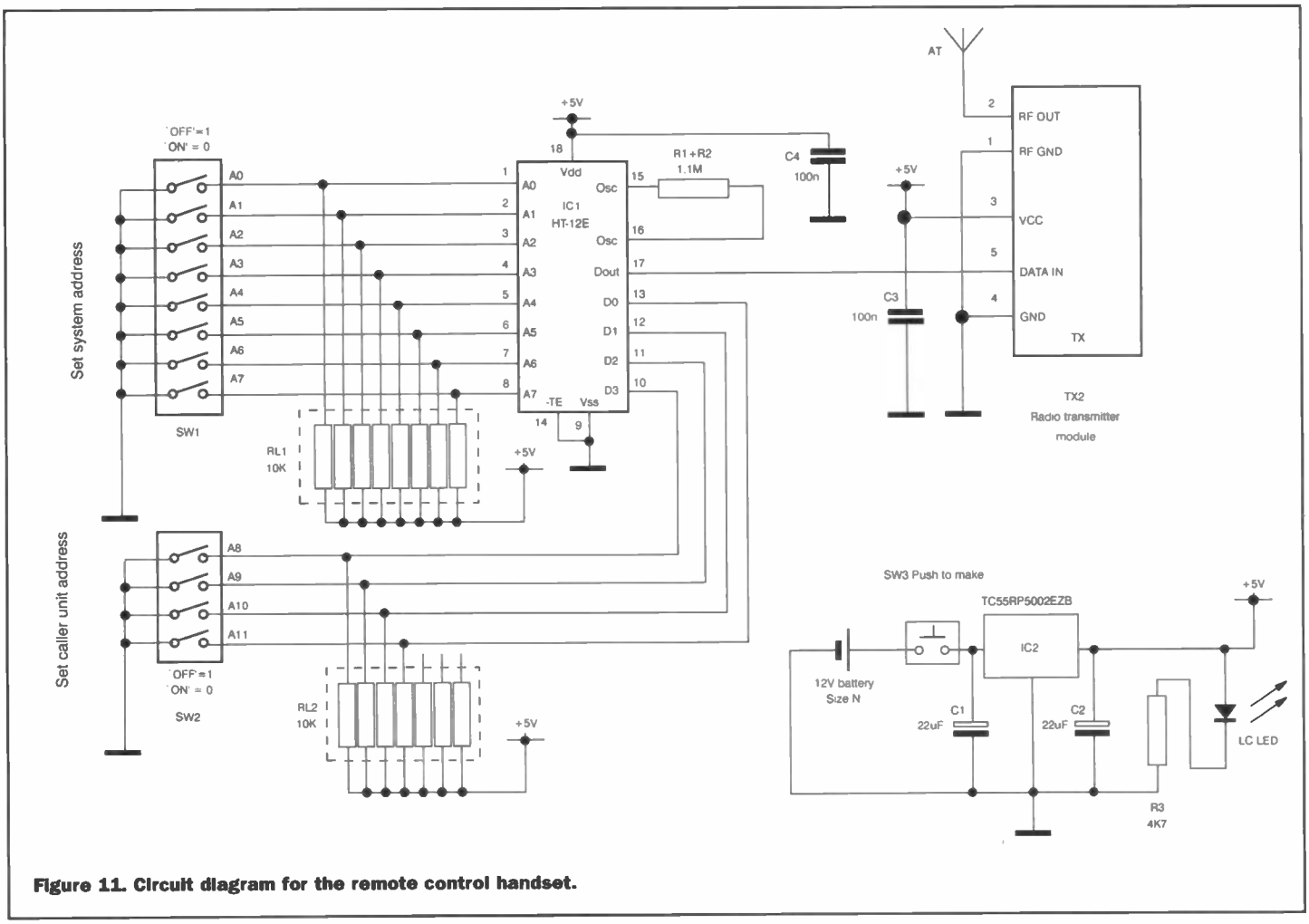


Figure 11. Circuit diagram for the remote control handset.

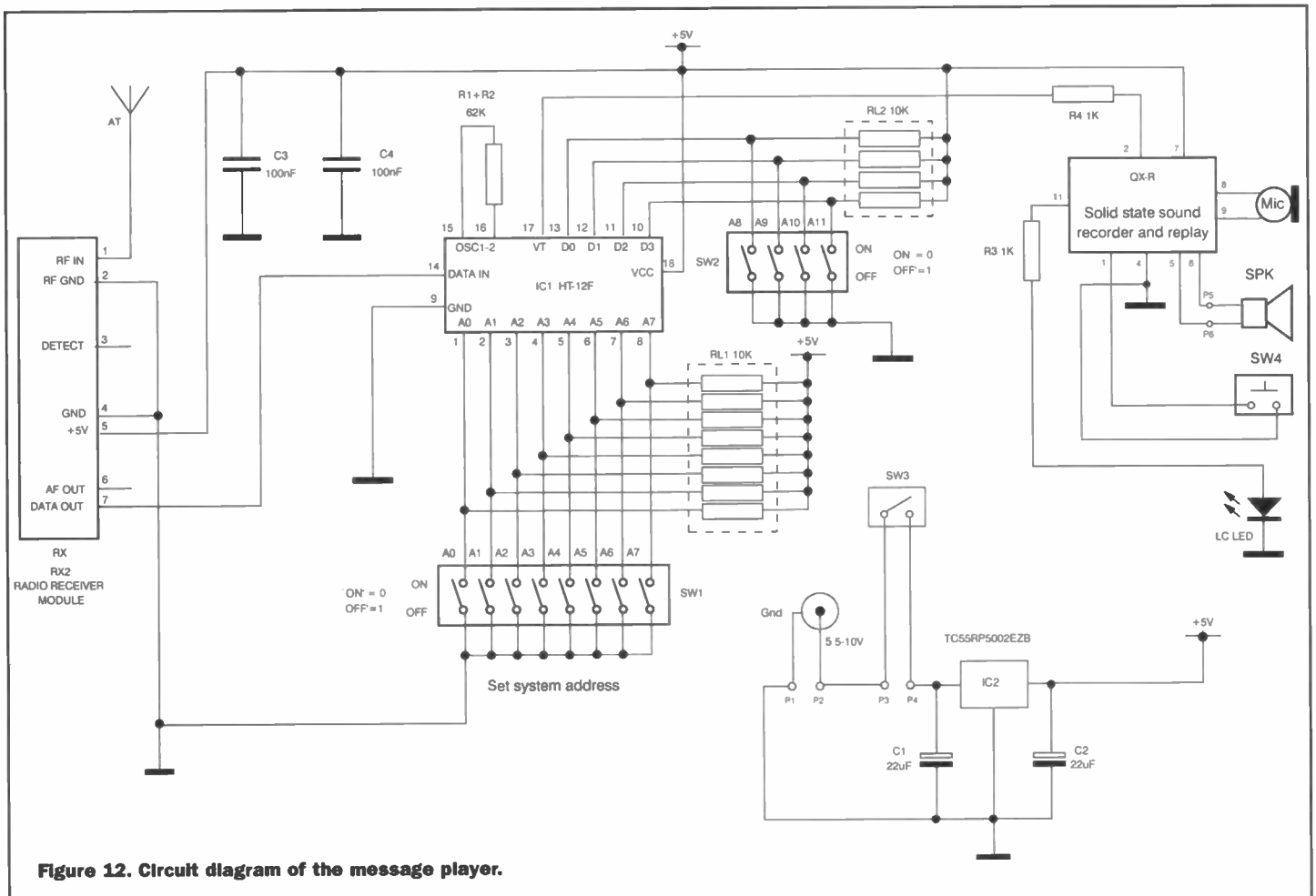


Figure 12. Circuit diagram of the message player.

resistor is connected between Pins 15 and 16. The chosen values of resistance will be given later (the details of this can be found in the data sheet2). The serial data output is from Pin 17. Pins 9 and 18 are connected to the negative and the positive rails of the power supply.

Initially, the HT-12E encoder is in the stand-by mode. Upon receipt of a -TE signal (low active), it begins a 4-word transmission cycle and repeats the cycle until the -TE signal becomes high (Figure 8a). Each word contains 2 periods: the pilot code period and code periods as shown in Figure 9a. The pilot code period has a 12-bit length period and is at logic low. The code period also has a 12-bit length period and contains the serial encoded data. The logic levels `0' and `1' are encoded in the manner shown in Figure 9b. The order of data bit transmission is from A0 to A7, then from D0 to D

Decoder, HT-12F

The HT-12F receives the 12-bit word and interprets all the bits as the address. When the received address matches the decoder's pre-set address, the Valid Transmission (VT) output goes high. The VT output remains high until the right code is no longer received. The flowchart of operation is given in Figure 8b. The serial data is input at Pin 14. The external oscillator resistor is connected between Pins 15 and 16. Pin 17 is the valid transmission output. Pin 9 and Pin 18 are connected to the negative and positive rails of the power supply.

External oscillation resistor

The ICs require low tolerance 5% resistors. The following table gives the resistance values for 3kHz and 4.3kHz oscillator frequencies for the encoder - the present circuit is set at 3kHz. For other frequencies, please refer to the manufacturer's data sheet[2].

HT-12E (encoder)		HT-12F (decoder)	
R	F_{osc}	R	F_{osc}
1.1M	3 kHz	62k	150kHz
750K	4.3kHz	33k	240kHz

QX-RD1 solid state sound recording module

QX-RD1 is a 20 second solid state sound recording IC', that can retain the recorded sound is retained after power is removed, and offers superb sound quality.

The module is compact measuring just 45 x 25 x 15mm. To make a complete sound recording and replaying device, requires three switches (recording, re-play and stop), one LED to indicate recording status, one 8Ω speaker and one electret microphone. The module requires a power supply from 4.5V to 6.5V DC. In record and replay modes, current consumption is typically 25mA. In idle mode, the current drops to 0.5 μA.

Pins	Functions
1	RECORD, Record (low active)
2	PLAYE, Play (low active)
3	PLAYL, Stop (low active)
4	Ground
5	Speaker +
6	Speaker -
7	VCC (4.5 to 6.5 V DC)
8	Microphone -
9	Microphone +
10	VANA not used
11	Record LED indicator (Low to indicate)

The QX-R module is shown in Figure 10a. The functions of the 11 pins are listed below.

A typical connection of the module is shown in Figure 10b. Press and hold the RECORD button causes the module to record sound. Users can now record speech via the microphone. While recording is in progress, the LED illuminates. Recording is terminated either by releasing the RECORD switch or after the maximum recording time of 20 seconds is exceeded.

Toggle PLAYE button once (press the switch and then release it) causes the module to replay the complete recorded sound - to stop, toggle the PLAYL switch. Press and hold the PLAYL switch will play from the beginning and release to stop.

Circuit of Remote Control Handset

Figure 2a shows the block diagram of the transmitter and Figure 11 gives the circuit diagram. The encoder, HT-12E, converts a 12-bit address (address) into serial data form. The 12-bit address is pre-set by SW1 and SW2. The serial data is available from Dout (Pin 15). The -TE input (Transmit Enable, Pin 14) is set permanently low to enable data transmission.

The serial data generated by the HT-12E encoder is fed into Pin 5 of the TX2 radio transmitter, with the RF signal supplied on Pin 2 of the module. In this design, a helical-type antenna is utilised.

The power supply is an N-type 12V alkaline battery (10mm diameter and 28mm length, 33mAh capacity). The voltage is regulated to +5V by a low-power, low-drop voltage regulator, TC55RP500. When SW3, a push-to-make switch, is pressed, the caller unit starts to transmit the code. This arrangement allows a maximum battery power saving to be achieved. The battery will last for at least 2300 calls.

Circuit of message player

The block diagram of the receiver is given in Figure 2b and Figure 12 gives the circuit diagram of the receiver. The radio frequency signal is picked up by the antenna and is fed into Pin 1 of the receiver module. The demodulated signal is output from Pin 7. It is then fed into the decoder.

The HT-12F decoder complements the HT-12E encoder. The decoder receives the serial data at Pin 14, checks for errors and outputs the received data if it is a valid transmission. The 12 bits of the received data must match the pre-set address of the decoder (set by SW1 and SW2 dip switches). If the two addresses match three times, the Valid Transmission output (VT, Pin17) goes high. If not, the VT output remains low.

SW4 is used to record sound, via an electret microphone, and is held down while recording is in progress. A small speaker is used for playback.

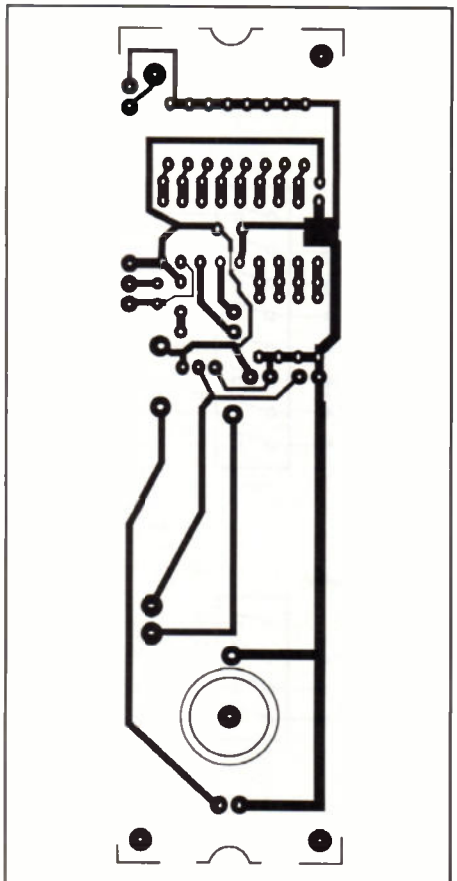


Figure 13. Remote control PCB board.

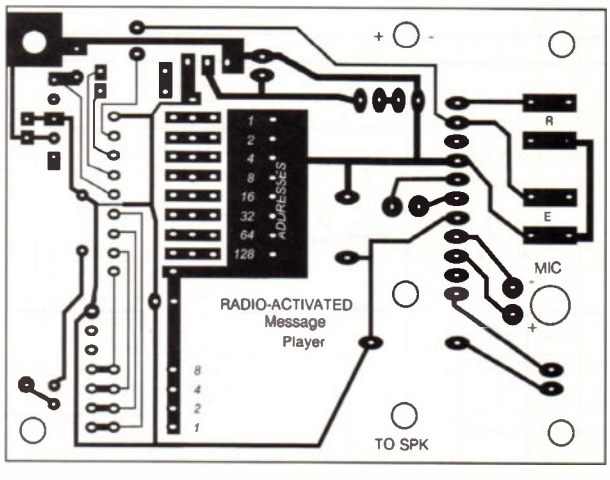


Figure 14. Message player PCB board.

Again, the voltage is regulated to +5V by a low-power, low-drop voltage regulator, TC55RP500. The quiescent current of the message player is approximately 20mA., rising a maximum current of 100m during playback.

Construction

The remote control handset and the message player are constructed on single-sided PCB boards (Figures 13 and 14). The antenna of the receiver is constructed using piece of copper wire (see Figure 5 for construction details). The component layouts are shown in Figure 15. Construction is straight forward, and should work fi tme, as no adjustment is needed for either the transmitter or receivers.

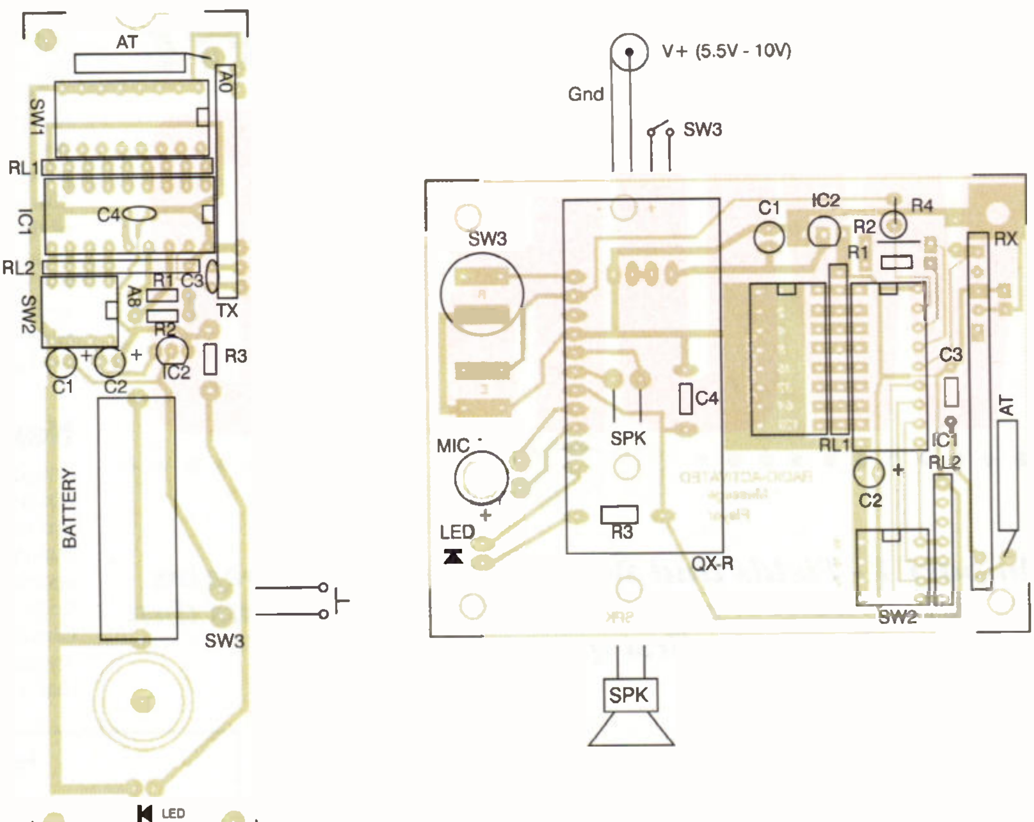


Figure 15. Component layout for the handset and message player.

Radio-communication Authority MPT1340

The radio transmitter module is type-proved to the RA MPT1340 for licence exempt use within the UK for telemetry, telecommand and in-building security, provided the following requirements are met.

1. The transmitting antenna must be one of the three variants given above (see Figure 5).
2. The transmitter module must be directly and permanently connected to the transmitting antenna without the use of an external feed. Increasing the RF power level by any means is not permitted
3. The module must not be modified nor used outside its specification limits
4. The module may only be used to send digital data. Speech or music is not permitted
5. The equipment in which the module is used must carry an inspection mark located on the outside of the equipment and clearly visible, the minimum dimensions of the inspection mark shall be 10 x 15 mm and the letter and figure height must be not less than 2 mm. The wording shall read: "MPT 1340 W.T. LICENCE EXEMPT"
6. The trimmer control on the module must not be easily accessible to the end user. This control is factory set and must never be adjusted.

Failure to meet the above conditions invalidates the modules' Type Approval. Further information on MPT1340 specification issued by the RA (DTI) may be obtained from the RA's library service.

Acknowledgement

I would like to thank Mr. Kangeyan from Radiometrix Ltd for his help on this project.

Reference

Data sheets for TX2 and RX2 are available from Radiometrix Ltd. Tel: 44(0)1814281220. Web site: www.radiometrix.co.uk Data sheets for HT-12 series from Holtek. Web site: www.holtek.com.twQX-RD1 solid state sound recording/replaying module and its data sheet are available from Intec Associates Ltd. Tel 44(0)1614779583.

Technical support

Designer's kit is available from the author. The kit includes PCB boards and components. Please direct your enquiry to Dr. Pei An, 11 Sandpiper drive, Stockport, Manchester SK3 8UL, Tel/Fax/Answer: 44-(0)161-477-9583. E-mail: pan@intec-group.co.uk

HANDSET PARTS LIST

RESISTORS:	
R1	1M 1% Metal Film Resistor
R2	100k Metal Film Resistor
R3	4k7 Metal Film Resistor
RL1	10k 8-way Resistor Array
RL2	10k 7-way Resistor Array
CAPACITORS	
C1, 2	22μF 16V Electrolytic
C3	100nF Ceramic Disc
SEMICONDUCTORS	
IC1	HT-12E Encoder
IC2	TC55RP5002EZB
LED	Low Current LED
MISCELLANEOUS	
TSW1	8-way DIL Switch Array
SW2	4-way DIL Switch Array
SW3	Push Button Switch (push-to-make)
TX	TX2 Transmitter
Battery	12V, N-size Battery
Holder	Battery Holder
AT	Helical-type Antenna

MESSAGE PLAYER PARTS LIST

RESISTORS:	
R1	62k Metal Film Resistors
R2	Not Required
R3	1k Metal Film Resistor
RL1	10k 8-way Resistor Array
RL2	10k 7-way Resistor Array
CAPACITORS	
C1, 2	22μF 16V Electrolytic
C3	100nF Ceramic Disc
C4	100nF Ceramic Capacitor (in-line type)
SEMICONDUCTORS	
IC1	HT-12F Decoder
IC2	TC55RP5002EZB
LED	Low Current LED
MISCELLANEOUS	
SW1	8-way DIL Switch Array
SW2	4-way DIL Switch Array
SW3	Toggle Switch
SW4	Push Button Switch (push- o-make)
RX	RX2 Transmitter Module
QX-R	20s Solid State Sound Recorder/ player Module
SK	2.1mm Power Socket
MIC	Electret Condenser Microphone
SPK	8Ω Speaker
AT	Helical Type Antenna

The Quantum WORLD

PART 1

In part 1 - Fields and Waves - David Clark begins with a look at the early scientific developments that led to the first quantum theory.

Introduction

The first year of the new millennium is the centenary of Planck's disclosure that radiation is emitted from objects in packets, or quanta, the revelation that began the era of quantum theory. Quantum theory will be at the heart of any 'Theory Of Everything', which if found will explain the existence, form, interactions and future of all matter and forces. A 'Theory Of Everything' is the Holy Grail of theoretical physics, and science is tantalisingly close to finding this sacred theory, a theory that possibly even includes an explanation of how a universe can 'pop out' of literally nothing. This three part feature examines this Quantum World, taking a journey that began over two and a half thousand years ago with the early Greek philosophers.

Philosophical Beginnings

Modern theoretical physicists are not the first people to want to know about the nature of matter and the reason for everything; perhaps not surprisingly the Greek philosophers had something to say about it. In the early sixth century BC a man named Thales was the first Western philosopher to suggest an origin of the world that didn't involve myths and legends. Inspired by the discovery of fossils of sea creatures miles inland, his theory was that everything had come from water, not out of the water as in modern evolutionary theory but that water in its different forms was the fundamental material of which earth, sky, gods, men, plants, creatures, everything, was composed.

Thales was succeeded by Anaximander, possibly a pupil of his, who is believed to have developed the first theory of the cosmos - that is of the universe as an ordered whole. He declared that the cosmos originated with a fundamental substance called 'apeiron' (see Figure 1), meaning 'unlimited,' which then broke down into opposites such as hot and cold, and dry and wet.

The interactions between these basic elements produced earth, water, air, mist and heat. Heat in the form of rings surrounded the whole cosmos, but this heat was only visible through holes in the mist which surrounded the heat rings, and these were the stars. He also believed that the heat would eventually evaporate the mist and that finally everything would return to the form of apeiron. This must have been one of the first logically argued theories that the universe had a beginning and would one day have an end.

Anaximander also seems to have been the first person to suggest that the Earth was not somehow supported by something which prevented it falling through a void. This was a big step forward in the understanding of the cosmos, however, in order to believe in an unsupported Earth he declared that the Earth was at the centre of the universe and at rest, a belief that like many other early Greek ideas remained virtually unchallenged for two thousand years.

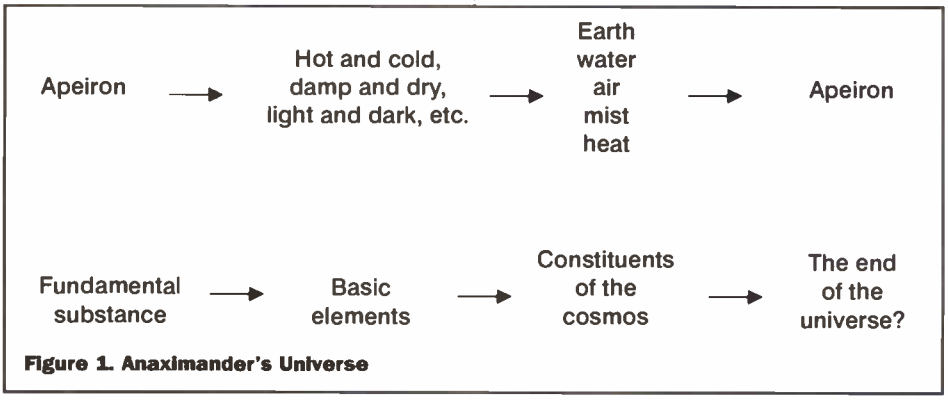


Figure 1. Anaximander's Universe

Next Steps

Anaximander was followed in turn by Anaximenes, who believed that air or mist was the fundamental material from which all matter was made, rather than water or apeiron. Anaximenes importance was that he proposed a means by which one material converted to another, which Thales and Anaximander had not done. This theory said that water and earth were made by the air being made more and more dense, i.e. condensed, and that if air was made less dense, or rarefied, it became heat or fire. See Figure 2.

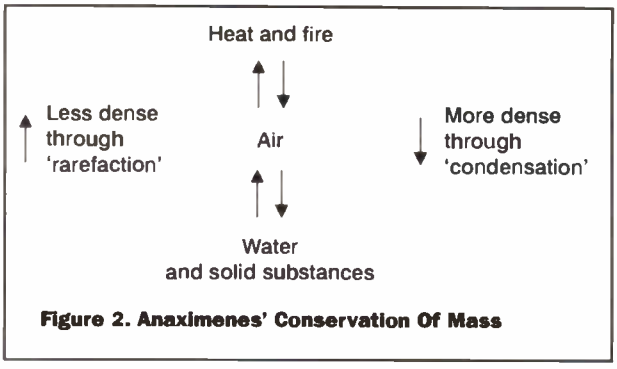


Figure 2. Anaximenes' Conservation Of Mass

The significance of this theory is that it says that even though the form of the material changes it is still fundamentally the same thing, ie matter is conserved, the same basic principle as the conservation of mass and energy in modern physics.

From Greece To Italy

Around 540 BC the traveller and poet Xenophanes took Anaximenes' philosophy with him from Greece to Italy. He used his poetry to express Anaximenes' philosophy in a more generally comprehensible way and used the theory, that matter is conserved, to ridicule the widely held belief in the Olympian gods and goddesses, who were replaced by a single god who ruled the whole universe, who had always existed and who always would exist. It was believed that this had to be the case since as all material is a different form of a fundamental material, nothing could initially be created from nothing nor could anything ultimately be destroyed completely to become nothing. These views came to the attention of a philosopher named Parmenides who added an extra dimension to the theories. His

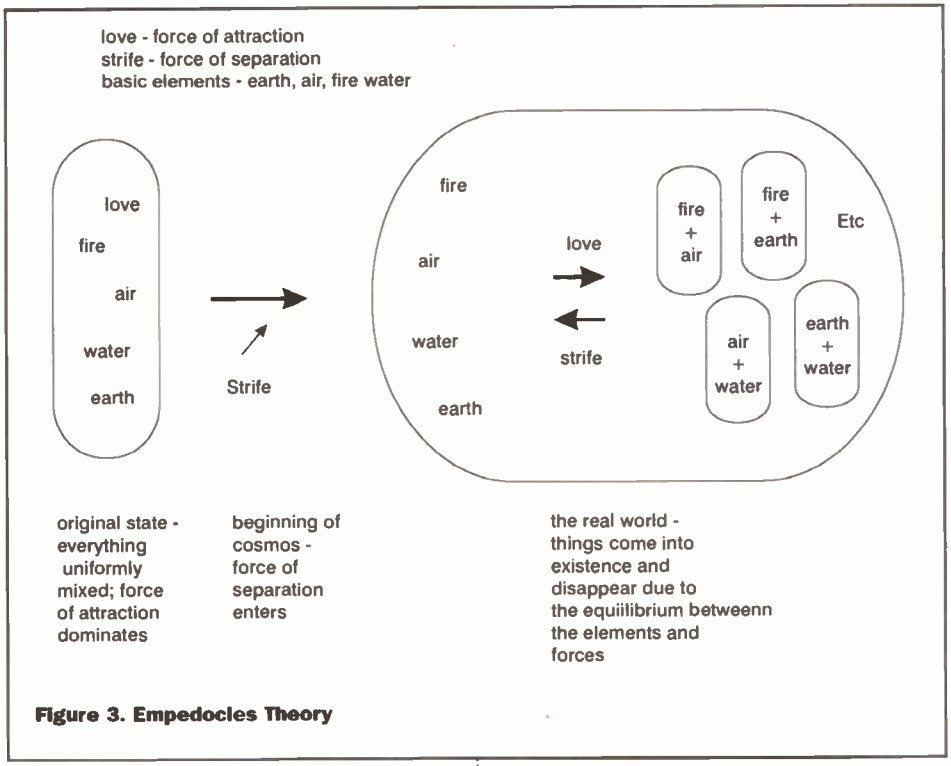


Figure 3. Empedocles Theory

school of philosophy said that reality is actually a matter of belief, the fundamental materials supposedly making up all observed matter for example don't exist in reality, they are merely ideas which enable observed objects to be explained. This apparent conflict between what is observed and an underlying theory to explain it has troubled some scientific and philosophical minds ever since, including the twentieth century physicist Schrodinger, an important contributor to quantum theory, who sometimes had difficulty accepting even his own theories.

Elements And Forces

Parmenides philosophy was an important concept, but it might be considered a backward step in the search for an explanation of the natural world. Other philosophers continued to put forward theories that would explain the complexity of the natural world without the need for the creation of material from nothing. About a century after Anaximenes, a man named Empedocles came up with another idea. He expressed his theory that there were four material elements, earth, water, air and fire, which he called the 'Roots Of Everything' and two forces, which slightly unscientifically, were called love and strife, representing forces of attraction and separation.

The fundamental principle was that the four elements and two forces were constantly interacting, combining to form other materials and decomposing back to their elements, and through this things can come into existence and disappear from existence, but the elements themselves are never destroyed or created. Another theory of about the same time was that of Anaxagoras, who declared that everything was composed of infinitely small parts which in the beginning were all in an even mixture. Then some sort of 'intervention' deliberately set these particles in motion which led to their becoming the materials composing the world. These basic ideas led to the next big step forward; the rise of the Atomists.

Atomists

The term atom, from atomos meaning indivisible, was coined by Democritus around 430 BC. He was a follower of Leucippus who is believed to have begun the philosophy of atomism, and between them they came up with the principle that the physical world consisted of empty space and atoms, atoms being indivisible. Perhaps due to the influence of Parmenides it was not so much a scientific theory as a way of explaining the natural world and the appearance of change. The Atomists believed that there were atom particles not only for the elements of matter but also for colour for example, and even for the human soul and attributes of character and appearance. There was of course disagreement over these ideas. Aristotle and Plato rejected the ideas as they simply could not accept that the whole of reality was built on small particles which defined everything. Democritus believed that matter could move through the vacuum of space and that light was rapid moving particles travelling through a void - Aristotle rejected even the idea of the possibility of the existence of a vacuum. Interestingly, some Atomists believed that atoms were divisible, and even out of Aristotle's thinking had come the idea that each kind of substance has its own 'minimum nature'. This idea said that if the minimum nature of a substance were to be divided, it would become another substance - two thousand years before the discovery of radioactive decay.

The Nature Of Things

Epicurus was an important man of ideas living around 400 BC and it is through his influence, which lasted over 800 years, that Atomist ideas were passed on. Around 100 BC the theories came to the attention of the Latin philosopher Lucretius, who was a poet as well as a philosopher and like Xenophanes before him used his talents to disseminate his thoughts to a wider population. It is because of his poem 'On The Nature Of Things' that much is known of these ideas. This epic poem extends to six books and must have effectively been the 'Theory Of Everything' of the time. In the first two books the basic principles of atomism are stated. In the third book the 'atomic' nature of the soul is explained. The fourth book describes the senses, thought and the workings of the body, and the fifth describes how the cosmos was created and how life evolved. The final book gives a description of the workings of the earth and sky - all in all a formidable piece of work!

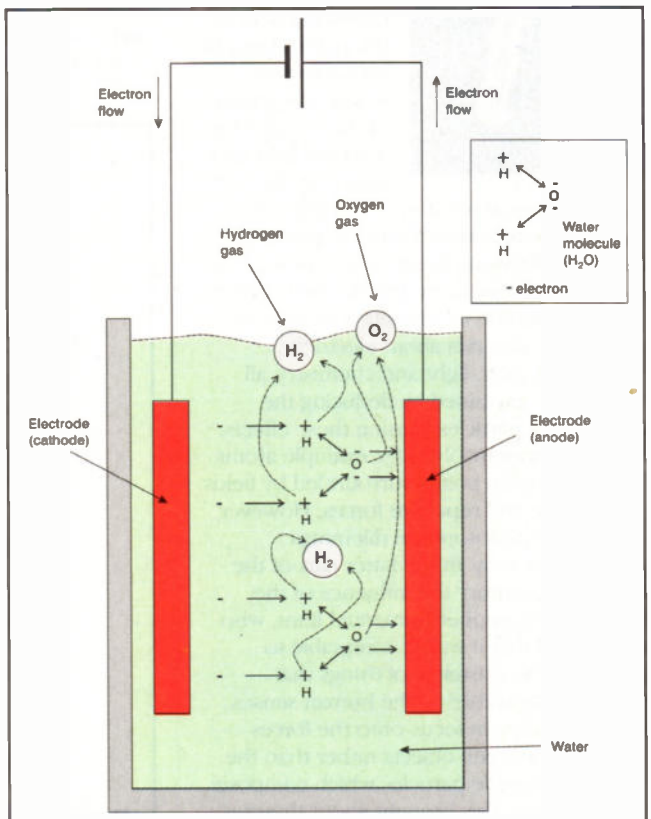


Figure 4. Electrolysis - A major step forward in the proof of the existence of atoms came at the beginning of the 19th century when it was shown that an electric current broke water down into hydrogen and oxygen.

Astronomy

In terms of understanding the nature of matter, the theories of the atomists were 'state of the art' for nearly 2000 years. Much of 'science' was effectively astronomy, an attempt to account for phenomena such as comets, meteors and eclipses, and to understand the movements of stars and planets, particularly relative to the Earth. The study of the heavens, involving perhaps most notably Galileo Galilei, led to the next major step forward in scientific understanding, the discovery that the Earth revolved around the Sun. Describing the motion of the planets around the Sun was one thing however, but what was the mechanism behind it? Problems of philosophy arose again, and in the seventeenth century the French philosopher Rene Descartes put his mind to the problems of matter and motion, which became known as mechanical philosophy. Descartes could not accept that bodies could act on each other through empty space, he thought all such interactions must be the result of small particles colliding, and under his guidance his pupil Christiaan Huygens, the Dutch physicist, formulated the laws which govern these collisions, the rules for momentum and energy, fundamental principles of vital significance for modern quantum mechanics.

Newton

Much of the scientific knowledge accumulated up to the end of the seventeenth century is held in the publications of Isaac Newton whose three laws of motion and his work on light and optics are the basis of classical physics, or the physics of the macroscopic world, and are primarily based on deducing things from observation rather than experiment. But the next century saw an explosion in scientific investigation and theory, theories about electricity, magnetism, heat, light and chemistry, all supposedly explained by deducing the existence of particles causing these effects. These theories involved for example atoms as mathematical points surrounded by fields of attractive and repulsive forces. However, as ever, the philosophical dilemmas wouldn't go away. In the latter part of the eighteenth century the influence of the German philosopher Immanuel Kant, who maintained that it wasn't acceptable to believe in the existence of things that weren't 'observable' to the human senses, led to a change in focus onto the forces occurring between objects rather than the unexperienceable particles which compose those objects. This brought about theories of fields of forces which exist throughout the cosmos and which therefore affect all objects within their influence, ideas which are the basis of field theory today.

Electromagnetism

The nineteenth century showed the beginnings of a desire to find a neat solution which linked together all the forces of attraction and repulsion. Hans Christian Oersted, the Danish physicist and chemist, believed that the discoveries by himself and his contemporaries regarding chemical reactions and electrolysis, electricity and magnetism, heat and light, must all be manifestations of an underlying effect. Oersted, and Michael Faraday, the English scientist, did much work on the connected nature of electricity and magnetism, i.e. electromagnetism, which resulted in theories about fields comprising energy 'spread out' through a system rather than concentrated in the particles making up a system. Following Faraday's work on electric and magnetic field lines, James Clerk Maxwell produced a theory of electromagnetic radiation, a theory which was to lead to the law of heat radiation. It was the failure of this theory under certain circumstances that led Planck to the basis of quantum theory.

Gases

While the physicists were working on electricity, magnetism, light and heat, (the 'imponderables,' or 'unweighable'), the chemists had been working on gases. Lucretius' poem 'On The Nature Of Things' had been 'rediscovered' in the fifteenth century by a priest, Pierre Gassendi, who tried to reconcile the existence of atoms with the existence of God by saying that God had created atoms. Twelve centuries earlier Aristotle had rejected Democritus' atomism because he would not accept that a vacuum could exist; in 1638 Galileo professed that a vacuum could indeed exist and shortly afterwards Robert Boyle, using a recently improved German air pump, began working on air and gases using reduced pressures. From this work Boyle decided that all matter is made of solid particles arranged into molecules; shortly afterwards Newton himself expressed that he too now believed in the theories of Democritus, Gassendi and Boyle - there could have been no greater recommendation of atomic theory at the time!

Atoms And Molecules

Also during this period a great deal of work was being done on chemicals, much of it by means of reactions with electricity from the newly available voltaic piles or batteries, and gradually the atomic and molecular nature of matter became understood. The work on heat, temperature and heat transfer, which had all been done and categorised before the atomic and molecular nature of matter was understood, now came to be explained in atomic and molecular terms, and additionally electrochemistry was giving clues as to the charged nature of the atomic particles of matter.

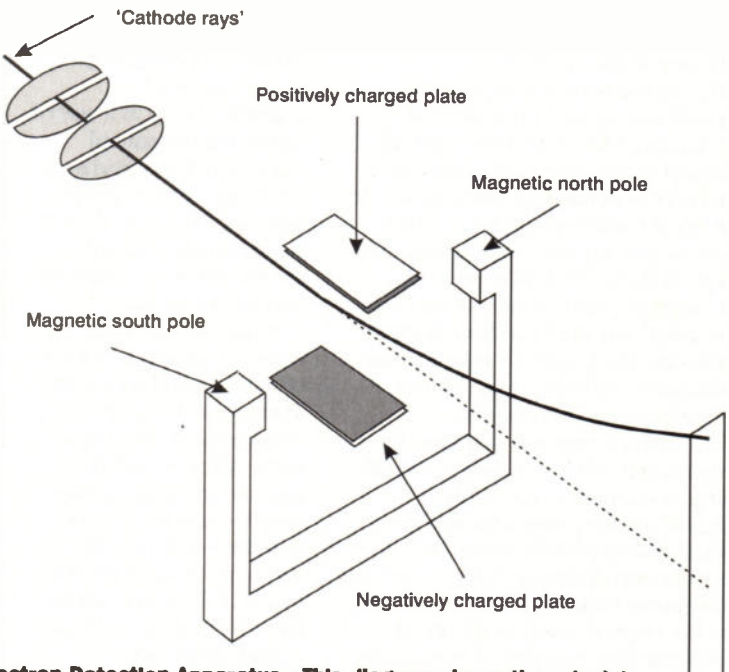
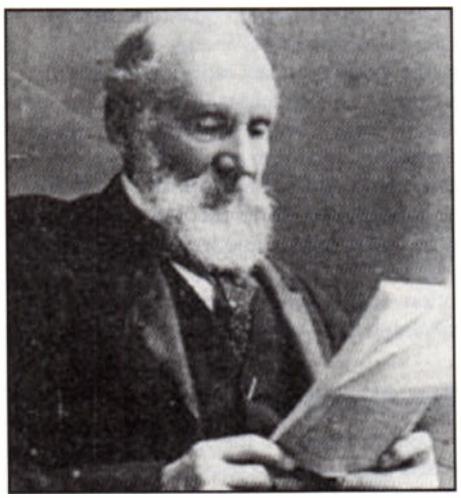


Figure 5. Electron Detection Apparatus - This diagram shows the principle behind the detection of the electron. J J Thomson discovered that cathode rays were deflected by both electric fields and magnetic fields; the deflection depended on both mass and charge, and this ratio was always constant. The first subatomic particle had been discovered!

Energy And Light

In another area of investigation James Prescott Joule established that heat is a form of energy, and also that mechanical, electrical and heat energy can not only be interchanged but that overall energy is conserved. Furthermore, it had been established that heat can be 'carried' by light; and so gradually all the theories about energy, electromagnetism, light, heat and atoms seemed to be coming together; one man in particular can be considered to have had a major influence on this convergence.

William Thomson



William Thomson, later Lord Kelvin, is considered to be a genius of the nineteenth century with the stature that Newton and Einstein had in their own particular times. His analysis of thermodynamics, electromagnetism and his initial theories on the electromagnetic nature of light which led to James Clerk Maxwell's fundamentally important electromagnetic theory of light were the foundations from which Planck 'invented' quantum theory. Thomson's view was that forces were caused by the movement of invisible matter as opposed to the prevailing one of light, heat, electricity and magnetism being imponderable fluids. Additionally, his study of all the different areas of physics brought about the view that the physical changes of all things were related to energy changes. These two tenets are the basis of quantum mechanics and relativity, and part of Thomson's belief that one day there would be a unified theory of energy and matter.

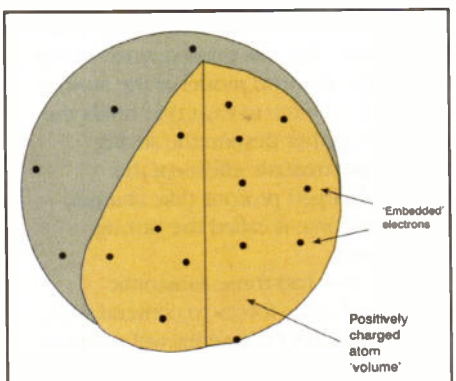


Figure 6. The 'Plum Pudding' Atom Model - The electrons are randomly embedded throughout a volume of positive charge, the negative charge of the electrons balancing the positive charge.

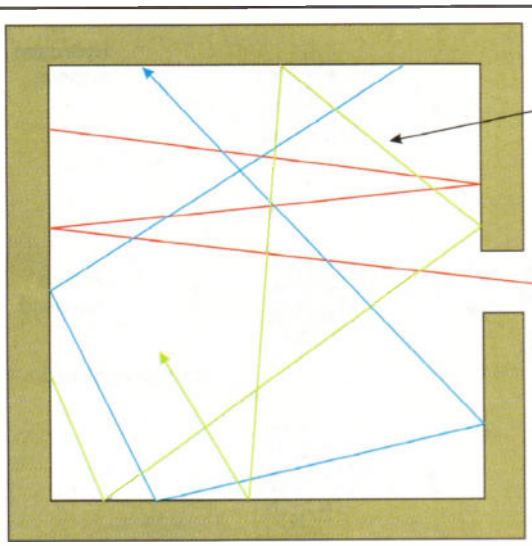


Figure 8. Blackbody Radiation - Some stars are the closest available approximation to a blackbody ie perfect radiator, one that emits radiation with a continuous frequency spectrum. For experimental purposes a cavity is used; this is heated so that radiation inside the cavity reaches equilibrium, and measurements are made through a small 'sampling hole'

Radioactivity And Electrons

During the 1890s two discoveries smashed for ever the concept of the atom as the smallest, indivisible particle of matter. The first was the discovery of radioactivity in 1896, and the second, in 1897, was the discovery of the electron (see Figure 5), along with 'positive rays,' positive ions produced inevitably at the same time as electrons, the smallest of which became called a proton.

Plum Puddings

With the discovery of radioactivity and electrons, the transmutation of one substance into another, and the existence of particles that could in turn break down other particles, it was realised that there must be material even more fundamental than the atom, and that the atom itself had structure. Around 1900 the first strongly accepted model for the structure of the atom was that of Sir Joseph John Thomson's 'plum pudding'. In this model an atom was believed to be a sphere of positively charged matter with electrons distributed uniformly within it. See Figure 6.

This model lasted until 1911 when the model proposed by Ernest Rutherford was accepted on the grounds of evidence gained from experiments in radioactivity, and in bombarding elements with alpha particles. The Rutherford model that replaced the 'plum pudding' consisted of a tiny (one ten thousandth of the diameter of the whole atom) positively charged nucleus surrounded by the electrons moving around in a volume of space or 'nothingness'. See Figure 7.

It was to be another twenty years before another subatomic particle could be added to this model; meanwhile work had been continuing on another major puzzle of the period, the blackbody radiation problem.

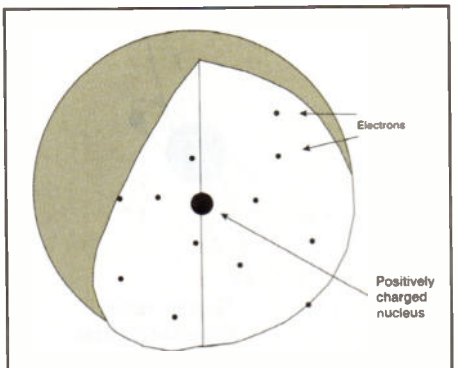


Figure 7. The Rutherford Atom Model - Rutherford established that the positive charge had to be concentrated in a highly dense but small nucleus at the centre of the atom, which he proposed was surrounded by orbiting electrons.

Blackbody Radiation

By 1879 it had been established that the total amount of radiation emitted by a blackbody (see Figure 8), one that can absorb and emit radiation at all frequencies, increased with temperature.

