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ELECTRONICS

The Maplin Magazine

Britain's Best Selling Electronics Magazine

No. 101

FULL SOR

MAY 1996 • £2.25

Printed in the United Kingdom

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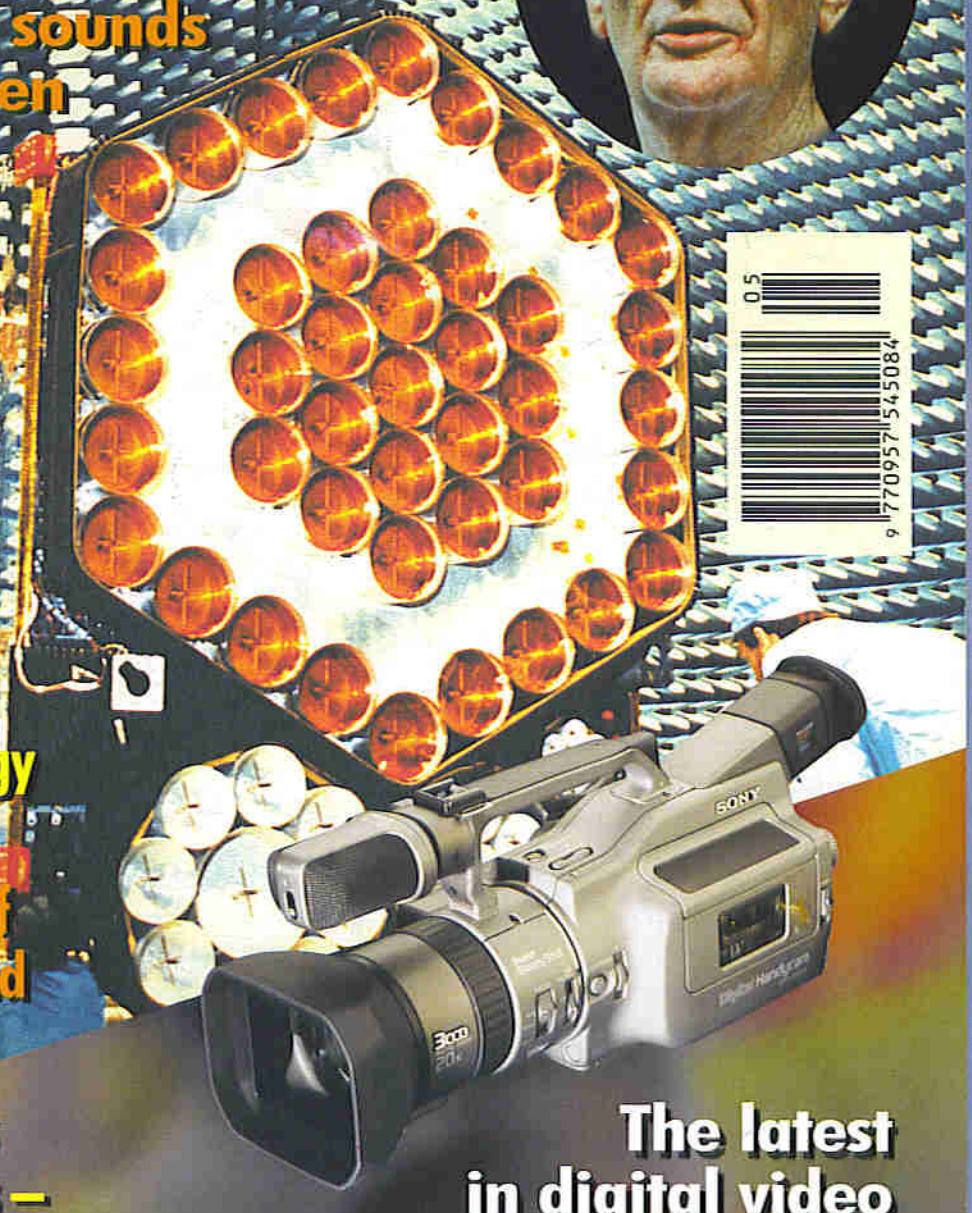