This seems obvious when thinking about heat radiation. But heat is just a small part, the infrared part, of the whole spectrum of frequencies of electromagnetic radiation, which includes radio waves, visible light, and cosmic gamma rays. The German physicist Max Wien did some work which took into account the frequency of the radiation, and found that within the range of frequencies of radiation emitted there was a frequency which gave out more radiation than the others, and that as the temperature increased the frequency at which this maximum occurred also increased. This also perhaps seems obvious when thinking about heat - as a metal is heated its colour

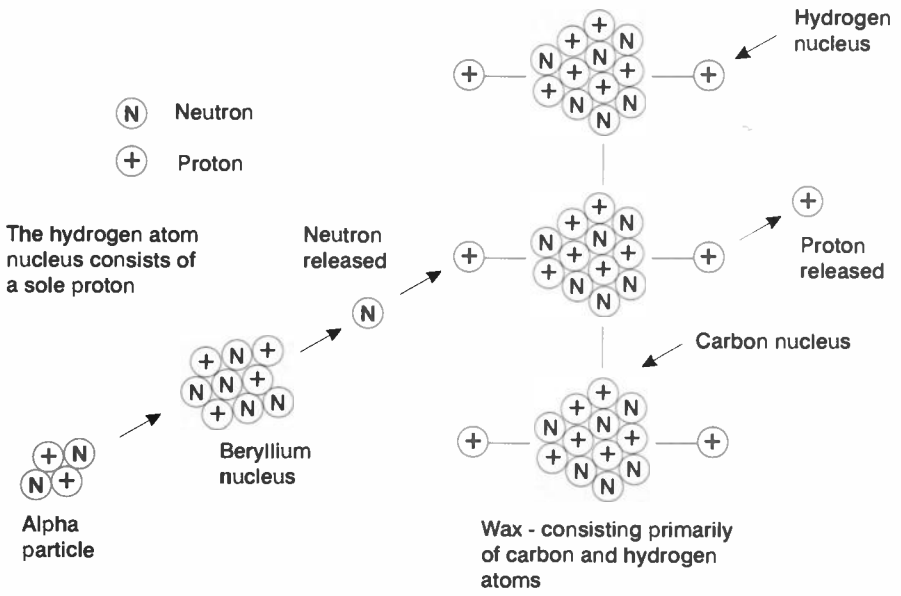


Figure 9. Discovery of neutrons - Neutrons were discovered by bombarding beryllium with alpha particles. Neutrons have no charge and so weren't detected directly, but by exposing wax to the released neutrons protons were released which, having charge, can be detected.

changes from red to orange to yellow, colour corresponding to frequency of radiation, yellow being a higher frequency than red. The atomic nature of material was by now accepted, as was the fact that heat was a form of energy, and that motion and energy were connected in that the vibrations of atoms are a consequence of the energy they possess. Combining these notions classical physics concluded that the radiation emitted by matter was a result of charged particles of matter, the atoms, oscillating at the frequency of the radiation they emitted, and that the intensity of the radiation increased as the frequency increased. But this meant that for a blackbody, the ultraviolet light frequencies outside the visible light spectrum at the high frequency end (just as infrared is outside the visible light spectrum at the low frequency end), should have a huge amount of energy, and the radiation at still higher frequencies should have virtually infinite energy, which is impossible.

Classical physics had run out of ideas - a new concept was needed.

Quantum Theory

Any oscillating system has its own natural or resonant frequency which depends on the properties of that system, for example, the resonant frequency of a guitar string or a pendulum depends on its length; the shorter the length the higher the frequency. Furthermore, an oscillating system won't vibrate at other than its resonant frequency unless it is an integer multiple i.e. two, three, four etc. times that frequency. In 1900 Planck suggested that the particles composing matter could only oscillate at these fixed frequencies, and could only change between these fixed frequencies by gaining or losing energy, the amount of energy depending on the frequencies involved. Using this idea the theory matched the experimental results perfectly - there was a limit to the radiation emitted instead of the infinite energy predicted by classical theory. The discrete changes in energy levels were called packets, or quanta, and the integer multiples were called quantum numbers. The Quantum Era had begun!

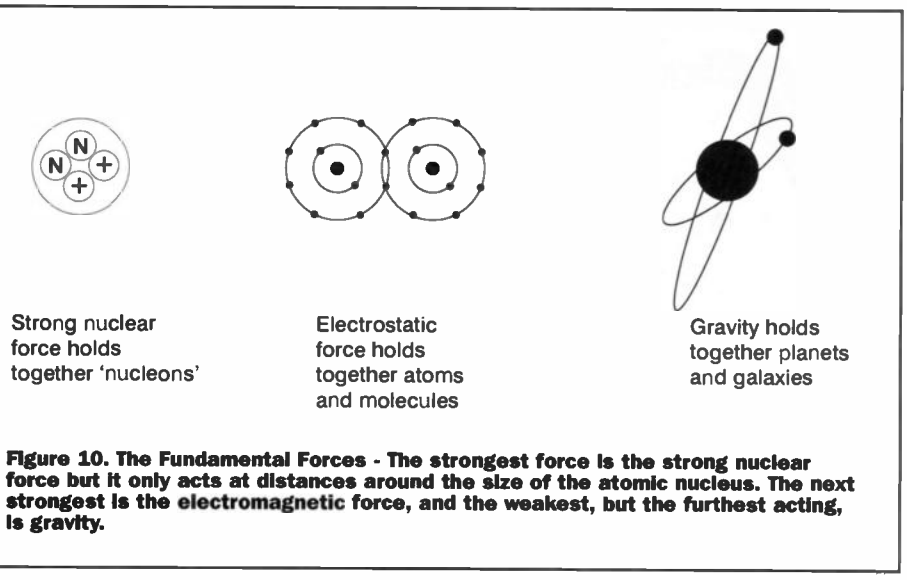


Figure 10. The Fundamental Forces - The strongest force is the strong nuclear force but it only acts at distances around the size of the atomic nucleus. The next strongest is the electromagnetic force, and the weakest, but the furthest acting, is gravity.

Einstein

Einstein's name is synonymous with relativity but he also had a significant involvement in the early days of quantum theory, and now, at the end of the twentieth century, quantum theory, relativity and (by definition!) the 'Theory Of Everything' are effectively inseparable. In fact, Einstein took the next step forward in quantum theory, stating that not only is energy emitted in quanta, but that in fact radiation itself is quantised, i.e. only exists in 'packets,' as well as having a frequency dependent on its energy. So a quantum of radiation is at the same time a packet of frequency, and this is the concept that allows the fundamental particle of electromagnetism, the photon, to behave both as a particle and a wave, a notion vital for understanding and explaining the Quantum World.

The Neutron

In 1932 the model of the atom had to be revised again with the discovery of a subatomic particle with the same mass as a proton but with no charge, a fact that had delayed its discovery as being chargeless, for it was unaffected by the electrical and magnetic fields which cause the deflections that enable the discovery of charged particles. Alpha bombardment of an element causes neutrons to be emitted; if these neutrons then bombard a second element protons are emitted which can be detected (see Figure 9).

The new atom model was that of electrons surrounding a nucleus composed of protons and neutrons, and this is the starting point for all further accepted explanations of the interactions and reactions of physics and chemistry.

Conclusion

Protons and neutrons are collectively called the nucleons, and one consequence of this nucleon and electron model of the atom is the need for a force to exist that holds the nucleons together despite the strong repulsive electrostatic effects of the positively charged protons (like charges repel). This force is called the 'strong nuclear force'.

Science now had three subatomic particles and three forces to contend with. The second part of this series will examine the early attempts to explain the interactions of these particles and forces, and the interactions of the multitude of other subatomic particles found after the neutron, attempts which led to the discovery of the fundamental particles and forces of the Quantum World.

Software HINTS & TIPS

by Mike Bedford

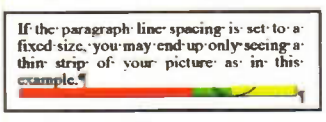
Microsoft Word might be described as a word processor but it's also pretty good with photographs and drawings.

Long gone are the days when a word processor simply automated the sort of thing you could do with a typewriter. All word processors now include facilities which were once the domain of DPT and, among other things, this means that they can handle line drawings and photographs. In this month's column we look at the picture handling features in Microsoft Word 97.

Inserting Pictures

If you've used your word processor for anything more than writing letters you've probably already inserted pictures into your documents. However, the chances are that you aren't familiar with all the options available. So, if we start off with something which is second nature to you, please stick with us - there's a good chance you will learn something new later on.

First of all let's look at how to insert a picture into your document, and by this I mean a picture you've created using a separate draw or paint package, downloaded from the Web or taken on a digital camera. Select Insert > Picture > From File, make sure the 'Link to File' and 'Float over Text' boxes are not checked, select the name of the file containing the picture you want to insert, and click on the Insert button. With a bit of luck your chosen picture will appear at the cursor position and you can resize it by clicking on it and dragging any of the eight resize handles. You may just find, however, that you end up with just a strip of your picture as shown below. If this happens, your paragraph line spacing is set to fixed size which is too small for your picture. To cure this, change to Single line spacing in Paragraph Formatting.



Often, you'll insert pictures into paragraphs which contain no text. You can then format the paragraph with Space Before and Space After to set it apart from the text in your document. However, it's also possible to include pictures truly in-line with your text. If it's a large picture this will upset your line spacing (so long as you don't have fixed spacing and, as we've seen, this causes its own problems) but it can be used to effect. For example, if you're writing a software manual, you may like to refer to keyboard keys by actually inserting a small picture of them in the text. The following screen shot shows in-line pictures used in this way.

Floating Pictures

Microsoft calls the type of pictures we've just looked at 'in-line' even if the picture is actually in a paragraph by itself, and as such, the picture will move around as text or other pictures are inserted or deleted before it. The alternative method is to insert it as a floating picture. To do this, do exactly the same as we described earlier but this time make sure that the 'Float Over Text' box is checked. Now the picture isn't fixed at any particular point in the text, it simply floats over the text and, depending on how you format that picture, the text on the page can either flow around it or overlap it.

Formatting Pictures

To change how text flows around or through pictures which float over the text, select the picture by clicking on it. You'll know when the picture has been selected since the resize handles will appear but, to differentiate it from an in-line picture, those resize handles will be white instead of black. Now select Format > Picture > Wrapping and try out the various options to get a feel for how they look and when you might choose to use each of them. If you find that all the wrapping options are greyed out, this is because the picture you've selected is in-line. Wrapping is only meaningful, of course, for pictures which float over the text.

The other picture formatting options available at Format > Pictures (but excluding Text Box which is concerned with something other than pictures) applies to all pictures - in-line or floating. Let's have a quick look at Size and Picture. In many respects the Size window just provides another means of scaling a picture and most people will find it easier to do it interactively using the resize handles. However, if you want a picture to appear at a specific exact size, the Size windows allows you to do this. This might be useful, for example, if you want to make sure that a number of pictures on the page are all the same size. This window also has a rotate facility but this only works with Microsoft Drawing Objects, not pictures imported from other applications. With line illustrations, but not with bitmaps, it may be possible to convert an imported picture to a Drawing Object - this is something we'll look at in a later column when we look at the drawing facilities in Word.

The Picture window allows you to crop a picture from any edge (although doing it this way is something of a trial and error exercise), and to adjust the brightness and contrast to make up for any deficiencies in the original image or to compensate for a particular printer's characteristics. However, there's a better way of adjusting pictures as we're about to see.

Picture Toolbar

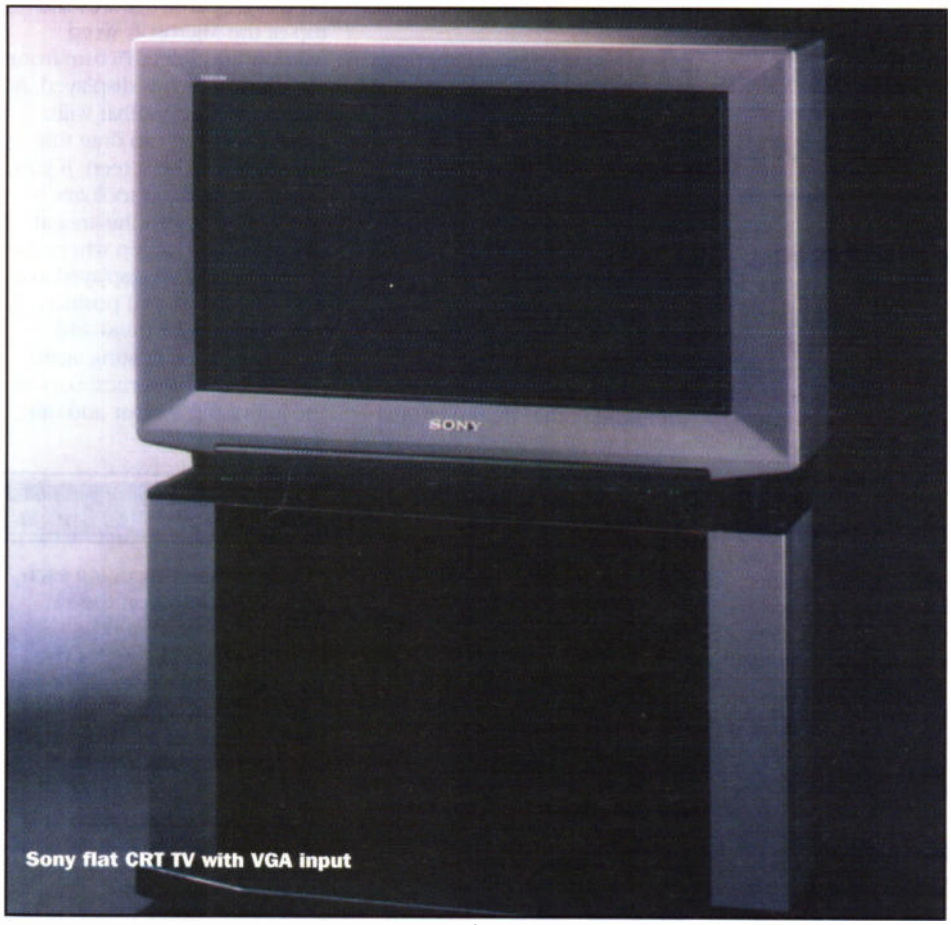
We've already seen that pictures can be scaled interactively or, if you want reproducibility, you can do the same thing from the Format > Picture > Size window. In the same way, if you don't have to be able to crop a picture to an exact size, or adjust the brightness, or contrast to an exact level you can do all this and more using the Picture toolbar.

If you're not familiar with toolbars and the Picture toolbar isn't already displayed (as it won't be by default) right click on the grey area towards the top of the Microsoft Word window and select Picture from the menu which is displayed. A floating Picture toolbar will appear and you can drag this anywhere on the screen. If you prefer to use fixed toolbars, simply drag it into the area at the top of the screen where the other toolbars are displayed and it will anchor at that position. If you change your mind and want to make it floating again, just click on the vertical bars at the left of the toolbar and drag it somewhere else.

Rather than describing each and every button on the Picture toolbar in mind-numbing detail I suggest you try them out for yourself. If you want to get an idea of what a button does before you press it just hold the mouse pointer over the button without clicking and a description will appear. If you find that most of the buttons on the Picture toolbar are greyed out this is because you don't have a picture selected. Under these circumstances, only the first button (Insert Picture) will do anything useful. Finally, a word on cropping since this isn't quite as obvious as the other functions. When you click on the crop button you might think nothing has happened. However, if you look carefully you'll find that the cursor has changed shape and now, by dragging a picture's resize handles you'll crop it instead of scaling it.

Multimedia SELECTION & STORAGE

Reg Miles discusses how we may all be watching digital TV - like-it-or-not!



Sony flat CRT TV with VGA input

If you think you are going to be able to take or leave digital TV as easily as you could analogue - think gain..They have ways of making you watch. At least, that is what they are planning. 'They', being the broadcasters and the equipment manufacturers. And the plan being to force feed you with digital TV.

Apparently, there will be more than 400 DTV channels in Europe (five times that number in the USA), with about 15,000 programmes per day. National numbers will be less; but still with cable, satellite and terrestrial, an unwieldy number; most of them transmitting 24 hours a day.

The plan is to provide users with the means of automatically selecting programmes that they might like, from all the programmes, day and night, and storing them for viewing at convenient times, first in the home, then eventually, via a connection to the home, from anywhere in the world. Likewise, programmes from anywhere in the world will at least theoretically, be directly accessible to the user at home. Also broadband TV signals will be complemented by narrowband Internet access.

STORit

The European Union's Storage Interoperability Technologies project, or STORit, is looking at all the above ideas. They are investigating the means of storage and the protocols for transmitting information simultaneously with broadcasts to fill Electronic Programme Guides (EPG), and automatically recording programmes based on user profiles. The end result being that a lot of programmes will be stored as more or less matching the user's profile, the closeness of the match will be indicated, and only a few of the programmes will actually be watched.

Whether even fewer commercials can be watched, or none at all, is not a part of the project. Although mention is made of directly targeting users with personalised commercials. So it will presumably be an advertiser's dream and a user's nightmare. A situation that will be further tipped in favour of the profit-makers by the addition of a return path, encouraging people to interactively buy the advertised products and informing the operator which commercials were watched - further refining the user's profile.

SMASH

The STORit project continues from where a previous project left off. This was called Storage for Multimedia Application Systems in the Home (SMASH); and ran from 1995 to 1998. Its brief was to devise means for mass storage and retrieval, that would also function as an interactive medium for multimedia - the SMASH Storage System or SMASH Combo Server. Three application areas were targeted:

- The storage and retrieval of Digital Video Broadcasts, mainly MPEG-2, received from cable and satellite (which were just beginning to change to digital at that time) - called DVB-VCR.
- Interactive remote education - at home or in a classroom, enabling the students to store most of their course material on tape and to access the Internet - called REA.
- The downloading and storage of Internet material, web pages and mainly MPEG-1 video - WEB-VCR.

At that time the solution to mass storage was a digital tape drive (DTD) giving 10-14 hours, while for interactivity a hard disk drive (HDD) was required. The trick was thus to get the two working together as if they were one in this hybrid system, and three areas were defined for investigation:

- File management, to handle the large amounts of data.
- File allocation strategies, to cope with the different storage systems.
- Search techniques, together with a database management system, to find everything again in a reasonable timespan.

These requirements were balanced by improving recording heads, and minimising access and transfer times between tape and disk. There was also the need to interface the SMASH storage unit with other elements that were likely to be in the user's home - audio, video and PC - for complete integration (Figure 1). The server did not have a user interface, but for TV it was accessed through the set top box (STB)

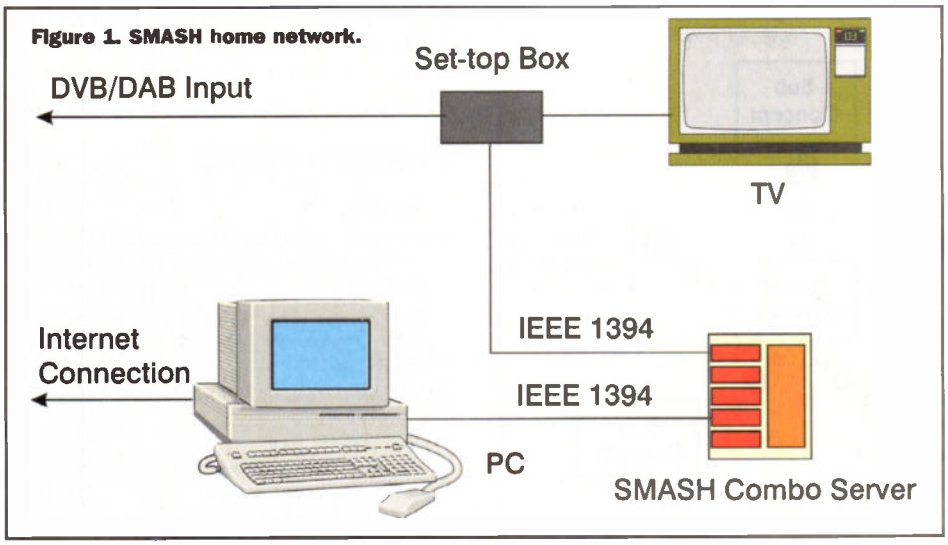


Figure 1. SMASH home network.

using MHEG and for the PC with an Internet/Java interface (MHEG: Multimedia and Hypermedia information coding Experts Group; and their system covering multimedia/hypermedia interactive applications - for more information see December issue, The MPEG Standards).The two components of the server were controlled by its Linux operating system. It requested access to data from the STB or a PC then went via an Application Programming Interface (API). The HDD provided pre-caching to improve tape response times; and converted variable bit-rate streams into constant bit-rate for tape recording; while the random access facilitated browsing and reduced delays in playing the material. It also enabled simultaneous recording and/or playback of multiple streams by acting as a buffer in conjunction with the tape. Thus the user might record a TV programme while viewing a previously recorded one or pause playback while the recording continued, then resume playback and watch the delayed programme or catch up to the live one by fast forwarding. Alternatively, a time-shifted programme could be viewed before the recording was finished.

The devices were linked with the IEEE 1394 serial bus (also known as Firewire and i-Link). However, because it only provided the basic layers for data transport, with no provision for streaming, an additional layer was developed and standardised. This is known as the Common Interface Packet and it adapts various data formats to IEEE 1394.

Philips TriMedia

In order to find particular places in large amounts of stored information, compressed video key frames were detected and extracted in real-time, using a Philips TriMedia video signal processor, and stored in a multimedia database. Then, displayed in sequences, the key frames provided the user with an insight into a programme's contents (Figure 2). Each sequence being a logical story unit (LSU) that could either be browsed through or animated.

Copy protection was also built in, using a 'watermarking' system in which signals were embedded into the pictures. Only one recording was permissable. When unmarked video was being recorded it was marked at the same time, and that prevented any subsequent recording by other storage units. The most promising technique was based on discarding parts of the 8 x 8 quantised DCT blocks in the compressed I-frames, where the top half if a '0' was embedded and the bottom half if it was a '1' - it being easy to detect the energy differences. To avoid any affect on the picture, the DCT blocks in the I-frame were psuedo-randomly shuffled, and the psuedo-random generator was the 'key' to decoding the 'watermark' (Figure 3).

All aspects of the DVB-VCR were under the control of a remote handset using on-screen displays, that provided an EPG as well as a table of contents (TOC) for the tape drive. It was augmented by screens giving a brief description of the program (from Teletext or web sites) and showed key frames. The WEB-VCR's interface had VCR like controls at the bottom of the monitor screen. Two types of interaction were possible: Internet, with connections to remote servers; and Combo, for accessing Internet material stored on the local server. The REA application used a graphical user interface (GUI) built using Java applets that presented lessons in the form of 'mind maps' - a display with the central concept surrounded by sub-concepts, together with a Windows tree structure (Figure 4).

But while the prototypes worked well so far as they went, the use of tape, even with the hard disk to speed up the process, limited access times. Also SMASH had not advanced the selection of recording TV programmes which continued to rely on the user, as with a VCR.

These factors were to be addressed in the STORit project. It focuses on the same application areas - DVB/Internet and Personalised Remote Learning. Again, Philips Research is the main participant, and their partners are: BBC R&D, Delft University of Technology, Olivetti Telemedia/Italia Online, Space Applications Services (Belgium), Tandberg Data (Norway) and University of Ljubljana (Slovenia).

The project initially made use of the hybrid storage server developed by SMASH but has subsequently replaced this with a hard disk system. They are also planning to incorporate removable media - DVD (including Recordable and ReWritable) and D-VHS - in the near future (the two year project has passed the halfway point). At a recent demonstration held at the International Broadcast Convention in Amsterdam under the title 'TV Anytime' a 50GB disk was used, which is capable of holding up to twenty hours of video with a couple of Gigabytes left over for caching data from EPGs, web pages, etc. The combination of hard disk and removable media provides a sufficient amount of video in the box to be getting on with, and an infinite amount - home recorded or pre-recorded - at hand or a walk to the video shop.

Linux was again chosen as the operating system for its superior multi-tasking, easy access to low level PC internals, and comparatively easy device driver development. The user interface and content management system were programmed in Java. The video handling modules, that control recording and playback, used C because of the real-time constraints that occur there.

Incidentally, although it was referred to as the STORit box, the demonstrator was in

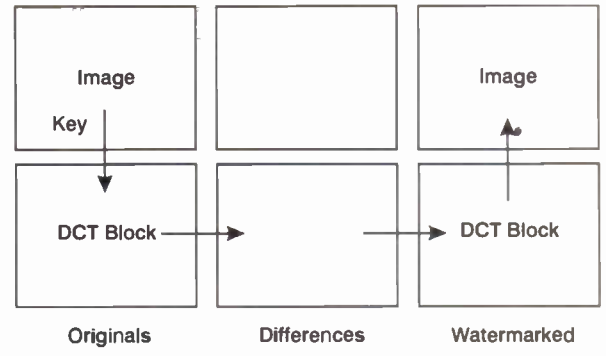


Figure 2. SMASH video browsing and navigation using key frames.

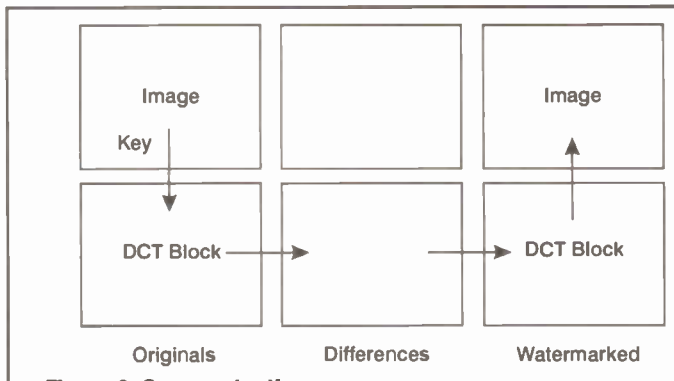


Figure 3. Copy protection.

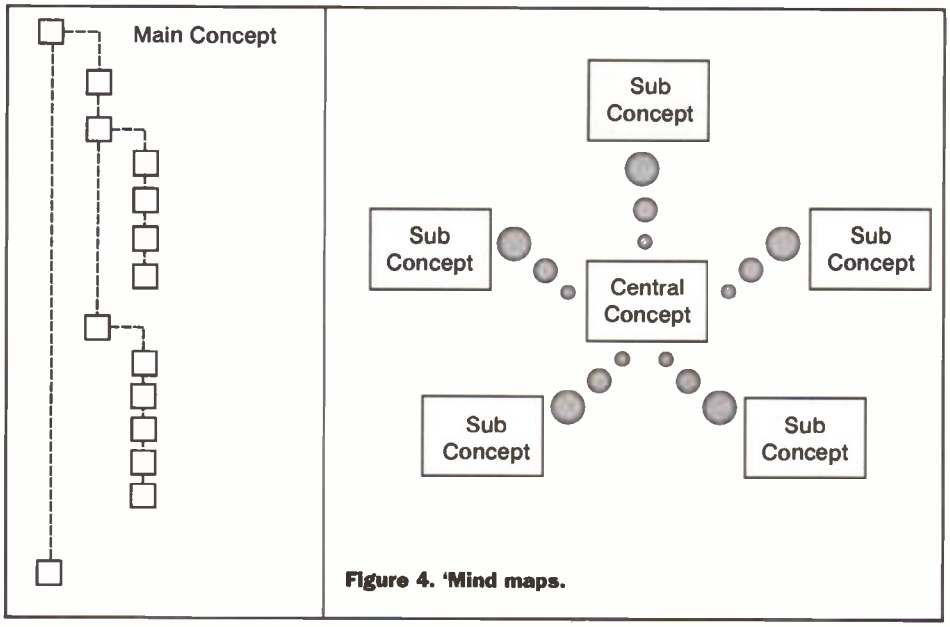


Figure 4. 'Mind maps.

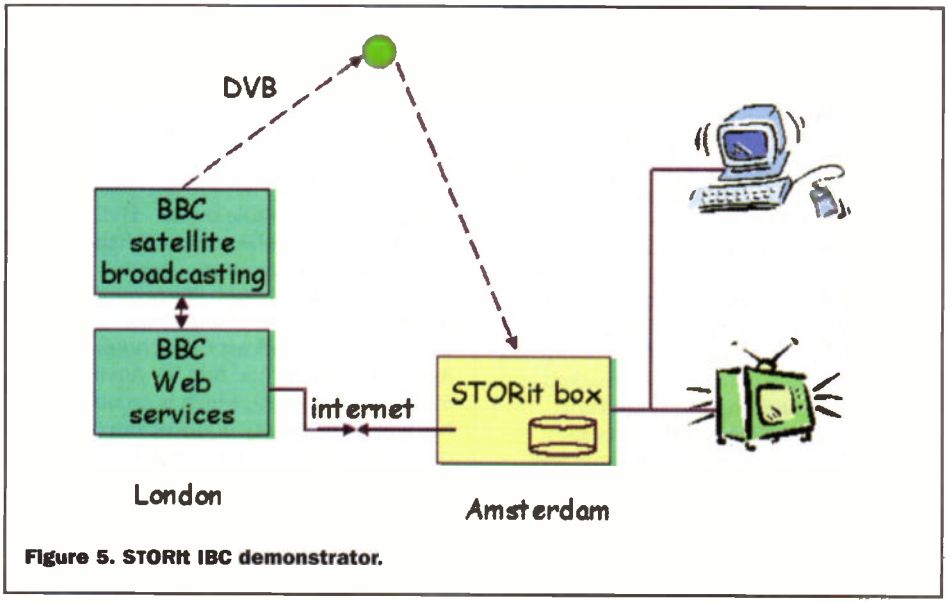


Figure 5. STORit IBC demonstrator.

fact a PC with external STBs for DVB reception and MPEG-2 playback (Figure 5). The feed is from the BBC, with additional data coming via the Internet. Part of that data was in the context of STORit, providing additional information on the programmes and web-based material for educational programmes. Also part of it was due to necessity, as there is no means as yet of incorporating the metadata and its related information into the satellite signal.

Metadata provides descriptive information about the content of programmes, such as synopsis, genre, etc. Future standardisation is being addressed by the MPEG-7 committee. They are attempting to standardise descriptions, or descriptors. They are: Description Schemes (DS), for the descriptors and their relationships and a Description Definition Language (DDL) to specify the DS. At the most recent MPEG meeting during October in Melbourne it was announced that experiments have been defined to test the utility of the descriptors and DS in 'real-world' applications. Additionally, work was begun on MPEG-7 Systems, with the emphasis being on streaming and compression of descriptors and DDL, and the transport over MPEG-2 and MPEG-4 Systems, as well as analogue media.

Four Data Tables

STORit relies on four data tables:

- Location Resolution, to reveal where and when a programme can be accessed.
- Group Resolution, which indicates whether a programme belongs to a particular group - such as a serial.
- The aforementioned Metadata.
- Segmentation Information, to show the beginnings and ends of individual items such as reports in a news programme.

All rely on an Extensible Markup Language (XML) at present because it is easily readable, and so simplifies alterations (Figure 6 shows an example of a metadata table regarding 'Eastenders,' including links to the series' web site and a related TV programme). However, when the project is commercialised a leaner coding scheme is likely to be adopted. A Unique Programme Identifier (UPI) is also required to refer to the content of a programme regardless of its channel or broadcasting time; enabling it to be selected on user preference alone, using a code number that is unique to a broadcaster. Finally, a Uniform Resource Locator (URL) to indicate from which DVB location it can be downloaded.

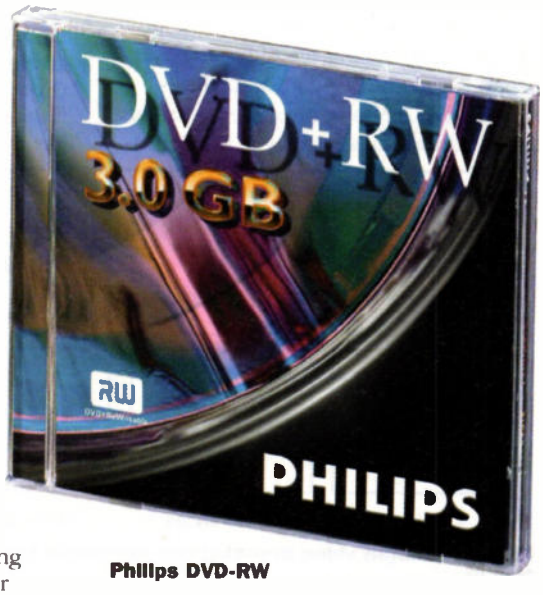
```
<META_DATA_TABLE>

<PROGMD
ID="upi:bbc:BlENeastenders"
TITLE="Series: EastEnders">
<SYNOPSIS>
"All episodes of this London
soap shown on BBC Television."
</SYNOPSIS>
<GENRE> "Entertainment:Soaps"
</GENRE>
<PERSONNEL>
<PERSON ROLE="Bianca Butcher"
NAME="Patsy Palmer"/>
<PERSON ROLE="Dan Sullivan"
NAME="Craig Fairbrass"/>
</PERSONNEL>
<MM_LINK TYPE=WEB TITLE="The
Eastenders WWW site"
URL="http://www.bbc.co.uk/
eastenders/"/>
<MM_LINK TYPE=WEB
TITLE="Eastenders revealed -
behind the scenes."
URL="http://www.bbc.co.uk/choic
e/eastenders/"/>
<PROG_LINK TITLE="EastEnders
Revealed"
ID="upi:bbc:CHENeastenders"/>
<KEYWORDS>"EastEnders" "London"
</KEYWORDS>
</PROGMD>

</META_DATA_TABLE>
```

Figure 6. Metadata table

Of course, the user will not see any of the coding. The manual selection of programmes for immediate viewing and/or storage will be by selection from the EPG - using text and, possibly, key frames, or from a trailer, or a web site that carries programme information (Figure 7) by a click on the programmes UPI link. But, unless the programmes are already familiar, it will take time to make use of the descriptors and trailers of the increasing number of programmes entering the home. It might eventually take more time to choose programmes than the time to view them.



Philips DVD-RW

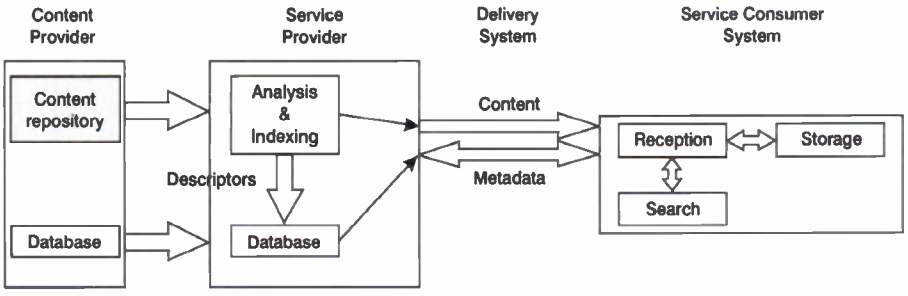


Figure 8. Analysing and processing programme material

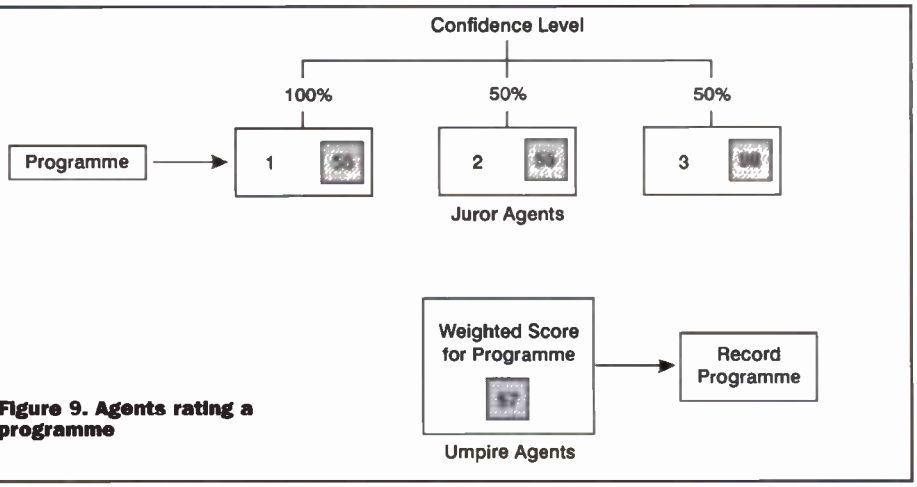


Figure 9. Agents rating a programme

'Agents'

Hence the concept of 'agents' - intelligent software that will use the metadata to do the choosing based on user interest profiles. Thus, before being transmitted the programme material must be analysed and processed to generate the necessary metadata (Figure 8). Procedures are also being defined for metadata to be generated during the production process - such additional data will include production attributes, a representation of the script and cues for linking the contents.

At the user end the metadata is collected by a gathering agent as it searches for likely programmes, which it can do 24 hours a day. This information is then filtered by other agents, or subsets, or jurors, whose algorithm each matches a particular aspects of the users' profile - sports profile, movie profile, etc. Each then rates the programme. The ratings are then averaged, but weighted by an umpire agent in favour of those agents whose selections have been more acceptable to the user in the past - the filtering agents are themselves filtered (Figure 9). The user's preferences are communicated to the system without the user being aware of it, and the algorithms are modified accordingly to make the filtering agents more responsive. If that hurdle is passed then the programme will be presented to the user for viewing or recording, or indeed recorded and presented later.

There will be a number of default filtering agents to start things off, which will cover most things: movies, entertainment, sports, news and documentaries, music and specialist, children. The user will be able to alter, remove and add agents. With each having a range of factors that can be altered: genres and sub-genres, languages and subtitle languages, countries of origin, programme names, channel names, keywords, days of the week, timespan - starting and finishing times.

To begin with the STORit box has of course no knowledge of the user's preferences. As TV and questionnaires don't mix, the solution has been to create 3D Lifestyle icons, or L-icons (like-ons), that appear at the beginning and state their name and personal interests - in programme terms, and the user chooses the one closest to their preferences as a representative. Included are 13 different L-icons, each representing a particular lifestyle, and each with six different animations. These are: introduction, being excited, having fun, being serious, being neutral or having no opinion, not being interested or disliking. These expressions both indicate the type of programme - e.g. fun = comedy, and the match with the profile - e.g., fun = good match. Figure 10 shows a L-icon expressing an opinion on a natural history programme (bottom right corner). The user can accept the L-icons opinions on broadcast and recorded programmes or ignore them - at all times there will be user overrule.

Personal Learning Assistant

The Personal Learning Assistant (PLA) - learning AnyTime and AnyWhere - just extends the DVB/Internet application, with the addition of a PC functioning as an intelligent digital VCR for acquiring and recording material. This is supplied by DVB and Internet, plus tapes, discs and, even, books, with support material supplied by DVB and Internet (Figure 11). The technology is also applicable to the wider STORit functions of entertainment.

A number of organisations and companies have formed the TV Anytime Forum to further develop the concept of local storage in the interests of increasing the market for the organisations and companies.

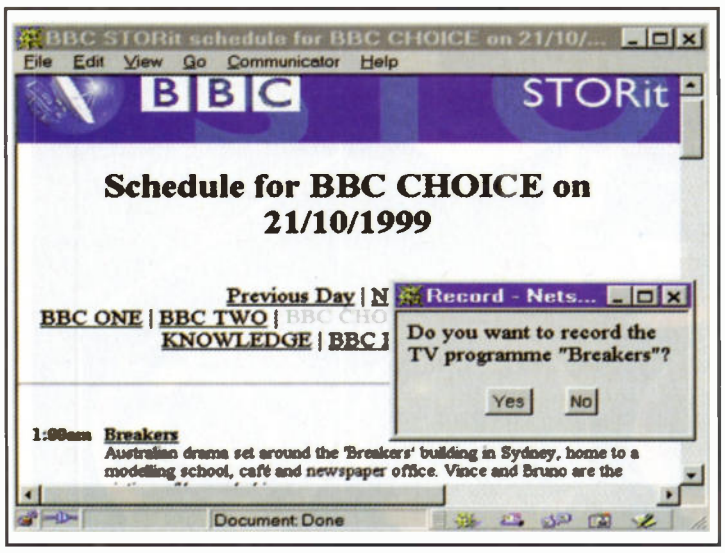


Figure 7. Programme selection from a web site

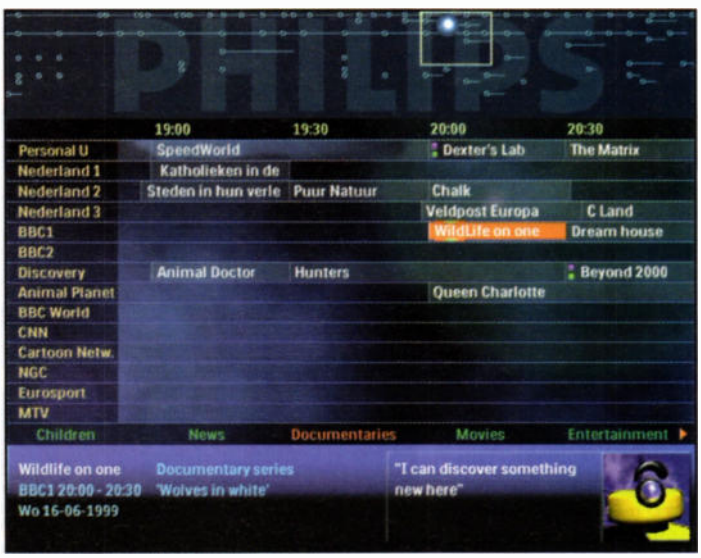


Figure 10. EPG with L-icon

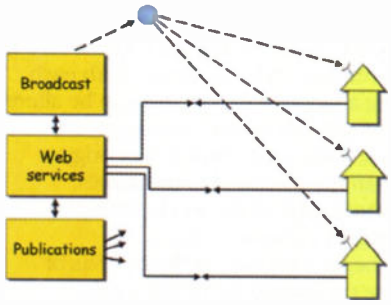


Figure 11. Learning material for the Personal Learning Assistant

TiVO

The STORit box is sometime away, but already there are services that offer similar, if more limited, personal selection, timeshifting of live broadcasts and storage features. One of those services is TiVo, the Silicon Valley based creator of Personal Television. Two receivers are available: a 14 hour (13.6 GB) unit for $499 and a 30 hour (27.2 GB) version for $999. They use MPEG-2 with four user adjustable compression ratios. Replay TV is a similar system.

Sony Corporation of America has formed an alliance with TiVo to manufacture personal video recorders and to provide original content and services. While Philips has launched TiVo based products in the US market; and has now joined forces with TiVo and the German company BetaResearch to bring Personal TV to Europe, adding it to the BetaResearch d-box at present used by all the German digital pay-TV providers.

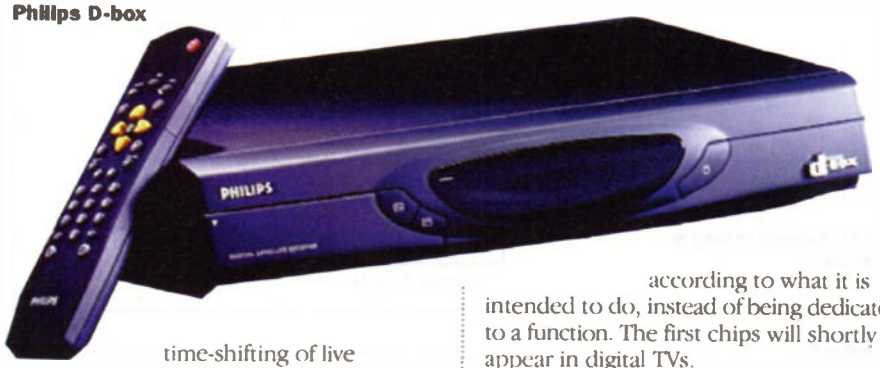
Mass Storage Development

Component manufacturers, such as C-Cube, iCompression, Quantum and Seagate, are busily developing low cost encoding and mass storage products for the forthcoming market. While, on the software side, Microsoft has announced the TV Platform Adaption Kit (TVPAK). The client software, Microsoft TV, will operate integrated TVs, STBs and Internet terminals, using an adaptation of Windows CE. While the server software, Microsoft TV Server, will allow enhanced TV services to be provided, using Windows 2000 server, the Microsoft BackOffice family and WebTV technologies.

Another related product is MGI Pure Diva from MGI Software. This will transform a Pentium III PC into a digital home entertainment system, with a digital recorder, time-shifting of live broadcasts, and software DVD and CD player.

Panasonic DVD player

Philips D-box



As the pace of change increases, Philips Semiconductors has announced the Nexperia Digital Video Platform; a computer on a chip that automatically uses the appropriate (and upgradable) software according to what it is intended to do, instead of being dedicated to a function. The first chips will shortly appear in digital TVs.

Finally, going back to what 'They' are planning. From what I could gather while writing this the intention is to connect up everything in your home, and to follow you with various devices whenever you go away - Figure 12 shows that you will never be able to escape again!

Figure 12. Everything connected - home and away.

COMMENT

by Keith Brindley

In an interesting move recently, Sony has announced a joint venture with Palm Computing. Now, Palm, as most readers will be aware, is the manufacturer of this popular personal digital assistant, the PalmPilot range of PDAs. Effectively, Sony now has the rights to use the operating system used by Palm PDA devices for use within its own line of handheld electronic products. In return, Palm Computing is now licensed to be able to use Sony's Memory Stick technology in future Palm handheld devices. The repercussions of this venture will affect most parts of the entertainment and information media, and go on through into computing fields too.

We'll start with computing and work backwards to see what these repercussions will be. As Palm PDAs account for more than half of the world's PDA market, they are already more popular than PDAs built around other operating systems. In truth, there's only really one other operating system to compare the PalmOS with - Windows CE, Microsoft's cut-down derivative of its Windows desktop computer operating system. I say this at the risk of annoying many readers with handheld devices based on other operating systems, but I sincerely believe that time will prove me right. I'm not saying that any one handheld operating system is any better than another, I'm just summing up what I feel will happen over the next year or so.

Actually, there's little to compare between PalmOS and Windows CE. Windows CE is only a handheld version of a desktop computer's Windows - designed down from an existing product rather than designed up from specific usage requirements. As such it's clunky, memory-hungry, and rather awkward to use in the hand. PalmOS, on the other hand (yes, OK, pun intended), was designed as a handheld operating system from its outset. It is relatively easy to use, and requires less overheads in the way of memory and hardware. The two handheld software operating systems are in fact vastly different in operational and user interface terms, and their resultant handheld hardware products are easily defined by these attributes. People using Windows desktop computers and wanting a handheld computing device might look to a Windows CE handheld device because it offers a similar (well, a little similar at least) interface to their desktop computer. However, people looking at a PDA as an organiser tool which has a largely different function to a computer might look at a Palm device first. Horses for courses.

Despite all this, Sony's opting for the PalmOS rather than a similar licensing deal with Microsoft to use Windows CE must be a bitter pill for Microsoft to swallow. In effect, when a large company like Sony makes a move into any electronics field, you can be guaranteed that it has done so only after detailed and careful consideration. To put it bluntly, I think it's a safe bet that Sony already knows what the future of PDAs will be. By buying into one particular operating system, it has merely accelerated the trend. Within a few years it's doubtful whether anyone but a few techies will use Windows CE at all. PalmOS will rule. After all, if you want a portable computer in the future, you'll use a, well, portable computer (they are so small in laptop formats these days, that it's no longer necessary to lug around half an office to be portable, anyway). However, if you want a PDA that's small enough to fit, and light enough not to rip (have you tried pocketing a Windows CE device?) your pocket, then you will opt for a PalmOS device. Sony is merely trying to make sure you'll buy a Sony-manufactured PDA, that's all.

But how does Sony's and Palm Computing's joint venture affect the entertainment and information media fields? Well, it's all to do with the fact that Palm Computing will now use Sony's Memory Stick technology in new Palm devices. The Memory Stick is Sony's attempt to define a standard in the portable memory card arena. Portable memory cards are used in many modern electronic gizmos these days such as digital cameras and portable MP3 players. There's only a small number of formats, which include SmartMedia, CompactFlash and now Memory Stick, to choose from. However, as you might expect they are incompatible. This can't last though as having incompatible portable memory formats is as daft a situation as having incompatible floppy disk formats in the computing arena years ago. As hard as it is for other companies to accept, there really has to be only one format - accepted as standard by all portable device manufacturers - if everyone is to succeed, and the general public is to be happy at buying the portable devices which use portable memory. After all, nobody wants to buy into a format that will disappear in a year or so, do they? Sony's venture with Palm Computing is nothing more than a carefully thought out business move to ensure that its Memory Stick becomes more popular than the other portable memory formats. Given Sony's history, this probably will work, but it'll take a while. For a start, it is probably going to be a year before any PalmOS handheld devices will have been developed (by either Sony or Palm Computing) which use a Memory Stick - next Christmas is more than likely the ideal time to launch such new products. Second, the other portable memory formats have a head start on the Memory Stick in terms of availability and price (not to mention numbers of current users). Nevertheless, it's probably safe to say that you can put money on Sony joining up with several other manufacturers with ventures similar to this one over the coming year or so, in an attempt to further bolster its Memory Stick.