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MAY 1996
VOL 15. No. 101

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DIGITAL STORAGE PC OSCILLOSCOPE 40
Build this superb project and transform your IBM-compatible PC into a well-specified and accurate Digital Storage 'scope, at a fraction of the price of purchasing a bulky dedicated instrument with equivalent functions! Comprises a parallel printer port-linked hardware interface unit and easy to operate software, which offers the facility to store and print out waveforms as they appear on the screen.

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FROM THE EDITOR . . .

Hello and welcome to this month's issue of *Electronics*! With the 100th issue of the magazine now passed, the editorial team have been as busy as ever producing a fine collection of features and projects for you to read and build.

This month we also feature our first cover disk. UK users will receive one month's free subscription or 10 free hours access to the AOL UK service. Subsequent costs will be £5.95 for up to five hours of use, plus £1.85 for each additional hour. Please note that the cover disk will not be available on our International version of the magazine.

Prize Draws

This issue also includes two free prize draws for our readers to enter. We have fifteen copies of *Hard Target* by James Adams to give away, with no purchase necessary. Lucky readers might also win tickets for entry to the Science Museum in London. Just return the coupons to be entered into the prize-draws.

Traffic*master*

Next month we are planning to have an article on the Traffic*master*™ and Traffic*mate*™ systems. There have been many changes since our original review on Traffic*master* in November 1991.

The Traffic*master* control centre.

Apologies

Please note that the High-Level Brake Light Flasher due to appear in this issue will not now be published. Information received indicates that the project might have put motorists at risk of prosecution. Maplin Electronics being a responsible company, and not wishing its readers to commit an offence have withdrawn this project.

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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:

1. Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering iron, side cutters, pliers, wire strippers and screwdriver). Test gear not required and no setting-up needed.
2. Easy to build, but not suitable for absolute beginners. Some test gear (e.g., multimeter) may be required, and may also need setting-up or testing.
3. Average. Some skill in construction or more extensive setting-up required.
4. Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.
5. Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

Ordering Information

Kits, components and products stocked by Maplin can be easily obtained in a number of ways:

Visit your local Maplin store, where you will find a wide range of electronic products.

If you do not know where your nearest store is, Tel: (01702) 552911. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance.

Write your order on the form printed in this issue and send it to Maplin Electronics, P.O. Box 3, Rayleigh, Essex, SS6 8LR. Payment can be made using Cheque, Postal Order, or Credit Card.

Telephone your order, call the Maplin Electronics Credit Card Hotline on (01702) 554161.

If you have a personal computer equipped with a MODEM, dial up Maplin's 24-hour on-line database and ordering service, CashTel. CashTel supports 300-, 1200- and 2400-baud MODEMs using CCITT tones. The format is 8 data bits, 1 stop bit, no parity, full duplex with Xon/Xoff handshaking. All existing customers with a Maplin customer number can access the system by simply dialling (01702) 552941. If you do not have a customer number Tel: (01702) 552911 and we will happily issue you with one. Payment can be made by credit card.

If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place orders directly onto the Maplin computer 24 hours a day by simply dialling (01702) 556751. You will need a Maplin customer number and a personal identification number (PIN) to access the system. If you do not have a customer number or a PIN Tel: (01702) 552911 and we will happily issue you with one.

Overseas customers can place orders through Maplin Export, P.O Box 3, Rayleigh, Essex, SS6 8LR, England. Tel: +44 1702 554000 Ext. 326, 327 or 351; Fax: +44 1702 553935.

Full details of all of the methods of ordering from Maplin can be found in the current Maplin Catalogue.

Subscriptions

Full details of how to subscribe may be found on the Subscription Coupon in this issue. UK Subscription Rate: £23.76/12 months, £11.69/6 months.

Prices

Prices of products and services available from Maplin, shown in this issue, include VAT at 17.5% (except items marked NV which are rated at 0%) and are valid between 19th March and 31st August 1996 errors and omissions excluded. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue.

Technical Enquiries

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics*, the Technical Sales Department may be able to help. You can obtain help in several ways; over the phone, Tel: (01702) 556001 between 9.00am and 5.30pm Monday to Friday, except public holidays, by sending a facsimile, Fax: (01702) 553935, or by writing to: Technical Sales, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Technical Sales are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due to any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
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£40.00 to £59.99	£30.00
£60.00 to £79.99	£40.00
£80.00 to £99.99	£50.00
£100.00 to £149.99	£60.00
Over £150.00	£60.00 minimum

Readers Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about *Electronics* and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read – your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editors discretion. Any correspondence not intended for publication must be clearly marked as such.

Write to: The Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex, SS6 8LR, or send an e-mail to AYV@maplin.demon.co.uk

TECHNOLOGY WATCH!

with Keith Brindley

Hot news for educational IT users is a deal between Acorn and Apple, which will create a new company selling computers from both computer manufacturers as solution-based technologies specifically for the education market. The deal is so hot that a new name for the joint venture has yet to be announced, although the company will be operational by early April.

Acorn, of course, has supplied computers to the education market for many years now, first within the BBC range of personal computers, but lately also with its A7000 computers. Apple's Macintosh computers are an educational success story in the US (with 63% of the market last year), but have only just begun to scratch the surface in UK schools.

If you think about it, the partnership is an ideal one. Both computer manufacturers make computers with an in-built graphical user interface operating system, rather than an add-on one in the form of Windows. To compete against each other, as well as competing against Wintel (Windows and Intel) computer manufacturers seems inappropriate. Also, Apple and Acorn have worked together successfully in another venture: Acorn's subsidiary Advanced RISC Machines makes the ARM processor for Apple's Newton personal digital assistant hand-held computer.

Although starting with a mixed bag of existing products from both companies, in the middle to longer term, the venture is expected to generate new classes of products and services. It is also expected that the PowerPC platform (as defined by Apple, IBM and Motorola) will form the next generation of the venture's personal computers, and Olivetti, Acorn's parent company, has licensed the Macintosh operating system (MacOS) from Apple to this end.

Doing it digitally

A new CD-ROM graced my doormat this month. Now, I get quite a lot of things to look at and review as part of my day-to-day work. Many of these things (particularly CD-ROMs) aren't even worth a mention. (CD-ROM content quality, or rather lack of it, has simply got to be one of my favourite hobbyhorses.) However, this one *is* worth a mention. It is also well-suited to readers of *Electronics – The Maplin Magazine*, because it looks closely at digital music and its production on computer.