Of course, there's a lot of ifs and buts here. Sony also has licensing deals with Microsoft to use Windows in its range of Vaio computers. As such, Sony won't wish to antagonise Microsoft in any undue way. Some of Sony's own digital cameras still use floppy disks for portable memory, so a move to a new format may alienate current users. But things move on in the ever-changing world of electronics. And Sony, after all, is one of the biggest movers there is.

Valves in the 21ST CENTURY

PART 2

In part 2, Mike Bedford gets down to valve numbering and operating modes.

Valves might be a blast from the past but, as we'll see throughout this series, they have yet to be totally superseded by semiconductor devices. For some applications there is still no viable alternative to the valve and even in areas where semiconductors are now the component of choice for most people, valves continue to have the support of a vociferous minority. Last month we started our tour of the world of valves by investigating how valves work and how they're constructed. We also looked at the different types of valves and saw, at a rather basic level, how they're used in real-world circuits. Our investigations will now become rather more practical by describing the numbering scheme used for valves and giving some guidance on where to buy valves. We'll then look in rather more detail at the principles of valve amplifiers before turning our attention to some real world applications later in the series.

Valve Numbering

Let's forget about valves for the moment and think about semiconductor devices. Have you ever made sense of all those numbers? Perhaps you might happen to know that a 2N3819 is an FET and that a BC184L is a general purpose NPN bipolar transistor but if you didn't already know, how would you determine that information from the part number? The rather amazing truth is that you wouldn't be able to, at least not fully. Semiconductor numbering is nowhere nearly as logical as you might hope or think. Part of the problem is that there are three main numbering schemes in use, the American standard (e.g. 2N3819, 2N2221A), the European Standard (e.g. BC184L, BFY51), and the Japanese Standard (e.g. 2SA1187) plus proprietary numbering schemes (e.g. ZTX301, MJE3055) and there are also the archaic numbers some readers may still remember (e.g. OC71). Not only this but within each of the major numbering schemes the information hidden in those codes can be minimal. In the American system, for example, you can figure out whether the device is a diode (1Nxxxx) or a transistor or FET (2Nxxxx) but the figures which follows the N provide no useful information whatsoever, they simply form a serial number. And in the European system, although the initial letters tell you whether you're dealing with an RF Diode RF, AF small signal transistor, AF power transistor, tunnel diode or whatever, and whether it's made of silicon, germanium or GaAs, beyond this the number doesn't tell you much - you don't even get to learn whether it's a PNP or an NPN device. Only the Japanese numbering system provides a reasonably good description of the device. And the situation with integrated circuits is even worse -about the only information you can get from the number is the family of which the device is a part.

Interestingly, as we return to valves, we find a somewhat more logical numbering system. As with semiconductors, valves never enjoyed a single unified scheme world-wide, but at least one of the systems which was commonly used does reveal a significant amount of information about the valve. The system in question was devised by Philips and Mullard and was adopted for general civilian use in Europe. It is summarised in Figure 19. Last month I suggested that 6.3V was the most common heater voltage but it certainly wasn't the only one. The first letter, therefore, specifies the heater voltage or current. The second letter specifies the number of electrodes, that is the basic type of valve and, in the

1st letter Heater		2nd letter(s) Electrodes		1st figure Base	Final figure(s) Serial No. #
A 4V	K 2V	A Diode (not rectifier)	K Octode or heptode (octode type)	1 Miscellaneous	Can be several figures to represent type e.g. ECC83, PL509
B 0.18A series	L 0.45A series	B Double diode		2 Miniature 10-pin	
C 0.2A series	P 0.3A series	C Signal triode	M Tuning indicator	3 International octal	
D 1.4V series/parallel	U 0.1A series	D Power triode	Q Nonode	4 Miniature 8-pin (B8A)	
E 6.3V series/parallel	V 0.05A series	E Signal tetrode	Y Half-wave rectifier	5 Magnoval (B9D)	
F 12.6V	X 0.6A series	F Signal pentode	Z Full-wave rectifier	8 Noval (B9A)	
G 5V parallel	Y 0.45A series	L Power tetrode or pentode		9 Miniature (B7G)	
H 0.15A series		H Hexode or heptode (hexode type)			

Figure 19.

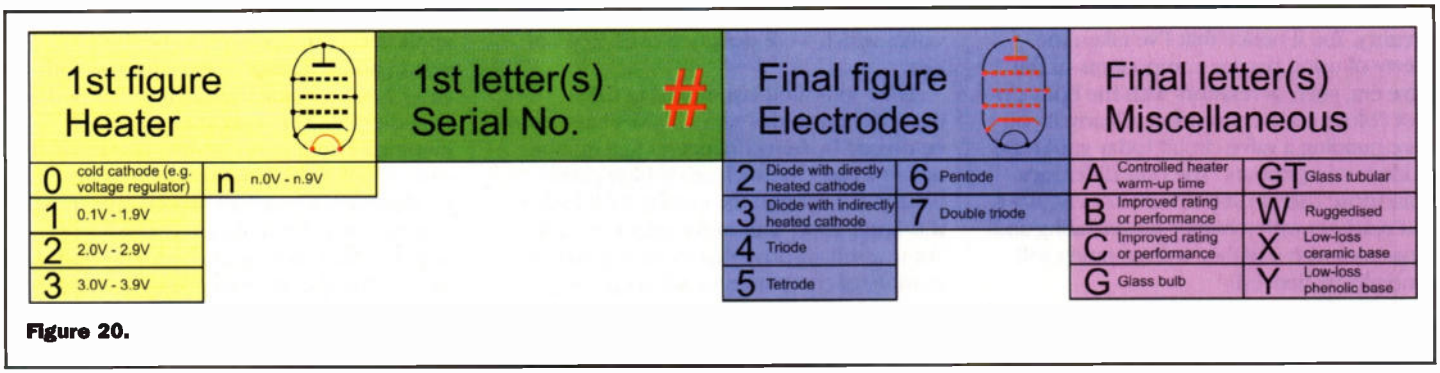


Figure 20.

case of double valves (except for the double diode which is already accounted for) there will be two letters. The first figure specifies the type of base. This is something we haven't looked at yet but, if we were to put this in the language of integrated circuits, this is the pin-out (e.g. 14-pin DIL, 16-pin SOIC, 168-pin PGA etc.). And the second and subsequent figures form a serial number to differentiate devices which have the same basic description. A couple of examples should serve to clarify all this - an EF42 is a 6.3V heater signal pentode with a miniature 8-pin base and an ECH81 is a 6.3V heater signal triode-hexode with a Noval base. Note also that some valve numbers are of this basic form but don't quite fit. A classic example is the E88CC. This is, in fact, a 'special quality' version of the ECC88 (double triode, 6.3V heater, Noval base) and in general, SQ variants are denoted by swapping the letters and numbers around in this way. SQ valves are electronically equivalent to their general-purpose counterpart but are manufactured to a higher mechanical specification. This gives rise to a more robust product and also reduces microphonics - modulation of the anode current by mechanical vibrations.

In passing, some of the early semiconductor devices actually adhered to an extension of this numbering scheme. Remember the OC71 transistor I referred to earlier? Well, according to the Philips/Mullard numbering scheme this is a triode (well, sort of) with no heater (ever seen a transistor with a heater?) and a base of a type which isn't defined for valves. Similarly, the OA91, which is still with us, is a semiconductor signal diode although it appears that some poetic licence was taken with the base type.

The second common numbering scheme, the American one, is summarised in Figure 20. The first letter gives the heater voltage in a rather more logical manner than with the Philips/Mullard numbering scheme. The first one or two letters is used as a serial number to differentiate devices which have the same basic description. The second figure is the total electrode count including the heater. Note that this gives rise to some ambiguity. Figure 20 gives one possible interpretation of the figure 6 - a pentode with an indirectly heated cathode - but it could also mean a double triode with a common indirectly heated cathode. Similarly, figure 7 could mean - among other things - a double triode with independent cathodes and a single heater. The final letter(s) which are optional, refer to various options as detailed in the diagram. We'll conclude with a couple of examples - a 12AT7 is a double diode with independent cathodes and a single 12.6V heater, and a 6L6 is a pentode with a 6.3V heater.Although these were the two most common valve numbering schemes they were by no means the only ones. Ones you'll come across which don't fit into either numbering scheme will probably be transmitter output valves and valves designed for early colour TVs which have also been pressed into service as transmitter output valves, especially in the amateur radio market. Some of these are still used today in hi fi amplifiers - a subject we'll look at later in the series. Examples are the 807 and 813 transmitter valves (both beam tetrodes) which have a long heritage, were used extensively by radio amateurs in home-build gear for many years and, surprisingly, are still produced in Russia and China. Another one which was common for many years was the 6146 transmitter valve (also a power tetrode) which was used in many of the commercial amateur radio transmitters of the 70s. Of course, there are also lots of very specialised valves which couldn't fit into any numbering scheme designed around general purpose valves but, once again, we'll leave a discussion of these until later in the series.

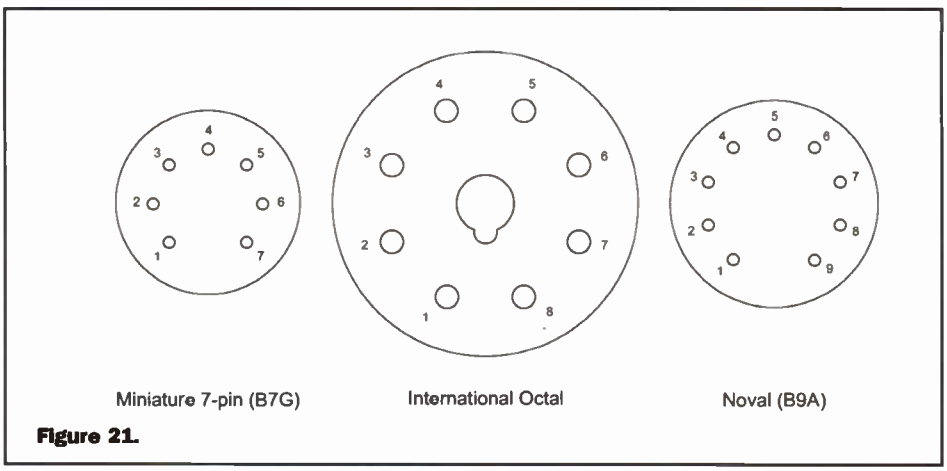


Figure 21.

Bases

Like integrated circuits, valves can have a significant number of terminals. There can be anywhere from a couple on a heater-less voltage regulator tube to eight on common valves like the ECH81 triode-hexode, and even more if we include more esoteric valves such as the ECLL800 triode-double-pentode. With the possible exception of the anode connection(s) which, on some valves, are pin(s) or cap(s) on the top of the valve, the connections are made to pins on the base of the valve. And, as we made reference to when we described the Philips/Mullard numbering scheme, there are a number of different standards for the layout of the pins on the base. These conventions are, in the main, designed with some sort of keying. This ensures that there's no possibility of the valve being plugged into its socket incorrectly. And yes, valves are nearly always socketed. Unlike ICs which may, as an alternative, be soldered directly onto the PCB, this is almost never the case with valves. There are two reasons for this. Firstly valves have a short lifetime, perhaps just a few thousand hours, and the lifetime for high power valves like those used in radio transmitters can be much shorter. So valves could need changing on a regular basis. Secondly, valves pre-dated the adoption of PCBs so the sockets were integral to the method of achieving a mechanically stable design. Sockets were bolted into holes in a metal chassis and the passive components such as resistors and capacitors were soldered onto the rear of the sockets as well as onto additional tag strips. Figure 21 shows the commonest base conventions and Figure 22 illustrates the

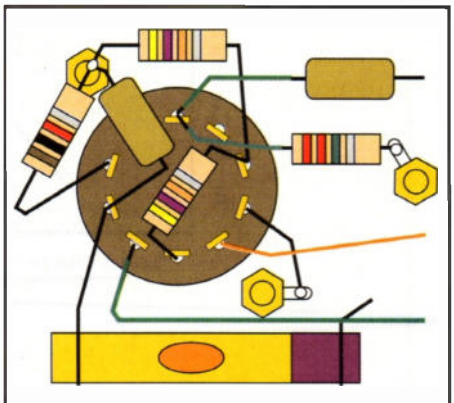


Figure 22.

classic constructional method used for valve circuitry. You'll notice that I've taken the liberty of using passive components of the valve era, such as resistors with the body-tip-spot colour code convention. Clearly, if you were building a valve circuit today you'd use modern components - the only difference from those used in semiconductor circuits is that resistors with a higher power rating and capacitors with a higher voltage rating will generally be needed.

Buying Valves

You might expect that buying valves would be a major problem. However, although it's true to say that they're very much rarer than semiconductors, it's really not as difficult as you might think. This applies not only to the more recent valves but even to those valves which were designed over 50 years ago.

As we indicated last month in the introduction to this series, valves have yet to be ousted by semiconductors in a number of key areas. One such are is high power broadcast transmitters, indeed we'll look at this application later in the series. So it'll come as no surprise that there are quite a number of companies world-wide who produce valves for this and certain other specialist applications. But although you might be interested to know that there are companies in France, Germany, USA and UK producing huge transmitter valves with power outputs measured in hundreds of kilowatts and costing an arm and a leg, this is not the type of valve you're likely to want to buy. If you do need valves your application is more likely to be the restoration of vintage radios, for use with older amateur radio transceivers, or perhaps in audiophile hi fi – another area we'll investigate later in the series. This being the case, you'll be looking for much more modest valves. The bad news is that most companies in North America and Europe have ceased production of general purpose valves. The slightly better news is that there are still companies in China, Russia, and some of the other ex-Soviet republics still producing a wide range of valves. However, these companies tend to have a reputation for poor quality. In some cases this reputation is justified, but undoubtedly some of these companies produce good quality valves. Nevertheless, some people spurn these newly manufactured valves in favour of so-called 'new old stock.' This apparently contradictory term means valves which were manufactured in the heyday of valves - perhaps fifty years or more ago - but which are supplied, unused, in their original boxes. The amazing fact is that there are still warehouses full of these new old valves. The downside of designing anything to make use of these valves, however, is that the supply of spares will inevitably dry up one day so you'd be designing in guaranteed obsolescence.

So valves are still being manufactured and valves manufactured years ago are still available brand new. But where can these valves be obtained? Well, for a start, you might be surprised to learn that Maplin carries a small range of valves intended for audio applications. For a larger range of valves, though, you'll need to turn to a specialist supplier. One company which advertises regularly in the amateur radio press and stocks 2,500 different types of radio, audio, military and vintage valves is Wilson Valves (01484 654650, wilsonvalves@surflink.co.uk). Another supplier I've seen highly recommended for their vast range of valves is Billington Export (01403 784961) although I understand there's a £50 minimum order.

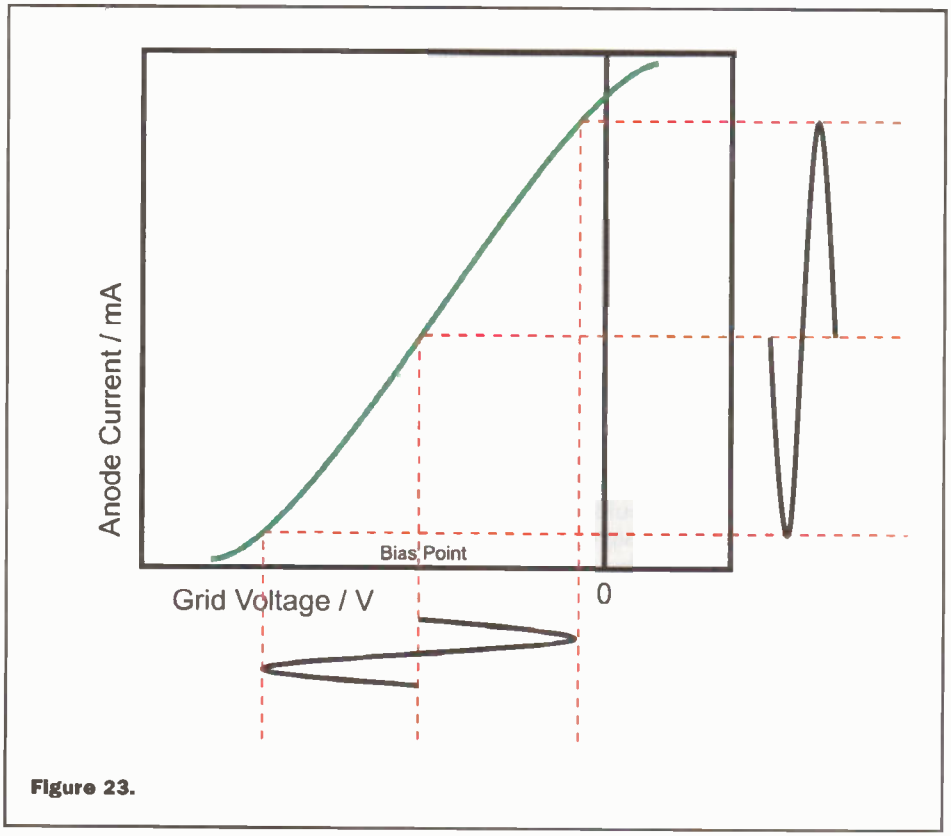


Figure 23.

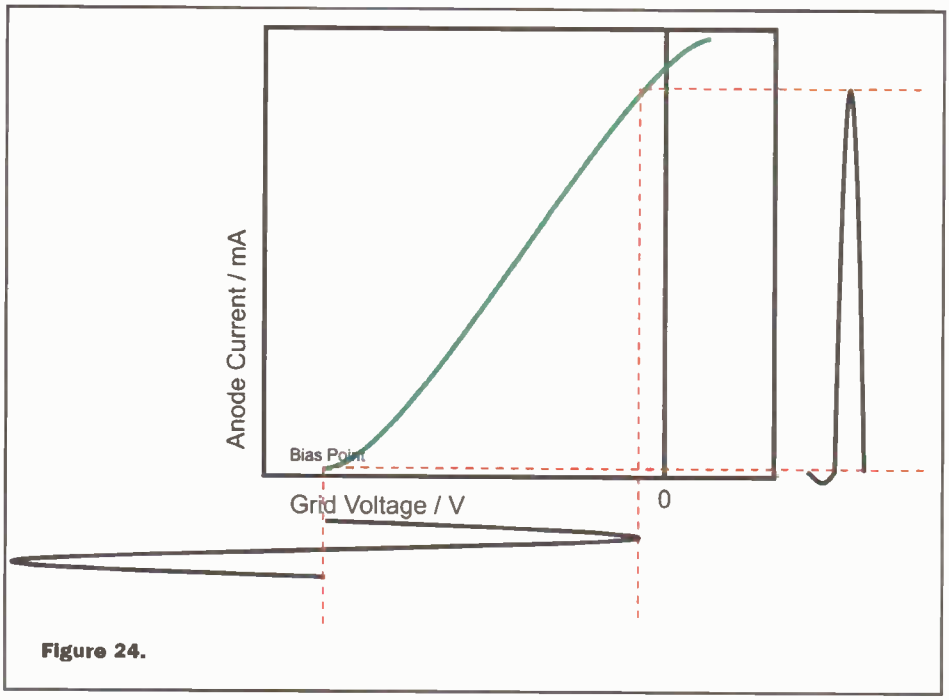


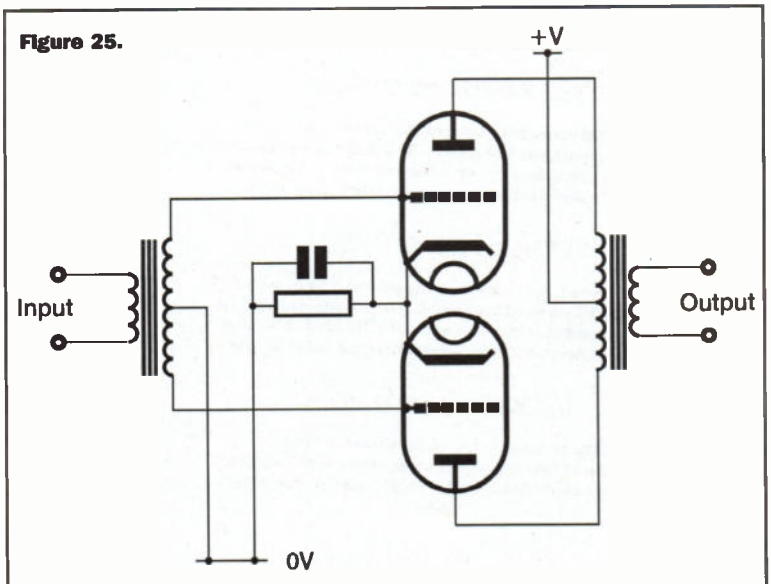
Figure 24.

Amplification Classes

OK, a change of subject now. In our final bit of theory before we move on to look at present-day valve applications, we'll take a quick look at amplification classes. Admittedly this isn't a subject which is concerned solely with valves, but if you've never taken much of an interest in amplifiers before - even semiconductor ones - it could well be that this is new to you. This information will help us to understand a bit more about the valve characteristic curves which we introduced in last month's article and it will be essential background material for subjects we'll cover later in the series.

Last month we introduced a couple of types of curve which describe the operation of valves. One showed the variation of anode current with anode voltage and the other showed how the anode current varies with the voltage on the control grid. A slightly modified version of the latter curve is shown here as Figure 23. First a quick recap on what we've already seen. If the

Figure 25.



grid voltage is sufficiently negative, the flow of electrons between the cathode and the anode is completely suppressed so no current flows. As the grid voltage becomes less negative a current will start to flow and the magnitude of this current depends on the grid potential. This

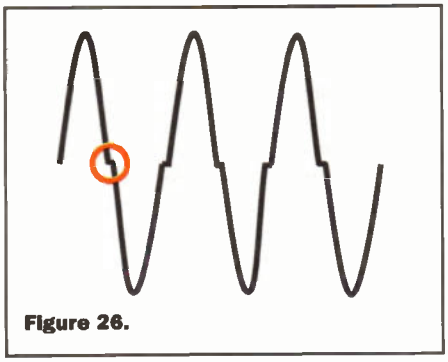


Figure 26.

trend continues until, at some positive value, the increase in anode current starts to tail off and eventually saturates. No further change in the grid potential will then affect the anode current. Within the range of voltages over which the curve is relatively straight, a small change in the grid voltage has a large effect on the anode current which is another way of saying that it acts as an amplifier. Figure 23 differs from the curve we presented last month by the addition of a sine wave signal on the control grid voltage axis. This sine wave is the input to the amplifier. The resultant output signal can be seen by 'reflecting' the waveform off the curve and we can see that, since the relevant part of the curve is almost a straight line, the output waveform at the anode current axis will also be a sine wave. In other words, the amplifier is linear - there has been no distortion. The amplifier in question is a Class A amplifier which means that the grid has been biased so that, with no signal present, the potential on the control grid is at the centre of the straight portion of the graph. Furthermore, for a Class A amplifier to operate correctly i.e. without distortion, the amplitude of the input signal should be such that it lies entirely within the straight part of the curve. From a quality viewpoint this is the best type of amplifier but there is a drawback. Since the control grid is biased to the central portion of the curve, an anode current flows all the time, not only when a signal is present on the grid. And the fact that current flows even when the amplifier is idling has a detrimental effect on efficiency and, of course, can reduce valve life significantly. High power Class A amplifiers need serious valves, large power supplies and generate a lot of heat.

The amplifier type which overcomes this drawback is the Class B amplifier. Figure 24 shows the salient features in just the same way that Figure 23 summed up the Class A amplifier. You'll notice that the grid is now biased to the point at which conduction starts so a current will flow only on the positive half cycles of the input waveform. On the negative half cycles, however, virtually no current will flow. The end result, therefore, is that the output waveform is a very different shape from the input waveform. More specifically, it's rich in both even and odd harmonics. Clearly a highly-distorted signal like this is useless in many applications so it tends to be used, certainly in audio applications, in a so-called push-pull configuration as shown in Figure 25. Now two valves are used in conjunction with a centre-tapped transformer such that each conducts for half the input waveform.

Figure 27.

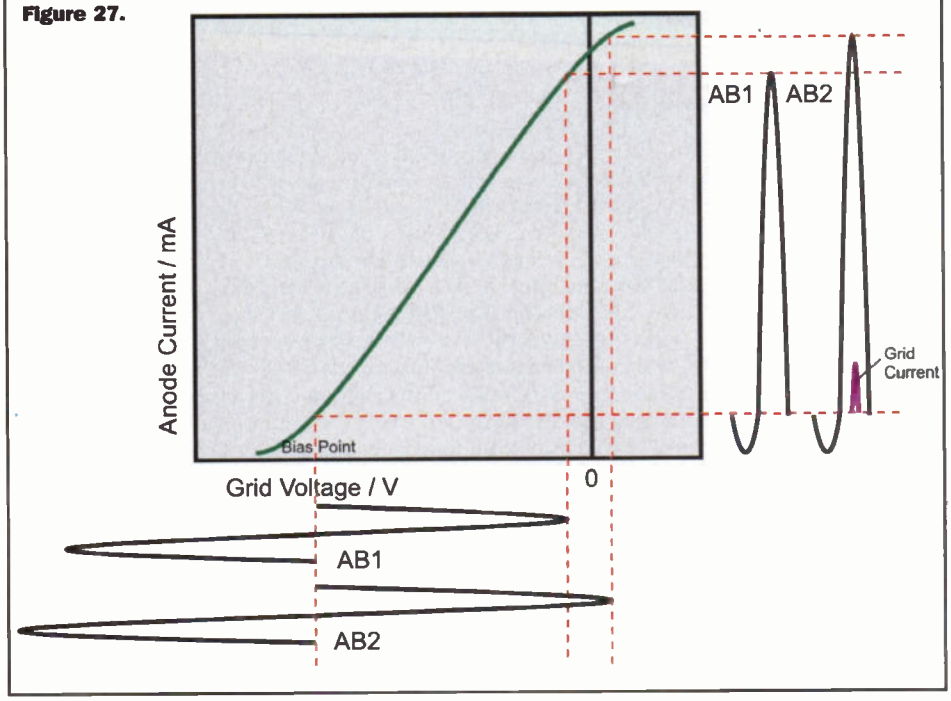
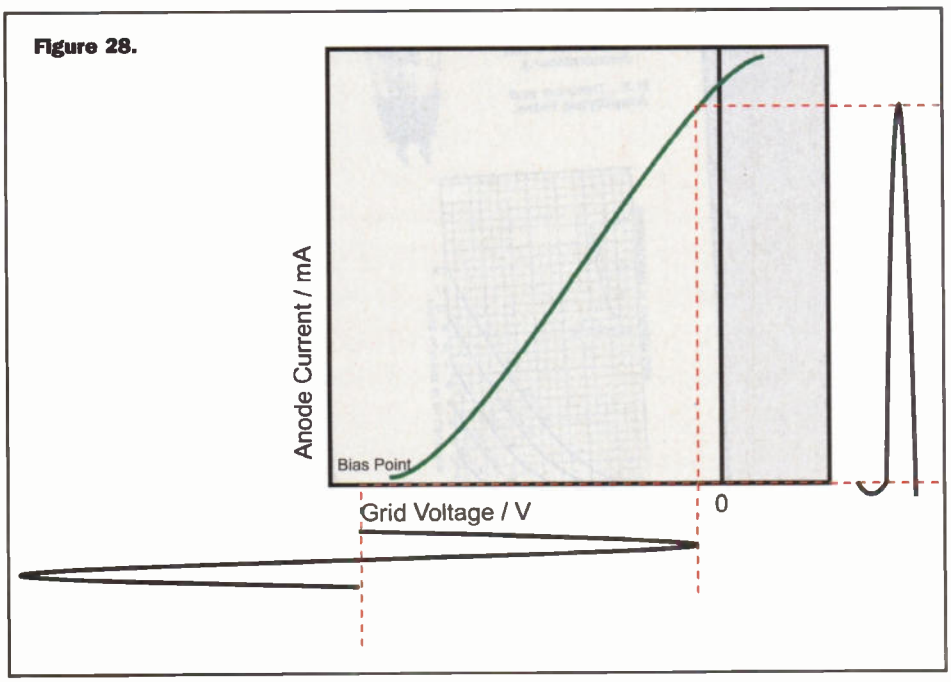
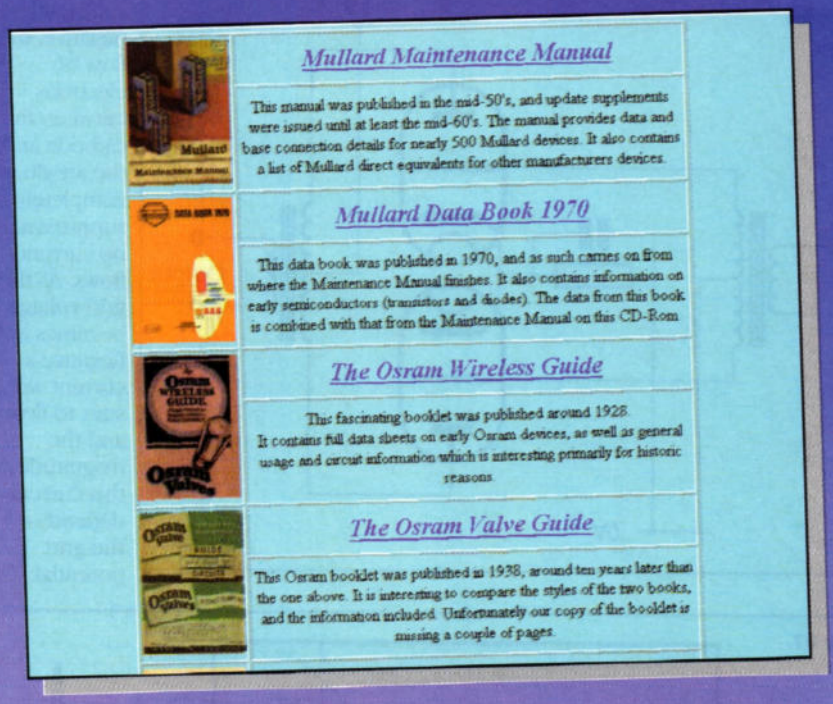


Figure 28.



The two output waveforms add together to give a non-distorted output signal. Well, at least that's the theory. In practice, because each valve takes a finite period of time to switch on at the start of its half-cycle, there is a degree of 'cross-over distortion' as shown in Figure 26. Needless to say, although this is a big improvement on the situation with a single-ended Class B amplifier, it's still far from ideal for high quality audio. The solution adopted is to use the Class AB amplifier as shown in Figure 27. For now, we'll forget about the difference between Class AB1 and AB2 and just look at the generic Class AB amplifier. This, like Class A and Class B is common to valves and semiconductors; only when we come to AB1 and AB2 do we find something which is peculiar to valves. In Class AB, the bias point is intermediate between that of Class A and that of Class B. In practice, though, the bias point is much closer to Class B so that each of the valves in a push-pull circuit conducts for just over half a cycle. The fact that there is some overlap between the conduction period of each of the valves significantly reduces the cross-over distortion. And the fact that the bias point is much closer to Class B that to Class A means that a Class AB amplifier is nowhere near as inefficient as the Class A counterpart - only a small current flows under idling conditions.

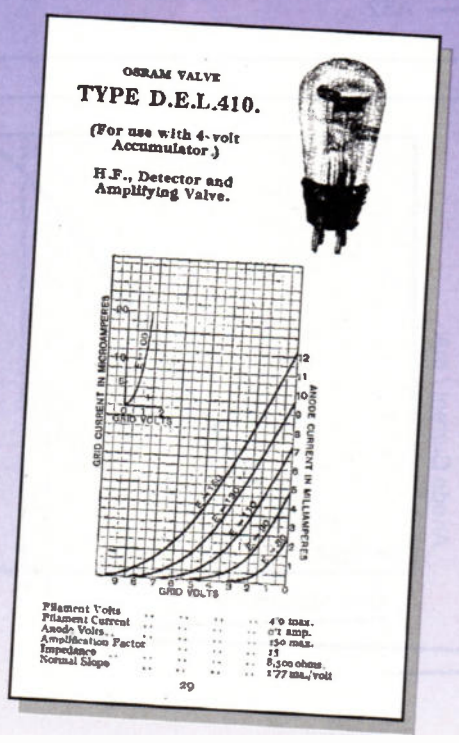
So what of the difference between Class AB1 and Class AB2? As I've already pointed out, unlike most of what we've seen about classes of amplification, this is something which refers only to valve circuits. In all the amplification classes we've seen so far, the biasing of the valve's control grid and the amplitude of the input signal are such that the grid never becomes positive. However, depending on the characteristics of the valve, it's possible that that amplification could also be possible when the grid is slightly positive for part of the input signal's cycle. Furthermore, with some valves the curve could still be relatively straight for low positive grid potentials. If a particular valve fulfils these conditions, it's quite feasible to design an amplifier in which peaks of the input waveform drive the grid positive – this is Class AB2 as opposed to AB1 in which the grid is always negative. The result of a positive going grid is that some of the electrons which would, otherwise, flow to the anode are captured by the grid and this results in a grid current. Needles to say there are pros and cons of the two approaches although we'll leave a discussion of this until we look at the use of valves in audio amplifiers later in the series. Finally, we have Class C amplification which is shown in Figure 28. Now the grid is biased even more negatively and the valve conducts for less than half an input cycle. This is useless for audio applications, even in a push-pull configuration but can be used in some RF applications. Just as Class AB is more efficient than Class A and Class B is more efficient than Class AB, so Class C is even more efficient despite it's very poor linearity. Obviously this is the motivation for using Class C amplification.



Valve Data CD-Rom

If you're serious about using valves you really need a comprehensive set of data sheets at your fingertips. Needless to say, with most of the world's manufacturers being in Russia and China and resellers being few and far between, data sheets are not nearly as easy to get hold of as are semiconductor data sheets. And if this is the situation with valves which are still being manufactured, the situation with obsolete valves is surely worse still. You'll be interested to learn, therefore, that a CD-Rom of valve data is available from Paul Stenning. The disk contains data sheets, equivalent tables and application notes on general-purpose valves, specialist valves, and even early transistors. This is drawn from various manufacturer's data books ranging from a 1928 Osram Wireless Guide to a 1970 Mullard Data book and from third party publications. Much of the data is in the form of scans of the original source material although some of the textual data is in ASCII format. The material is presented in a hyperlinked format. Quite apart from it's serious use as a source of valve data, this disk is also fascinating from a historical viewpoint.

The Valve Data CD-Rom costs £15 (including postage, world-wide) and can be ordered from Paul Stenning, PO Box 15, Hereford HR4 9WX. Alternatively, orders may be placed at www.vintage-radio.com although the credit card price is US$35 to cover additional handling costs.



Diary Dates

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

January 2000

26 to 27 Jan. Computer Trade Show, NEC, Birmingham. Tel: (0208) 541 5040.

February 2000

2 to 3 Feb. Legal IT 2000, Business Design Centre, London. Tel: (0207) 221 1155.

8 to 9 Feb. Accounting IT, G-MEX Centre, Birmingham. Tel: (0171) 221 1155.

9 to 10 Feb. Communications for Business, Barbican Centre, London. Tel: (01923) 676 867.

9 to 10 Feb. Softworld in Human Resources & Payroll, Wembley Exhibition Centre, London. Tel: (0181) 541 5040.

10 Feb. Video Forum - Video Equipment Trade Show, Wembley Exhibition Centre, London. Tel: (01273) 836 800.

15 to 16 Feb. Digital Mapping Show, Barbican Centre, London. Tel: (01883) 652 661.

16 to 17 Feb. Image Processing & Optic Technology, NEC Birmingham. Tel: (01822) 614 671.

22 to 24 Feb. PC@HOME - Small Office & Home User Computer Show, Donington Exhibition Centre, Derby. Tel: (01895) 630 288.

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: (0117) 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.

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?

Entrepreneur Urges Start-ups to Create New Business Models

Guy Kawasaki, chief evangelist officer of Garage.com at <www.garage.com>, addressed an international gathering of Internet developers, programmers and venture capitalists in November at the first Hewlett-Packard E-services Developers Conference in San Jose, California.

Kawasaki urged the audience to drive a technological revolution by jumping to the next curve in creating new business models and developing new electronic services for the Internet.

Garage.com helps promising start-ups find qualified investors, who make seed capital investments between £600,000 and £2.5 million - amounts that typically are too small for traditional venture capitalists.

Since January 1999, Garage.com has helped 20 technology startup companies raise more than £37 million in seed capital, through its wholly owned broker/dealer subsidiary, Garage.com Securities.

Last month, the firm announced it had successfully completed a £7.5 million round of financing led by E*TRADE Group with additional funds from Advanced Technology Ventures, Mayfield Fund and Credit Suisse First Boston. The funds will be used to continue to expand the firm's operations into high technology centres such as Boston, Seattle, and elsewhere in the world.

Morals for Robots and Cyborgs

Bull at <www.bull.com> has called on the computer industry to open a dialogue with government, business and the public about the implications of the rapid development of computer technology.

Bull has launched a unique study called 'Morals for Robots and Cyborgs' which examines the ethical and public policy issues surrounding the use of highly advanced computers - in particular, in robotics, digital agents and neuro-computer linkages.

The study outlines 15 principles of techno-ethics, ranging from the need to monitor the economic effects of the deployment of artificial intelligence to ensure that we can manage and compensate for changes in the demand for human labour that may result from the industrial use of thinking machines.

In addition, Bull sponsored an opinion survey to investigate how the general public currently perceive computers and technology. Over one thousand British adults were surveyed during the last weekend of October, and just under one-third of those interviewed stated that they are worried by the speed of technological change, with a further 53% believing that society is in danger of entering a robot state where everything is automated.

When asked about regulating and controlling the development of science and technology, 48% responded that they would least trust Government to control development, with academia being the most trusted group with 25%.

Government is most trusted to regulate the advance of computer technology by just 12% of the survey - less than the amount who most trust the computer industry (14%) and charities (13%) to control this area. Technology has already had a significant impact, with 63% of respondents stating that computers have taken over too many human jobs.

BT Tariff Could be Biggest Driver of Britain's E-Economy

BT's announcement that it will slash dial-up Internet access costs to less than 1p a minute is the biggest shot in the arm yet for Britain's e-economy, according to Web cacheing firm CacheFlow at <www.cacheflow.com>, whose technology makes it far quicker for users to access Web sites.

BT at <www.btconnect.com> has stated it aims to make it possible for Internet service providers (ISPs) to launch radically new subscription tariffs, which may include unlimited dial-up access for a flat monthly fee.

"For the UK's Internet user, this is like the Berlin Wall coming down," said Nigel Hawthorn, European marketing director, CacheFlow.

"It means smaller companies can be online all day for less than £15. While the Government has made a lot of noise about lighting a fire under Britian's e-economy, this news is the real wake-up call for our companies. It's Christmas come early for corporations, small businesses, online customers and everyday Web surfers alike," said Hawthorn.

Stanford Project Aims to Add Intelligence to Search Engines

Like millions of consumers, Stefan Kaufmann started his shopping trip on the Web. Looking for ideas on chairs, he typed 'chair' into the search box for a newspaper database and produced what most search engines won't – a list of interior decorating articles that included some that contained the word chair but others that contained the words 'rocker', 'chaise' or 'couch'.

Hoping for more good luck, Kaufmann went to a 10-year old Associated Press database. Asking again for articles about chairs, he retrieved articles this time with these headlines: 'Pipe-Bomb Killer Dies Without Seeing Execution Chamber' and 'Murderer Who Stole Christmas Presents Executed'.

Therein lies one lesson from researchers at Stanford's Centre for the Study of Language and

Information (CSLI): You can tell words by the company they keep, but they hang out with different crowds in different databases. Kaufmann, a graduate student in linguistics, is using that reality of natural language to develop better data mining techniques. For a demonstration visit **<matsu.stanford.edu/cgi-bin/semlab/Webif/Webdemo>**.

His was one of several dozen research projects discussed or demonstrated at a conference for the centre's industrial affiliates at the University of Stanford in November. More than 60 industrial researchers from companies and government labs in the United States, Asia and Europe attended.

Kaufmann's concept-based information retrieval method already has been applied by one of the companies to a commercial product but promises to underlie more. Kaufmann said he has a lot of work left, but

he has begun to show that he can train this data miner to be more billngual than any bilingual dictionary.

Using a statistical method that finds how often words co-occur in a database record, Kaufmann trained his tool on Japanese and American databases of patent applications by grouping words of both languages into the same set of 'concept' boxes. Later searches for a specific type of patent in either database found the correct patent in 44 of 45 tries, compared to only three of four tries when words were simply translated from one language to the other.

The technique helps deal with changing jargon and slang, but is especially important to cross-language mining, he said, because words display more ambiguity across languages.

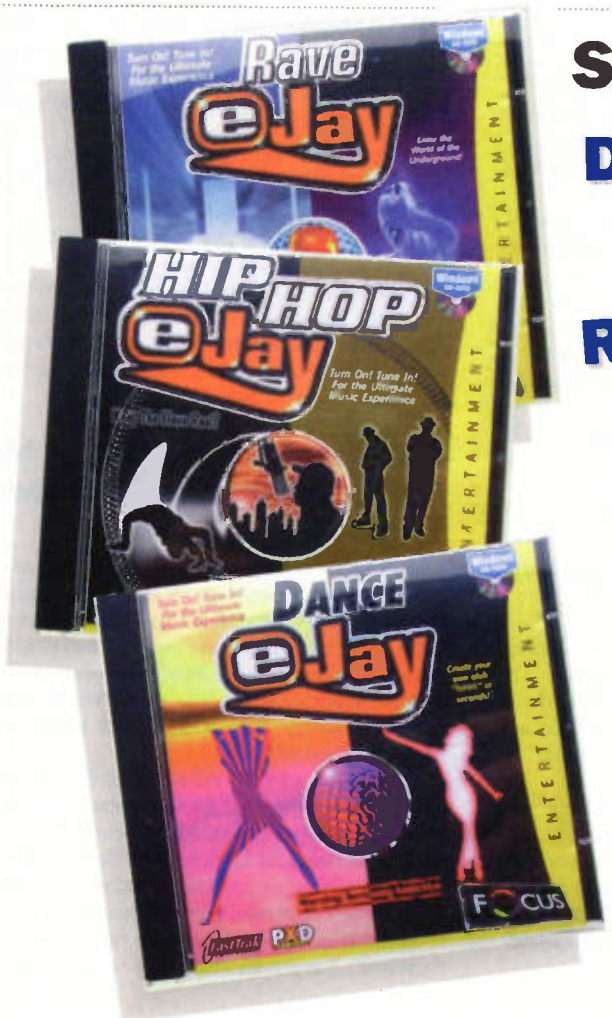
The project is one of several in the computational semantics laboratory led by linguistics Professor Stanley Peters. Another involves developing Japanese dialogue for a speaking office robot, which, unlike a factory robot, needs to adjust to a changing environment and exchange information with humans. For further information see **<www-csli.stanford.edu/semlab/juno>**.

A third semantics team develops constraint-based English grammars and dictionaries intended to be used across software applications, and another group is using a Java interface to provide dictionary content in formats more suitable for children and others with limited literacy skills.

Assistant Professor Chris Manning of computer science and linguistics demonstrated the latter technique for a dictionary of Warlpiri, an oral Australian aboriginal language, which has a written version developed by linguistic scholars of the 1950s.

"Most online dictionaries do very little to exploit the advantages of a computer," Manning said. Even worse, dictionary writers are language experts who confuse novice students with technical notations like 'transitive verb' at the beginning of entries, he said.

His dictionary interface allows Warlpiri children to use 'fuzzy' spelling to find words and to explore relationships between words in colour-coded diagrams. Antonyms are in one colour, derived words in another, and dialect in another.



Software Quick Review

Dance e-jay
Hip Hop ejay
Rave ejay

£9.99 each

from Focus Multimedia

These are mean pieces of software and for the price of a tenner you cannot go wrong. These have just got to be the quickest fixes for dance and party music ever. With full 8 track arrangement and stereophonic effects you can pick your voice samples, base line, melody, percussion and effects on a drag and drop basis from over 1000 samples on each disc. The simplicity is breathtaking for even young kids can get to operate it in seconds and put together these samples. Autosynchrony means you can never be out with your timing and each sample is quantised and can be joined seamlessly. The sound quality of the samples are excellent. If you get fed up with all the sounds on the disc you can import your own .wav files or go on to the internet to down load some more. Store your creations on hard drive or record straight to tape or CD and party the night away! OK, you are limited to a fixed tempo, but for the sake of a tenner for each music type, you really cannot go wrong. As it says on the front: **Warning: Seriously Addictive** - they certainly are!

Available from selected Maplin Stores along with the full range of Focus Multimedia.

Maplin order codes are:

Dance TH48 Rave TH49 Hip Hop TH50

@Internet Special

8-page pull-out

Expand your Mind

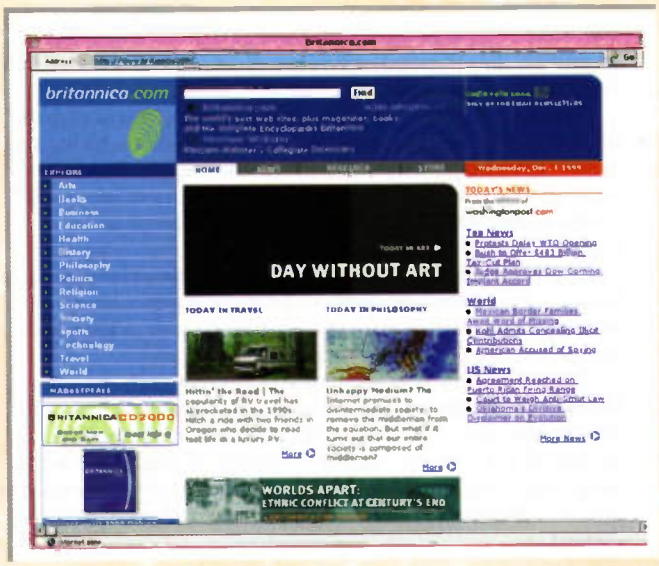
MindExpander is a useful utility that automatically expands compressed files in any of the following popular formats - .sit, .sea, zip, .bin and .hqx. As such it's great for both Mac and Windows users, as these are just the types of compressed file formats that are found on both platforms. Plus it's a cross-platform utility, which means that any of its supported compressed files received by a Windows user from a Mac user can be expanded, and similarly any of its supported compressed files received by a Mac user from a Windows user can be expanded. Both versions can be downloaded freely from <http://www.mindvision.com/Consumer>.

The beauty about MindExpander is that it should help to eradicate the problems that are caused when files are received - particularly by email - where the sender has compressed files in a way that the recipient can't otherwise use them.

Apart from an almost invisible method of expanding files, MindExpander also has the neat feature that you can check you have the latest version over the Internet, making sure you can continue to expand files even when their formats undergo version changes in the future.