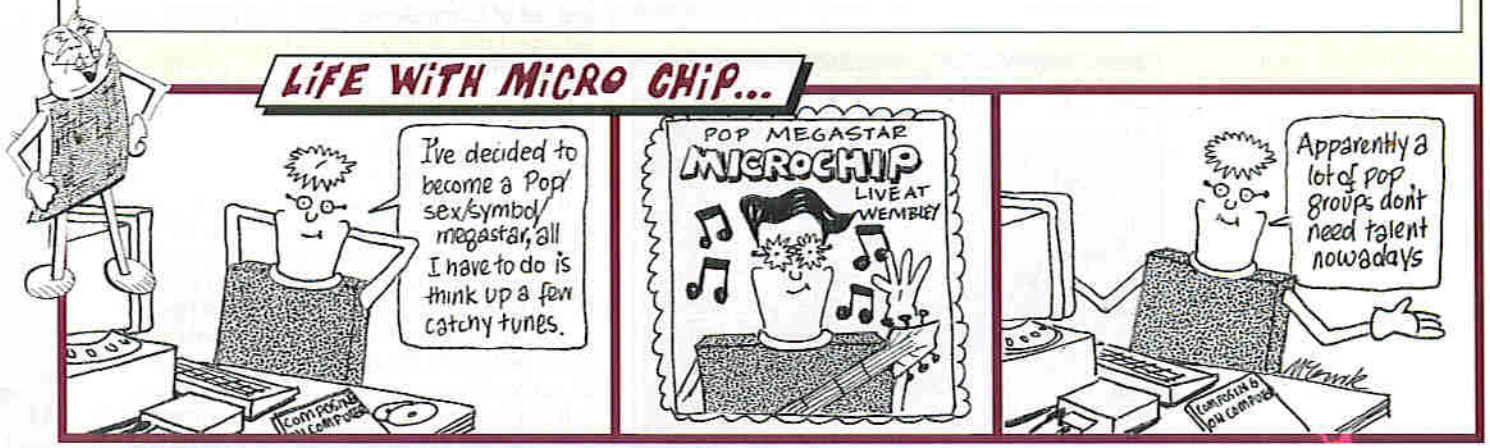
Computer Music: an Interactive Documentary is, like most CD-ROMs, a US-produced work, but don't let that put you off. Topics, and the way they are presented are suited to UK users equally. It is produced as a hybrid, running on both Windows and Macintosh computer platforms, so if you are equipped with a multimedia-capable computer of either platform it will work. All other requisite utilities are supplied on the CD-ROM.

Main interface to the CD-ROM is a graphical jukebox-type arrangement, called the VidBox. There are four main areas: Tech Tunes, Synthesis, MIDI, and Composition. An area is selected by clicking it, then a sub-topic is played by dragging it to the on-screen player. To be honest, when I first played the CD-ROM I thought this was a bit tacky, but once I got into the CD-ROM content I have been forced to acknowledge that it is a good way to get the technical content across. After all, you've got to start somewhere and if you are coming into a new topic, much as I was, it is not a bad idea to do it in a way which splits up technical content into manageable and understandable chunks. Without trying to patronise, this could be an important feature for any musician (with a technical or non-technical background) approaching the computer as a musical tool. Important, too, for the music student, however young.

It is sufficiently detailed, on the other hand, that even quite experienced electronic musicians will be able to find things of interest. Developed in association with the University of California, Santa Cruz, the producers have ensured a high level of technical content is available from the graphical front-end. For example, there are over two hours' of animation and video footage, featuring people who work in the business. This is balanced against a good level of interactivity for users to get hands-on experience.

Contact: Digital Studios, 209 Santa Clara Avenue, Aptos, CA 95003, USA. Tel: +1 (408) 688 3158. Price: (US Dollars) $49.95. You can also download demo versions from **http://www.netins.net/showcase/macintosh/cyblearn.htm** or contact the producers by email at: **nolan@cyberlearn.com**.

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



Electronics has teamed up with AOL this month to bring you access to the Internet, and the company's range of online services. Here, Fred Entwistle shows you how to get online, and what to expect once you are there.

THE NEW CYBER PROVIDER

THERE is a new kid in town. America Online UK (AOL UK) launched aggressively in the UK in January. In a counter reaction, rival CompuServe immediately announced that it was introducing personalised addressing and extending its UK network.

There is no doubt that the temperature in the Internet provider market is rising. While it is clear that AOL has a battle on its hands in the UK, it is here to fight. According to managing director, Jonathan Bulkeley, the company intends to take the number one slot from CompuServe by January next year. The traditional home-grown providers such as CIX, Demon Internet and UK Online have a real fight on their hands if they are to maintain and increase market share.

Online Issues

Online service provision is far from being a commodity market. There are a number of issues for the potential subscriber to consider. While cost is a recognised influencing factor, content, high-speed connection links, local points of presence (POPs) and quality of client software are also important. It is by recognising the importance of each of these areas that Bulkeley reckons AOL UK will win through.