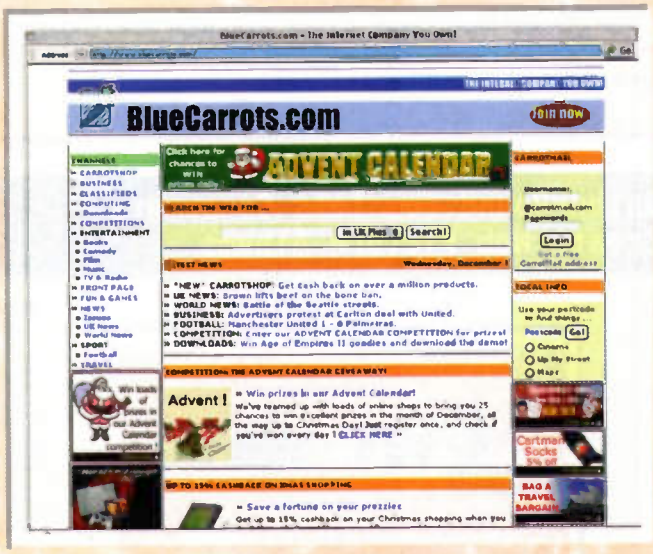
'Ere. Wanna Buy a Set of Encyclopaedias?

Gone are the days of the travelling salesman, calling door-to-door to sell you a set of Encyclopaedia Britannicas. Britannica's in the computer age now, first with CD-ROM derivatives, now with its own Website, where you can access Britannica's information. Interestingly, when it first went on line the Britannica server simply couldn't cope with Internet visitors, but after a rapid upgrade, you'll find it live and kicking, at: <http://www.britannica.com>. The Internet always did promise to be an all-encompassing encyclopaedia of information. With Websites like Brittanica's, it finally looks as though it's going to be just that.



Blue Carrots

It's certainly a name that's hard to forget - and it's a service that does the same. Blue Carrots is the first user-owned Internet company. Like most Internet service providers these days, it provides free dial-up access to the Internet, with users paying only the access calls they make to the service using their usual telephone provider. Users can register either as dial-up subscribers (telephone 0870 6007256 for a CD-ROM), or as pure Internet surfers at the Blue Carrots Website. Once registered, members each receive 1000 member shares in the company. At some stage in the future (on or before 11 August 2001), when the company is listed or sold, members who have used the Blue Carrots service regularly will have the option to convert the shares to ordinary shares which can be traded in the usual ways.



One of the problems with any free access Internet service providers is the level of churn that occurs with members. Churn is simply the term for the fact that many users of such free access Internet services tend to move on to other free access Internet services after a while - a case of the other man's free access ISP is always greener. So, in an attempt to maintain users rather than have them churn after a month or so, Blue Carrots is structured so that members actually own 80% of the company. It's this that Blue Carrots believes will provide the incentive for members to actually stick with the service. When the company is sold, members can reap the rewards of not churning, in the form of saleable shares. The value of the company at sale time of course depends largely on how successful the company is at signing on new members, so existing members have the incentive that each new member they recommend earns them an extra 50 member shares.

There's no doubt, this is an interesting and novel venture. Best of all, members effectively have nothing to lose. If the company goes tail-up, dial-up members merely have to move to another free Internet service provider. Members who merely surf to the site merely lose a Website to surf to. On the other hand, if the company is successful then both types of members could find themselves quids in. When you consider the share price of other free access Internet service providers, Dixon's Freeserve, for example, then 1000 shares could mean quite a lot of money.

Checkout the Blue Carrots Website, at: <http://www.bluecarrots.com>, where you'll find a healthy, vibrant, portal site that offers a wide range of services.

e.Digital to Support QDesign Music Playback

e.Digital at **<www.edig.com>** will support QDesign Music playback in e.Digital's portable Internet music player design.

The QDesign Music technology is the award-winning audio compression solution for QuickTime 4, Apple Computer's cross-platform architecture for digital media creation and delivery.

The QDesign Music Codec is a new generation audio coding technology that was designed to deliver the highest quality audio at the lowest possible data rates.

GatherRound.com lets Consumers Create Web Picture Albums

GatherRound.com at <www.gatherround.com>, a new imaging Web site that helps consumers use the Internet to share pictures and personal stories easily and quickly with family and friends.

Created by Intel in collaboration with MGI Software, GatherRound.com lets users create their own password-protected, personalised picture albums, complete with captions and descriptions. Once albums are created, consumers can e-mail personal invitations to their friends and family to visit GatherRound.com and view their albums.

Friends and family can make comments about what they've seen using a feature called Album Talk. There is no charge to use GatherRound.com.

To start creating picture albums, consumers go to GatherRound.com and download the GatherRound Picture Organiser that allows them to crop and enhance their pictures, as well as add titles and descriptions. When finished, consumers click a button to upload their edited pictures to their GatherRound.com album.

Toysrus.com Anchor Toy Store in MSN eShop

Toysrus.com at **<www.toysrus.com>** has announced a strategic relationship with MSN eShop. The new deal will position Toysrus.com as the toy anchor merchant on the new MSN eShop.

Toysrus.com's relationship with MSN eShop demonstrates its determination to provide customers with the best online shopping experience. The deal will make it easy for consumers to find exactly what they want to buy without all the usual hassles.

Soundtrack for a Century Web site is Launched

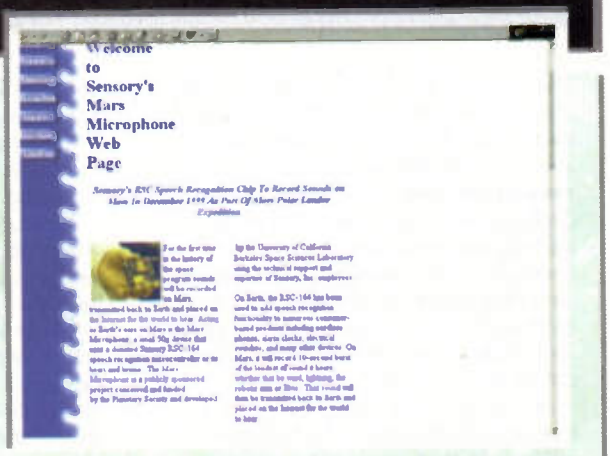
The most comprehensive collection of popular music ever assembled, has inspired one of the most original and entertaining Web sites.

This site has been especially designed to help you embark on a rich, experiential adventure. Utilising a unique technology called 'Thinkmap' - an interface that encourages discovery - you can lead yourself through the past century of music - 547 songs, nearly 500 artists, 12 distinct musical areas and a century's worth of historical events.

Enter the home page at **<millennium.sonymusic.com>** and options are everywhere: links to 12 musical genre areas present themselves at the opening gate, as well as links to Artists, The Story, Tracks, and more.

The Millennium Timeline at the bottom of each page is a horizontal timeline that is meticulously segmented from pre-1890 to the year 2000. This is Thinkmap technology at its optimum, not only pulsing with a variety of links provided by artists and song titles, but also containing historical events that put the entire century of music into legitimate socio-political context.

Sound Adds a New Dimension to the Exploration of Mars



After nearly a quarter century of breathtaking, but silent, photos from the Martian surface, a fascinating new project to record sound on Mars is about to add a new auditory dimension to our collective virtual space experience.

Following a nearly year long odyssey through the harsh environment of interplanetary space, the Mars Polar Lander will touchdown near the northern edge of the Martian South Pole and begin to study the Martian soil looking for signs of water beneath the planet's surface. However, unlike all preceding missions this one will be all ears.

Piggybacked on the Russian Science Academy LIDAR experiment is a small 50g device known as the Mars Microphone, a privately sponsored Planetary Society project. After touchdown, the Mars Microphone will begin a three month long experiment to determine what sounds would be heard on the surface of Mars.

Those sounds, regardless of whether they're the thin Martian wind blowing against the Lander, the Polar Lander's robotic arm or Martian spiders singing David Bowie tunes, will be made immediately available over the Internet at **<www.sensoryinc.com/html/Mars.html>** for all humanity to hear.

Unlike past missions to Mars, which have relayed thousands of silent photographs and video images of our sister planet, never has the added dimension of sound been realised. Even in the manned missions to the Moon the only sounds ever heard were the canned dialogue of Astronauts made possible by the artificial environments of spacesuit and spacecraft.

In the surrounding conditions of the airless Moon and the vacuum of space sound is not possible, even though Hollywood would have you think otherwise. Though Mars, unlike the Moon, has enough of an atmosphere to allow sound waves to travel and therefore be heard and recorded. Sound on the surface of Mars is expected to be similar to that on Earth, except much fainter and at a lower pitch because there is less atmosphere to push around.

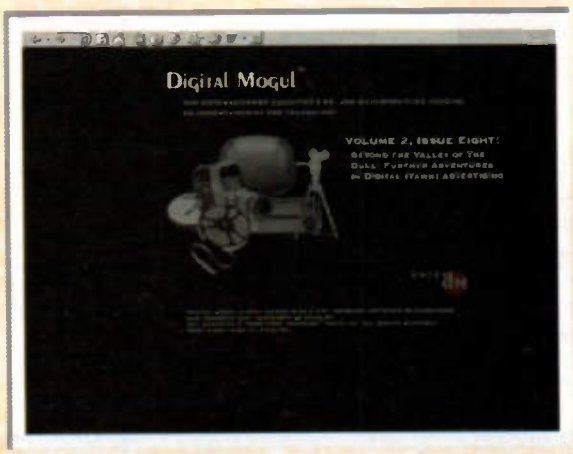
Originally proposed by Dr. Carl Sagan for the first Viking missions to Mars in the mid-seventies, the Mars Microphone was never realised until now due to overwhelming cost and technical restraints of that era.

Microsoft and Sony Enable High-quality Music Files to be Downloaded

Microsoft at **<www.microsoft.com>** and Sony at **<www.sony.com>** are set to collaborate on the interoperability between Microsoft Windows Media and OpenMG, a copyright protection technology developed by Sony. Sony has also agreed to support Windows Media Audio, an audio compression technology, on its upcoming VAIO Music Clip (MC-P10) in addition to Sony's own proprietary ATRAC3 format.

The effort between the two companies delivers on their shared vision of providing consumers with a high-quality digital media experience on PCs and portable devices, while also providing artists, music labels, and other right holders with a digital rights management solution that enables them to protect their intellectual property.

Digital Mogul Says Online Ads are Ineffective



The online advertising industry is at risk of discrediting itself due to an over-reliance on bland campaigns designed for mass-market portals, according to a report released by Digital Mogul at **<www.digitalmogul.com>**.

Consumers will increasingly by-pass and react negatively to online advertising campaigns unless the industry changes focus. Digital Mogul was the first to predict, in March 1999, that consumers would show little loyalty to portal brands - where most online advertising is focused. Recent studies from other market researchers have supported these findings.

Digital Mogul is counseling its clients that the real battleground for consumers is on the destination sites. Generic portal campaigns are showing continued evidence of consumer indifference. Digital Mogul is also counseling its clients to start experimenting creatively, since the current effectiveness of online ad art is not justifying the cost of major online campaigns.

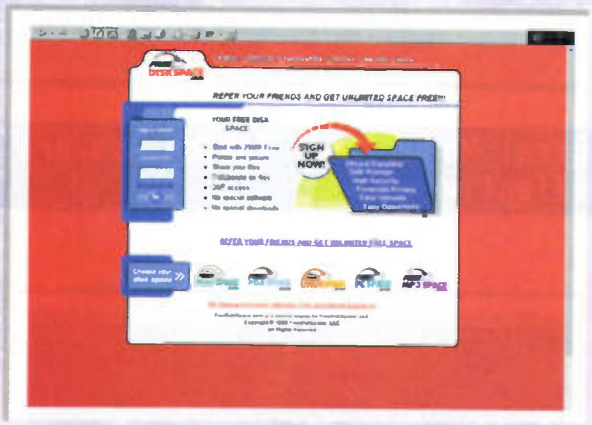
Users Claim Web Browser Bookmarks are Useless

The ability to bookmark a Web page for future reference does not help computer users, according to the results from a survey conducted by Giage at <www.giage.com>, a software start-up dedicated to solving the problem of information overload in computing. Browsers are software programs used to view information on the Web and corporate Intranets. The programs allow users to bookmark information so that it can be readily viewed.

According to the Giage study, the majority of computer users have more bookmarks than they can handle and often cannot remember the origin or reason for a specific bookmark. Many of the people surveyed indicated that bookmarks are inefficient vehicles for storing Web and Intranet information since links often change or expire.

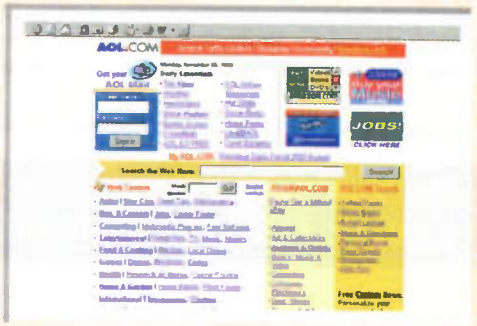
Results from the survey, which were collected over a three-month period, clearly show a frustration with the concept of browser bookmarks as 80% of respondents said they regularly lose information because a bookmark link is dead or changed since originally saved and 50% of the respondents said they always avoid using bookmarks because they cannot remember what they referenced.

FreeDiskspace.com Stores and Shares Files



In addition to being able to store files on the Web for free, FreeDiskspace.com subscribers can now up and download multiple files at once to and from the Web at <www.FreeDiskspace.com>. In adition, users can notify other users about those files, allow other users to read or to edit those files and track which users have accessed their files.

AOL Launches Mail on the Web



AOL has launched AOL Mail on the Web at <www.aol.com>. AOL Mail on the Web is one of the 'AOL Anywhere' suite of products available on AOL.COM that extend the benefits of AOL to the Web and other emerging interactive platforms.

AOL Mail on the Web makes it even easier and more convenient for AOL members to access their AOL e-mail when they are away from their personal computer or do not have access to the AOL service - while at work, school or when traveling - at no additional charge and without having to download any additional software or plug-ins.

By entering their AOL screen name and password on the AOL.COM home page, members can now read, save, respond to, and forward their AOL e-mail, as well as create and send new e-mail messages.

Net2Phone Unveils Enhanced Internet Telephony Client

Net2Phone has released its most sophisticated Internet telephony software, Net2Phone version 10 (V.10).

The Net2Phone V.10 software incorporates advanced digital technologies for improved sound quality and a variety of additional new features, including Net2Phone's free VoicEmail, free PC-to-PC calling, ICQ buddy PC2PC calling and PC-to-Fax solutions, in addition to the company's flagship PC-to-phone service. The new software is free and can be downloaded at <www.net2phone.com>.

Net2Phone, the first company to offer a commercial PC-to-Phone service, has included free PC-to-PC service in its new Net2Phone V.10. All users equipped with a multimedia PC and the new Net2Phone V.10 software can conduct voice conversations over the Internet for free, via Net2Phone's proprietary IP telephony network. Along with the new PC-to-PC service, Net2Phone V.10 users can take advantage of Net2Phone's low global rates for PC-to-Phone service.

Those using Net2Phone's PC-to-PC service must designate a Net2Phone virtual number or nickname in order to be called by another PC. Future versions of Net2Phone will allow users to receive calls on your Net2Phone, via an actual telephone, to these phone numbers.

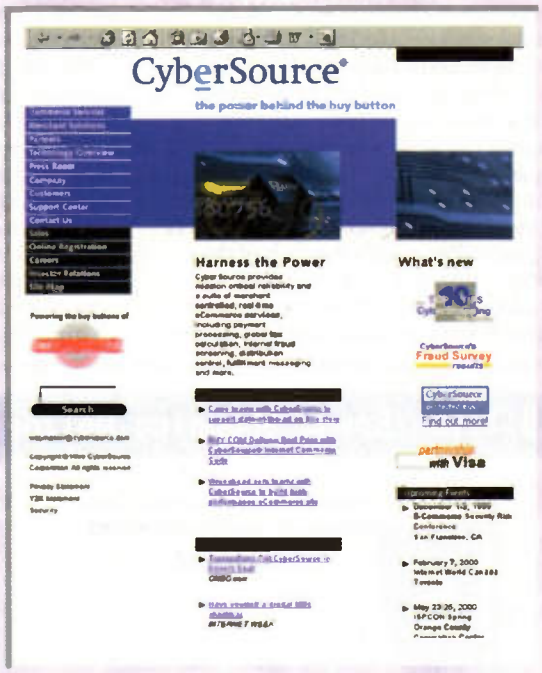
Giga Information Group Launches Web Site Analysis Service

Giga Information Group has announced the Web Site ScoreCard at **<www.gigaweb.com>**, a comprehensive service that evaluates an organisation's Web site to help it better compete online. Giga's Web Site ScoreCard provides a detailed Web site analysis and compares it to an organisation's competition and related sites.

The Web Site ScoreCard provides an in-depth assessment with recommendations on how to strengthen an organisation's e-commerce and online initiatives. ScoreCard results and recommendations are not made public by Giga, but are designed as internal documents to help an organisation improve its Web site in order to gain competitive advantage.

Giga's Web Site ScoreCard is the first Web site assessment service that measures an organisation's compliance with the proposed Standard for Internet Commerce, a set of guidelines for Internet commerce best practices that is supported by more than 300 business, community and government organisations. In addition to providing a comprehensive analysis of a Web site, the Web Site ScoreCard will measure an organisation's progress in meeting the proposed guidelines.

Survey Reveals that Internet Fraud is a Growing Concern



75% of online merchants consider credit card fraud to be a concern, yet 41% do not know that they are held financially liable when online fraud takes place, according to a recent independent fraud survey commissioned by CyberSource at **<www.cybersource.com>**, a developer of e-commerce transaction services.

The research, representing over 100 online businesses worldwide, reveals that online fraud is a business-operating problem for those e-business retailers and brands that are on the frontlines of the online shopping explosion.

The CyberSource fraud survey found that lack of confidence by consumers is the number one concern for online merchants, followed by stolen credit cards, unauthorised access to customer information, hacking and chargeback fees. Respondents also expressed frustration at the lack of adequate controls from credit card companies and the government.

Fear of the negative impact fraud can have on online brand image was also mentioned as a strong concern for merchants. 72% of online merchants surveyed believe that sales would increase somewhat if online shoppers were not worried about fraud.

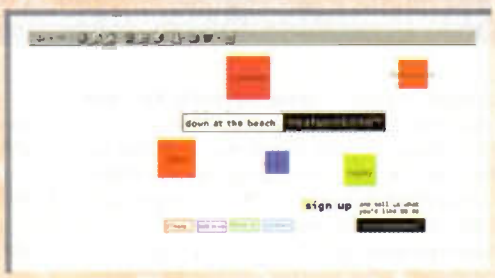
nextweekend Signs with Business-Incubator.Com Consortium

A consortium of the IT industry's leading e-business companies has announced nextweekend as the first organisation to use an innovative new service aimed specifically at the Internet start-up market.

business-incubator.com at **<www.business-incubator.com>**, which launched in September at the 'dot com your business' event, is a partnership between Oracle, Sun Microsystems, Cisco and Exodus. It represents a £5 million pound investment designed to help budding UK 'dot coms' test their ideas before trading in the global marketplace.

nextweekend at **<www.nextweekend.com>** is a unique e-business concept that is set to revolutionise that most precious commodity of modern life - leisure time. Harnessing the power of the Internet, nextweekend will enable individuals to plan their time off in a way that has not been possible before.

As all organisations, whether they be Internet start-ups or established organisations, look to move into e-business, they must address the major barriers to entry of technical infrastructure, funding and building a global customer base.



business-incubator.com minimises the technical barriers by offering a secure, reduced-risk environment at a significantly reduced price to develop and test e-commerce systems for three months before launching a full e-business.

Site Takes Strain Out of Moving Home

<www.reallymoving.com> is an independent Web site covering all the essential services associated with moving home, from finding a property on the UK's leading database, to booking your solicitor, removal company, surveyor, insurance company and cleaning company.

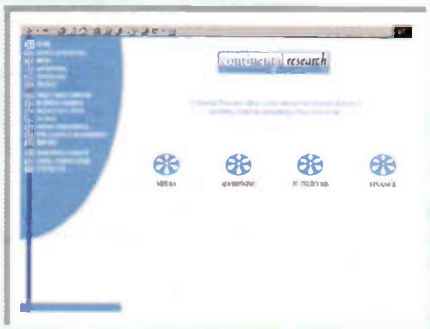
The site is free to all users, and enables visitors to the site to receive a selection of real time online quotes for each of these services at any time of day or night.

In addition to enabling easy contact with relocation services, reallymoving.com has a database of thousands of properties for sale and rent, powered by Internet Property Finder.

The site guides users through the multitude of mortgage providers, and also provides a planner and reminder service to ensure all essential activities associated with home moving are carried out in good time.

These reminders range from when to book your structural survey, to how and when to tell the utility companies about your move and even a reminder to contact DVLC if you own a car.

£2 Billion Spent Shopping Online



Among the 11.1 million regular users of the Internet each spent on average £170 online over the past 12 months, according to Continental Research's 5th Annual report at <www.continentalresearch.com>. Nearly £2 billion was spent in total.

Given that an estimated £194 billion was spent in the high street in the last year, e-commerce purchases accounted for 1% of all retail purchases.

Continental Research's report tracks the growth of awareness and usage of the Internet and views its development in home, at work, and at places of education. Detailed information is also provided on e-commerce, advertising and media usage.

The report found that 18.6 million people (40% of the UK population) have access to the Internet from home, work, school or college.

Meanwhile 11.1 million (24%) use the Internet once a month or more, 11% spend less time sleeping, 33% spend less time watching TV; and 11% spend less time with their families as a result of their Internet usage.

E*TRADE First Online Broker to Feature Techmark Index

E*TRADE UK at <www.etrade.co.uk>, the UK's first Internet-only online investing company for private investors, announced that from November the service will feature the FTSE techMARK index.

techMARK is the London Stock Exchange's new market for technology companies. E*TRADE UK is the first online broker to support techMARK by including the index as part of its information service.

Visitors to the E*TRADE site will be able to view the techMARK index on the market indices page as well as being able to access the latest performance of all techMARK constituent companies.

E*TRADE UK fully supports the creation of this technology market which provides private investors with a new investment benchmark. In addition, this enables investors to more easily target young and innovative technology companies.

An online poll of E*TRADE UK users demonstrated that over 80% were in favour of the creation of techMARK and believed that E*TRADE UK's inclusion of techMARK data would be beneficial to them.

lastminute.com recognised as Best UK Internet Start-Up

lastminute.com at <www.lastminute.com> continues to pile on the accolades with the announcement that it was selected as the best UK Internet start-up in the 1999 e25 ranking as voted on by Management Today and Bain Consultancy. The e25 aimed to identify the most exciting entrepreneurial ventures in the Internet space in the UK.

After extensive research from both Management Today and Bain, lastminute.com made it top of the chart. The overall rankings were based on six key criteria - concept, innovation, execution, traffic, financing and public profile.

This award follows the Best Commercial Web Site award at the Yell UK Web Awards 1999 and the first prize in the retail category at the New Media Age awards 1999.

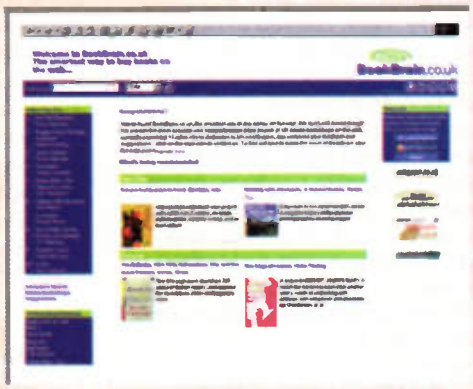
lastminute.com launched in October 1998 and is one of the UK's few dedicated consumer ecommerce start-ups which gives consumers a real reason to buy online. Lastminute.com generates its continually refreshed inventory of offers by working directly with the best suppliers in the travel, entertainment and gift industries.

Kidz.Net Launches in Europe

Kidz.net at **<www.kidz.net>** an Internet service especially designed for families and launched in the UK at the beginning of December. The move is part of the company's global strategy to provide a comprehensive, secure Internet community for children, parents and teachers.

Kidz.net actively selects and reviews the very best sites for relevance and suitability, focussing strongly on Education for children and Entertainment for parents. These sites are then accessed through Kidz.net's fast fun browser which contains a dynamic database of over one hundred thousand sites subdivided into six channels including Education, Sports, Games and Metro. Unsuitable sites describing topics such as drugs, guns and pornography are not included.

BookBrain Set to Revolutionise Buying Books



BookBrain.co.uk at **<www.bookbrain.co.uk>** launched at the beginning of December claiming that it is the most comprehensive and accurate way to search all major UK online bookshops for book price and availability information.

BookBrain contains a powerful search engine, which can identify a required book by title, author, publisher, ISBN or a combination of these. To achieve this, BookBrain uses data from the acknowledged authorative source Whitaker. This means that the price and availability search only returns information on the relevant book, which makes BookBrain the most accurate site in its field. BookBrain identifies significant savings on books.

For example, by comparing on-line bookshop prices you can currently save £10 on The Naked Chef by Jamie Oliver, £16 on The Dorling Kindersley World Atlas and £10 on The Oxford Companion to Food.

As well as price and availability information, the site also provides the Top Ten Online Bestsellers and will soon provide objective information including book reviews, forthcoming releases, and performance ratings of the online bookstores.

Convert to High Speed Service for Half Price with BT Together

BT Internet customers will be able to convert their existing line to a high-speed BT Highway line for less than half the normal price, if they convert to the new BT Together service. BT Together customers who long for faster downloading from the Internet, can convert their existing line to a digital Home Highway line for just £49.50 (normally £116.33) and experience speeds of up to 128k.

Furthermore, a monthly fee (including rental) of £39.99 will include £13 worth of call time, which is equivalent to 21 hours of weekend or evening Internet calls.

BT Highway will let you download information from the Internet up to four times faster than using a 28.8k modem. Alternatively, users can go online at a fast 64k while keeping the standard phone line open for voice and fax calls.

BT Together customers will also benefit from simpler, lower call prices. Call charges have been reduced as follows:

- 4p per minute for national daytime calls (normal price 8p)
- 3p per minute for local daytime calls (normal price 4p)
- 2p per minute for national evening and weekend calls
- 1p per minute for local evening and weekend calls

These prices are subject to a minimum call charge of 5p per minute. Where there are no BT Together price per minutes rates specified, the charge will be at the standard rate (including BT Chargecard calls).

The new call charges mean that once customers have used up the call allowance of £13 per month, Internet calls will cost no more than 1p per minute on evenings and weekends, and 3p per minute during the day.

BT Launches Comprehensive Internet Comparative Shopping Service

BT has launched btspree.com at **<www.btspree.com>**, claimed to be the UK's most comprehensive on-line comparative shopping service developed in conjunction with Inktomi.

The new Web-based service integrates Inktomi's shopping engine technology to allow users to compare products, prices and brands from 21 categories as well as order goods on-line from a large range of UK and US-based specialist and high-street retailers.

Most shopping on UK-based Internet sites is either through direct store contact or through simple search sites. btspree.com offers more than two million goods including flowers, chocolate, lingerie, clothing, books, games, CDs, gifts and more specialist items such as pet accessories.

Already, 74 retailers have signed up to the service, including Tower Records, Value Direct, CD Zone, Smartshop, ChocExpress, 21Store.com and Kitbag. BT expects more companies to join soon. The service is subscription-free and does not require registration.

btspree.com also offers a dedicated shoppers guide to successful buying from US Web-sites. US merchants are geared up to ship products to the UK and considerable savings can still be made even when carriage costs are included.

The service is designed to take the user through the process of shopping - from browsing to selection and purchasing, with the added benefit of providing genuine price comparisons. After launch, the service will also include product reviews to make purchase decisions even more straightforward.

Site Survey

The months destinations

Destinations of the month

When All the King's Men featured on television recently, we wanted to find out more about The Soldier poem that was read during the drama. Granny thought it was written by Wilfred Owens, Dad thought maybe not, Mum just snored. Anyway, a search entering the first line 'If I should die, think only this of me;' into the MacOS Sherlock Internet find tool brought to light a wonderful Website listing the first lines of poems written by modern British poets, in alphabetical order, that allowed us to locate the poem within seconds. Find the Website at: **<http://www.bartleby.com/103/index4.html>**. And, oh yes, the poem was of course written by Rupert Brooke.

If you missed the eclipse in the Summer (due to cloud, illness, business, holiday, laziness and so on) and want to catch up on the phenomenon, the Deutsches Museum in Munich has a complete Website devoted to it. Here you'll find photographs, descriptions, and movies of the event which is made all the more interesting when you consider that the total eclipse didn't even take place there.

Yet another Internet site provides mapping facilities. Multimap, at: **<http://uk.multimap.com/map/>** lets you access street-level location maps directly in your Web browser. The maps can be accessed by entering the name of a city, town or village, by streetname (in London only), or from postcode information. You can then zoom in or out as you wish. It's only in beta testing phase at the moment, but it seems to work extremely well. Some users may be disappointed however, as - although the site says all of Great Britain is covered - it only actually works throughout the UK mainland. Northern Ireland is not included.

On the Trail of e: SOME SURPRISES

Photo: Courtesy N. Clark Huntarian Museum

Douglas Clarkson concludes his analysis of John Napier and his famous logarithms

Introduction

In writing about John Napier and his famous logarithms, there comes into play the original derivation of common or base ten logarithms in respect of the equation :-

$$N = 10^L$$

and whose particular function is shown in Figure 1. This is quite different from Napier's base value of just less than unity where the base value had to be raised to high values to reduce the value of N accordingly.

A particular practical question would arise in initially calculating values of N from values of L where L is described as the common logarithm of N. If we select an expression:-

$$N = 10^{0.7351}$$

how could the initial value N have been calculated?

The number can be expressed in the format:-

$$10^{0.7} \times 10^{0.03} \times 10^{0.005} \times 10^{0.0001}$$

so that if we can produce tables to cover the spread of values for each place of decimals in the value of L, we can multiply up the terms as previously undertaken by Napier to calculate the value of N.

The starting point for serious evaluations of logarithms, therefore, would have been to develop a master table of the structure of Table 1. The accuracy of these values would of course determine the accuracy of any values subsequently calculated.

	$10^{0.1}$	$10^{0.01}$	$10^{0.001}$	$10^{0.0001}$	$10^{0.00001}$
x1	1.25892542	1.02329299	1.00230524	1.00023029	1.00002303
x2	1.58489320	1.04712855	1.00461579	1.00046062	1.00004605
x3	1.99526234	1.07151930	1.00693167	1.00069101	1.00006908
x4	2.51188647	1.09647819	1.00925289	1.00092146	1.00009211
x5	3.16227771	1.12201845	1.01157945	1.00115196	1.00011514
x6	3.98107179	1.14815362	1.01391139	1.00138251	1.00013816
x7	5.01187246	1.17489755	1.01624869	1.00161311	1.00016119
x8	6.30957362	1.20226443	1.01859139	1.00184377	1.00018422
x9	7.94328259	1.23026877	1.02093948	1.00207448	1.00020725

Table 1: Structure of values for determining common logarithm values to 8 places of decimal.

Origins of e

So far the number e has not raised itself in these deliberations. In Figure 2 we plot a series of curves of the function b^x where b is a base greater than unity, there is no obvious striking feature about the curve for with b = e = 2.7182818.

It was to be after the assimilation of the differential calculus developed independently by Newton and Liebnitz that a greater perspective came to be focused on exponential and logarithmic functions. In science, a great many discoveries were found to include the exponential function in a very real way.

In coping with the broad range of functions in the differential calculus, it is easy to overlook the significance of the e^x function. In many episodes in which the function appears, however, the function can appear as $y = e^{kx}$ where k is a positive or negative constant. By the same token, if we plot the slope of the line (e^{kx}/y) for various values of k, as in Figure 4, we confirm that the gradient or slope of the

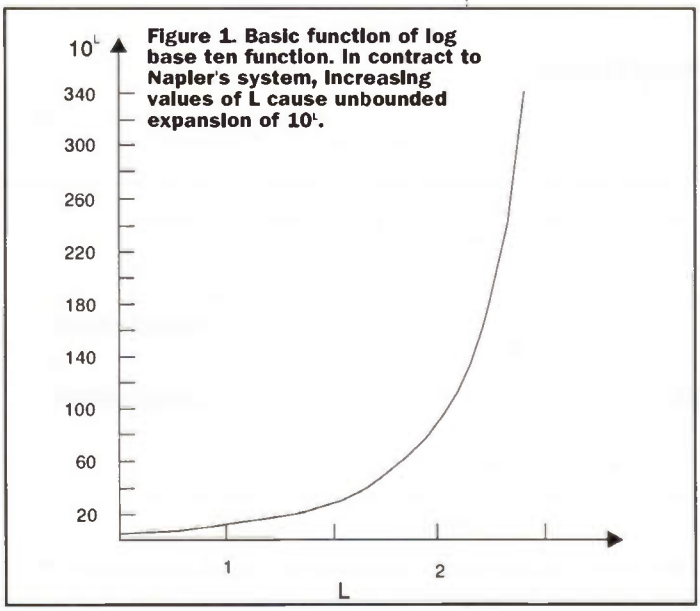


Figure 1. Basic function of log base ten function. In contract to Napier's system, increasing values of L cause unbounded expansion of 10^L.

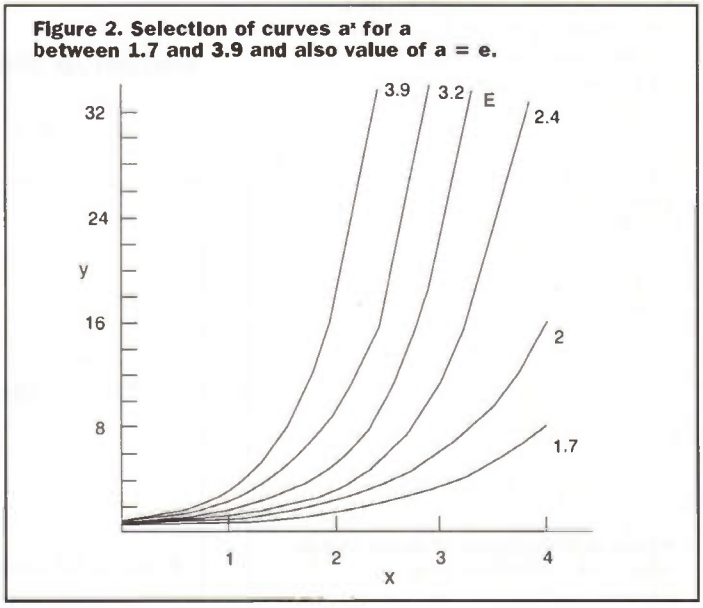


Figure 2. Selection of curves a^x for a between 1.7 and 3.9 and also value of a = e.

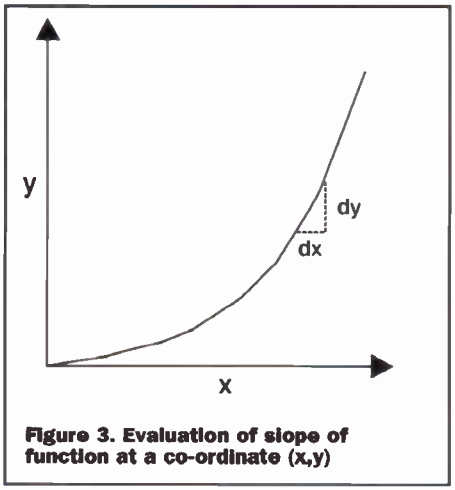


Figure 3. Evaluation of slope of function at a co-ordinate (x,y)

function ekx is kekx. This is a basic function of the differential calculus, but it is useful to remind ourselves of this since so many expressions involve this function.

As one example, the rate of decay of mass of a radionuclide was expressed as being proportional to the existing mass of radionuclide.

$$dm/dt = - a\ m$$

where m is the mass of the radionuclide remaining and a is a constant. This provides for a relationship:-

$$m = m_o\ e^{-at}$$

where m_o is the mass initially.

One reason why the rich become richer is due to the law of compound interest which is also a reflection of the exponential function and given by the function:-

$$A = Pe^{rt}$$

where A is the balance after time t years and at rate r with initial principal P.

Seen in this perspective, does this mean that barring conflicts, rogue asteroids and the lack of environmental pressures, the global economy is simply growing according to some in-built exponential function - commerce begets commerce. Also perhaps the most easy to understand exponential function is that of the world's population.

In a simple RC circuit indicated in Figure 5 with the capacitance charged to voltage V at time t , the voltage on the capacitance when the switch is thrown is :-

$$V = V_o\ (1 - e^{-t/RC})$$

We can relate this to equating voltages around the circuit:-

$$V_o = IR + Q/C$$

$$V_o = dQ/dt\ R + Q/C$$

$$dQ/dt = -Q/RC + V_o/R$$

This is the origin of the term $e^{-t/RC}$ in the expression. Thus the exponential function appears across many sets of equations in electronics.

Logarithm - e Symmetry

Thus we can interpret the e number as a value which should naturally appear very generally in expressions representing a broad range of relationships. It is useful, also, to consider in this light the natural logarithm function. Where we express:-

$$y = e^x$$

the natural logarithm is described as:-

$$y = \ln(x)$$

In the basic definition of the exponential function where :

$$y = e^x$$

then from definition:-

$$x = \ln(y).$$

Similarly if we define $x = e^y$ then $y = \ln(x)$.

$$\text{and } dx/dy = e^y$$

$$\text{then } dy/dx = 1/e^y = 1/x$$

Thus the slope of the ln(x) function is 1/x. This is inherently linked in with the property of the exponential function.

What this also implies is that ln(x) is the integral of the function 1/x. Thus there is the inverse relationship as it were between the exponential and natural logarithm functions.

Relative Perceptions

The so called Weber-Fechner law originated in the work of Erst Heinrich Weber (1795-

Photo: Courtesy N. Clark Huntarian Museum

1878) who discovered that human appreciation of sensation tended to be relative to the absolute level of the quantity being determined. What tended to be the case was that the stimulus associated with the perception was proportional to the factional change in the level of the stimulus.

The law can be expressed as:

$$ds = k\ dW/W$$

where ds is the change in stimulus, dW is the change in parameter relative to its level W and k is a constant.

Based on the previous expressions, the law described here is logarithmic, viz:-

$$s = k \ln(W) + C$$

where C is a constant. A good example of this perception based relationship is relative loudness in dB where

$$dB = 20 \log(p1/po)$$

where dB is the relative loudness in dB, p1 is a stimulus level of sound pressure amplitude and po is a reference pressure level.

Keeping with auditory perception, we can relate to sensation of frequency space of the equal temperament scale with n = 0, 1, 2 etc.

$$f = fo\ 2^{(n/12)}$$

Taking logarithms to base 2,

$$n = 12 \times \log2(f/fo)$$

where n is the value of the relevant semitone relative to fo where n=1.

What would happen if we create a scale based on natural logarithms rather than The

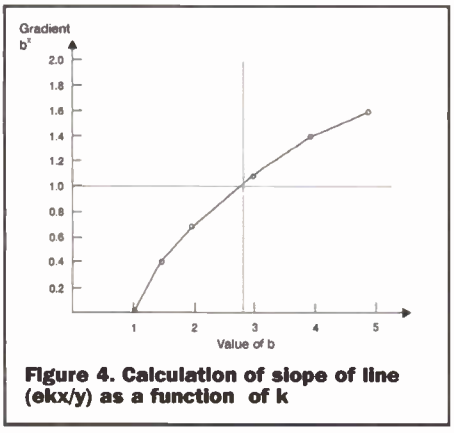


Figure 4. Calculation of slope of line (ekx/y) as a function of k

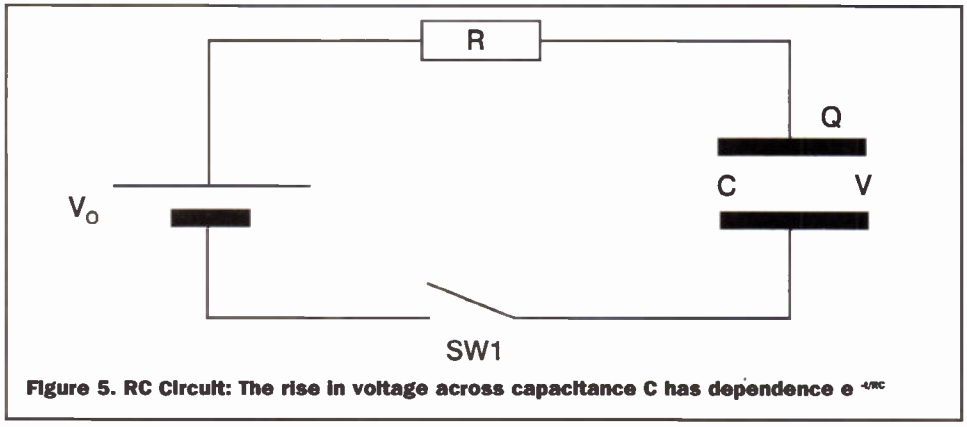


Figure 5. RC Circuit: The rise in voltage across capacitance C has dependence $e^{-t/RC}$

base 2? We would have:-

$$f = fo\ e^{(n/12)}$$

$$n = 12 \times \ln(f/fo)$$

What happens here is that the steps between semitones is increased so that the ratio of initial semitone to 12th semitone is the value e. Thus if we start at 100Hz, the 12th semitone is 217.828Hz.

It is interesting to note, however, that we can write the expression of the equal temperament scale as:-

$$f = fo\ e^{(\ln(2)*n/12)}$$

We can think therefore of a generalised function for mapping out frequency space of the form:-

$$f = fo\ e^{(const * n/semi)}$$

where const is a constant, n is integers 0,1,2 etc and semi is the number of 'semitones' in the equivalent 'octave'. Based on the previous definitions of the function e^x, the instantaneous slope of the standard equal temperament scale of frequency as a function of n is given by ln(2)/12 times the value of the frequency at a given point.

There is also a subtler side to the logarithmic relationship of stimulus based systems. Do aspects of human behaviour indicate similar characteristics? In the power game of becoming seriously wealthy, for example, is it the case that the perception of the increment of wealth follows a logarithmic function?

Logarithmic Spirals

Jakob Bernoulli (1654-1705) was to spend a considerable amount of time describing the logarithmic spiral - known also as the growth spiral and the equiangular spiral. Initially is was described as:-

$$\ln(r) = a\theta$$

This is now more commonly written as:-

$$r = r_0\ e^{a\theta}$$

as indicated in Figure 6. A simple programme to generate logarithmic spirals is indicated in LOGSPIR in QuickBASIC.

Where the value of the constant a is positive, the spiral will grow with increasing angle - as indicated in Figure 7a and if we

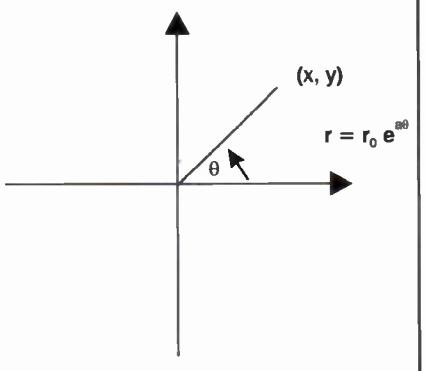


Figure 6. Basic geometry of the logarithmic spiral

```
10 REM log spiral LOGSPIR
20 SCREEN 2 : rem graphics screen
30 print "input start radius"
40 INPUT rθ
50 PRINT "input value of constant a"
60 INPUT a
65 PSET (300,100): rem mark origin
   CLS : rem clear screen
70 FOR jj = 1 TO 3500: rem vary this
   number as required
80 theta=jj/90
90 r1 = rθ * EXP(a * theta)
100 x1 = r1 * COS(theta)
110 y1 = r1 * SIN(theta)
120 xcord = 300 + x1 * (400/140)
130 ycord = 100 + y1 * (200/168)
140 PSET (xcord, 200 - ycord)
150 NEXT jj
```

follow the spiral inwards we travel clockwise. In Figure 7a we have started from a given starting radius and work with a negative value of constant a, so that with increasing angles, the radii get smaller. In this case if we follow the spiral towards the centre we travel in a counter clockwise direction. In forming these spiral graphs, the programme spends most of its time trying to draw points towards the centre rather than on the periphery.

In Figure 7a we have selected a value of a of 0.119 and a start radius of 1.0. In Figure 7b we have selected a value of a of -0.119 and a start radius of 100. This is because with positive values of a, the spiral will eventually grow significantly while in negative values of a the spiral will get smaller.

It can be quite interesting to determine the value of a for various natural shells which demonstrate the logarithmic spiral. If we can identify the spiral pattern as in Figure 8, then by measuring the ratio of lengths AD/BC we can determine the value of a of the spiral.

The ratio of AD/BC is given by the ratio of the sum of the two radii at theta $+2\pi$ and theta $+ 3\pi$ and the sum of the two radii at theta and theta $+ \pi$

$$\text{Thus } AD/BC = e^{2\pi a}$$

$$a = [\ln(AD/BC)]/2\pi$$

For a middle Jurassic ammonoid fossil a value of 0.15 is typical. This implies that the structure increases size more rapidly with angle. Across the wide number of shells which exist in nature, there is this intrinsic simplicity of the logarithmic spiral shape and which we can also express with a basic parameter.

It is quite fascinating to run the small mini programme LOGSPIR with a value of a of 0.1503 and with a start radius of 1 units and see the same shape appear on a PC screen.

The logarithmic spiral was initially discovered by Descartes around 1638. Jakob Bernoulli was so fascinated by the logarithmic spiral that he described it as 'Spiralis miribabilis' (the miraculous spiral). On his tombstone around a spiral was engraved 'Eadem mutata resurgo' - though transformed, I shall arise again unchanged. Bernoulli was equating the properties of the

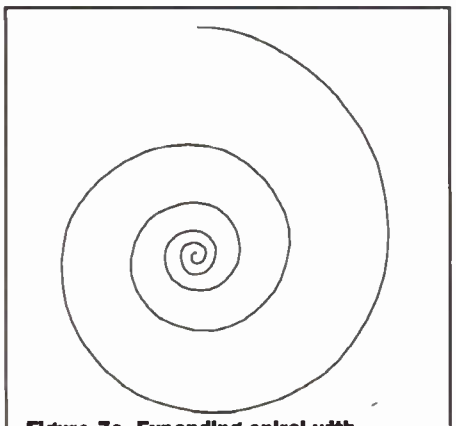


Figure 7a. Expanding spiral with positive value of constant a (0.119)

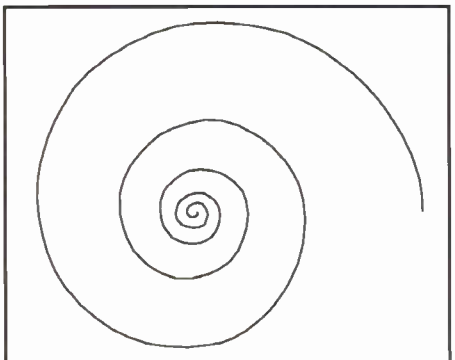


Figure 7b. Contracting spiral with a negative value of conatant a (-0.119)

logarithmic spiral with his anticipation of the hereafter. This was apparently a somewhat shortened version of is original phrase 'Eadem mutata resurgo semperdem' he had used in his 1692 paper - though transformed, I shall arise again unchanged, again and again. One of the key properties of the logarithmic spiral is its power to regenerate itself in scaling of co-ordinates.