Ultimately, however, Bulkeley claims that it is content which is key. "Anyone can invest in hardware, it is what you see once you're online that will become the critical factor. What makes AOL UK fundamentally different to existing online services is that we provide content developed specifically for the UK consumer. Our primary aim is to offer a service rich in content, but we realise it has to be easy to use, accessible and affordable", said Bulkeley.

Based in London, AOL UK is part of a joint venture created in March last year by America Online and media group, Bertelsmann AG. America Online has over 5 million users in the US and revenues in excess of $394million, while Berstelsmann AG is an $11billion global group of companies in publishing and entertainment.

Photo 1. AOL front end dashboard.

Photo 2. Personal filing cabinet.

High-speed Network

AOL already has 80% of the UK covered by local call point of presences, and aims to achieve 100% by the end of April. What makes AOL even more appealing, is the fact that all connections points are at 28·8K-bit/s, allowing users with high-speed modems to make full use of available bandwidth.

AOL's client software, AOL 2.5i, is an integrated suite containing e-mail software, a WWW browser and a front end dash board to AOL's own online services. Unlike similar approaches such as Pipex with its Dial application, AOL 2.5i is tightly integrated. This means that the user need not get involved configuring the browser software for dialler applications or TCP/IP addressing. All of AOL's features, such as the WWW browser and e-mail package, are accessed from within the main dashboard.

Dashboard Navigation

In terms of graphical content, AOL stands on its own. As Photo 1 shows, the front end graphical user interfaces (GUIs) are crisp and glossy, a far cry from the '70s look and feel of CompuServe. Users with a sound card also get sound clips as they navigate through the online service. Unfortunately, as yet, AOL 2.5i is only available on the PC for Windows 3.1 or above. A Macintosh version is promised for later in 1996, but AOL has yet to confirm a release date.

AOL 2.5i is the framework for users to access the online services of AOL. Once online, new graphics, text and sound files are cached to the hard disk. When initially navigating around the system, this can become tiresome. Almost every option selected requires new files to be downloaded to disk. The good news is that you are not charged for this download time. The bad news, perhaps, is that BT will certainly make a fair bit of cash while you download additional material.

BT's profits aside, there are definite advantages to be had by this approach. By caching graphics and other

files to the hard disk, subsequent visits are far faster. And when it comes to updating menu options or adding new features, subscribers are able to access new material as soon as they get online, instead of waiting for a new version of the application software to be released.

Pricing

New members signing onto AOL using the *Electronics* cover disk get one month's free AOL membership including 10 free hours online. After this, the monthly subscription charge is £5.95, which includes five hours online time. Subsequent usage is charged at £1.85 per hour.

Online subscribers also have access to AOL's freephone helplines, open Monday to Friday from 8.00am to 10.00pm and Saturday from 9.00am to 5.00pm. And here's a first; when we called up one Saturday afternoon, we got through within three rings.

Offline Reader

AOL 2.5i includes an offline reader called FlashSession for users who want to have incoming and outgoing mail and newsgroup messages without straying into any of the other online services. Users are able to set the level of functionality required during a FlashSession by moving through a series of menus accessed from the e-mail menu. For instance, you may wish to pick up and send e-mails but not newsgroup messages. FlashSession's can also be scheduled as a background task to check regularly for new mail while another Windows application is being used, or during the night to avoid monopolising the phone line.

Messages of whatever form are stored in a personal filing cabinet, as shown in Photo 2. The personal filing cabinet, accessed from the e-mail menu allows you to organise documents and files such as incoming and outgoing mail, newsgroup messages and attached files.

Without a FlashSession, messages can be downloaded during the course of any online session. In this instance, the user must respond to new message prompts from the AOL server. These can then be read and if appropriate, responded to online. If you want to keep copies of these messages in your personal filing cabinet for later reference, you must amend your personal preferences accessed from the members menu. By selecting mail and marking the retain options, you will ensure that copies of all incoming and outgoing mail will be filed in your personal filing cabinet.

Internet Access

Users wanting to access the World Wide Web (WWW), Gopher and FTP can do so via the Internet menu, (see Photo 3) which is itself accessed from the main online menu. Access to Internet services such as the WWW is via AOL's own browser package, (see Photo 4). There are clear benefits in having the browser integrated within the main online suite. The main advantage is that users can access hot links from within the online service. The software is smart enough to realise that when you click on a WWW address, it needs to open the browser and access that site.

An integrated browser does mean that subscribers are limited to using AOL's proprietary NaviSoft package. WWW pages designed to make use of the multimedia features available under Netscape 2.0 for Windows '95 will not work without the addition of application files.

Consider an example. Photo 5 shows the *Private Eye* home page loaded under AOL. Compare this with Photo 6. Here, the same home page has been loaded up in Netscape 2.0. Because AOL's WWW browser is proprietary, it is unable to load the background for the *Private Eye* home page, and similarly, struggles to format the text and graphics.

Online Content

Although AOL's content may not be as deep as its main rival CompuServe, it is very broad, and unlike CompuServe, there are no premium tariffs. Here, we look at some of the services supported by AOL in the UK.

Sports

ClubCall, the telephone information service for football information, has joined forces with AOL to create a sports area, focusing on football and rugby union. AOL members can access ClubCall's online service to check fixtures, results, statistics, historical information and all the latest football and rugby information. In addition, ClubCall is also establishing lively chat areas and an independent weekly column written by ex-England and Bath prop-forward, Gareth Chilcott, who discusses current issues in rugby union.

Photo 3. Internet menu, from which WWW access is selected.

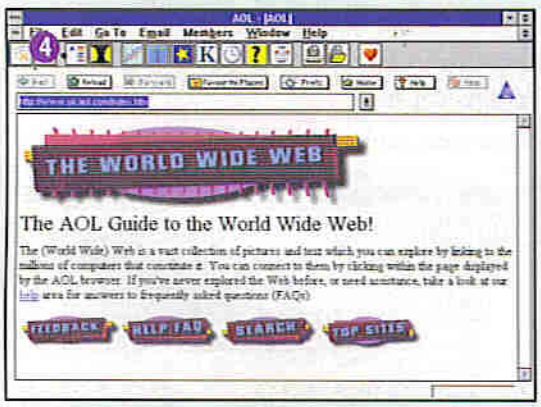


Photo 4. AOL proprietary WWW browser.

Photo 5. *Private Eye* home page loaded via the AOL browser.

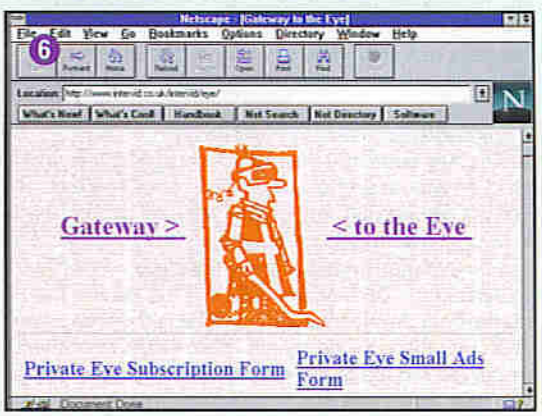
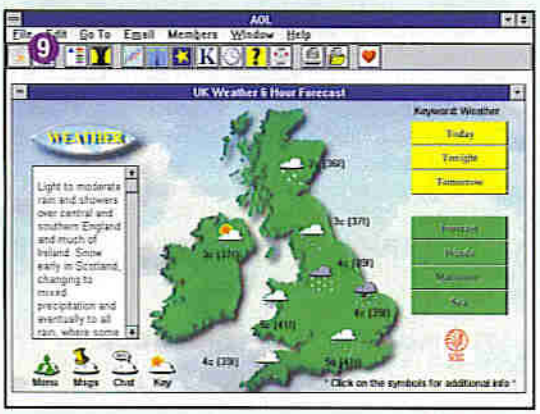


Photo 6. *Private Eye* home page loaded via Netscape 2.0 browser.