Convergence of Symmetry

It can be shown that the logarithmic spiral, the Fibonacci number sequence and the Golden Mean are all linked together. The Fibonacci number sequence is that sequence where the following number is the sum of the two previous numbers. Thus the sequence is 1,1,2,3,5,8,13,21.....

The Golden Mean is expressed as the

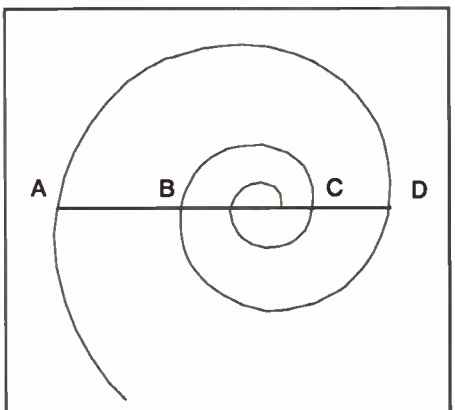


Figure 8. Determining the constant a for a logarithmic spiral. It is easy to measure radii at points indicated

value 1.61538 and is variously derived, and was well known from Ancient Greek times. The number is also described as the Golden Ratio or the Golden Number. If we calculate the values of 8/5, 13/8, 21/13 etc. as ratios of successive values in the Fibonacci sequence, then the limiting value is in fact the Golden Mean itself.

The Golden Mean can also be calculated from basic mathematics. If we have a line which we divide in lengths unity and length Δ as indicated in Figure 9. One interpretation of the Golden Mean is that the ratio (Δ/1) is equal to the ratio of (1/(1 +Δ)). Then

$$\Delta+\Delta - 1 = 0$$

We can see in the figure, as we make Δ change from small to larger values, the Golden Mean is produced when the two curves cross over.

After solving the equation for d the positive root of the expression is given a value:-

$$\Delta = (-1+5^{0.5})/2, \text{ or } 0.6180339887..$$

If we form a sequence of squares as in Figure 10 where the side of a larger square is made from the sum of two smaller squares, we can fit into it a logarithmic spiral which increases its size by the factor of the Golden Mean in a quarter revolution as indicated in Figure 10. The angular constant is approximately 0.3063. Apparently for a Nautilus shell, the spiral increases by a factor of the Golden Mean after an increase in angle of 180° -

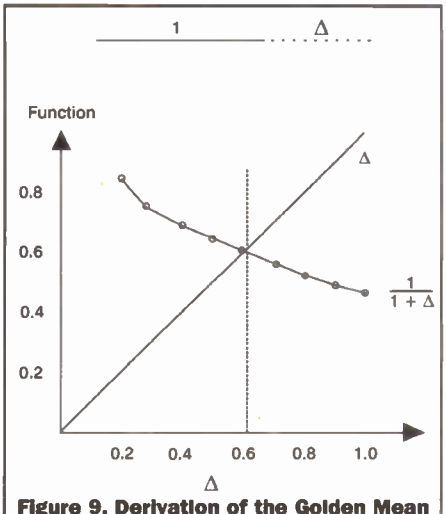


Figure 9. Derivation of the Golden Mean

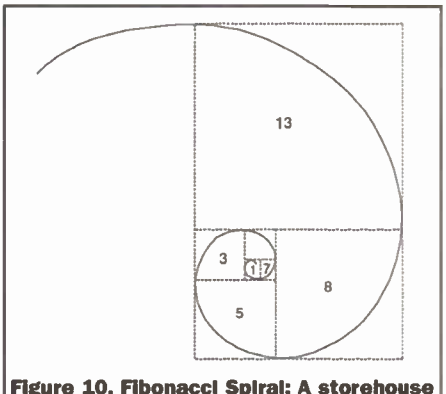


Figure 10. Fibonacci Spiral: A storehouse of symmetry

corresponding to an angular constant of 0.1519.

Clearly, the structure of Figure 10 is a very special one and represents a convergence of symmetry linking a range of mathematical identities. It has been much used for architecture and design in general.

It is interesting to reflect on linking the geometry of the Golden Mean to our system of sound scales. We can express semitones on an equivalent 'Golden Mean' scale as:-

$$f = f_o\, e^{(\ln(1.618034)*n/12)}$$

where we have defined an increase in frequency of a factor of 1.0258 between semitones and the frequency increases by a factor of 1.618034 between 12 equivalent semitones. The short programme NOTES indicates how notes can be created to correspond to any set geometric scale. For the equal temperament scale select a ratio of 2 and for one reflecting the golden mean select a ratio value of 1.618034.

```
10 REM NOTES
20 PRINT "input start frequency (Hz)"
25 INPUT f0
30 PRINT "input ratio of frequencies
   after 12 semitones"
40 INPUT ratio
50 FOR jj = 1 TO 12
60 note = f0 * EXP((LOG(ratio) / 12) * jj)
70 PRINT jj, note
80 SOUND note, 3
90 NEXT jj
```

As if we should ever forget that our principle organ of hearing, the cochlea, resembles a logarithmic spiral. It has an angular constant of around 0.38714 so it is therefore expanding more rapidly than the Fibonacci spiral. Which branch of our long evolutionary cycle is responsible for the selection of this geometry?

Logarithmic spirals can also be seen on the base of pine cones moving away from the base attachment point. On sunflowers the spiral of seeds can be observed radiating from the centre of the seed head. Also, on the crown of various species of cacti, spines appear to radiate in logarithmic spirals.

Moore's Law and The Golden Mean

What we do find in our society today in terms of measuring the extent of our technological development is a logarithmic function. If we plot the gate density as a function of time, then the gate density appears to be doubling within a period of around 18 months. This has been apparent since the 1960's when estimations of chip densities first became practical to evaluate. This relationship is already fundamentally influencing our technological and employment infrastructures and looks certain to dominate trends in the future.

Using the direct exponential form of the relationship we can write :-

$$y = yo\, e^{(\ln(2)\, t/1.5)}$$

where t is the time in years from level of technology level yo.

Thus the rate of change of the technology graph is ln(2)/1.5 times the value of the function itself. This is certainly a very strong linkage. The question arises, is this indicative of an intrinsic law of evolution?

We can write this expression as y = yo $^{(\ln(1.618)\, t/380)}$ where 1.618 is the value of the Golden Mean. This is another way of saying that technology is advancing by a value of the Golden Mean every 380 days!

Summary

We live in an age when there exists much more in the way of technology to demonstrate the inherent significance of the number e and various of the key functions derived using it. In particular the logarithmic spiral offers up a whole world of symmetrical relationships and geometric symmetry which is also reflected in the natural world.

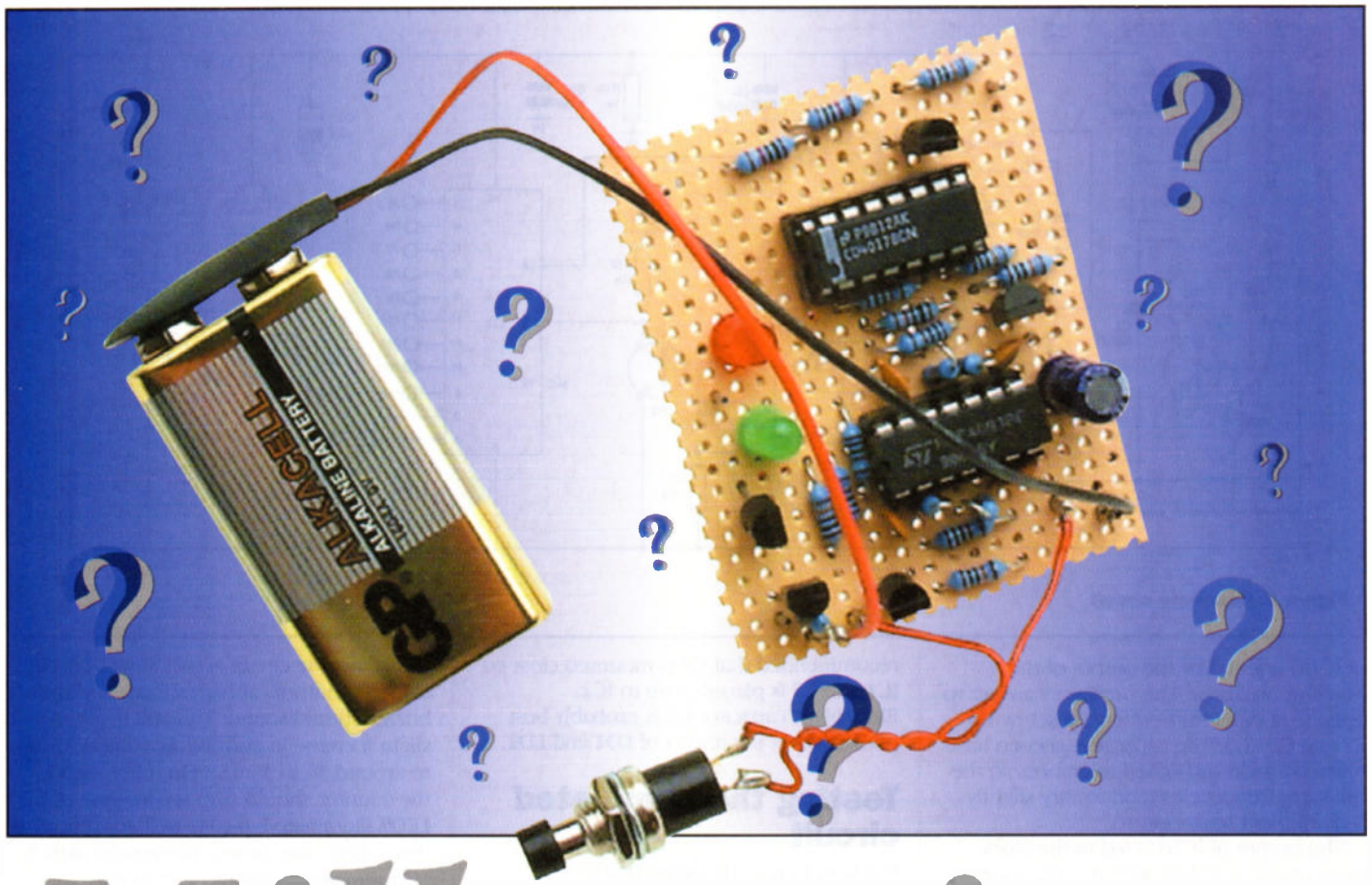

Photo: Courtesy N. Clark Huntarian Museum

Points of Contact
Bernoulli Society, Professor WS Kendall, University of Warwick, CV4 7AL.email w.s.kendall@warwick.ac.uk
http://www.math.ruu.nl/bernoulli/logo.html

Further Information
The Golden Mean
http://www.mathsoft.com/asolve/constant/gold/gold.html

Fibonacci Spirals
http://www.ee.surrey.ac.uk/Personal/R.Knott/Fibonacci/fibnat.html

Logarithmic Spiral
http://www.treasure-troves.com/math/LogarithmicSpiral.html
http://www.notam.uio.no/%Eoyvindha/loga.html



Millennium DECISION MAKER

Gavin Cheeseman describes a simple novelty to help you survive the millennium

Introduction

Many games and other activities rely on a deliberately introduced element of uncertainty over which there is no direct control. This usually involves throwing dice, flipping coins, spinning wheels etc. Over the years, many designs have been produced for electronic circuits that attempt to emulate traditional methods, some more effectively than others. Typical examples are electronic dice and roulette wheels. Commercial products of this type are now often based on microprocessors or purpose designed IC's but simpler circuits using discrete components and logic IC's can still be both fun to build and educational.

In order to be usable the circuit must be capable of producing a result that is unpredictable and ideally entirely random. The production of truly random results is not as simple as it may sound and most circuits rely on generating an output that, although not truly random, is practically unpredictable in the normal operating environment. Simple circuits often indicate the result by lighting one of a number of LED's. This arrangement is relatively straight forward and inexpensive to implement. Other types of display such as LCD may be used but often the cost can be prohibitive when producing a one off circuit.

Circuit description

Figure 1 shows the circuit diagram of the decision maker. Transistors TR1, TR2 and associated components control the power supply to the rest of the circuit. The main function of this stage is to switch the circuit into standby mode automatically when the unit is not in use. The circuit is switched on by temporarily connecting terminals P3 and P4. In practice this operation is performed by momentarily operating a simple 'push to make' switch. When the switch is closed TR1 is switched on. As a result C1 is discharged and current flows in the base of TR2 via limiting resistor R5. TR2 is switched on connecting power to the rest of the circuit (+V1). When the switch is released disconnecting P3 from P4, TR1 switches off and C1 starts to charge via R5. The charge current partially flows through the base of TR2 ensuring that the transistor remains active until the capacitor has almost fully charged. During this period, the power supply remains connected to the circuit. Resistor R13 helps to ensure that the circuit switches off correctly.

IC1 is a CMOS 4093 quad Schmitt NAND gate IC. Each section is configured as a separate oscillator that (with the exception

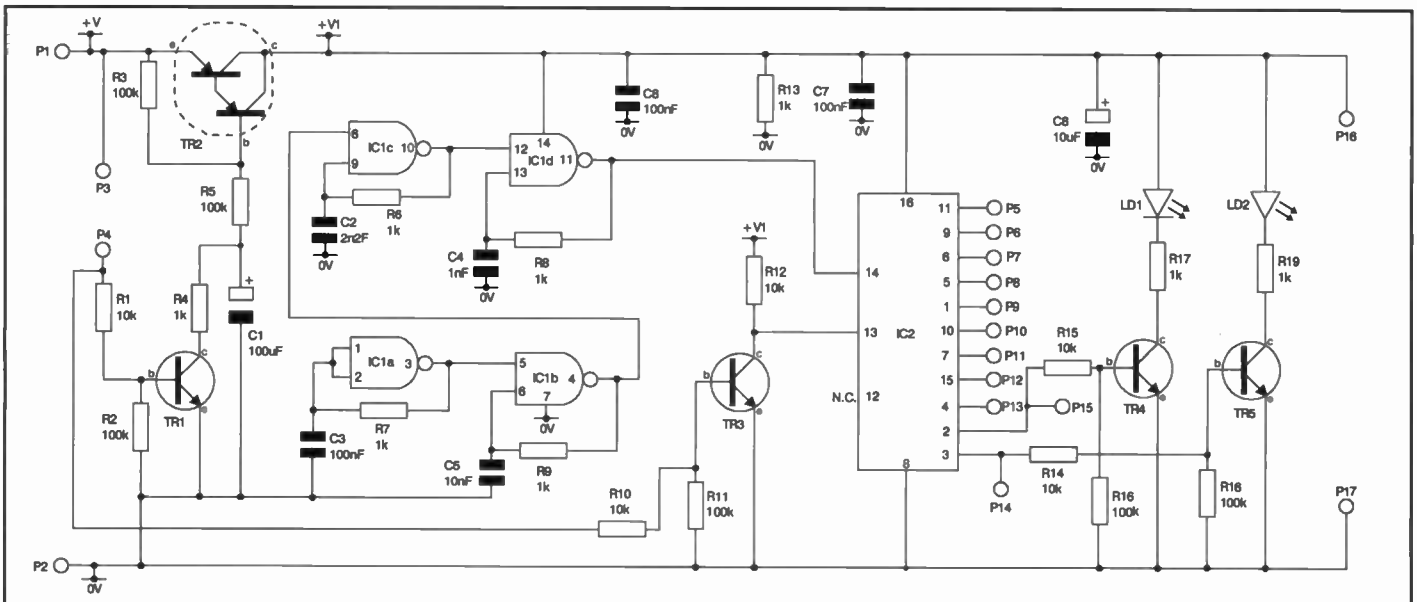


Figure 1. Complete circuit

of IC1a) is gated by the output of the previous oscillator. The oscillators are set to operate at different frequencies set by R6 - R9 and C2 - C5. The capacitors chosen have relatively wide and varied tolerances so the oscillator frequencies tend to vary slightly with ambient temperature.

The output of IC1d is fed to the clock input of IC2, a CMOS 4017 decade counter. The clock inhibit line of the counter (IC2 pin 13) is controlled via TR3. Normally IC2 pin 13 is held at +V1 potential by R12 inhibiting the counter. However when terminal P3 is connected to P4, TR3 is switched on pulling the inhibit line low. In this condition the clock pulses applied to IC2 pin 14 increment the counter. Terminal P12 allows access to the reset line of IC2 and may be connected to any of the IC output terminals so as to reset the counter when the relevant output changes to logic high. In normal use, only two of the outputs are required, so P12 is connected to P13 and the counter is reset each time a logic high appears on P13. When P3 is disconnected from P4 the counter's inhibit line goes high and the count stops.

The outputs at IC2 pins 2 and 3 are connected to transistor switches formed by TR4 and TR5 respectively and in turn these drive LED's LD1 and LD2. When P12 is connected to P13 the counter will always reset on reaching 2 (the count starts at 0). Therefore when the counter is stopped either LD1 or LD2 will remain illuminated until TR2 disconnects power to the circuit after a few seconds.

Construction

Building the circuit is relatively straight forward and does not require the use of specialised construction techniques. Almost any of the standard methods of construction may be used including PCB and matrix board. The IC's are CMOS types so take care to avoid static damage as far as possible. Use of DIL sockets is recommended to avoid thermal damage during soldering and to implify replacement should this be required. Layout is not too critical. However it is recommended that C6 is mounted close to IC1 and C7 is placed close to IC2. Electrolytic capacitor C8 is probably best positioned in the region of LD1 and LD2.

Testing the completed circuit

It is best to test the circuit before it is installed in any final housing. The circuit is designed to operate from a 9V PP3 type battery; alkaline types are recommended. A bench power supply may be used when testing the circuit as long as the output is suitably short circuit protected or current limited (100mA is adequate). If available, a multimeter set to read current may be connected in series with the positive power supply line when testing the circuit. Unexpectedly high or low current readings can provide an early indication that all is not well with the circuit. An oscilloscope is also useful to check the outputs of the clock and counter stages but this is by no means an essential requirement.

Clip the battery into the battery connector. When power is first applied one or other of the LED's may illuminate. This is normal as TR2 is switched on by the charging current of capacitor C1. After a few seconds the LED should dim and extinguish. When the LED is illuminated the current consumption should be around 20mA falling to less than 10µA after the circuit has switched to standby (off) condition. Press and hold S1 for a moment and then release. During the time that the switch is depressed both LED's should appear to light (in actual fact the circuit is switching between alternate outputs at high speed) and the buzzer should sound. This will result in a slight increase in current consumption (up to around 30 to 35mA). On releasing S1, the counter should stop leaving one of the LED's illuminated. If all is well, try repeating this action a few times. The results (which LED remains lit) should vary in an apparently unpredictable manner. This is not to say that each time the switch is pressed the result will be different as that would clearly be predicable. Successive presses will often result in the same LED remaining on in a similar way that a flipped coin may land on one side several times in a row but equally the result could be different. If S1 is not pressed for a few seconds the circuit should revert to standby condition with both LED's extinguished.

PROJECT PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless stated)

R1, 10, 12, 14, 15	10k	5	M10K
R2, 3, 5, 11, 16, 18	100k	6	M100K
R4, 6-9, 13, 17, 19	1k	8	M1K

CAPACITORS

C1	GenElect 100µF 16V	1	AT40T
C2	Ceramic 2200pF	1	WX72P
C3, 6, 7	Minidisc 100nF 16V	3	YR75S
C4	Ceramic 1000pF	1	WX68Y
C5	Disk 10nF 50V	1	BX00A
C8	GenElect 10µF 63V	1	AT77J

SEMICONDUCTORS

IC1	4093BE	1	QW53H
IC2	HCF4017BEY	1	QX09K
TR1, 3-5	BC548	1	QB73Q
TR2	MPSA65	1	QH61R
LD1	5mm Red LED	1	WL27E
LD2	5mm Green LED	1	WL28F

MISCELLANEOUS

P1-17	Pin 2145	17 pins	FL24B
	DIL Socket 14-Pin	1	BL18U
	DIL Socket 16-Pin	1	BL19V
S1	Red Push to Make Sw	1	FH59P
	PCB Buzzer	1	KU58N
	PP3 Clip	1	HF28F

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

Microsoft and the Dark, Dark Alley

Dear Sir

I get a little tired of reading pieces about the evils of Microsoft, usually written by people who never laid hands on a computer before 1990. Microsoft has often behaved badly and been a bully. But...

When I first started in Computers in 1980 there were a proliferation of computers from different manufacturers, all of whom (Unisys, Digital, IBM, HP etc) were running their own little defacto monopolies. The machines were sky-high expensive and very complex to use. Operations that, today, we regard as more or less trivial - setting up a modem link, exchanging documents or files from one machine to another, sending a message to a distant user on a different manufacturers computer etc - were expert jobs, or just plain impossible. I personally was paid for two days consultancy in about 1984; the job was to copy two small files from an IBM machine to a Digital Equipment Co VAX computer - and that level of difficulty was the norm back then. Unless you were using computers in those days you can have no inkling of how painful it could all be. There were no windows systems - you had to type in enormous long commands all the time - and there were no automatic installations or set-up procedures. Everything was very complicated.

The computer industry user groups of the 1980s were crying out to the 'big boys' for interoperability between computers. The big boys were dragging their feet all the way because they - correctly - foresaw that providing interoperability would lead to the commoditisation of computing - what UK technology entrepreneur Alan Sugar described as "Computing for truckdrivers". Commoditisation automatically implies cut-throat price competition and that was something that the computer industry of the mid-late 1980s could not face up to because it was fat and happy. Another very important feature of the 1980s computing scene was that IT departments were seen as fortresses inhabited by empire builders upon whom the rest of the company could exert very little leverage - simply because the technology was so little understood by those outside the fortress. There was therefore a hunger amongst the non-IT departments to get back some control over their data.

The achievement of Microsoft was to identify a platform (the Intel chip) that could be mass-produced at commodity prices, to create a visually appealing user interface (Microsoft Windows) that was a lot easier to use than what was around then, and to create a package of useful applications which could inter-operate with one another. By taking this package to market at a price that was way below the prices of the 'big boys' they not only managed to appeal to the non-IT departments in industry, but also to begin to make it feasible to have a computer at home. This strategy succeeded on almost all counts. In my opinion it is no accident that the rise of PCs coincided with the 1980s fashion in industry for devolved management styles, and the tendency to concentrate on purchase costs whilst ignoring the true cost of ownership. Those people in industry who had been critical of their IT departments could now buy a PC or two and keep all their data within their departments. Better yet, the machines were quite easy to use and maintain and you could easily exchange data with other departments (who had also bought a PC) and cut out the IT department altogether. So, intentionally or not, Microsoft rode on the back of organisational trends in industry and the desire for interoperability between systems and - effectively - won the race. One by one the old-guard computer giants had to come to terms with commoditisation and embrace it. The old vested interests made many attempts to arrest Microsoft's runaway success, as did other competitors who wanted to be commoditisers. However, through a combination of sheer momentum, business acumen, popular support and sometimes utterruthlessness, Microsoft prevailed. Microsoft commoditised, democratised and sanitised computing and we should all be very grateful to Bill Gates - at least for that. Whether that gratitude should take the form of $10bn personal fortune is a different and far more difficult question. Whether Microsoft's achievement of democratising computer availability would survive the fragmentation of Microsoft is a dark alley, and I for one would sooner not go there.

So, I say, Microsoft is not perfect and neither are its products - but hey, it's a lot better than what went before! But you need to have used the older stuff to appreciate that - and I don't believe that most of the scribblers on this subject have that perspective.

Alan Trevennor
e-mail

I think I can go back a little earlier - to Fortran, punch tape/cards and waiting 48 hours to find out that you missed a comma out in your program and it would not run! But as you rightly say, it was the advent of Windows and the accompanying software that finally saw the demise of all the other various computer possibilities (except one), plus, I believe, the 'engineering' aspect of the PC. Like the BBC 'B', you could take the lid off, poke about inside and with the help of bolt-on extras, make the machine do all sorts of interesting things. Plus you could build one from scratch using readily available boards etc. (this was how I got my first PC).

However, you did not mention one other computer whose operating system was way ahead of Windows, and that is still very much around today - the Apple Mac. While we were all playing with DOS, Mac users had the luxury of a graphical user interface. Perhaps if the cost of a Apple Mac and its software had not been so high, things may have been very much different today.

Tacky Father Christmas!

Dear Sir

The front cover of your December issue is 'tacky'. Father Christmas is supposed to be a fat jolly old bearded gentleman, swathed in furs.

If you really believe that your aim in life is to find an excuse to get a scantily clad young female onto the front cover then perhaps you should get a job with a tabloid newspaper!

One feature of the issue pleased me enormously. I wrote to suggest a radio microphone project a couple of years ago. I hope to modify the front end to take an instrument as well as a microphone.

Keep up the good work but leave the pin-ups to the girly mags!

Gerry Bates
Sheffield.

Well, we could never be accused of being boring! Hopefully, it made readers sit up and look, and see what was on offer! We felt it was a nice way to see out the old century and herald in the new millennium. You will notice that this front cover is back to normal (anyway, who would you rather see coming down the chimney!?) We are pleased that you found John Dakin's project enjoyable, there should be no problems in adapting the circuit to fit your requirements.

RESEARCH NEWS

by Dr Chris Lavers

In the December issue of Electronics & Beyond recent developments in solar cell technology was featured by Mark Hammonds of BP Solarex; unsurprisingly major developments are also taking place in the storage of electrical power from the smallest scale to the largest.

National Power has recently unveiled its proposed Regenesys system, marking a major step forward in the technology of energy storage. Regenesys must have a rapid response time, supplying power on demand. National Power plans to construct a 100 MegaWatt hour power plant at Didcot. At the heart of the new storage system is a redox (reduction/oxidation) flow cell. Electrical energy is first converted into stored chemical potential energy by charging two different salt solution electrolytes and then subsequently releases the stored energy in the discharging mode. Most secondary, or reversible batteries use electrodes as part of the electron transfer process and also to store the products or reactants. Consequently both energy storage capacity and the power rating depend upon the electrode's size and shape. In regenerative cells, however, these electrodes are inert and do not take part in the electrochemical processes involved or limit the cell's storage capacity. The power level is determined by the electrodes area and the energy is determined by the electrolyte volume used. The conversion of electrical to stored chemical energy and finally back again to electrical energy can be repeated many times with no significant degradation of long term cell performance. Regenesys fuel cells will probably be linked together in modules to provide the power levels required in a realistic system. Modules are linked in series to form the desired DC voltage, and additional modules may be added in parallel to give the required power rating. Electrolyte storage tanks of the necessary volume are added to establish the energy rating of the system and the storage capacity is restricted by the size and number of the tanks.

The planned Didcot plant should provide energy for Southern Electric's 33kV distribution system. The start up time 'from cold' should be under 10 minutes, or if in 'standby mode' with electrolyte filled modules, less than two minutes. The plant must have a rapid dynamic response and when connected to the National Grid must be capable of being switching from a fully charged to a fully discharging mode in 0.02s.

At the smaller end of the market Philips Research in the Netherlands has just revealed a technology that may revolutionise the battery manufacturing industry. Philips' technology includes an innovative process enabling thin rechargeable batteries to be manufactured with higher production yields and lower costs than manufacturing methods currently used. With this new process batteries will also be safer and offer a higher charging capacity than similar batteries of the same size. The production process works from single batteries up to multiple battery stacks, making it suitable for applications in mobile phones and laptop computers. Manufacturers have seen the market for thin rechargeable batteries (2.5mm to 4mm thickness) grow over 200% in the last few years and this trend is set to continue.

Philip's new process uses Lithium-ion (Li-ion) cells (or Lithylene™ 'holes-technology') and a special polymer employed to hold the battery stack together, are the two significant differences compared with existing technology (Figure 1). Part of the manufacturing process involves making microscopic holes in the battery components (electrodes and electrolyte separator), and pushing a special polymer through these holes under controlled heat and pressure conditions. Once the polymer cools it sets hard, and keeps the cell's active materials together, providing a very stable battery structure. The polymer's material characteristics ensure that there is sufficient pressure to provide electrical contact between the different layers in the battery, eliminating the need for a conventional metal can. Without a can, significant amounts of space can be saved in thin batteries saving over 30% in volume.

Laboratory tests have shown that batteries manufactured with this process are safe as the micro-porous membrane melts if the battery overheats, closing the membrane pores and preventing excess current from flowing from one electrode to another, so that no thermal runaway effect can occur. Like other rechargeable Lithium batteries a battery made using

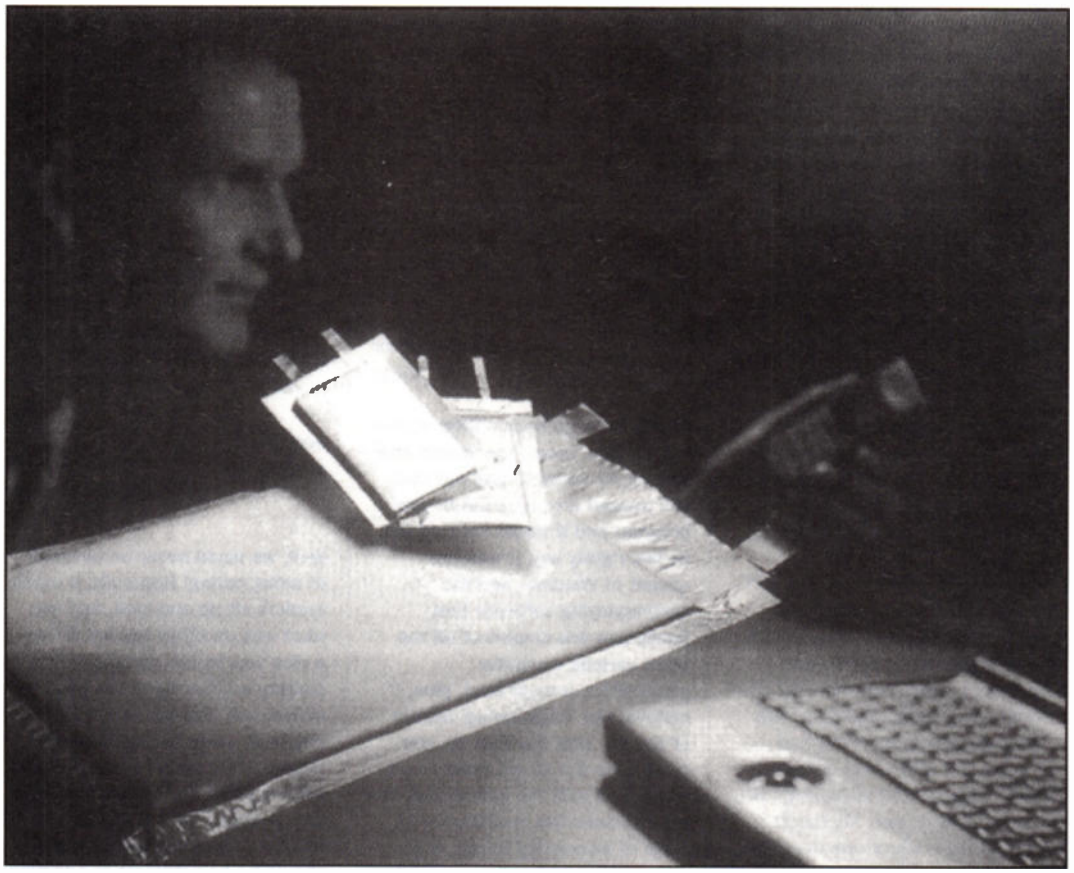


Figure 1. Lithylene™ new battery technology. Courtesy of Philips Research.

this process would also require safety electronics installed to prevent over-charging and provide current limiting.

The good news for battery manufacturers is that production methods for this process are simple so that there are less processing steps for manufacturing faults to occur, and higher production yields can therefore be achieved. The process uses Li-ion battery manufacturing technology which is environmentally less damaging than conventional Nickel-Cadmium (NiCd) technology. Philips Research is confident that this new process will reap handsome rewards for battery manufacturers, especially with the way the market has grown in recent years.

More information can be found at **www.lithylene.philips.com** or by contacting:

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IRFPA Sensors

Researchers at Napier University in Edinburgh led by Dr T Binnie and Dr Alistair Armitage have 'raised the temperature' in developing low-cost pyroelectric Infra Red Focal Plane Array (IRFPA) sensors. Pyroelectric polymers have the potential to be used in a large number of applications making low-cost infrared sensors commercially viable. These materials are available commercially in metal-coated thin-film sheets of different thickness. Alistair recently demonstrated an IRFPA using Complementary Metal-Oxide-Semiconductor (CMOS) technologies; offering technical and economic advantages if the readout circuitry, signal processing and sensor can be integrated onto a single chip.

Pyroelectric materials are polar and respond to thermal radiation by changing the orientation of a built in electric dipole. The process is caused by the polymer absorbing incident heat radiation which causes a change in the material's temperature. These materials are broad-band absorbers across most of the middle infra-red and far infra-red spectrum and have a relatively fast response compared with other thermal detectors such as bolometers and thermocouples. The technical aspects of the IRFPA is relatively simple. The sensing structure consists of a thin film pyroelectric polymer bonded to a silicon substrate. Exposure to chopped thermal radiation induces a small oscillation of the mean temperature of the polymer resulting in a varied charge on the sensor electrodes. This charge is transferred to silicon and detected by subsequent charge sensitive electronic circuitry. In an array format with on-chip or monolithic signal processing and pixel addressing, the sensor is capable of discriminating infra red radiation between 7 to 14μm. The sensor is based on Polyvinylidene Fluoride (PVDF) thin films which is attractive because it is commercially available, pre-poled and is intrinsically absorbing in the infrared.

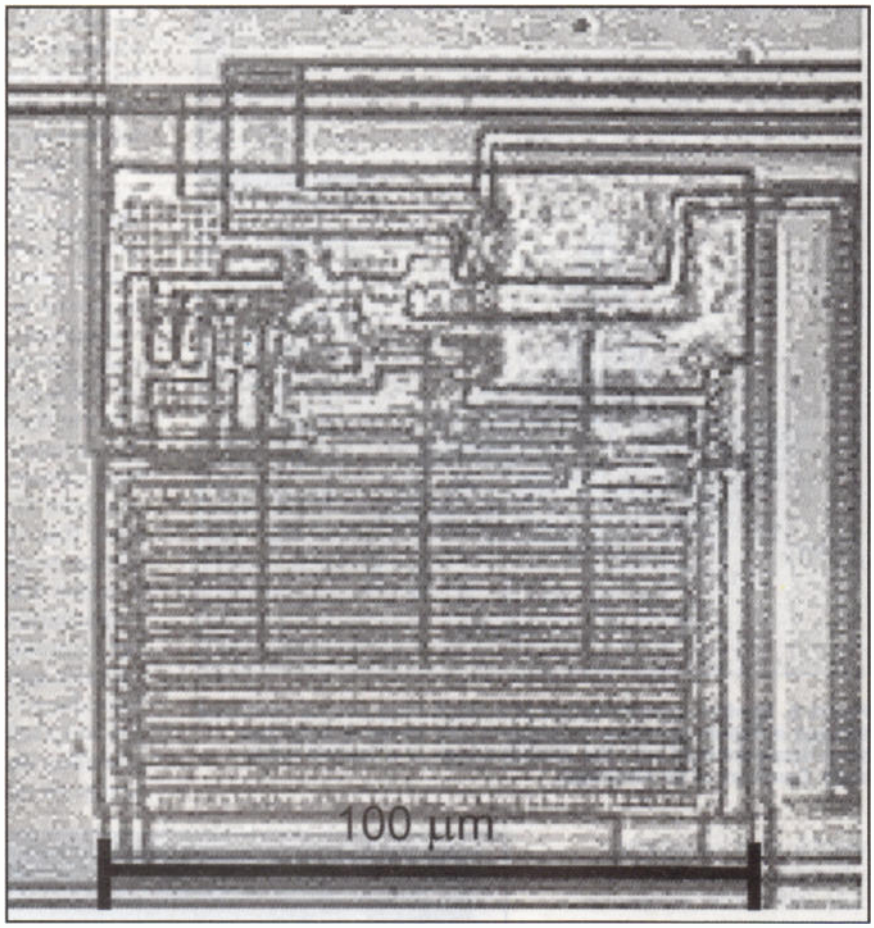

Figure 2. Microphotograph of single pixel-CSA structure Courtesy of Dr Alistair Armitage Napier University Edinburgh.

Table 1 PVDF focal plane array characteristics. Courtesy of Dr Armitage.

Parameter	Value	Unit
Array resolution	16 x 16	--
Array size	2.1 x 2.1	mm^2
Pixel size	10^5 x 10^5	μm^2
Pitch	130	μm
Mean responsitivity	2200	V/W
Noise voltage	13 x 10^{-9}	$V/\sqrt{Hz}$
NEP	2.7 x 10^{-11}	$W/\sqrt{Hz}$
D*	4.4 x 10^8	$cm\sqrt{Hz}/W$

The Charge Sensitive Amplifier (CSA) has a large DC gain and bandwidth. A microphotograph of a single pixel-CSA structure is shown in Figure 2 having 100μm dimensions. A double metal layer CMOS process is used. The minimum array pitch is determined by the pixel size, the electrical connections necessary to run to and from each pixel, and by the CSA integrating capacitor which cannot be placed under the upper metal layer. Typical PVDF based focal plane array characteristics are shown in Table 1. At a chopping frequency of 10Hz, chosen as this is the typical rate of flicker for a flame (useful for a commercial product), the mean voltage responsivity is 3.51kV/W. Spatial measurements have been obtained by placing a small aperture between a calibrated black body source and the sensor. The output voltage after a single frame scan is plotted in Figure 3.

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Patience Rewarded!

At long last Space Imaging in Colorado has succeeded in launching its Ikonos satellite which will provide 1m resolution imaging from space, important for: map making, oil and gas exploration amongst many other applications. The market for high-resolution imaging is enormous. This is the second Ikonos spacecraft to be launched by a Lockheed Martin Astronautics Athena II launch vehicle. After many delays, (Space Imaging was first featured in a Research News article back in August 1997), and the failure of the first Athena II launch to put an identical satellite into orbit on April 27 1999 success has finally been achieved. Apparently the first failure was due to separation failure of the launcher's payload shrouding causing it to burn up in the Earth's atmosphere. Ikonos'

digital imaging sensors can provide pictures with 1m resolution in black and white or 4m resolution in colour. Representative high-resolution imagery is shown of Cupertino in California in Figure 4. One metre resolution quality will be

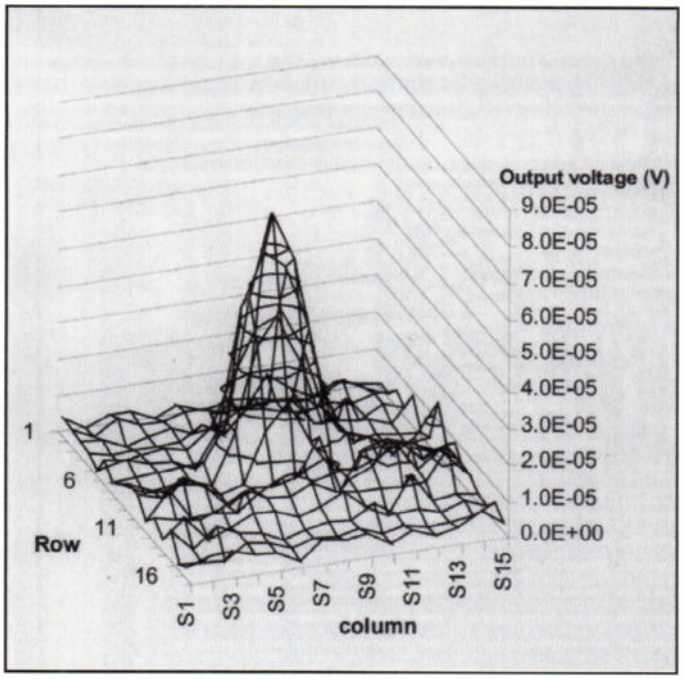

Figure 3. Spatial representation of a black body source observed through a 0.6mm aperture. Armitage's 256 element array has been demonstrated with the spatial image of a heated black body. Courtesy of Dr Armitage.

available after testing and calibration is completed in early 2000. Other companies are also in the running to provide digital imaging services including Orbimage based in Dulles, USA. Orbimage currently operates two satellites: Orb View-1 a weather monitoring satellite and Orb View-2, the world's first source of daily multispectral Earth imagery. Two high-resolution satellites are currently in production: Orb View-3 with a 1m panchromatic and 4m multispectral imaging capability similar to Ikonos, and Orb View-4 with hyperspectral imaging capability in addition to Orb View-3's abilities. Orb View plans to provide unique radar imaging information from RadarSat-2 in 2001. Customers are in no shortage for such high-resolution imagery with Orbimage already believed to have $500M in orders.

The Ikonos launch was the third in the Athena II program, which includes the Lunar Prospector launched in January 1998, recently deliberately crashed! into the lunar surface in order to establish once and for all the presence of frozen ice and other useful materials in the lunar polar regions. Analysed data failed to detect water. Hopefully Ikonos' success will end a string of recent US launch failures which has stunned market analysts in an otherwise successful aerospace industry. Lockheed Martin has lost several satellites, including two military satellites launched on 9 April and 30 April 1999 worth respectively $682M and $800M. The loss of a second Mars Orbiter, the Mars Climate Orbiter, presumed to have broken up in the planet's atmosphere on 23 September, is also extremely embarrassing for NASA, potentially revealing a flaw in the mentality of "faster, better, cheaper". The Mars Climate Orbiter was supposed to enter orbit no lower than 155km from the surface, however it descended to within 57km due to a faulty metric/imperial conversion and not surprisingly burnt up. The problem appeared to have been due to incorrect figures fed into a software package for modelling back on Earth. Computer modellers beware!

NASA was pleasantly surprised to find that its latest space science budget was cut by only $44M instead of the anticipated $184M -the price of another Mars Orbiter mission.

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Figure 4 Space Imaging Simulated Satellite Imagery courtesy of Space Imaging.

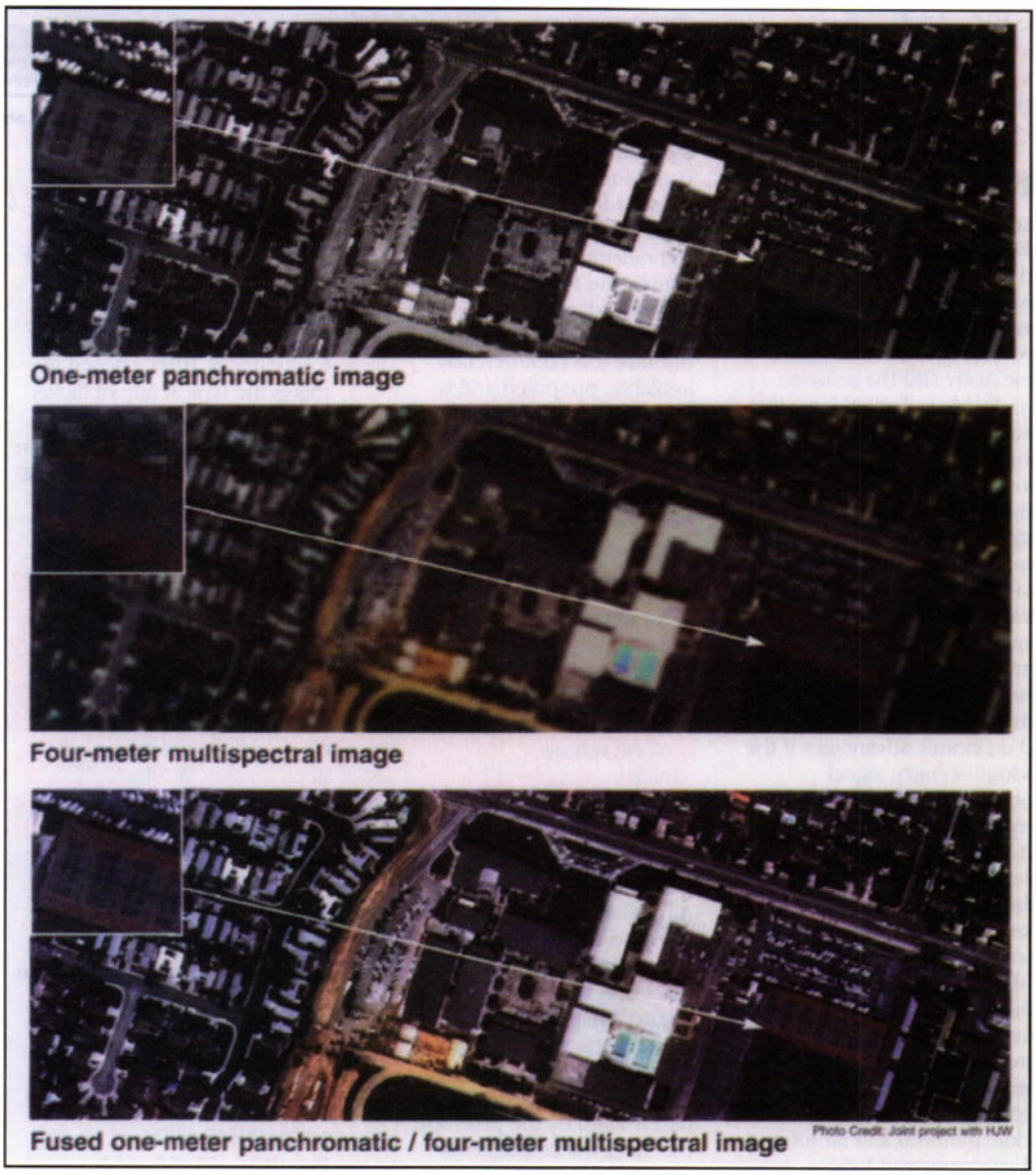
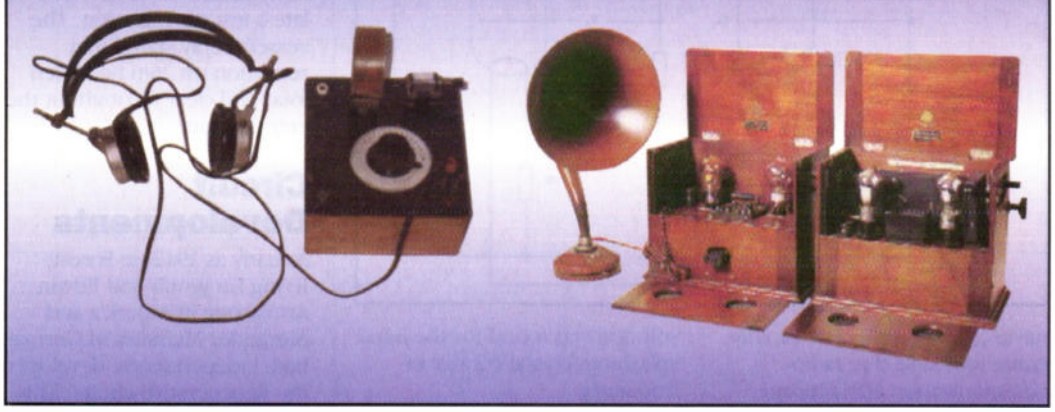


Figure 4. Space Imaging Simulated Satellite Imagery. Courtesy of Space Imaging.

An Electrifying CENTURY

THE RISE OF ELECTRONICS 1900 - 2000

In this second part, Gregg Grant journeys back to 1925 when speech could be heard across the World.



The Beginning of Electronics

In 1904, the British electrical engineer John Ambrose Fleming patented the diode valve which, he suggested, could be used for the rectification of high frequency currents. The phenomenon that Edison had discovered 20 years earlier, that of the passage of electrons across a vacuum, had found a role at last.

Two years later, the American inventor Lee de Forest made the second fundamental discovery in the field of electronics and electrical engineering, the amplifying thermionic valve. He applied for a patent for his invention - towards the end of the year which he termed an Audion, illustrated in Figure 1. De Forest's achievement - subsequently the subject of bitter patent litigation, only finally resolved in 1943 - would result in the grafting of speech on to a radio signal, thus revolutionising communications across the globe.

It would also, in the course of the next quarter of a century, lead to improvements in valves and other components, the further development of electronic circuitry, the study of noise and finally, the beginnings of radar.

Radio Communication

The year 1906 was auspicious in other ways. On the 23rd of March Henry C. Dunwoody - a close colleague of de Forest - applied for a patent on the Carborundum, or Crystal, detector and by Christmas Eve, the first successful speech and music broadcast had been made at Brant Rock, Massachusetts.

The Canadian-American engineer Dr. Reginald Fessenden, employing a Radio Frequency, (RF), alternator operating at 50kHz and delivering around 1kW of output power made this, the earliest documented, broadcast. The carrier was modulated by a microphone hard-wired into the antenna circuit. The reception was - apparently - quite clear, it being picked up at a number of locations as well as by ships at sea.

In the following year de Forest himself began broadcast trials from his New York laboratory. His system was virtually identical to that of Fessenden, consisting of an arc transmitter whose 0.5kW output was again modulated by a microphone strapped between the antenna and earth. In 1908 de Forest experimented with his equipment from the Eiffel Tower in Paris and - two years later - from New York's Metropolitan Opera House. In each location, he found that the major drawback in such a system was the high noise inherent in this type of transmitter.

It was at this time too that the American researcher G.W. Pickard found that other minerals besides silicon possessed detection properties. One was iron pyrites, which he termed Pryon and another was zinc oxide in hexagonal crystalline form - termed zincite - in close contact with copper pyrites. This combination Pickard termed Perikon, a term he derived from PERfect plcKard cONtact. Although perikon was very sensitive, it required a great deal of adjustment in comparison with silicon, which was stable and tough, capable of surviving quite heavy static discharges. Pickard's work would lead to the 'Cat's Whisker' radio of Figure 2.

Marconi's successful bridging of the Atlantic Ocean by radio led to the suggestion - made independently by Arthur Kennelly in America and Oliver Heaviside in Britain - that there was a conducting layer in the upper atmosphere, which 'bent' the signal such that it could follow the Earth's curvature.

Soon it became apparent that this could not explain the considerable field strengths being received at the distant terminals. In 1912 the British scientist William Eccles - in many ways the first physicist of radio - examined the phenomenon and developed his concept of ionospheric propagation, which he based on the ionising effect of sunlight and the refractive index of an ionised medium.

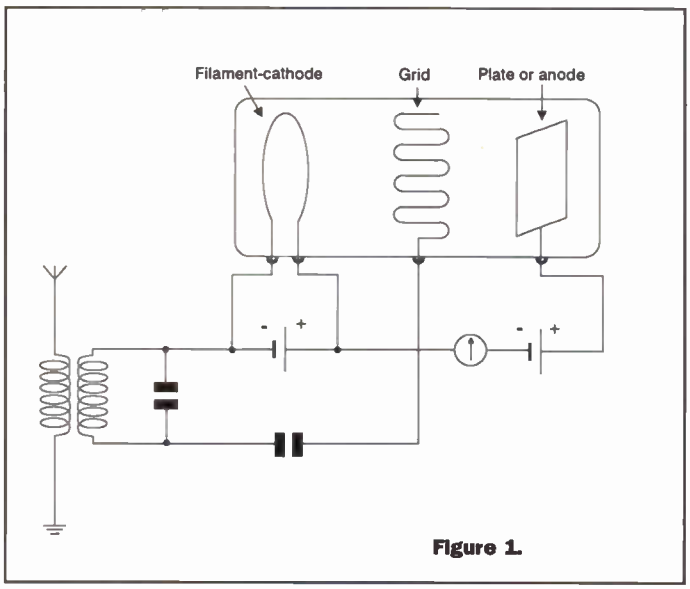


Figure 1.

Twelve years later another British physicist, Sir Joseph Larmor, having studied the work of Eccles and others, put forward the view that much of the refractive effect was due to the very considerable number of free electrons resulting from solar radiation. Larmor's work too would be further developed by physicists of the stature of Hartree, Appleton - a future Nobel prizewinner - Tuve and Breit so that, presently, the effects of the Earth's magnetic field and of oblique propagation are also taken into account.

Three years after Eccles had published his paper on propagation J. R. Carson, a research physicist with the American Telephone and Telegraph's (AT&T) research laboratory began investigating the bandwidth required for the transmission of speech over telephone lines. He swiftly proved that only one sideband was required for the transmission of intelligence and, in 1918, the earliest application of this development showed that, commercially, single-sideband transmission could indeed be used to increase channel capacity on a telephone line.

It was at this period too that the British physicist G. N. Watson began a mathematical study of radio wave propagation. He demonstrated that radio waves emitted by an antenna located on the surface of a perfectly conducting sphere were attenuated exponentially at a distance. His predicted field strengths were much lower than other known experimental values. In fact, radio communication was reaching something of a crossroads at this time, as the recent world conflict had shown.

Both the British and German navies, for example, had rapidly come to realise that radio communication was a mixed blessing. Arc and Spark-Gap transmitters were - to put it mildly - dirty radiators, blasting across broad swathes of the long and medium frequency spectrum. Consequently, a signal transmitted from a vessel at sea revealed its presence - if not its exact location - to any other vessel within range.

The radio operators of both navies could readily distinguish their own, or an enemy's, vessel by the note of its transmitter - in the case of the Germans almost invariably a Telefunken set, in that of the British a Marconi design - the class of signal sent, or each others' callsigns, and so could 'dead reckon' its range. Three years after the cessation of hostilities however, a solution was found for the band splashing: crystal control of frequency.

Figure 2.

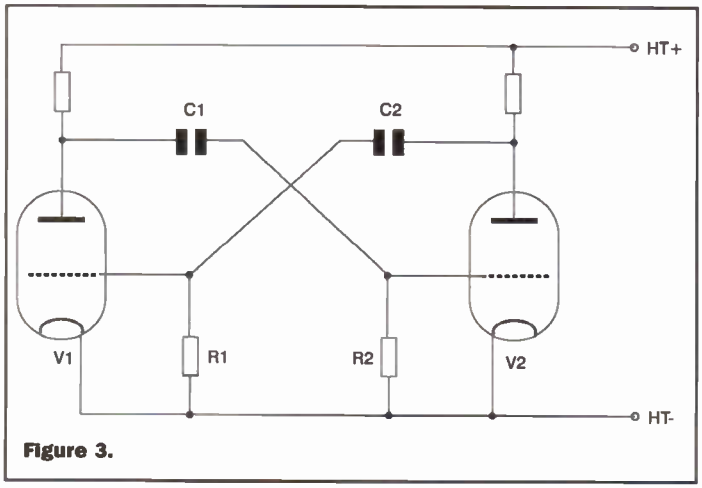


Figure 3.

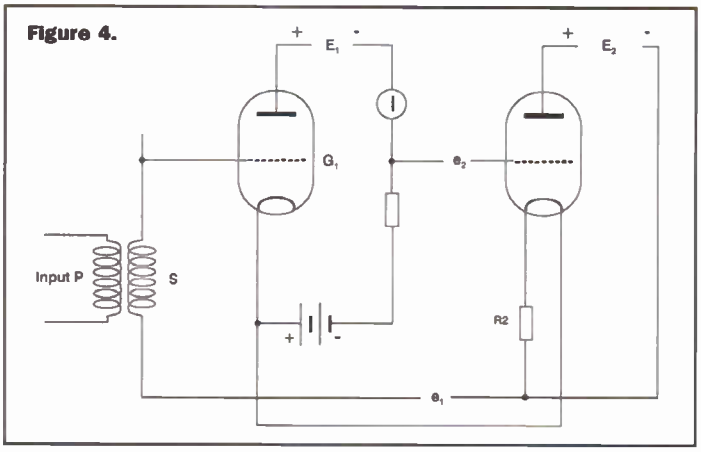


Figure 4.

Walter G. Cady was experimenting with a quartz crystal which he had connected in the circuit of a valve oscillator, when he found that the oscillating frequency could be stabilised by the crystal over a very small range. He then took matters further by connecting the crystal in a three-valve feedback circuit, so that the system would oscillate only at the crystal's resonant frequency.

In January 1923, Cady gave a demonstration of his circuit to Harvard University's Professor George W. Pierce and three months later, he was granted US Patent No. 1450246 for what he termed a Crystal Resonator. Pierce went on to develop a number of innovations where oscillators were concerned, among which was the single valve circuit that bears his name.

As the first quarter of the 20th century drew to a close, shortwave commercial radio communication became a reality. A Dutch research engineer, Jan Was van Boetzelaer, had just received a new, water-cooled transmitting triode from Philips of Eindhoven. This was no ordinary valve: producing an output power of 4kW, its grid-anode capacitance was low enough to enable it to generate oscillations at 11.5MHz.

Van Boetzelaer's employers, the Nederlandsche Seintoestallen Fabriek, asked the trading vessel 'Prins der Nederlanden' to keep a daily listening schedule for the test transmissions in the course of its voyage to the Dutch East Indies.

The transmitter's designer remained at the Morse key far into the night, hoping that his transmissions would be picked up. Gradually, the ship's results came back via the coastal stations en route and they were all encouraging. When the vessel reached the Malabar coast however, van Boetzelaer boldly asked the operator to reply directly if he received his latest test transmission. The vessel's reply stated that reception on 26m had been loud and clear throughout the entire voyage.

Circuit Developments

As early as 1912 de Forest, Irving Langmuir and Edwin Armstrong in America and Alexander Meissner in Germany had, independently, developed the Regenerative circuit. This provided positive feedback from anode to grid at the carrier frequency, thus improving circuit sensitivity. It was at this time too that a number of experimenters and researchers proposed the Superheterodyne system for radio reception.

Among the most prominent in this field were E. F. Alexanderson, Alexander Meissner, J. H. Hammon and, above all, Edwin Armstrong whose 1920 patent was the driving force behind the practical application of 'Superhets.' Indeed Armstrong's concept remains today the basic layout for all radio receivers.

Another crucial circuit development of the period was electromagnetic filters. In 1915, G. A. Campbell in America and K. W. Wagner in Germany were both working on filter designs. Campbell in fact had developed his inductance-capacitance, or L-C, filter as early as 1909, but did not issue his patent until 1917. Campbell was one of the earliest designers to analyse his circuits mathematically, as well as being one of the few design engineers at this time who understood the importance of filters. Filter design would

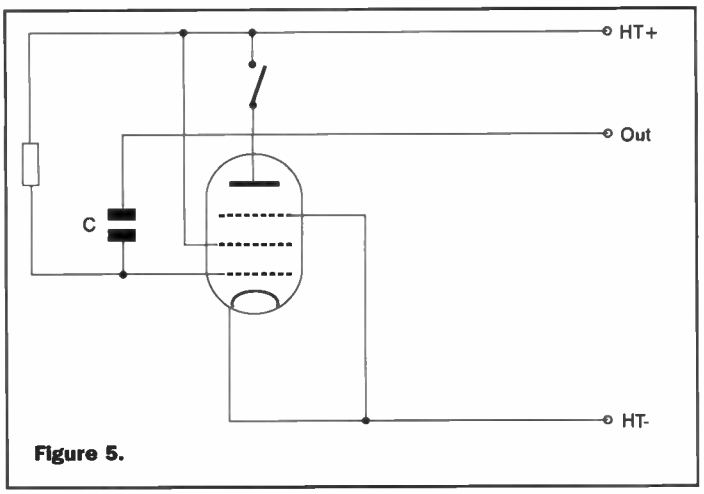


Figure 5.

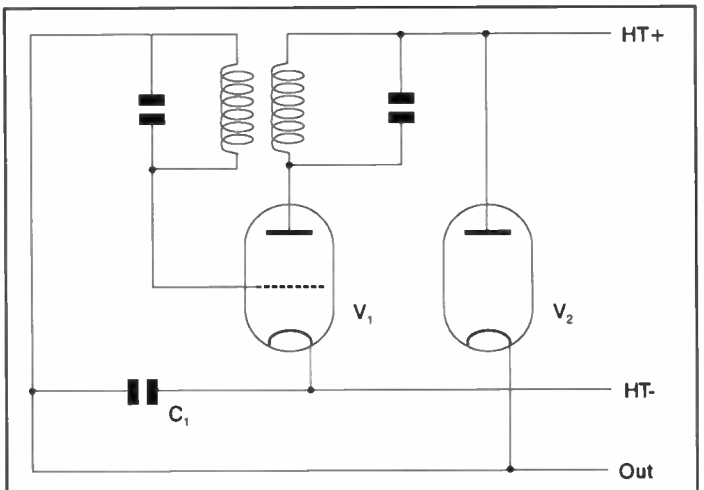


Figure 6.

continue to gain in importance such that today, it's virtually a separate discipline almost, within electronics.

Three years later H. Abraham and E. Bloch - working at the French Ministry of War - developed the Multivibrator circuit, shown in Figure 3 which, originally, was used as a pulse generator. In the following year the British researchers W. H. Eccles and F. W. Jordan developed the now near-universally applied bistable 'flipflop,' or 'one stroke relay,' circuit whilst working for the British Admiralty. This design - shown in Figure 4 - was the first digital electronic circuit.

By the late 1930s these circuits, strapped in tandem, were used to reduce the counting rate of Geiger-Muller counters. They were, in short, binary counters whose final 'carry' pulse was used to activate a mechanical register, a development which would lead - in time - to the advent of high-speed electronic counters. Another circuit development of the period was the Time Base circuit, one of the earliest being that of the American electronics engineer J. M. Millar, shown in Figure 5.

In 1923 another Time Base appeared, designed by Edward Appleton, J. F. Herd and Robert Watson-Watt. The Squegging Oscillator of Figure 6 employed a transformer-coupled triode valve which had a capacitor in its grid-cathode circuit. Each positive voltage peak at the grid drove current through the valve via the transformer secondary, building up an increasingly negative charge on C1, thus making the grid increasingly negative also.

In time, this action cut off the triode current along with the alternating grid potential. The circuit remained in this state until the charge on C1 leaked away through V2, to a point where oscillations were recommenced.

In the following year another British physicist, R. St. G. Anson, built what is generally regarded as the first linear time base. Some authorities believe that the circuit was the result of Anson's development of the relay called after him, in which he used a neon tube to shape the signal for use with telegraph receivers.

Electronic Detection and Ranging

As early as 1906 Telefunken in Germany and Marconi in Britain began to investigate the directional properties of certain types of antenna. Marconi shortly discovered that if the inverted 'L' antenna's horizontal section was made longer than that of the vertical segment, the polar diagram produced a large bulge away from the line of the horizontal section.

He went on to arrange several such antennas radially, around a receiver shack, and by opting for the antenna with the strongest signal, he found he could determine the general direction of the transmitter. Telefunken on the other hand concentrated on the transmit properties of the inverted 'L,' culminating in the system shown in Figure 7, which became known as the Telefunken Compass.

The transmitter sent a 'start' signal to the central antenna, which was followed by transmissions of 1-second duration on each of the 32-antenna array, spaced at each point of the compass around the equipment shelter.

A terminal using the beacon simply had to activate a stopwatch on receiving the 'start' transmission and then stop it the moment the received signal reached its maximum strength. The watch came with the equipment and had a sweep-hand which made one revolution of the watch-face in 32 seconds, the latter being calibrated in compass points.

In 1907, direction finding received a further boost with the invention of the Goniometer, by the Italian research engineer Alessandro Arton. At roughly the same time two of his fellow countrymen, physicists Dr. Enrico Bellini and Alessandro Tosi, developed the system shown in Figure 8. It consisted of two loop receiving antennas at right angles to each other, the whole independently energised by a rotatable coupling device: Arton's goniometer. The direction of incoming transmissions could be determined by the magnitude of the currents induced in these antennas.

By the outbreak of World War One, both these pieces of equipment had been developed further and the Bellini-Tosi system was used by both the major combatants, not least - where the Germans were concerned - because it was simpler to construct and more stable than the Telefunken Compass. In fact Horst von Buttlar-Brandenfels, perhaps the most successful airship commander of the war, thought that electronic navigation - such as it was at this time - was superior to astral navigation in many respects.

Such equipment was the precursor of future radio direction-finding beacons - both civil and military - and they were much appreciated by the airship crews, despite the inherent problems with propagation at this time. British direction-finding techniques - based on a modified Bellini-Tosi system developed by one of Marconi's most distinguished engineers, H. J. Round - were no less successful.

If the Zeppelin airships were a worry for the civilian population, the submarine was a major headache for the government. Being the leading sea trading nation of the day, as well as a significant sea power, the British were anxious to find a way of detecting and destroying this menace. Consequently, in 1914 the British set up a committee - subsequently termed the Allied Submarine Detection Investigation Committee, or ASDIC - to look into the problem.

The result was a series of trials with a piezo-electric oscillator, which emitted sound waves as a method of underwater detection and ranging.

In the following year a French member of this committee, Professor Pierre Langevin, succeeded in further developing the initial equipment such that, by the early months of 1918, Admiralty scientists at the experimental shore establishment at Harwich succeeded in receiving supersonic echoes from a submarine. Although the range was only a few hundred yards, it established that the committee's approach was sound. ASDIC in short, was worth investing further.

Component Improvements

As radio technology evolved, several able men began to take a closer look at the components in use. As early as 1909 for example G. Hilfert in Germany and J. L. Snoek of the Philips laboratory at Eindhoven, began an investigation of ferrites, particularly those fashioned from nickel and manganese.

In 1913 the British physicist Dr. W. F. G. Swann read a paper to the British Association for the Advancement of Science, (BAAS), detailing his experiments with Thin Metal Films. He noted that very thin films had very high resistivity as well as a negative temperature coefficient of resistance, particularly in the thinnest examples.

Four years later, the American physicist E. C. Wente developed the Condenser Microphone, designed for a uniform response rather than sensitivity. It was at this time too that Walter Schottky began his now classical investigation into the causes of noise. He put forward his conclusions in his December 1918 paper 'Theory of Shot Effect.'

By 1925, J. B. Johnson in America had published his paper 'Thermal Agitation of Electricity in Conductors,' in which he outlined his discovery of Thermal, or Johnson, noise. This occurred in amplifiers using 'quiet' valves, and Johnson showed that this type of noise was proportional to the valve's amplification.

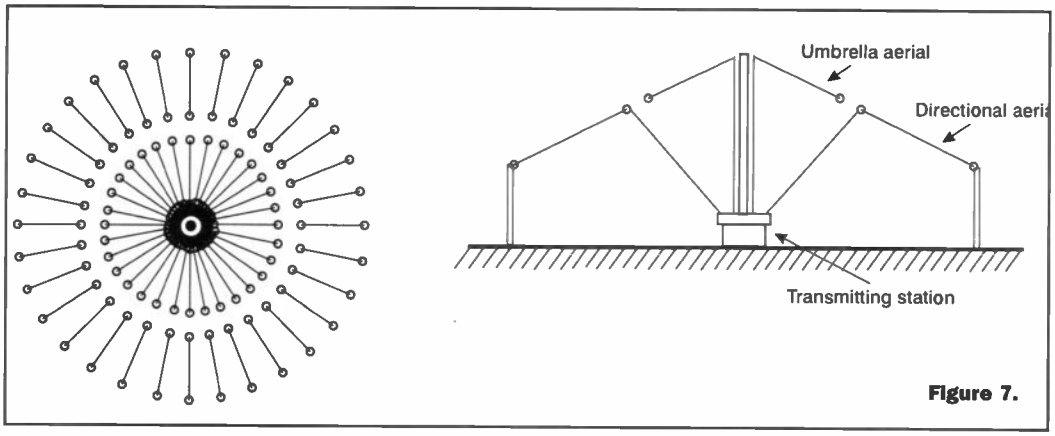


Figure 7.

In 1919, the American engineer W. G. Housekeeper developed the valve seal called after him, which enabled base metals to be sealed through glass. He was well aware that the coefficient of expansion of the commonest electronic metals - copper - was 165 x 10^{-7}/°C, whilst that of glass - the material used for the valve envelope - was 52 x 10^{-7}/°C. Consequently a matched seal was simply not possible.

Housekeeper got round the problem by tapering the copper to a razor-thin edge and then bonding the envelope to this edge. His ingenuity ushered in the age of high power valves with water-cooled anodes and, consequently, high-power broadcast transmitters, an early example of which was the British Broadcasting Corporation, (BBC), station at Rugby.

The second decade of the 20th century saw the development of tape recording. In 1920, the Austrian physicist Dr. Pfleumer replaced the steel wires and tape used by Valdemar Poulson in his original recorder of 1898, with plastic magnetic tape. This development meant that tape recording would no longer be a laboratory curiosity.

Two other inventions of the early 1920s were firstly the Iconoscope of Vladimer Zworykin, which would become the earliest indication thus far that a television camera tube was possible. It would be no inaccuracy to say that, virtually, all subsequent camera tubes would be descended from it.

Secondly, in 1924, Georg Neumann of the German Reisz Corporation invented the Transverse Current Carbon Microphone. This device, with its well-damped and extremely light diaphragm, was far superior to the general run of such instruments and, from 1926, became the standard microphone of the BBC for more than a decade.

By the close of the first quarter of the century, the Cracked Carbon resistor had been developed by the German Siemens and Halske Company and the Electrostatic Loudspeaker was under active development in both Europe and America.

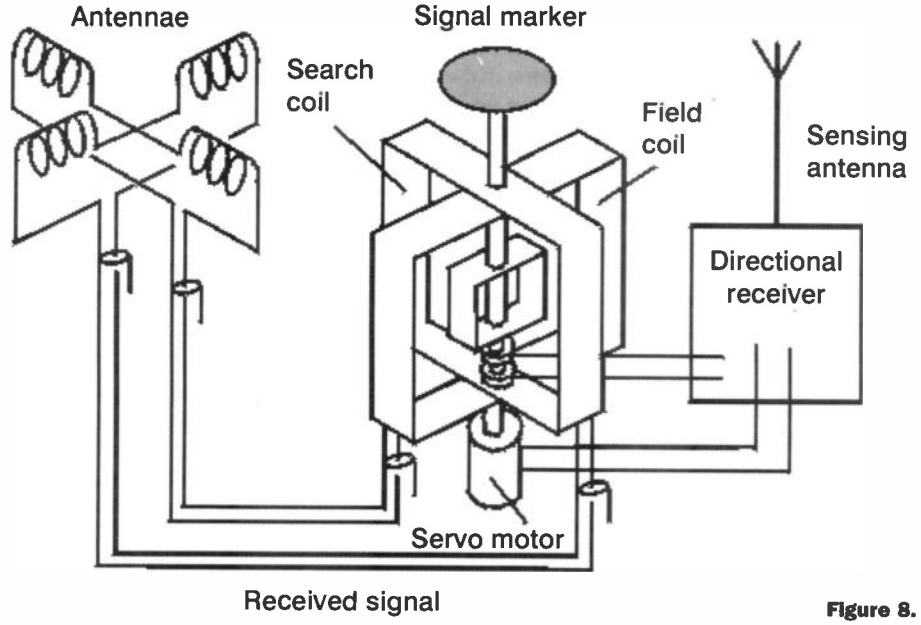


Figure 8.

Landline Communication

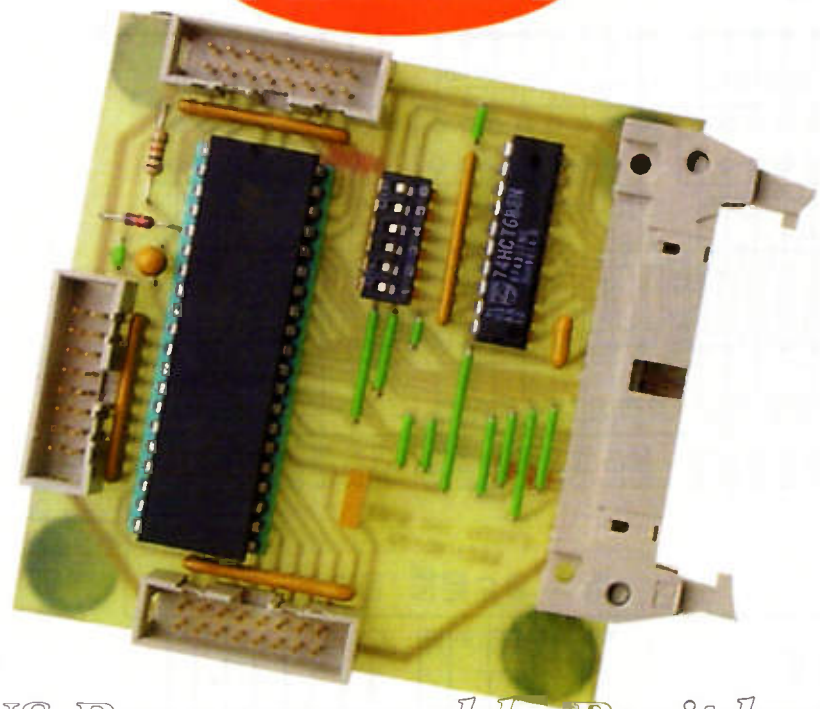
Whilst radio engineering developments tended to catch the eye of both press and public, landline communication was also advancing albeit in a quieter, less spectacular, manner. In 1916 two important developments took place, firstly the arrival of the 'Telex' and secondly the practical development of the 'Crossbar' telephone exchange.

The first practical Telex machine was developed by the Markrum Company of Chicago and the system went into public use some 12 years later. It was swiftly expanded throughout the continental United States by the Bell Telephone Laboratories, who also coined the acronym Telex from the expression Teleprinter Exchange.

The 'Crossbar' switching concept - perhaps the most widespread of the electromechanical switching arrangements - had originated in America, at the beginning of the century. However, an idea is one thing: making it practical quite another. It took the best part of 15 years before J. G. Roberts and J. N. Reynolds of Bell Telephones patented a practical system followed, independently, by Gotthelf Betulander and Nils Palmgren of Sweden, who were the designers of the first, really satisfactory, mechanism.

The first public crossbar exchange began operating in Sweden in 1926 and by the outbreak of the Second World War, the system had been further developed such that it began to replace the Strowger system. Thus by the end of the first quarter of the 20th century, speech really was being carried across the world.

PROJECT



IBUS Programmable Peripheral

INTERFACE MODULE

Neil Johnson of Cambridge Consultants Ltd adds a programmable peripheral interface module to his IBUS system.

This latest expansion module for the IBUS series brings on board the power of the popular 8255 programmable peripheral interface (PPI). It is the first in a new breed of intelligent and powerful modules for the IBUS system. A number of example applications for this module, highlighting the various operating modes of the 8255, are given at the end. So, sit back, relax, and enjoy the rest of the show.

The versatile Interface Bus (or IBUS for short) was introduced way back in issue 119. It offers a simple, flexible and expandable interface system for the PC. Many various interface modules have already been presented, including digital I/O, relay outputs, opto-isolated inputs and outputs, 8-bit analogue I/O, and both parallel and serial port control. Issue 127 served up a potpourri of application ideas for the IBUS system.

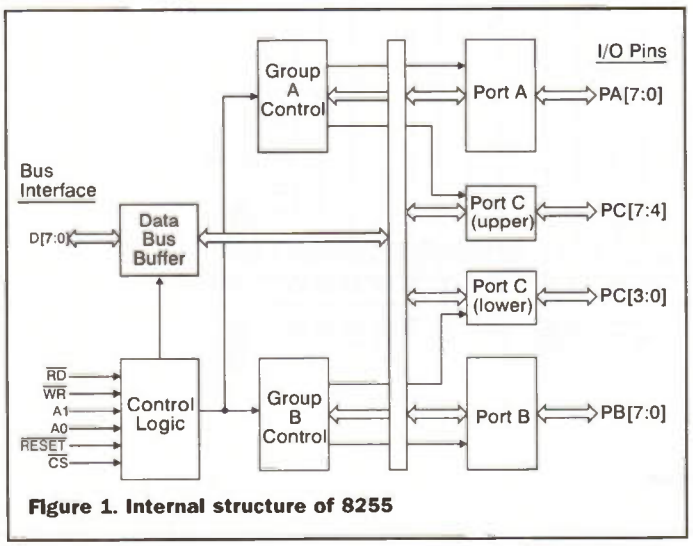


Figure 1. Internal structure of 8255

Programmable Paradise

In the glorious heydays of the 8-bit micros, when such giants as the 6502, Z80 and 8085 walked the earth, Intel produced a useful device they christened the 8255 Programmable Peripheral Interface (PPI). The intention was to provide a versatile interfacing module that could be used in a wide range of applications that most 8-bit micros found themselves in. The 8255 became an industry workhorse - scanning keyboards, driving printers and displays, controlling digital hardware and other general I/O duties.

The 8255 PPI packs quite a lot of functionality into its forty pins. Figure 1 outlines the internal structure of this device. Most of the innards are concerned with talking to the outside world. This is accomplished with the three main groups of I/O ports - Port A, Port B and Port C. The remainder of the innards deals with controlling the operating modes of the I/O ports and communicating with the host processor. It is the variety of modes that lies at the heart of the 8255's versatility. The Intel datasheet for the 8255 weighs in at 23 pages. Almost half (eleven to be precise) are devoted to explaining the three modes of operation.

Mode 0

This is the basic input/output (I/O) mode. In this configuration each port can be programmed for simple input and output operations. There is no handshaking, data is simply passed to and from the ports.

Mode 0 provides two 8-bit ports and two 4-bit ports. Each port can be individually programmed as an input or latched output, for a total of 16 different I/O combinations.

Mode 1

The first of the two advanced modes, Mode 1 has two strobed I/O ports. Port A and the upper half of Port C implement Group A, and Port B and the lower half of Port C implement Group B.

Each group provides an 8-bit latched input or output and four control and status lines. A group can be programmed as an input port or as an output port. This mode of operation is useful for semi-intelligent peripherals, and where a high rate of throughput or confirmation of operation is required.

Each group can be separately programmed for input or output. A group programmed for input has eight data inputs; an active-low STROBE line to load the data into the input latch; an ACKnowledge output to confirm that the data has been loaded into the input latch, and an INTerrupt request output that is set when both the STROBE input goes high after a load and the ACKnowledge output goes high. The INTerrupt request output is reset after reading the input latch.

A group set for output has eight data outputs, an active-low Data Ready line, an active-low ACKnowledge input, and an INTerrupt request output that is set when data has been written to the output

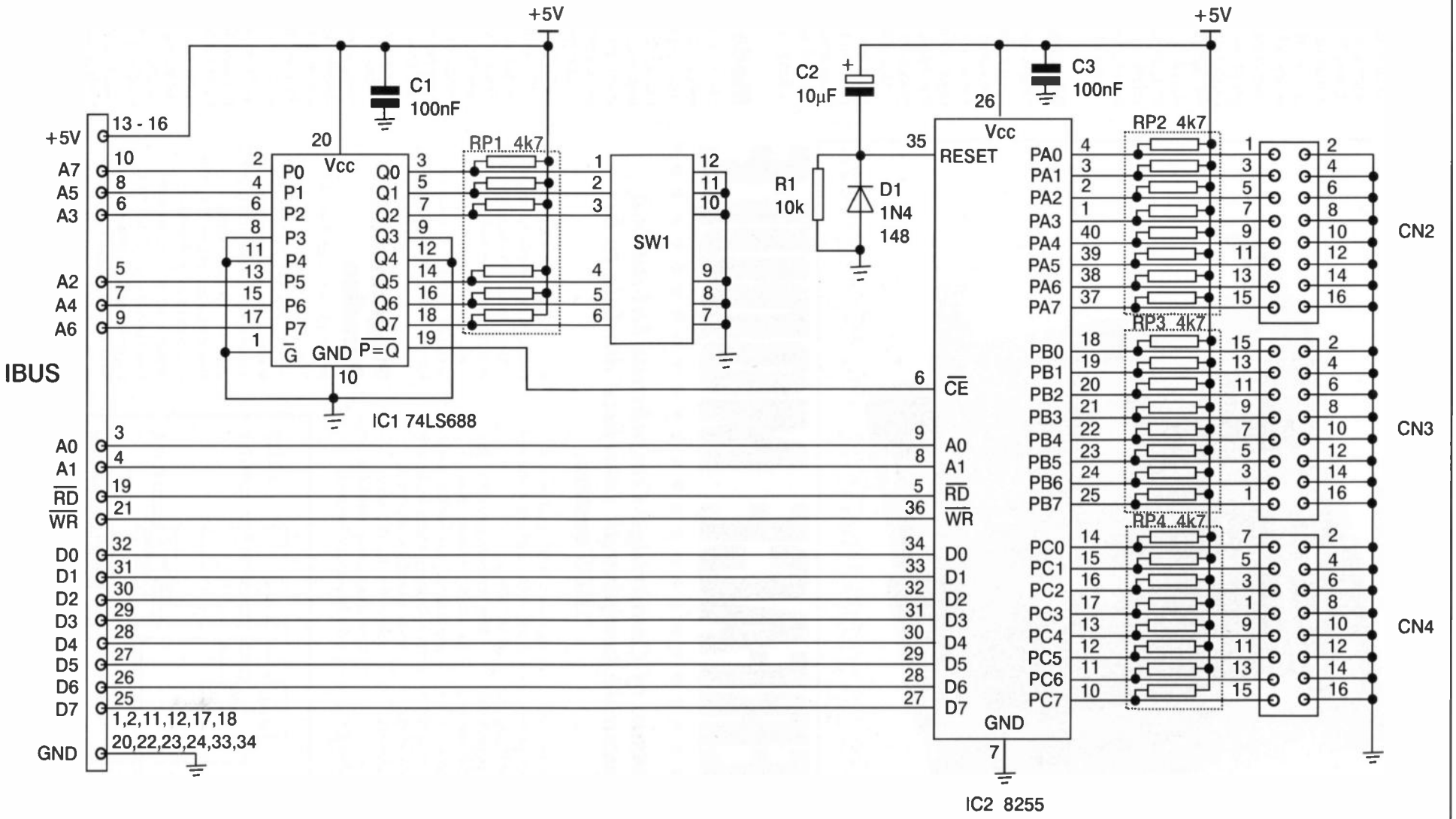


Figure 2. Complete circuit of programmable peripheral interface module

port, and the peripheral device has acknowledged receipt of the data. The INTerrupt request output is reset after writing new data into the output register.

Mode 2

This is the most powerful of the two advanced modes, and provides a fully strobed bidirectional bus. Mode 2 operation is only available for Group A. However, the other I/O pins can be configured for Mode 0 or Mode 1 operation and for input or output.

The eight data lines are initially in a high impedance state. When the host writes data to the output register the Data Ready output goes low. The peripheral can then read the data by setting the Output Enable input low. This signals the output register to send out the data onto the eight output lines. When the Output Enable input returns to a high the INTerrupt request output will also go high, indicating that the peripheral has completed it's read cycle.

Inputting data into the 8255 is very similar. The data is presented to the eight data lines and the STROBE input is set low, loading the input latch from the data lines. After the data has been stored the input ACKnowledge output goes high. Finally, the INTerrupt request output goes high to indicate the end of the peripheral's write cycle.

Mode 2 is designed for interfacing with intelligent peripheral devices. In combination with the other parts of the 8255 a powerful interface can be implemented. For example, it could be used as a post box between two processors, allowing asynchronous communication between the two. The additional I/O lines of Group B could be used for other control purposes, obviating the need for other I/O interface devices.

Circuit Description

The circuit schematic of this project is shown in Figure 2. Its simplicity belies its power and versatility. The 8255 has four internal registers - a Control register and three Data registers (refer to Table 1 for further details). The bottom two address lines, A0 and A1, select one of the registers, while the remaining six address lines are decoded by IC1 and SW1. When the bit pattern of A2 to A7 matches the setting of SW1, IC1 enables IC2 to allow communication with the IBUS. The data bus and the two strobe signals (RD and WR) connect directly to the 8255.

A1	A0	No.	Register
0	0	0	Port A Data
0	1	1	Port B Data
1	0	2	Port C Data
1	1	3	Control

Table 1: The internal registers

The reset circuit, consisting of R1 and C2, generates an active-high reset pulse when power is first applied to the board. Diode D1 protects the reset input from reverse voltages when the board is turned off.

The I/O pins of the 8255 are brought out to the three connectors CN2, CN3 and CN4. Pull-up resistor packs (RP2, RP3 and RP4) can be fitted if needed, for example if switch or open-collector input are used.

Power is taken from the IBUS itself. The board will consume about 10mA when active, dropping to about 1mA when idle.

Soldering On

Puns aside, this project should be well within the reach of most constructors. Follow a few basic steps and construction should be trouble-free. Figure 3 shows all details of the PCB .

Start by giving the board a thorough visual inspection. The author has been caught on a couple of occasions by barely visible hair line cracks in PCB tracks. Attach the components to the board starting with the twelve wire links and resistors followed by the capacitors and semiconductors and finishing with the connectors. Use 18swg tinned copper wire or similar for the wire links.

Do not forget the three pull-up resistor packs, RP2, RP3 and RP4, if you decide to fit them. These components are polarised, so do fit them the correct way, or you will experience some odd faults.

The completed module is now ready for adding to your IBUS system. All that is needed is to plug it in, program the PPI, and attach your gadgets.

Connection Set

The pinouts for the three peripheral connectors are given in Table 2. The pinouts for Ports A and B are the same, while that for Port C has sacrificed pin-compatibility for simple PCB layout.

CN2 - Port A

PA0	1	-	2	GND
PA1	3	-	4	GND
PA2	5	-	6	GND
PA3	7	-	8	GND
PA4	9	-	10	GND
PA5	11	-	12	GND
PA6	13	-	14	GND
PA7	15	-	16	GND

CN3 - Port B

PB7	1	-	2	GND
PB6	3	-	4	GND
PB5	5	-	6	GND
PB4	7	-	8	GND
PB3	9	-	10	GND
PB2	11	-	12	GND
PB1	13	-	14	GND
PB0	15	-	16	GND

CN4 - Port C

PC3	1	-	2	GND
PC2	3	-	4	GND
PC1	5	-	6	GND
PC0	7	-	8	GND
PC4	9	-	10	GND
PC5	11	-	12	GND
PC6	13	-	14	GND
PC7	15	-	16	GND

Table 2: Peripheral connector pin-out details

For connecting switches and the like, the pull-up resistors should be used, with the switch connected between the input and ground. For more active peripherals the port pins operate at CMOS I/O levels. Be aware that this basic module offers no protection of the 8255, so carefully check your circuits before switching on.

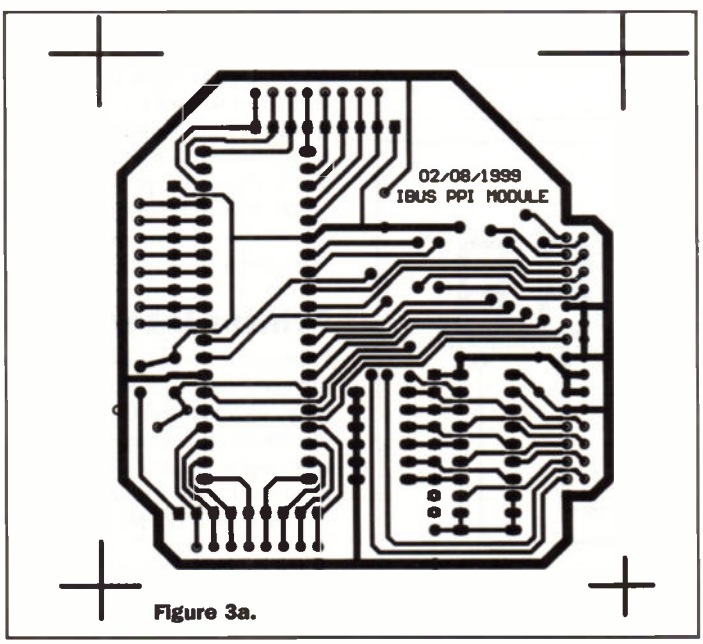


Figure 3a.

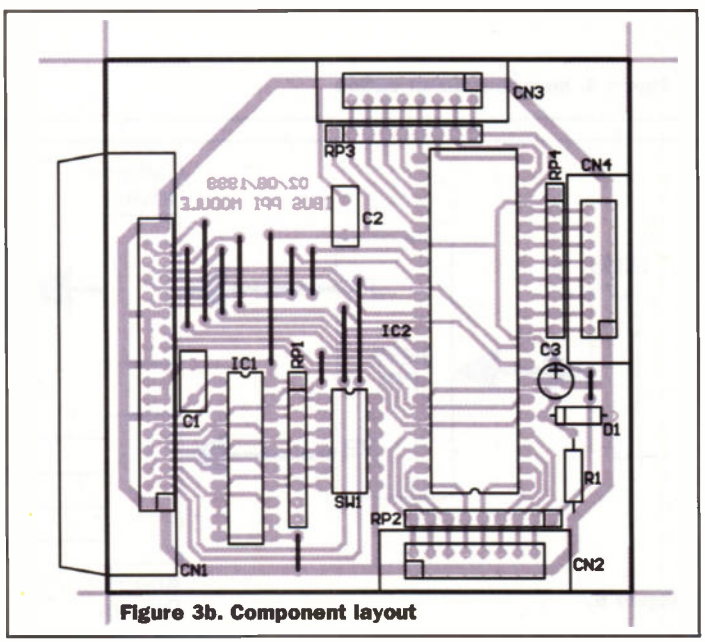


Figure 3b. Component layout

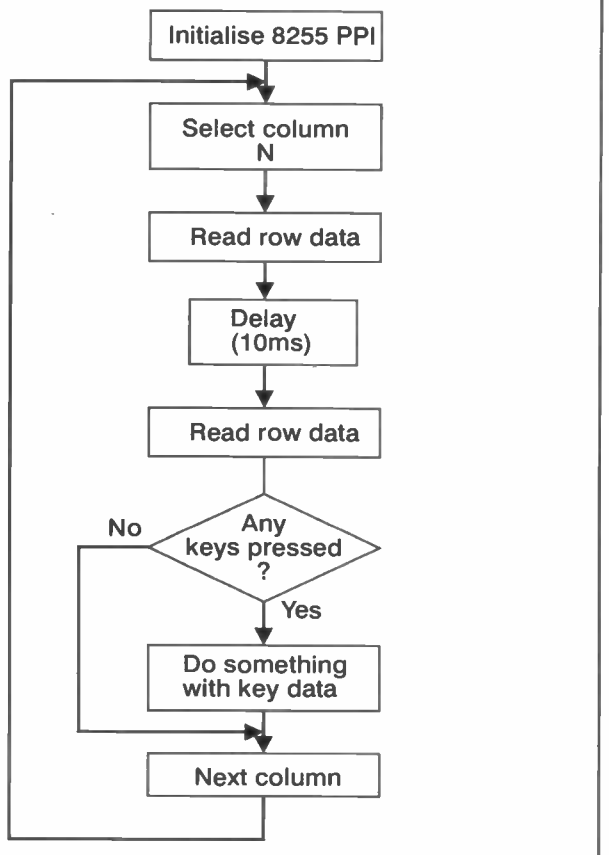


Figure 5. Flowchart for scanning keypad

So there we have it - another member of the expanding IBUS PC Expansion System. Of course, this project would not be complete without a few ideas on what to do with it.

Great Expansions

At its simplest, the 8255 PPI module offers twenty-four digital I/O pins. But we already have the digital I/O module for that. So this module should be able to do lots more - and it can.

But first, an alternative view. If you are developing an application specifically for the 8255, or are working on a system which is designed to interface to an 8255, then you could use this project for development purposes. You could develop your system, prototype your software, and test your application before committing to a final design.

However, this is a narrow field, and so the rest of the ideas presented here will concentrate solely on this IBUS module.

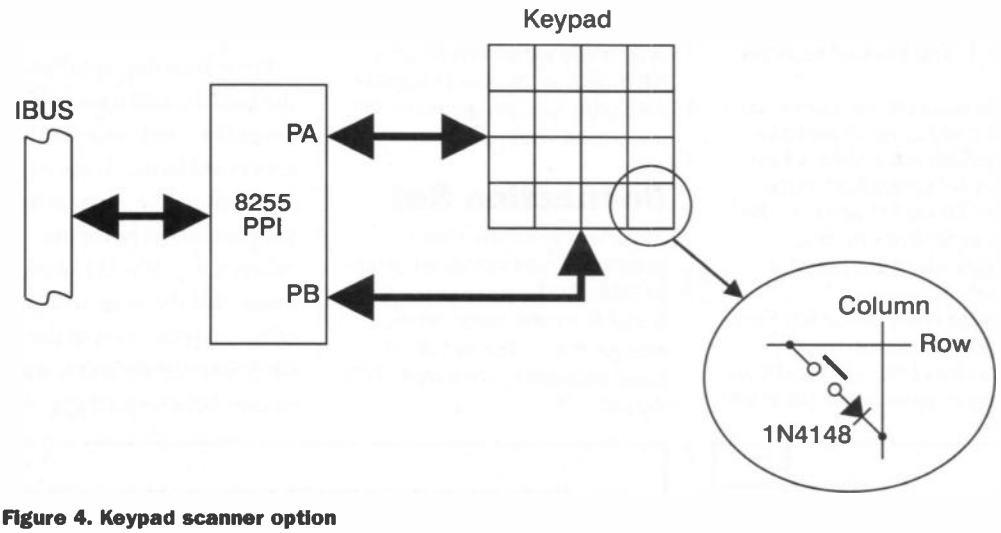


Figure 4. Keypad scanner option

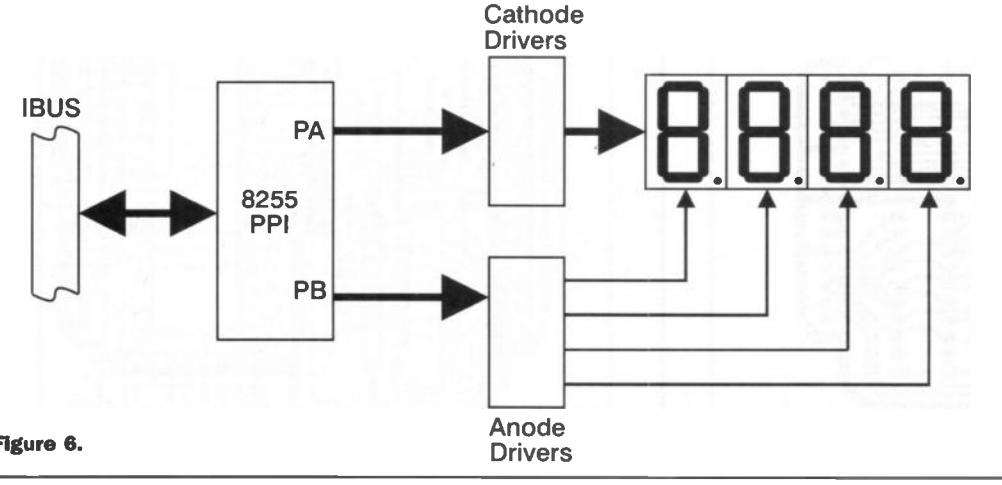


Figure 6.

Keypad Scanner

A keypad, or an array of switches, is a convenient and direct method of entering data into a computerised system. With the addition of a few resistors the 8255 PPI can scan up to 128 keys arranged in a matrix.

A typical example is shown in Figure 4. Port A reads up to eight buttons at a time. Normally, all but one column is driven high by Port B. Each column in turn is pulled low by the output pin, and any keys pressed will be detected by a corresponding low on the input of Port A. The diodes prevent the possibility of a short between two columns if two adjacent keys are accidentally pressed at the same time.

The software for scanning the key matrix is in two stages, repeated in an endless loop. The flowchart in Figure 5 outlines the stages necessary to scan the key matrix. The delay is to allow for simple key switch debounce in software. The key press data could be stored in a buffer, or could generate a message to be sent to another part of the system.

Display Driver

A display naturally complements a keypad. The 8255 PPI is easily capable of driving several LEDs or LED displays using a time-multiplexed approach. Figure 6 shows four seven-segment LED displays connected to the 8255.

The software to drive the display is similar in principle to that used to scan the keyboard. The anode for the first display is driven high and the corresponding segment data is sent to the bank of cathode drivers. After a short pause the first anode is turned off and the second one is turned on, together with the segment pattern for the next digit. And so on for the remaining two displays, after which the cycle starts again. The eye's natural persistence of vision makes the display look like all the separate displays are on at the same time.

Printer Interface

Printers are complex beasts - not only do they need data to print, they also need a number of control and status signals. Here again the 8255 PPI is ideally suited to the task.

A simplified printer interface is shown in Figure 7. This application uses the Mode 1 strobed output mode of the 8255. In this mode, operation of

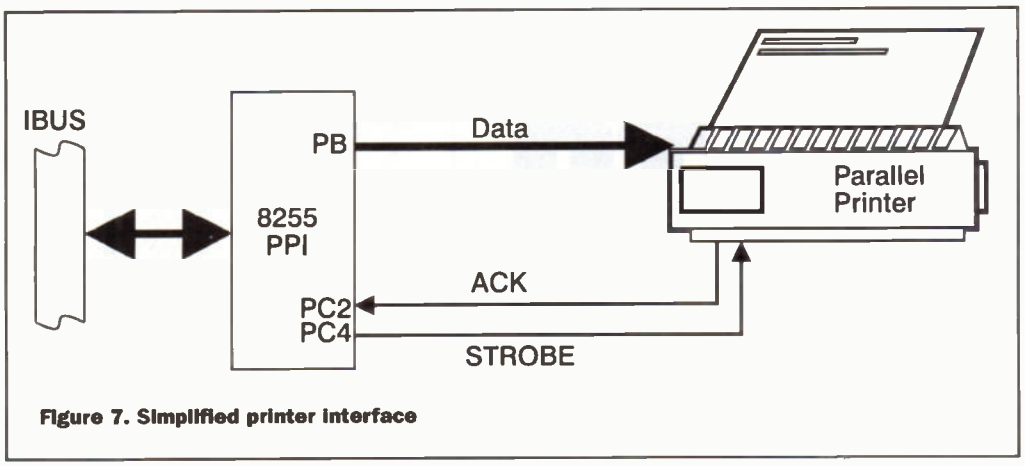


Figure 7. Simplified printer interface

the printer is quite simple: the software waits for an ACKnowledge signal from the printer, sends the next byte of data to Port B and toggles the STROBE line, telling the printer there is fresh data for it to process.

Further Ideas

There are many more possible uses for this module; for example driving stepper motors, interfacing to non-IBUS compatible devices - ADCs, DACs and the like. This IBUS module adds a higher level of capability to the IBUS system. Time to play.

Acknowledgements

The author would like to express his thanks to Cambridge Consultants Ltd, Cambridge, for their help in providing development facilities for this project.

PROJECT PARTS LIST

RESISTORS: All 5% 0.25watt (Unless stated)

R1	10k	G10K
RP1-4	4k7 8-way SIL Resistor Pack	RA29G

CAPACITORS

C1, C3	100nF Ceramic	RA49D
C2	10µF 16V Radial Electrolytic	VH06G

SEMICONDUCTORS

IC1	74LS688	KP49D
IC2	82C55	YH50E
D1	1N4148	QL80B

MISCELLANEOUS

CN1	34-way IDC right-angled PCB header	FA44X
CN2-4	16-way IDC straight PCB header	JB86T
SW1	6-way DIP switch	CJ90X

IC sockets (optional), PCB, solder, wire

A set of foil pattern transparencies (two originals) is available from the author at the address below for £5 plus postage (£2.50 for the UK, £5 for everywhere else). Write, with cheque or postal order payable to "Neil Johnson", to: Neil Johnson, IBUS PPI Module, 2 Chapel Field, Dixter Road, NORTHIAM, East Sussex, TN31 6PQ, UK.

FET Principles & CIRCUITS

PART 1

Ray Marston explains FET (Field Effect Transistor) basics in this opening episode of this new 4-part series.

Field-Effect Transistors (FETs) are unipolar devices, and have two big advantages over bipolar transistors; one is that they have a near-infinite input resistance and thus offer near-infinite current and power gain; the other is that their switching action is not marred by charge-storage problems, and they thus outperform most bipolars in terms of digital switching speeds.

Several different basic types of FET are available, and this opening episode of this new series looks at their basic operating principles; Parts 2 to 4 of the series will show practical ways of using FETs.

FET Basics

A FET is a three-terminal amplifying device; its terminals are known as the source, gate, and drain, and correspond respectively to the emitter, base, and collector of a normal transistor. Two distinct families of FET are in general use. The first of these are known as 'junction-gate' types of FET, this term generally being abbreviated to either JUGFET or (more usually) JFET. The second family are known as either 'insulated-gate' FETs or Metal Oxide Semiconductor FETs, and these terms are generally abbreviated to IGFET or MOSFET respectively. 'N-channel' and 'p-channel' versions of both types of FET are available, just as normal transistors are available in npn and pnp versions, and Figure 1 shows the symbols and supply polarities of both types of bipolar transistor and compares them with both JFET versions.

Figure 2 illustrates the basic construction and operating principle of a simple n-channel JFET. It consists of a bar of n-type semiconductor material with a drain terminal at one end and a source terminal at the other; a p-type control electrode or gate surrounds (and is joined to the surface of) the middle section of the n-type bar, thus forming a p-n junction.

In normal use the drain terminal is connected to a positive supply and the gate is biased at a value that is negative (or equal) to the source voltage, thus reverse biasing the JFET's internal p-n junction and accounting for its very high input impedance. With zero gate bias applied, a current flow from drain to source via a conductive 'channel' in the n-type bar. When negative gate bias is applied, a high resistance region is formed within the junction, and reduces the width of the n-type conduction channel and thus reduces the magnitude of the drain-to-source current. As the gate bias is increased, the 'depletion' region spreads deeper into the n-type channel, until eventually, at some 'pinch-off' voltage value, the depletion layer becomes so deep that conduction ceases.

Thus, the basic JFET of Figure 2 passes maximum current when its gate bias is zero, and its current is reduced or 'depleted' when the gate bias is increased. It is thus known as a 'depletion-type' n-channel JFET. A p-channel version of the device can (in principle) be made by simply transposing the p and n materials.

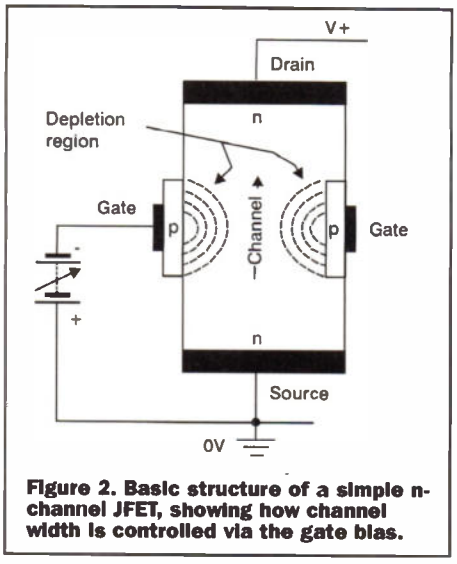


Figure 2. Basic structure of a simple n-channel JFET, showing how channel width is controlled via the gate bias.

JFET Details

Figure 3 shows the basic form of construction of a practical n-channel JFET; a p-channel JFET can be made by transposing the p and n materials. All JFETs operate in the depletion mode, as already described. Figure 4 shows the typical transfer characteristics of a low-power n-channel JFET, and illustrates some important features of this type of device. The most important characteristics of the JFET are as follows.

(1). When a JFET is connected to a supply with the polarity shown in Figure 1 (drain +ve for an n-channel FET, -ve for a p-channel FET), a drain current (I_D) flows and

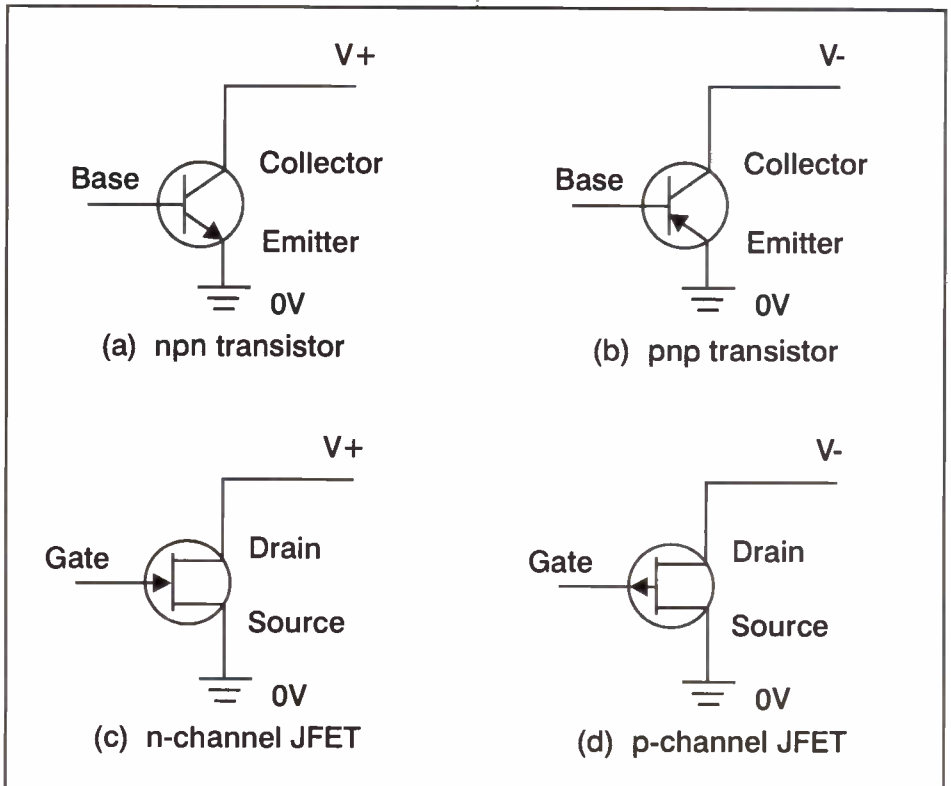


Figure 1. Comparison of transistor and JFET symbols, notations, and supply polarities.

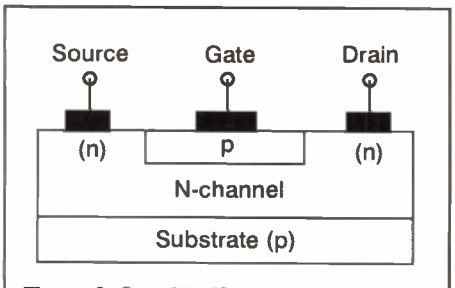


Figure 3. Construction of n-channel JFET.

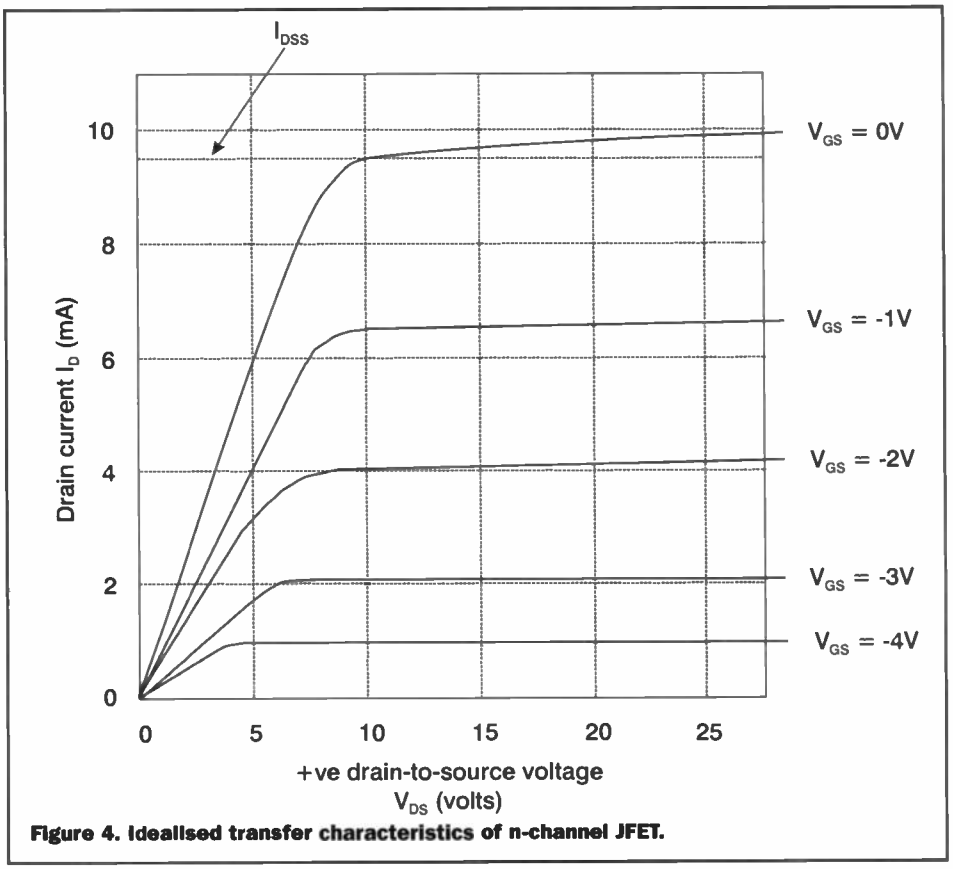


Figure 4. Idealised transfer characteristics of n-channel JFET.

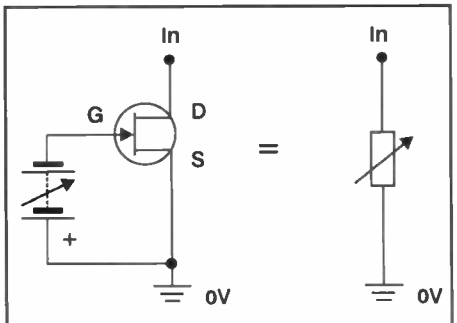


Figure 5. An n-channel JFET can be used as a voltage-controlled resistor.

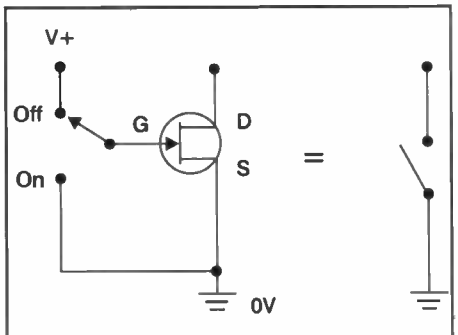


Figure 6. An n-channel JFET can be used as a voltage-controlled switch.

can be controlled via a gate-to-source bias voltage V_{GS}.

(2). I_D is greatest when V_{GS} = 0, and is reduced by applying a reverse bias to the gate (negative bias in a n-channel device, positive bias in a p-type). The magnitude of V_{GS} needed to reduce I_D to zero is called the 'pinch-off' voltage, V_P, and typically has a value between 2 and 10V. The magnitude of I_D when V_{GS} = 0 is denoted I_{DSS}, and typically has a value in the range 2 to 20mA.

(3). The JFET's gate-to-source junction has the characteristics of a silicon diode. When reverse biased, gate leakage currents (I_{GSS}) are only a couple of nA (1nA = 0.001μA) at room temperature. Actual gate signal currents are only a fraction of a nA, and the input impedance of the gate is typically thousands of megohms at low frequencies. The gate junction is shunted by a few pF, so the input impedance falls as frequency rises. If the JFET's gate-to-source junction is forward biased, it conducts like a normal silicon diode, and if excessively reverse biased avalanches like a zener diode; in either case, the JFET suffers no damage if gate currents are limited to a few mA.

(4). Note in Figure 4 that, for each V_{GS} value, drain current I_D rises linearly from zero as the drain-to-source voltage (V_{DS}) is

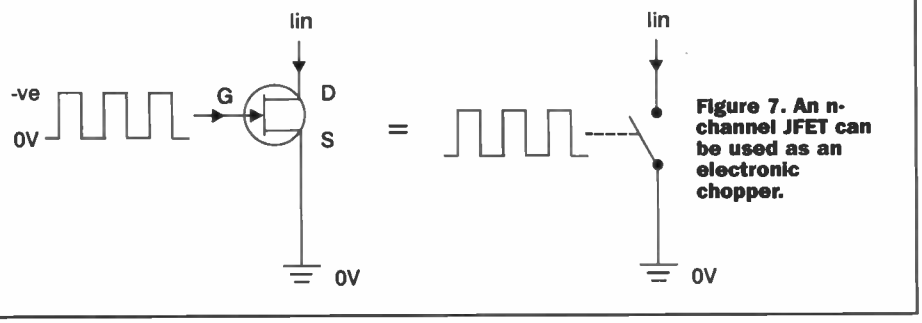


Figure 7. An n-channel JFET can be used as an electronic chopper.

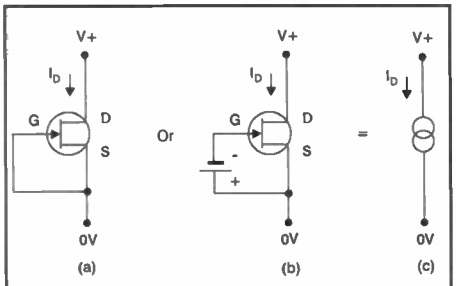


Figure 8. An n-channel JFET can be used as a constant-current generator.

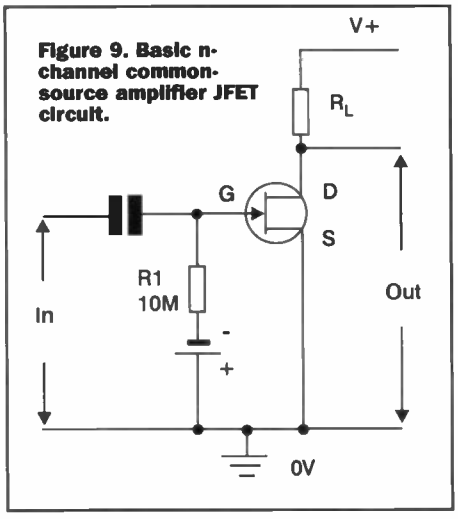


Figure 9. Basic n-channel common-source amplifier JFET circuit.

increased from zero up to some value at which a 'knee' occurs on each curve, and that I_D then remains virtually constant as V_{DS} is increased beyond the knee value. Thus, when V_{DS} is below the JFET's knee value the drain-to-source terminals act as a resistor, R_{DS}, with a value dictated by V_{GS}, and can thus be used as a voltage-variable resistor, as in Figure 5. Typically, R_{DS} can be varied from a few hundred ohms (at V_{GS} = 0) to thousands of megohms (at V_{GS} = V_P), enabling the JFET to be used as a voltage-controlled switch (Figure 6) or as an efficient 'chopper' (Figure 7) that does not suffer from offset-voltage or saturation-voltage problems.

Also note in Figure 4 that when V_{DS} is above the knee value the I_D value is controlled by the V_{GS} value and is almost independent of V_{DS}, i.e., the JFET acts as a voltage-controlled current generator. The JFET can be used as a fixed-value current generator by either tying the gate to the source, as in Figure 8(a), or by applying a fixed negative bias to the gate, as in Figure 8(b). Alternatively, it can (when suitably biased) be used as a voltage-to-current signal amplifier.

(5). FET 'gain' is specified as transconductance, g_m, and denotes the magnitude of change of drain current with gate voltage, i.e., a g_m of 5mA/V signifies that a V_{GS} variation of one volt produces a 5mA change in I_D. Note that the form I/V is the inverse of the ohms formula, so g_m measurements are often expressed in 'mho' units; usually, g_m is specified in FET data sheets in terms of mmhos (milli-mhos) or μmhos (micro-mhos). Thus, a g_m of 5mA/V = 5-mmho or 5000-μmho.

In most practical applications the JFET is biased into the linear region and used as a voltage amplifier. Looking at the n-channel

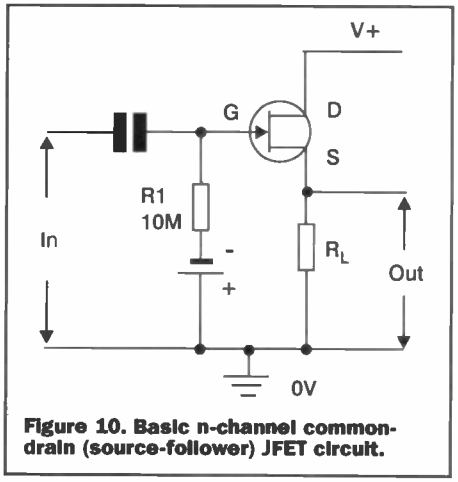


Figure 10. Basic n-channel common-drain (source-follower) JFET circuit.

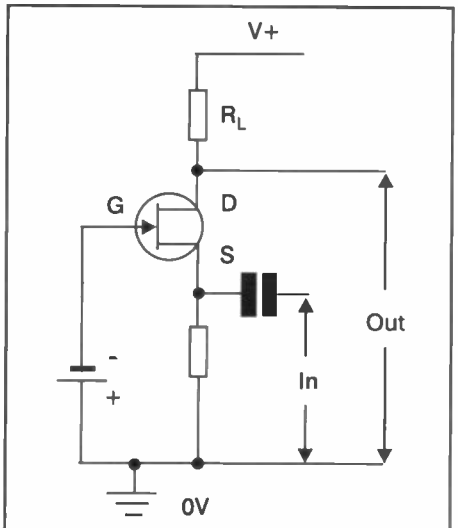


Figure 11. Basic n-channel common-gate JFET circuit.

JFET, it can be used as a common source amplifier (corresponding to the bipolar npn common emitter amplifier) by using the basic connections of Figure 9. Alternatively, the common drain or source follower (similar to the bipolar emitter follower) configuration can be obtained by using the connections of Figure 10, or the common gate (similar to common base) configuration can be obtained by using the basic Figure 11 circuit. In practice, fairly accurate biasing techniques (discussed in Part 2 of this series) must be used in these circuits.

The IGFET/MOSFET

The second (and most important) family of FETs are those known under the general title of IGFET or MOSFET. In these FETs the gate terminal is insulated from the semiconductor body by a very thin layer of silicon dioxide, hence the title 'Insulated Gate Field Effect Transistor', or IGFET. Also, the devices generally use a 'Metal-Oxide Silicon' semiconductor material in their construction, hence the alternative title of MOSFET.

Figure 12 shows the basic construction and the standard symbol of the n-channel depletion-mode FET. It resembles the JFET, except that its gate is fully insulated from the body of the FET (as indicated by the Figure 12(b) symbol), but in fact operates on a slightly different principle to the JFET. It has a normally-open n-type channel

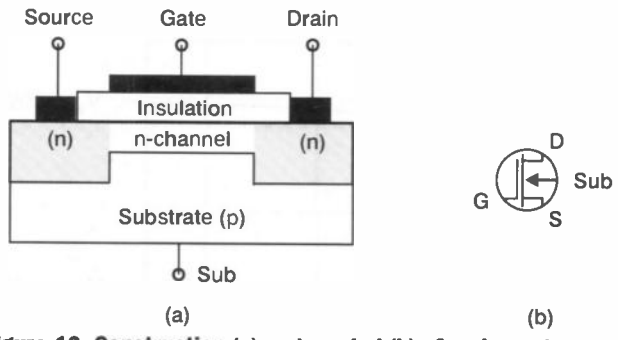


Figure 12. Construction (a) and symbol (b) of n-channel depletion-mode IGFET/MOSFET.

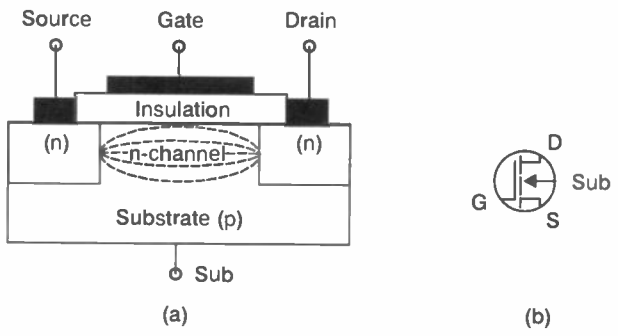


Figure 13. Construction (a) and symbol (b) of n-channel enhancement-mode IGFET/MOSFET.

between drain and source, but the channel width is controlled by the electrostatic field of the gate bias. The channel can be closed by applying suitable negative bias, or can be increased by applying positive bias. In practice, the FET substrate may be externally available, making a 4-terminal device, or may be internally connected to the source, making a 3-terminal device.

An important point about the IGFET/MOSFET is that it is also available as an enhancement-mode device, in which its conduction channel is normally closed but can be opened by applying forward bias to its gate. Figure 13 shows the basic construction and the symbol of the n-channel version of such a device. Here, no n-channel drain-to-source conduction path exists through the p-type substrate, so with zero gate bias there is no conduction between drain and source; this feature is indicated in the symbol of Figure 13(b) by the gaps between source and drain. To turn the device on, significant positive gate bias is needed, and when this is of sufficient magnitude it starts to convert the p-type substrate material under the gate into an n-channel, enabling conduction to take place.

Figure 14 shows the typical transfer characteristics of an n-channel enhancement-mode IGFET/ MOSFET, and Figure 15 shows the V_{GS}/I_D curves of the same device when powered from a 15V supply. Note that no I_D current flows until

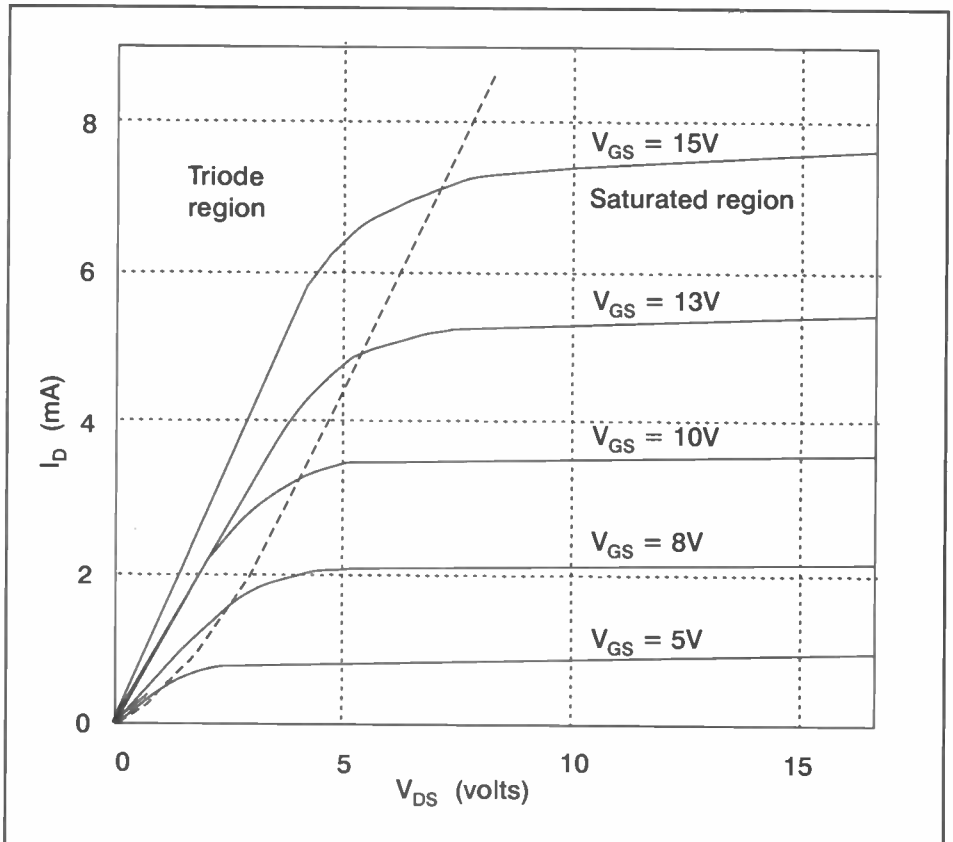


Figure 14. Typical transfer characteristics of n-channel enhancement-mode IGFET/MOSFET.

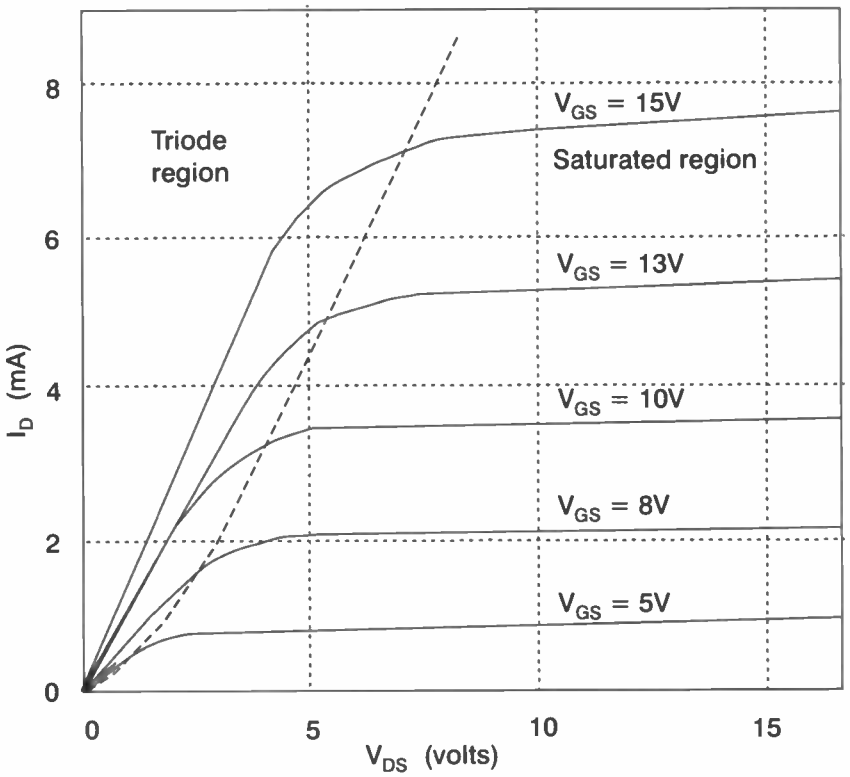


Figure 15. Typical V_{DS}/I_D characteristics of n-channel enhancement-mode IGFET/MOSFET.

the gate voltage reaches a 'threshold' (V_{TH}) value of a few volts, but that beyond this value the drain current rises in a non-linear fashion. Also note that the transfer graph is divided into two characteristic regions, as indicated (in Figure 14) by the dotted line, these being the 'triode' region and the 'saturated' region. In the triode region, the device acts like a voltage-controlled resistor; in the saturated region it acts like a voltage-controlled constant-current generator.

The basic n-channel MOSFETs of Figures 12 and 13 can - in principle - be converted to p-channel devices by simply transposing their p and n materials, in which case their symbols must be changed by reversing the directions of their substrate arrows.

A number of sub-variants of the MOSFET are in common use. The type known as 'DMOS' uses a double-diffused manufacturing technique to provide it with a very short conduction channel and a consequent ability to operate at very high switching speeds. Several other MOSFET variants are described in the remainder of this opening episode of this new series.

Note that the very high gate impedance of MOSFET devices makes them liable to damage from electrostatic discharges, and for this reason they are often provided with internal protection via integral diodes or Zeners, as shown in the example of Figure 16

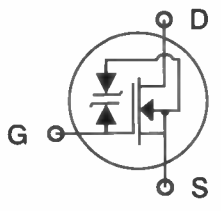


Figure 16. Internally-protected n-channel depletion-mode IGFET/MOSFET.

VFET Devices

In a normal small-signal JFET or MOSFET, the main signal current flows 'laterally' (see Figures 3, 12, and 13) through the device's conductive channel. This channel is very thin, and maximum operating currents are consequently very limited (typically to maximum values in the range 2 to 40mA).

In post-1970 times, many manufacturers have tried to produce viable high-power/high-current versions of the FET, and the most successful of these have relied on the use of a 'vertical' (rather than lateral) flow of current through the conductive channel of the device. One of the best known of these devices is the 'VFET', an enhancement-mode power MOSFET which was first introduced by Siliconix way back in 1976.

Figure 17 shows the basic structure of the original Siliconix VFET. It has an essentially 4-layer structure, with an n-type source layer at the top, followed by a p-type 'body' layer, an epitaxial n-type layer, and (at the bottom) an n-type drain layer. Note that a 'V' groove (hence the 'VFET' title) passes through the first two layers and into the third layer of the device and is electrostatically connected (via an insulating silicon dioxide film) to the gate terminal.

If the gate is shorted to the source, and the drain is made positive, no drain-to-source current flows, because the diode formed by the p and n materials is reverse biased. But if the gate is made positive to the source the resulting electrostatic field converts the area of p-type material adjacent to the gate into n-type material, thus creating a conduction channel in the position shown in Figure 17 and enabling current to flow vertically from the drain to the source. As the gate becomes more positive, the channel width increases, enabling the drain-to-source current to increase as the drain-to-source resistance decreases. This basic VFET can thus pass reasonably high currents (typically up to 2A) without creating excessive current density within the channel regions.

The original Siliconix VFET design of Figure 17 was successful, but imperfect. The sharp bottom of its V-groove caused an excessive electric field at this point and restricted the device's operating voltage. Subsequent to the original VFET introduction, Intersil introduced their own version of the 'VMOS' technique, with a U-shaped groove (plus other modifications) that improved device reliability and gave higher maximum operating currents and voltages. In 1980, Siliconix added these and other modifications to their own VFET devices, resulting in further improvements in performance.

Other Power FETs

Several manufacturers have produced viable power FETs without using 'V'- or 'U'-groove techniques, but still relying on the vertical flow of current between drain and source. In the 1980's Hitachi produced both p-channel and n-channel power MOSFET devices with ratings up to 8A and 200V; these devices were intended for use mainly in audio and low-RF applications.

Supertex of California and Ferranti of England pioneered the development of a range of power MOSFETS with the general title of 'vertical DMOS'. These featured high operating voltages (up to 650V), high

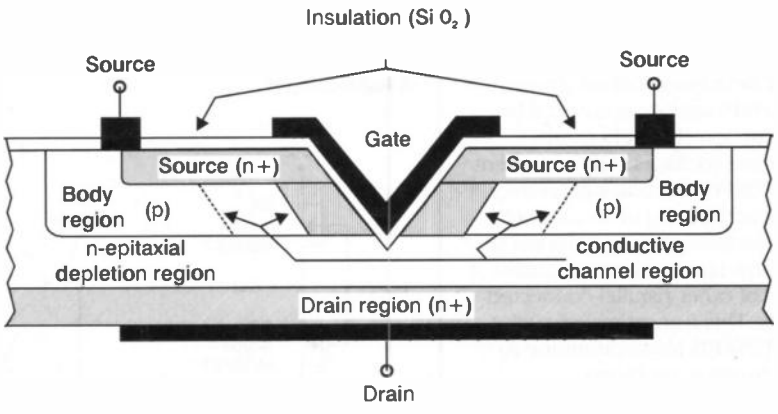


Figure 17. Basic structure of the VFET power device.

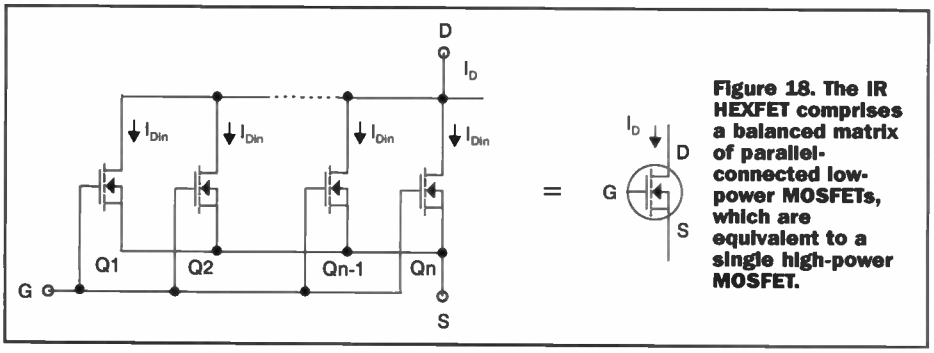


Figure 18. The IR HEXFET comprises a balanced matrix of parallel-connected low-power MOSFETs, which are equivalent to a single high-power MOSFET.

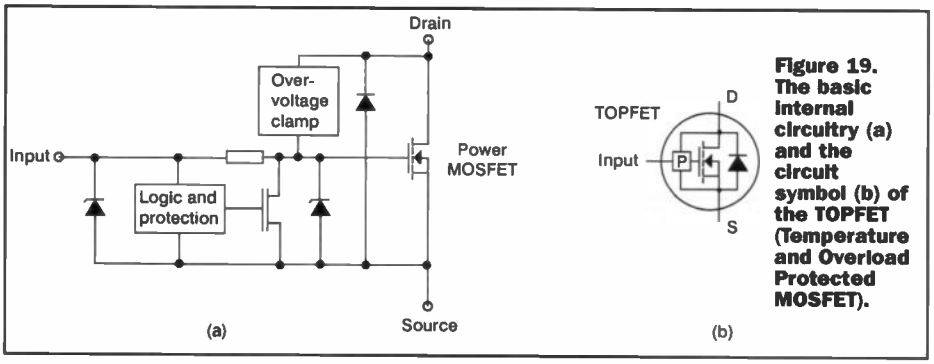


Figure 19. The basic internal circuitry (a) and the circuit symbol (b) of the TOPFET (Temperature and Overload Protected MOSFET).

current rating (up to 16A), low on resistance (down to 50 milliohms) and very fast operating speeds (up to 2GHz at 1A, 500MHz at 10A). Siemens of West Germany used a modified version of DMOS, known as SIPMOS, to produce a range of n-channel devices with voltage ratings as high as 1kV and with current ratings as high as 30A.

One International Rectifier (IR) solution to the power MOSFET problem is a device which, in effect, houses a vast array of parallel-connected low-power vertical MOSFETs or 'cells' which share the total current equally between them and thus act like a single high-power MOSFET, as indicated in Figure 18. These devices are named HEXFET, after the hexagonal structure of these cells, which have a density of about 100000cm² of semiconductor material.

Several manufacturers produce power MOSFETs that each comprise a large array of parallel-connected low-power lateral (rather than horizontal) MOSFET cells that share the total operating current equally between them; the device thus acts like a single high-power MOSFET. These high-power devices are known as lateral MOSFETs or L-MOSFETs, and give a performance that is particularly useful in super-fi audio power amplifier applications.

Note that, in parallel-connected MOSFETs (as used in the internal structure of the HEXFET and L-MOSFET devices described above), equal current sharing is ensured by the conduction channel's positive temperature coefficient; if the current in one MOSFET becomes excessive, the resultant heating of its channel raises its resistance, thus reducing its current flow and tending to equalise it with that of other parallel-connected MOSFETs. This feature makes such power MOSFETs almost immune to thermal runaway problems.

Today (in the year 2000), a vast range of power MOSFET types are manufactured; 'low voltage' n-channel types are readily available with voltage/current ratings as high as 100V/75A, and 'high voltage' ones with ratings as high as 500V/25A.

One of the most important recent developments in the power-MOSFET field has been the introduction of a variety of so-called 'intelligent' or 'smart' MOSFETs with built-in overload protection circuitry; these MOSFETs usually carry a distinctive registered trade name. Philips devices of this type are known as TOPFETs (Temperature and Overload Protected MOSFETs); Figure 19 shows (in simplified form) the basic internal circuitry and the circuit symbol of the TOPFET.

The Siemens version of the smart MOSFET is known as the PROFET. PROFET devices incorporate protection against damage from short circuits, over temperature, overload, and electrostatic discharge (ESD). International Rectifier produce a range of smart n-channel MOSFET known as SMARTFETs; these incorporate protection against damage from short circuits, over temperature, overvoltage, and ESD.

Finally, yet another recent and important development in the n-channel power MOSFET field has been the production - by various manufacturers - of a range of high power devices known as IGBTs (Insulated Gate Bipolar Transistors), which have a MOSFET-type input and an internally protected high-voltage high-current bipolar transistor output. Figure 20 shows the normal circuit symbol of the IGBT. Devices of this type usually have voltage/current/power ratings ranging from as low as 600V/6A/33W (in the device known as the HGTD3N603), to as high as 1200V/520A/3000W (in the device known as the MG400Q1US51).

CMOS Basics

One major FET application is in digital ICs. The best known range of such devices use the technology known as CMOS, and rely on the use of Complementary pairs of MOSFETs. Figure 21 illustrates basic CMOS principles. The basic CMOS device comprises a p-type and n-type pair of enhancement-mode MOSFETs, wired in series, with their gates shorted together at the input and their drains tied together at the output, as shown in Figure 21(a). The pair are meant to use logic-0 or logic-1 digital input signals, and Figures 21(b) and 21(c) respectively show the device's equivalent circuit under these conditions.

When the input is at logic-0, the upper (p-type) MOSFET is biased fully on and acts like a closed switch, and the lower (n-type) MOSFET is biased off and acts like an open switch; the output is thus effectively connected to the positive supply line (logic-1) via a series resistance of about 100Ω. When the input is at logic-1, the MOSFET states are reversed, with Q1 acting like an open switch and Q2 acting like a closed switch, so the output is effectively connected to ground (logic-0) via 100Ω. Note in both cases that the entire signal current is fed to the load, and none is shunted off by the CMOS circuitry; this is a major feature of CMOS technology.

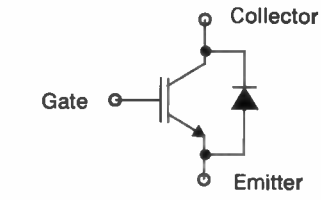
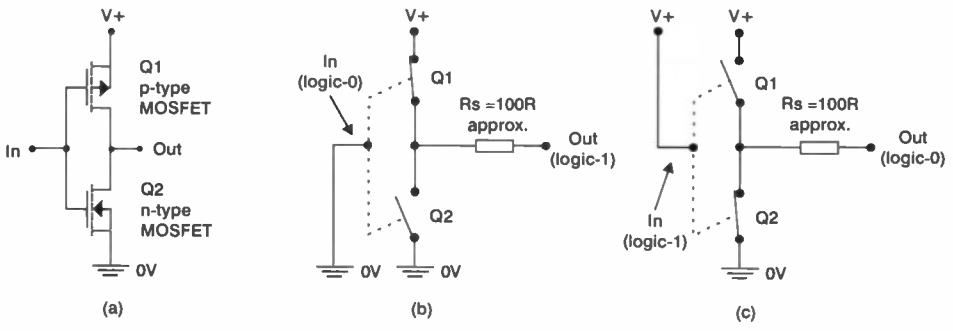
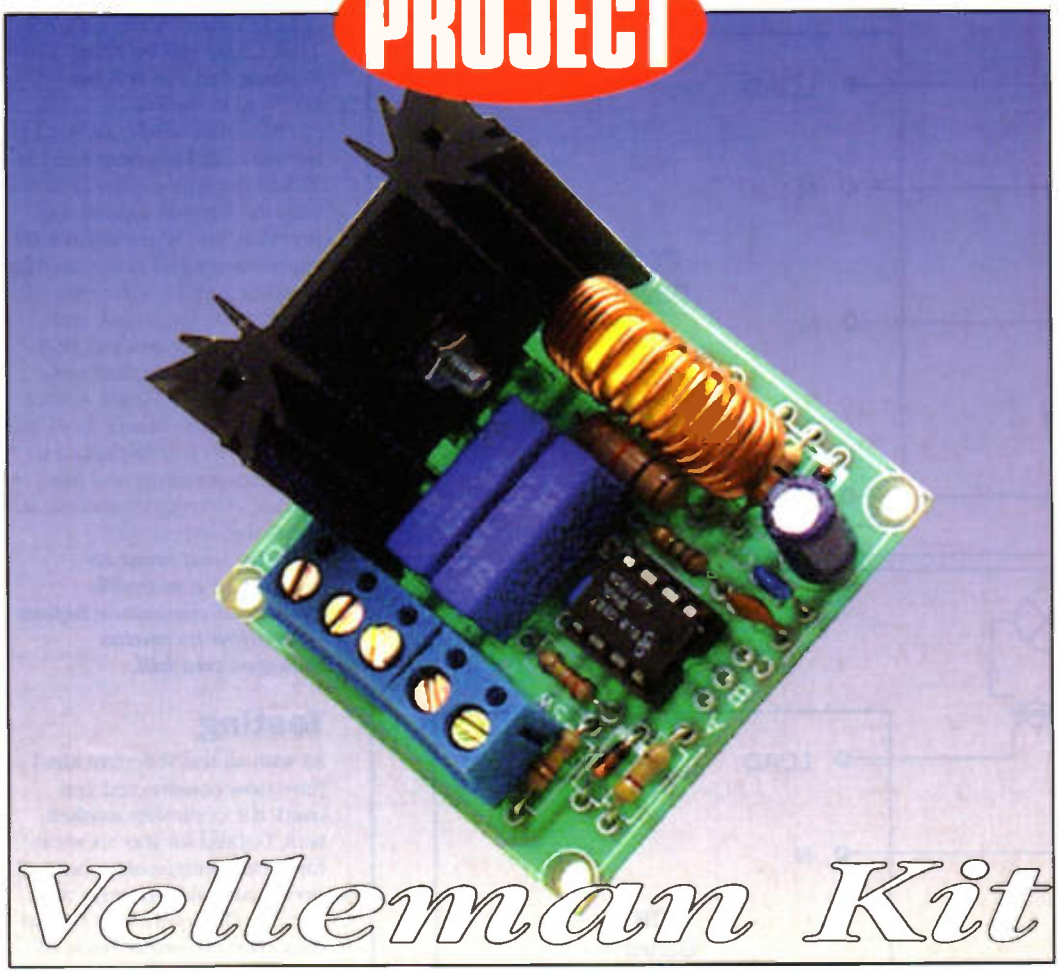


Figure 20. Normal circuit symbol of the IGBT (Insulated Gate Bipolar Transistor).

Figure 21. Basic CMOS circuit (a), and its equivalent with (b) a logic-0 input and (c) a logic-1 input.



PROJECT



HALOGEN LIGHT DIMMER

This month John Mosely builds a versatile mains dimmer

SPECIFICATION

Mains voltage input: 110 or 220-240V ac 50/60Hz

Maximum power: 750W/220V or 380W/110V

Control: simple push button, with three operating modes

Dimming duration: 3.5s approx.

PCB size: 45 x 48mm

It is often useful to vary the intensity of mains equipment, and this useful kit from Velleman is particularly handy as it is designed for use with a wide range of appliances with 'induction current' inputs such as transformers, motors etc. plus halogen lighting. The designed is rated at 750W/220V ac, and features push-button control.

The dimmer could replace a switch, but although the board is small, the heatsink attached to the triac is quite tall, so any box will have to be deep.

Control is by a simple push-button switch, or any number of switches mounted in parallel. This allows the board to be controlled from several

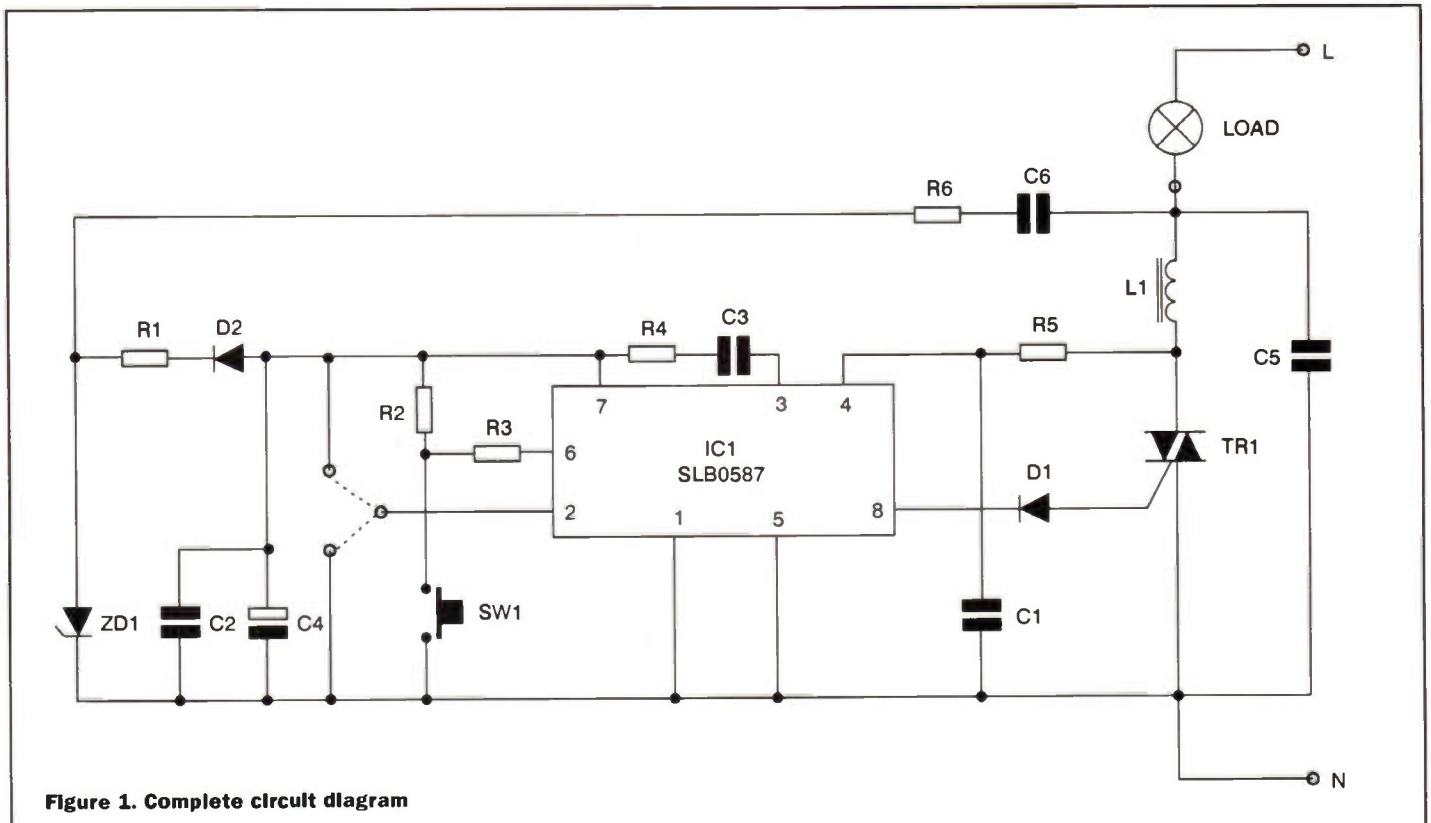


Figure 1. Complete circuit diagram

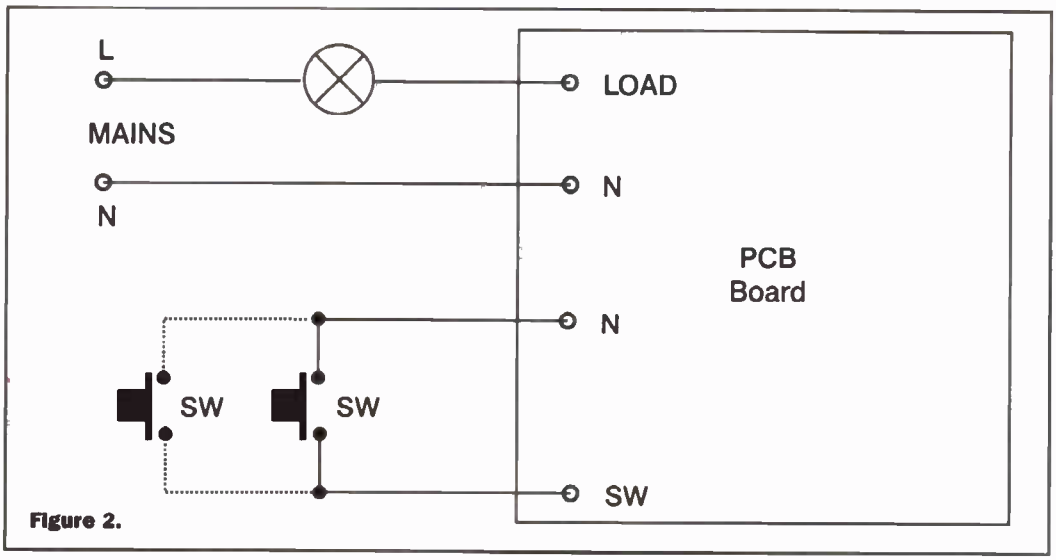


Figure 2.

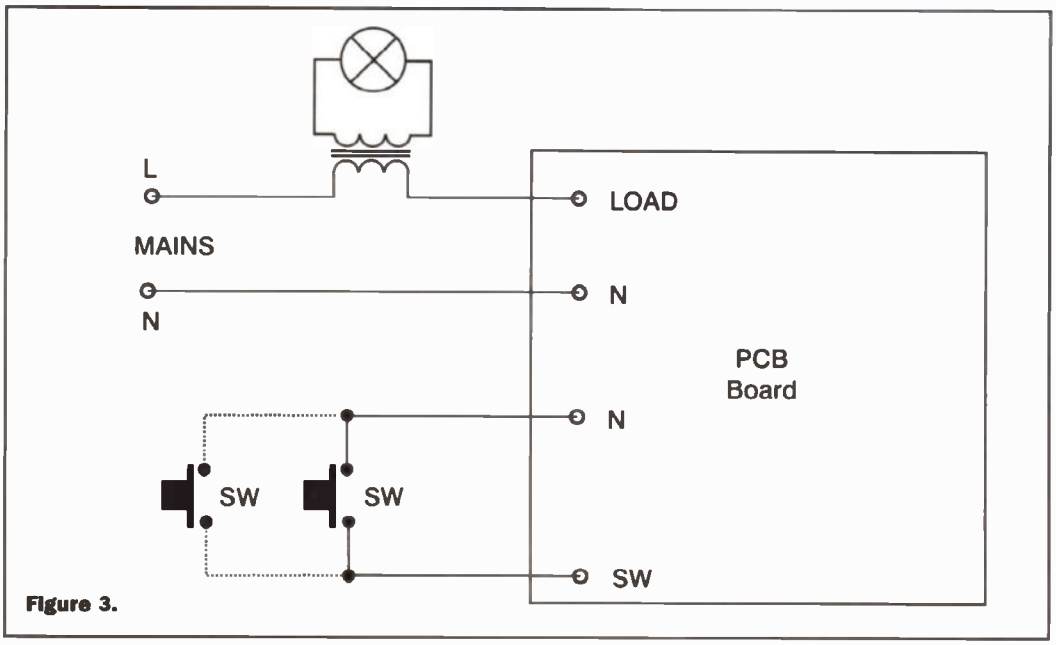


Figure 3.

locations. Additionally, there are three modes of operation:-

- Continuous direction dimmer function - short repeated switch pressure is a basic start/stop, a long switch pressure produces a dim, which if repeated continues the dim. This is a progressive action.
- Memory function - a short repeated pressure continues from the previous dimmer level, but a long switch pressure produces a dimming action, and a repeated long pressure , produces a reverses the dim action.
- This is the same as 1., but reverses the dim action with repeated long switch pressure. Again a progressive action.

There are jumper positions on the board to determine the mode of operation - jumper A-B for mode 1, jumper B-C for mode 3, and no jumper for mode 2, which is probably the preferred mode of operation. Note A-C must never, under any circumstances be jumpered together. When you have made the kit you may care to experiment to see how the dimmer behaves in the different modes of operation. But remember this board operates at mains voltages so exercise the utmost care, and remove all mains from the board and appliance before attempting any alterations to the mode of operation.

Circuit and Construction

The circuit diagram is shown in Figure 1. It is a very conventional circuit with all the 'control' work carried out by IC1. Start construction with the smallest components first. The kit came with two values of R5 - a 1.5MΩ resistor for 220V mains working, and a 680kΩ resistor for 110V mains working - so ensure you select the correct value. Incidentally, for 110V, C6 should be 220nF 250V working, but this was not supplied in the kit.

TR1 is mounted on a vertical heatsink, and is assembled last. Mount the triac on the heatsink with the flat side against the heatsink, and finger tighten the supplied nut and bolt. Carefully position and align the triac and heatsink on the board, and secure the heatsink too PCB using the two supplied self-tapping screws. Finally, solder the triac to the board. As usual, a quick check of the board to check solder joints and that diodes, electrolytics and the IC are in the correct way.

N.B The unit must be housed in a suitable insulated container before operation as mains voltages can kill.

Testing

As with all the Velleman kits I have now constructed and used, the controller worked well. I opted for the 'memory' function configuration, but as I previously said, you may wish to carefully experiment to find your own preferred mode of operation. Note, that if you wish to control a halogen lamp then you will need a transformer to drive the lamp, which will depend on the halogen lamp used - see Figure 2. Figure 3 shows the arrangement for other applications.

ELECTRONICS

PROJECTS PART LIST

RESISTORS	
R1	33R Min Res
R2	120k Min Res
R3	470k Min Res
R4	330k Min Res
R5	1M5 Min Res (≤220V working)
	680k Min Res (110V working)
R6	1k 1W
CAPACITORS	
C1	6.8nF
C2, 3	100nF
C4	100µF Electrolytic
C5	100nF 400V
C6	100nF 400V (≤220V working)
	220nF 250V (110V working)
SEMICONDUCTORS	
D1, 2	1N4148
D3	5V6 1.3W Zener Diode
TR1	T0609MJ
IC1	SLB0587
MISCELLANEOUS	
L1	50µH 6A Inductor
	8-pin DIL Socket
	3-pole PCB Mounting Mains Connector
	2-pole PCB Mounting Mains Connector
	Heatsink
	Suitable Push-switch(es)

The kit is available from Maplin Electronics (order code VF37 Price £19.99)

TECHNOLOGY WATCH

With Martin Pipe

Martin Pipe looks at how you can get DAB-quality radio reception 'on the cheap'. Indeed, you might already have the gear needed!

Let's get this straight - I'm not old-fashioned by any stretch of the imagination. I enjoy music, clubbing, sport and the other interests expected of a man my age. I am, though, tending to reject the increasingly lowest-common-denominator rubbish being foisted upon us by the television companies. Well, sex sells doesn't it? Perhaps that's why we see it in so many forms these days, whether it's in the close-to prostitutional clothing worn by the average female childrens' presenter, dumbed-down science programmes or tacky eye-on-the-wall documentaries about 'humans' on holiday. What's more, there's no incentive to be original - if TV executives spot a formula that appeals to the public, they largely copy it and do the genre to death ('real-life' showzzzz, anyone?). If there's little money involved, then so much the better. Quizzes, chat shows and imported programmes are cheap - and heaven knows, most of the commercial broadcasters had to offer damagingly-expensive bids to the last administration in order to gain (or retain) their franchises. The obvious examples aside, there is simply very little TV programming of merit around these days. And here we are, in the midst of the multi-channel revolution. That ever-diminishing pool of quality sure has to go a long, long way, doesn't it? Perhaps that's why so many satellite and cable channels simply repeat comedies and documentaries from an earlier (but not necessarily better) era. And a good explanation as to why most broadcasters are becoming deeply involved with Internet ventures. They're simply keeping their options open, I suppose.

That's not to say that I shun the outpourings of broadcasters entirely. Call me old-fashioned, but I'm finding increasing solace in the world of radio. The Beeb may seem to favour television - in budgetary as well as promotional terms - but there's still a lot of good stuff among its five national services. Radio One has stolen the dance music crown - and indeed most of the famous DJs - from the pioneering Kiss FM. Oh yes, and there's the Evening Session and broadcasting legend John Peel. Radio 2, meanwhile, generates an almost-constant stream of pleasant musical wallpaper, light comedy and Saturday night concerts featuring hour-long performances from some well-known artists. Then there's Radio Three, which is brave enough to air new works as well as the music of established composers. Radio Four is well-known for news and analysis, but there's some superb comedy - indeed, a surprising proportion of it ends up being adapted for television. Some of the station's plays are also worth sitting in for, not least because you're encouraged to exercise your imagination. When was the last time TV did that? Finally, Radio Five Live is fast becoming the only option to sports enthusiasts who don't want to pay Mr. Murdoch lots of money for the privilege of following their favourite team. Add to this the variety of local and national commercial stations, and you've got a powerful incentive to reach for your radio.

DAB To The Rescue!

TV is benefiting from the digital revolution, with widescreen programming, interactivity and freedom from ghosting among other things. Radio is also taking advantage of digital broadcasting, although in a way that's much more low-key. The BBC and independent stations are plugging Digital Audio Broadcasting (DAB). This system, which occupies a band of frequencies between 217.5MHz and 230MHz, employs MPEG Layer 2 coding to compress studio-originated 44.1kHz-sampled PCM (i.e. CD-quality) datastreams into a more manageable 192 kilobits per second. DAB promises better stereo separation than the archaic Zenith pilot-tone system, and less distortion than FM. You also get the potential of full 20kHz bandwidth - broadcast FM only goes up to 15kHz. Add to this a far superior dynamic range and intelligent services, and you've got yourself an attractive proposition. Unfortunately, the DAB receivers are ludricriously expensive at the moment. A DAB tuner for your hi-fi system will cost you anything between £500 and £1000. Car radios are also expensive, and nobody has yet announced portable DAB radios of any variety.

The BBC didn't exactly go overboard when announcing the commencement of digital radio broadcasting via satellite. Here's the only 'official' announcement I could find, on BBC Online.

Digital TV set top boxes, conversely, are now virtually given away (they're certainly 'free' if you agree to sign up for a year's subscription). As we approach the analogue switch-off date, chances are that they'll become even cheaper. The government is, no doubt, drooling over all of the money they can make by auctioning off the UHF broadcasting band - to the extent that they could heavily subsidise the digital receivers for those who haven't updated their analogue equipment by the time analogue transmissions are switched off. We can also expect very cheap 'basic' set top boxes, which will allow 'second sets' (portables, etc.) and VCRs to be upgraded to digital reception. The VHF FM radio spectrum (Band II) is much smaller - it occupies 20MHz, compared to the 400MHz, or so, of the TV band - and is hence unlikely to feature heavily in the government's priorities. It may have eventual plans for Band II, but the MW, LW and SW bands will be left alone - the limited bandwidth is of little value to bidders, and in any case these internationally-agreed frequencies have propagation characteristics that are ideal for long-range analogue broadcasting.

The Nokia 9200 forms an ideal - and inexpensive - basis of a tuner that rivals DAB for sound quality.

DAB may be the future of national radio broadcasting, but most will stick with FM until the prices drop. A DAB

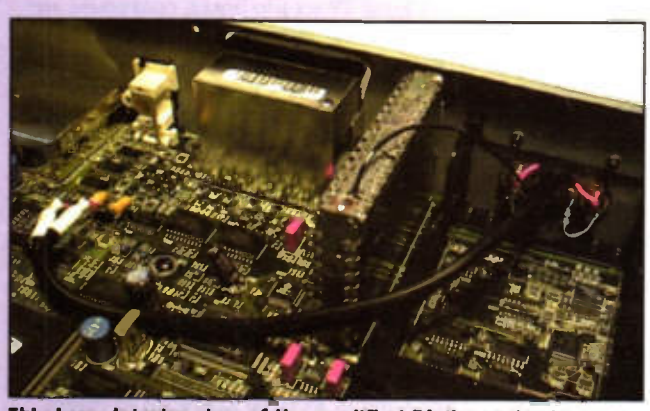
'softceiver', developed by start-up company Radioscape, was announced nearly two years ago. It has yet to appear in the UK market, although I was recently told by Radioscape that manufacturing was ramping up in the Far East. The softceiver is designed to be used in conjunction with a PC. A plug-in expansion card contains the tuner/demodulator, which retrieves the MPEG datastreams from the radio channel of interest. These are then passed to a software MPEG decoder (which is rather like the Winamp program that MP3 enthusiasts know and love) and thence to the PC's soundcard. The Softceiver will also allow the streams to be recorded to the hard disk, for later enjoyment.

One could suppose that those MPEG files could be written to recordable CDs, or even uncompressed into 16-bit stereo PCM WAV files - that way, CD 'burner' owners could edit their favourite songs and concert performances, and write them to standard 'Red Book' audio CDs that can be handled by any player. BBC Radio has high hopes for DAB, as do the high number of commercial stations signing up to be included within the multiplexes. For the time being, though, there's an alternative - at least as far as home listening is concerned. The BBC don't appear to be actively promoting the service in the UK, though. There's nothing on the BBC Engineering department's teletext pages (BBC2 page 698), although there is some information on its web site.

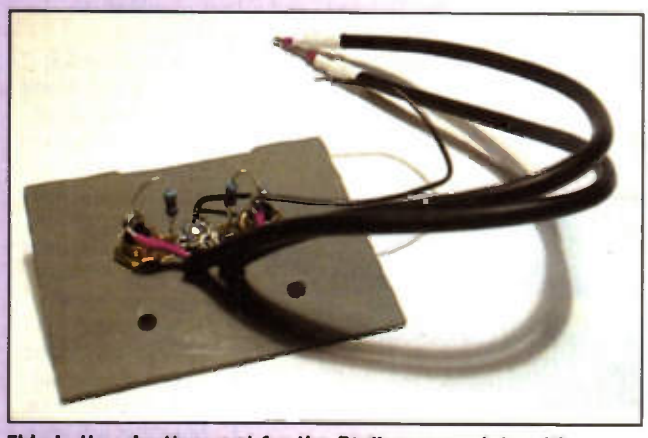
Via Satellite

For a good few years, the BBC has been simulcasting its radio services via the Astra satellites at 19°E. You'll find them on analogue FM subcarriers 'piggybacked' on some of the Sky services - any modern analogue satellite system within the Astra footprint will be able to access them. Radios 1 and 3, for example, can be found on UK Living's transponder (10.979GHz, vertical polarisation). The stereo audio subcarriers are 7.38(left channel)/7.56MHz(right channel) and 7.74/7.92MHz respectively. Other broadcasters also make use of this technology - in fact, Astra offers rich pickings to any radio enthusiast. Virgin Radio, for instance, broadcasts in stereo (7.38/7.56MHz) on Sky News' transponder (11.377GHz, vertical polarisation). There are also a host of foreign language services - and you'll even find the music feed for Asda supermarkets!

Other satellites, such as Eutelsat Hotbird (13°E) also offer FM radio services alongside their analogue channels. To receive these, you'll have to retune your receiver, and move your dish to the relevant satellite. As far as dish movement is concerned, you could always acquire a kit that motorises your existing dish (such as the Gentrack and IRTE mounts featured on page 88 of the latest Maplin catalogue). The FM subcarriers occupy a bandwidth that's much narrower (180kHz) than that occupied by Band II FM broadcast channels. To ensure a fair dynamic range, a Dolby 'B'-like compander system, known as Panda 1 (geddit?), is employed at the uplink and receiver ends. Best results, then, are achieved from a receiver equipped with a Panda-1 dynamic range restoration circuit. Many receivers produced in the last five or so years feature Panda-1. They don't always proclaim the fact on their front panels, in order to avoid paying a licence fee to Wegener Communications - the American company that developed the system. If your receiver is one of the many to have an ITT MSP3400 analogue audio 'jungle' chip in it, then it is Panda-1 compatible regardless of the front-panel logo (or absence thereof).



This is an interior view of the modified Digibox prior to case reassembly. Note that a ground connection was taken from the tuner's screening can. All audio connections were made using audiophile-grade screened cable.



This is the plastic panel for the Digibox, complete with cables and socketry, just before it was fitted into the receiver.

Despite the processing involved, the subjective sound quality from analogue satellite radio is actually very good if you have a half-decent receiver (Pace or Nokia, for example). It's certainly on a par with a reasonable hi-fi tuner. Indeed, in at least one respect - stereo separation, it's a good deal better. Theoretically infinite, in fact, because the stereo channels are carried by independent subcarriers. You should definitely consider satellite radio if FM reception is poor in your area. Remember that as long as you're in the Astra footprint - which covers the entire UK - you'll be able to tune in. Note that the BBC provides the Astra simulcast primarily for the benefit of European listeners, and British listeners currently residing in Europe. Unfortunately for these people - and anybody else who listens to radio in this way - Sky is going digital. Chances are that the broadcaster will shut down the expensive (one transponder per channel, compared to digital's seven or more) analogue services as soon as it can.

Analogue - The End Is Near!

Some industry pundits reckon that Sky analogue could disappear within two years, free set-top boxes being issued to any subscribers who haven't upgraded from analogue by that time. The transponders thus freed will then be reallocated to digital packages - probably those of European pay-TV operators. All of this means, of course, that the BBC analogue radio subcarriers will disappear too - not much fun if you're an expatriate living in Euroland. The gradual shift of Sky's subscriber base from analogue to digital does mean that there's a lot of receivers and dishes being thrown out. Much of it ends up at council tips, or car boot sales. Acquire some of this gear, and you could still enjoy satellite radio reception for a while. Even when it disappears, the dish could be aimed at another satellite that hasn't yet 'gone digital'.

Good though analogue satellite radio's sound quality is, it can't hope to compete with DAB. Very recently, though, the BBC introduced a digital alternative that can. The idea is to provide both analogue and digital satellite radio services in parallel - by the time that Sky analogue closes operations, most of the audience will have upgraded to digital receivers of one kind or another. Unfortunately, the BBC digital radio service is disseminated via the Astra 2A satellite (28.2°E) that carries Sky Digital, instead of Astra 1x. In other words, listeners who currently get their BBC fix via the analogue subcarriers will need to reposition their dishes, or acquire a motorised/second dish. Amazingly, the digital service has only been promoted via a low-key page on the BBC Online web site (http://www.bbc.co.uk/info/reception/fm_recep/astradig.shtml), although it has been the focus of much discussion on the alt.satellite.tv.europe Internet newsgroup.

Europe - The Preferred Audience?

One can imagine that Europe is the target audience - the lack of fanfare in the UK would suggest that the BBC would prefer British listeners to fork out for DAB receivers instead. This is incredibly short-sighted of the BBC, because anybody with a Sky Digital receiver - well over a million people at the last count - will be able to

tune in! Effectively, the broadcaster is denying high-quality reception to UK licence-payers who don't live within usable range of a land-based FM transmitter. Ironically enough, the BBC list the Sky EPG (electronic programme guide) numbers - and you can't buy Sky Digiboxes outside the UK! These EPG numbers are listed in Table 1. Only a cynic, of course, would surmise that the BBC doesn't want to offend the producers of DAB home receivers. As far as the musings of a non-cynical is concerned, I tried to extract some kind of explanation from BBC Engineering, but it didn't even bother to return my call.

On a Par With DAB

A similar sound quality to DAB? Potentially, the sound quality is just as good. As with DAB, the four main services have a 192kbps bit rate and are broadcast in stereo. Chances are that, for these stations, the DAB and digital satellite services are fed by a common MPEG encoder. Radio Scotland, Radio Wales, Asian Network and Radio Ulster - stations that aren't found on the Astra 1x analogue subcarriers - are also broadcast in stereo, but at a lower bitrate (i.e slightly less quality) of 128kbps. You'll also find a brace of mono services (Radio 4 Long Wave - parliamentary and cricket coverage - Radio 5 Live and World Service) that have a 96kbps bitrate - i.e. half that of the four main stereo stations, because half the number of audio channels is involved.

Because the broadcasting rights of some of its sporting events are specific to the UK, Radio 5 Live is encrypted. It can only be received via an 'activated' Sky Digibox, which has the necessary Videoguard decryption hardware. If you don't need Radio 5 Live, then your choice of receiver is much wider. All of the other services can be received with any DVB-compliant digital satellite receiver - including 'free-to-air' (FTA) models, and those supplied by European pay-per-view operators to their subscribers. FTA receivers are widely-available in the UK, via specialist satellite dealers, and prices start at under £200 - i.e. much less than that of a DAB hi-fi tuner. In all cases, the sound quality is much superior to FM. Radio 1, in particular, has a much better dynamic range. Its FM radio feed is heavily processed by a compressor-limiter, which effectively kills dynamic range. Commercial broadcasters also employ the same technique, so that marginal reception - in cars and so on - isn't spoilt by hiss.

Side Effects

Unfortunately, there appear to be unwanted side effects. I, for one, can make out noticeable distortion (particularly at higher frequencies), brash treble and muddled basslines. I'm old enough to remember when Radio One did use to sound good - this was in the pre compression-limiter days, when it didn't have its own frequencies. Back then, Radio One took over Radio Two's VHF/FM frequencies on Sunday evenings. Ironically, the future is like a welcome return to the past as far as sound quality is concerned. Although there is some compression on the digital service, it's nowhere near as obvious. Compare a broadcast song with the CD original, and you'll find that the difference is nowhere near as marked as it is with FM. Check out the other services via the digital satellite feed, and you're in for a real treat - particularly as far as the wide dynamic range of Radio 3's classical music is concerned.

Limiting Factor

The only limiting factor to sound quality is undoubtedly the analogue audio circuitry of the average digital satellite receiver - it's hardly the audiophile-grade stuff fitted to expensive DAB tuners. The Sky Digibox, for example, has a lot of signal routing/switching circuitry between the DAC and the audio output socketry, and this doesn't exactly do much for sound quality. If you're prepared to delve into your receiver, a digital output for recording/audiophile DACs - after all, DAB tuners have this useful facility, don't they? Sadly, no. Scoping the output pin (TX, pin 5) of this 44-pin surface-mounted chip revealed nothing more than a tiny amount of noise. Not only that, but there were no output signals present on the left and right audio outputs - even when sound could clearly be heard through the connected TV's outputs. Hmmm... But what's this? A separate DAC on the board (U501)? Let's take a closer look, shall we? This 24-pin device is a 4319 from AKM. Time, methinks, to pay a visit to AKM's web site (**www.akm.com**)! The 4319 employs 1-bit conversion techniques, and has digital filtering built in. The device isn't, interestingly enough, fed from the MPEG audio decoding functionality of the CS4922. Instead, it takes its source - as separate clock

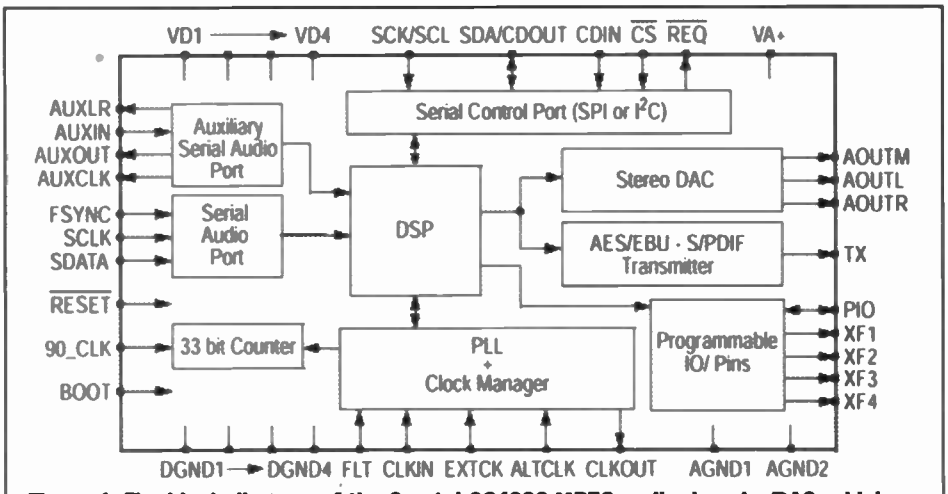


Figure 1. The block diagram of the Crystal CS4922 MPEG audio decoder/DAC, which is built into many digital receivers - note the SP/DIF output (pin 5). Unfortunately, the device appears to be redundant in the Sky Digibox. An earlier version of very similar functionality, the CS4920, was specified for Nokia's digital receivers - amongst others.

though, you could acquire a much better feed for your hi-fi system. Sadly, little details on the interior workings of the Digibox are available. BSkyB, which licensed its design to a group of manufacturers, likes to keep such details restricted - and, considering its commercial interests, who can blame it? However, datasheets for the various chips that make up the unit can easily be obtained via the relevant manufacturers' websites.

One of the chips in the box is a Crystal CS4922 MPEG audio decoder/DAC (U3002 in the Pace-built model), the block diagram and pin-out of which are reproduced in Figures 1 and 2. These diagrams, and the datasheet from which they are taken (downloadable from **www.cirrus.com**), reveal some interesting design aspects - not least of which is a SP/DIF transmitter. Could this be harnessed to provide

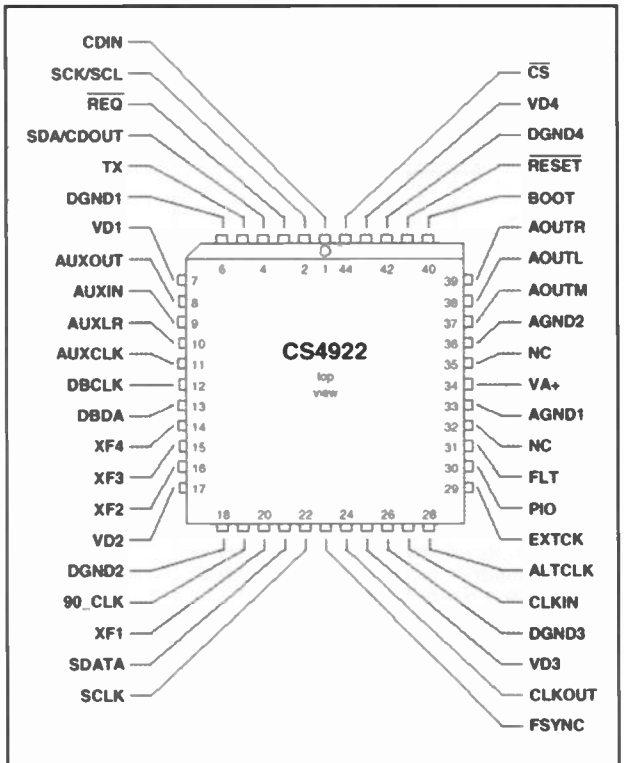


Figure 2. The pin-out of the Crystal CS4920/22 MPEG decoder/DAC, as specified within many digital satellite receivers. The SP/DIF feed can be found on pin 5 (TX).

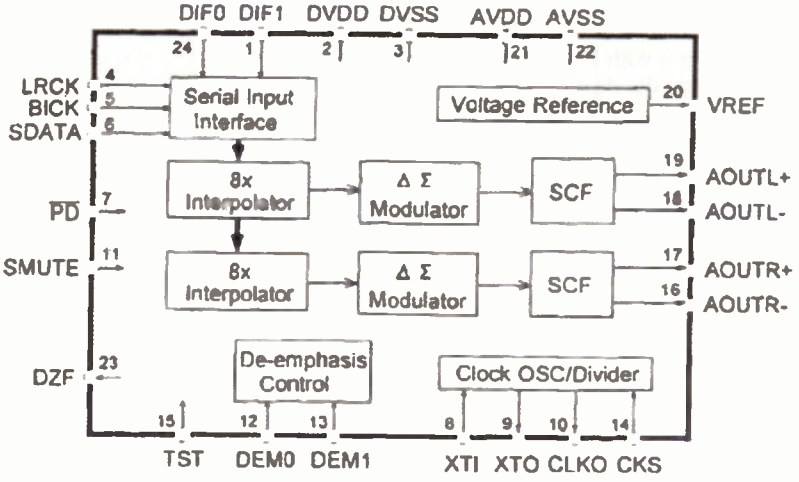


Figure 3. The block diagram of AKM's 4319 DAC, as used in the Sky Digibox

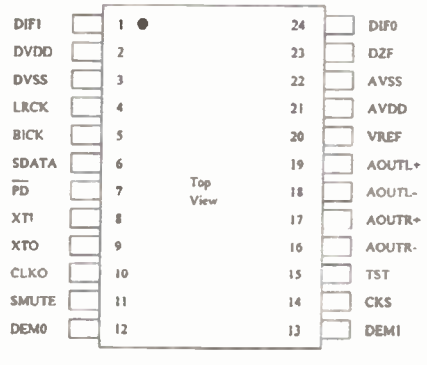


Figure 4. The pin-out of the AKM4319 DAC

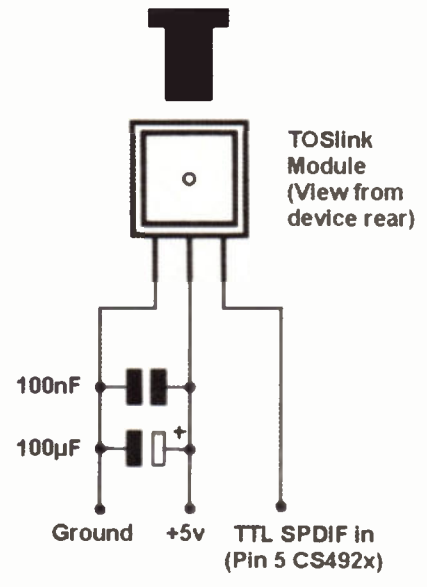


Figure 5. Here's the minimal circuitry that's required to add a TOSlink SP/DIF output to a Nokia 9200. The Sharp GP1F32T TOSlink transmitter can be obtained from Hero Electronics Ltd, which can be contacted on (01525) 405015. The company can also be contacted by writing to them at Hero Electronics, Dunstable Street, Ampthill, Beds MK45 2JS. As an alternative, you could e-mail at hero@heroelec.co.uk. The cost, inclusive of VAT and post/packing, is less that £10.

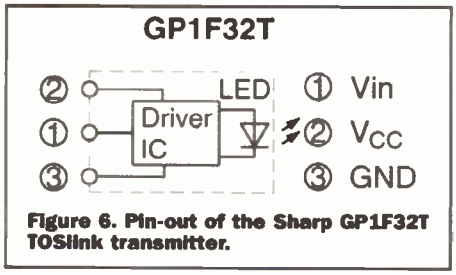


Figure 6. Pin-out of the Sharp GP1F32T TOSlink transmitter.

and serial audio data signals - from a Thomson STi3520 MPEG audio/video decoder. Effectively, then, there are two sets of components capable of doing the same job. Why? After all, it adds to the cost of making the thing! It's a shame that the Digibox's CS4922 is dormant. I for one would love a digital output. Other DVB receivers can be modified though, and we will discuss these later.

Digibox

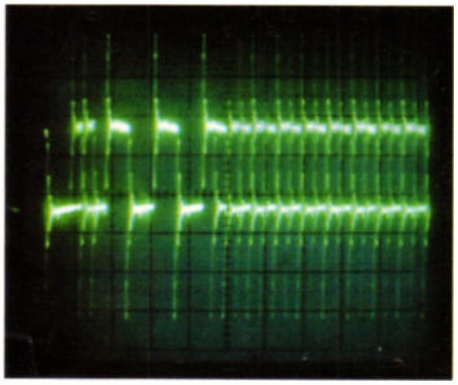
For now, though, it's back to the Digibox. The AKM4319, the block diagram and pinout of which are reproduced in Figures 3 and 4, has differential analogue audio outputs for each stereo channel. These are fed into an active low-pass filter - one for each channel. The filter is based around an op-amp, which is a TL084 (U905) in the case of the Digibox. The TL084 is a quad op-amp, and the two other devices within the chip are used to buffer the filtered audio signals prior to their distribution to the AV switching circuitry. However, most audio amplifiers have a very high input impedance, and will present very little load. I took the audio outputs directly from the active filters (pins 1 - left - and 7 - right) and connected them to phono sockets via 10mF tantalum capacitors soldered directly (careful!) to the op-amp pins. Use screened cable for all audio interconnects, otherwise you might pick up unwanted noise from the digital circuitry. On the sockets, 27k termination resistors were wired between the signal pins and ground. The signal ground was taken from the tuner screening.

I didn't particularly want to drill holes in the back of my Pace-manufactured Digibox. Thankfully, there's a removable plate on the back of the receiver, which provides access to a conditional access module socket. The plate was removed, and a plastic one was cut to the same dimensions. Holes for the phono sockets and Digibox chassis mountings were then drilled on the plastic plate. When assembled, the whole thing looks good - as you can see from the photos - and the Digibox can easily be restored to its original condition if it needs to be repaired or sold. The new outputs are at a somewhat more 'hi-fi friendly' level than the existing rear-panel phono ones, which are a good deal on the high side. The improvement in sound quality is subtle, but worth your bravery - it transcends the outpourings of pretty much any analogue FM tuner! A reasonable hi-fi system will reveal a tangible increase in transparency and detail. The existing audio outputs are unaffected, even with audio equipment connected, and so loading is minimal.

SP/DIF Feed

The lure of a SP/DIF feed proved too strong to resist, though, and so alternatives were investigated. Theoretically, the serial audio data and clock outputs of the Thomson MPEG decoder could be converted into a SP/DIF output - I recall that specialist ICs are available for the purpose. I could not verify whether a SP/DIF output is available directly on the Thomson chip, because a full datasheet is not available (on the Thomson web site, certainly). If further details come to light, then I shall reveal them in a follow-up article. However, I discovered that a second receiver in my possession (a Nokia 9200 FTA DVB receiver) has a Crystal MPEG audio decoder/DAC chip. The IC in question is a CS4920 - essentially the predecessor of the CS4922 found in the Digibox. Like the CS4922, it has a TTL-level SP/DIF output available on pin 5 (TX). Scoping it revealed that the output was enabled and working (the scope display is reproduced elsewhere in this article). This output can be used to feed a TOSlink optical transmitter module - refer to Figures 5 and 6. Drilling details for the GP1F32T are given in Figure 7. As a cheaper alternative, you could construct the circuit given in Figure 8 - this converts the TTL SPDIF output to a standard 0.5v pk-pk one that can be fed directly to the 'coaxial digital' inputs of audio equipment.

Easy Mod



What the CS4920's TTL-level SP/DIF output looks like on a scope. If you see something like this when probing around the digital audio circuitry of your set-top box, then you'll be able to modify your equipment.

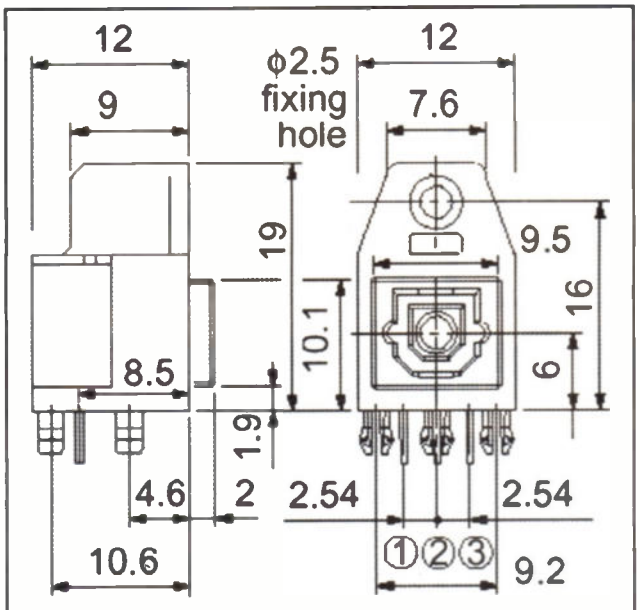


Figure 7. Rear-panel drilling details for the Sharp GP1F32T TOSlink transmitter, which can easily be added to a digital satellite receiver with TTL-level SP/DIF output. Because it relies on an optical connection to the amplifier/recorder, you get complete isolation.

The modification is easy to do, and opens up the world of (near!) end-to-end digital recording. Not only that, but you could drive audiophile DACs for the best possible sound quality. In such cases, DAB and digital satellite radio will offer an identical sound quality - but guess which is cheaper? The Nokia 9200, and its close relative the 9600, have been around for some three years now and can be acquired quite cheaply on the second-hand market - they've since been superseded by newer models. Note that my 9200 had the FTA 1.0 software - apparently, the CS4920's SP/DIF output isn't enabled on earlier versions of the software. Fortunately, you can download the latest firmware from Nokia's web site (`www.nokia.com/multimedia/downloads/index.html`) free of charge.

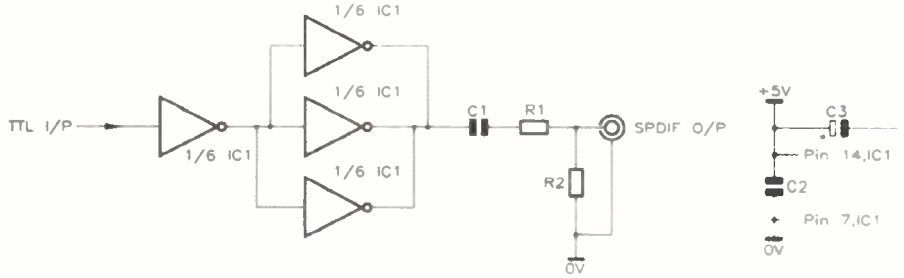
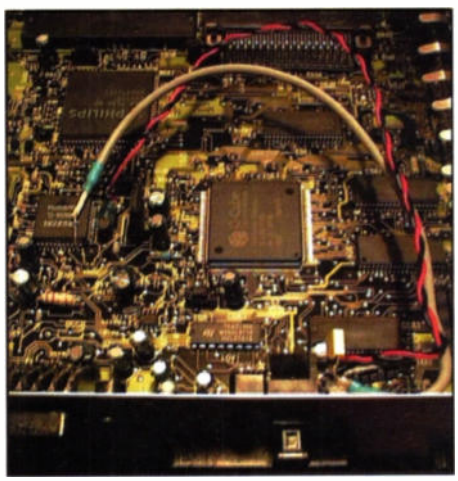


Figure 8. If you don't want to run to the expense of a TOSlink transmitter, you could always build this unit, which buffers the TTL output from the MPEG audio decoder, and brings it down to the 0.5v peak-to-peak level that is standard for coaxial SP/DIF connections. The parts list is given in Table 2. Note that care should be taken, because the output isn't isolated. Commercial digital audio equipment achieves this with a pulse transformer.



A view of the Nokia 9200's innards, showing the SP/DIF modification. Be careful when making the connection to pin 5 of the CS4920 (IB01) - it's a delicate operation. As the photo shows, I used screened cable for the digital interconnection. The 5 volt and ground connections were taken from the hot and cold sides of capacitor CB05 (22mF/50v). This capacitor is next to the CS4920

Interestingly, Nokia's latest digital satellite receiver (the 9800) has a coaxial digital output as standard - it's the only current model with the feature. Note that some other digital receivers could, with a bit of fact-finding, also be modified. At the very least, you should be able to improve the analogue side of things.

Need a Dish?

OK, so you need a dish. Big deal - you don't need a big one. Indeed, you can use the 'mini-dish' specified by Sky Digital if you only want to listen to the Beeb. These, together with the 'universal' (wideband) LNBs, can be acquired inexpensively from satellite dealers or traders at radio ralllies. The only other real difference between DAB and digital satellite radio is the quantity of services offered. DAB will give you access to local BBC/commercial and national commercial stations, as well as the BBC's five national services. Digital satellite gives you the national BBC five, but you can eavesdrop on BBC services that can otherwise only be heard in Scotland, Wales and Northern Ireland. Plus you get the Beeb's Asian-language programming and World Service. Although there's little chance of local stations making it onto satellite, the national commercial stations (Classic FM and Virgin) are likely to join up at some stage. Not only that, but you'll also get hundreds of foreign-language stations if you invest in a motorised dish - and TV channels to boot. If I was planning to learn another language, I know which route I would take!

Watch It!

Maplin Electronics and the author accept no responsibility for your equipment, should you damage it whilst attempting modifications. So be careful!

PROJECT PARTS LIST

RESISTORS: All 1/4W 5% Metal Film

R1	1	330R	(M330R)
R2	1	100R	(M100R)

CAPACITORS

C1,2	2	100nF Monores	(RA49D)
C3	1	Minelect 47µF/16V	(YY37S)

SEMICONDUCTORS

IC1	1	74HCU04	(UB04E)

Specification

Satellite:	Astra 2A (28.2°E)
Frequency:	11.795GHz (Transponder 5)
Polarisation:	Horizontal polarisation
Symbol rate:	27.5Mbaud
Forward error correction (FEC):	2/3

Station	Sky EPG Number	Stereo/Mono	Data Rate
Radio 1	911	Stereo	192kbps
Radio 2	912	Stereo	192kbps
Radio 3	913	Stereo	192kbps
Radio 4 FM	914	Stereo	192kbps
Radio 4 LW	934	Mono	96kbps
Radio 5 Live*	915	Mono	96kbps
World Service	926	Mono	96kbps
Radio Scotland	927	Stereo	128kbps
Radio Wales	928	Stereo	128kbps
Radio Ulster	929	Stereo	128kbps
Asian Network	930	Stereo	128kbps

Table 1. Tuning details for BBC digital radio

* For copyright reasons, this channel is encrypted using Sky's Videoguard CAM (Conditional Access Module) and can hence only be received using a Sky Digibox. You will also need a smartcard, whether its of the 'free-to-air' or full-subscription variety.

Martin Pipe welcomes comments and ideas. E-mail him as: *whatnet@cix.compulink.co.uk* Or look out for him online! His ICQ ID is: 15482544

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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