Photo 7. *Time Out* listings.

Photo 8. *PA News*.

Photo 9. Weather reports are available for 6-, 12-, 24-hour and 5 day forecasts.



Education

In a deal with Anglia Multimedia, the education and multimedia partner of Anglia Television, AOL will carry a wide-ranging education area, developed especially for the UK market. Initially, there will be two key strands: Education Anglia is an interactive forum carrying curriculum materials for both students and teachers, and a site for Anglia Television's Survival series.

"Education Anglia's Curriculum Service has been built to help the child who is looking for support for homework or just keen to delve deeper into a particular subject. Whether it is languages or mathematics, history or science, geography or design technology, there will be material on the AOL Education Anglia area to help the enquiring mind. We also plan a 'staffroom' for teachers to exchange information and a 'playground', where students can take a break and communicate with friends around the world", said Ajay Chowdhury, managing director, Anglia Multimedia.

The Anglia Survival site will appeal to adults as well as children with ecological and environmental interests. The site will provide up-to-date information on ecological and environmental subjects around the world. Topical issues will be explored in depth, and will include opinions of experts in the field. Additionally, a virtual wildlife park is currently in development and will be in the area where AOL members will be able to make safaris from their desktops, and a gateway to a comprehensive wildlife database, covering the entire planet.

Digital City London

AOL is planning a series of Digital Cities. These are electronic guides to what's on and where to go. Digital City London is already on the map, and includes content from *Time Out*, the leading London listings magazine, as shown in Photo 7.

Digital City London is accessed via its own interface from the main menu, and includes easily searched guides and listings, including the *Time Out* Critic's Choice. Updated weekly, Digital City London carries details on the best of current theatre, cinema, music and comedy events, guides to books, galleries, childrens' activities and the *Time Out* restaurant guide are also featured in the area.

In addition, Digital London contains links to major relevant web sites such as *The Tube Planner* and *Time Out*. Other areas provide a daily local news area, a City chat area, message boards and a lonely hearts feature. Over the next year, AOL will launch other UK Digital Cities.

Scottish Listings

Subscribers in Scotland, as well as its visitors, will be able to access a comprehensive guide to what's on in Glasgow and Edinburgh through a digital service provided by Scotland's best-selling magazine guide to arts and entertainment, *The List*. The latest information on films, music, theatre, cinema, clubs and art will be updated fortnightly on the AOL service. Additionally, *The List*'s Student Guide will be included and foodies will be able to check out the best restaurants, bars and cafes via *The List*'s food guide.

Computing

Ziff-Davis are providing a variety of computer content for the new AOL online service, including message boards, live events and shareware and freeware libraries.

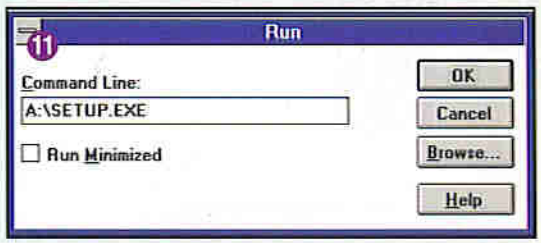
"Our three UK magazines – *PC Magazine*, *PC Direct* and *Computer Life* – will each have areas on AOL with in-depth info on products and companies, drawing from and adding to the huge investment in high quality content that Ziff-Davis makes in its print publications", said David Craver, managing director, Ziff-Davis.

Other publishing houses are following suit. With its first online service deal, VNU is providing an active area which will extend the editorial value of *Personal Computer World*.

According to publisher Jonathan Ross, AOL members will be able to access the VNU *Personal Computer World* area to access more information than the printed publication can provide. "With our traditional printed format, we are naturally limited to the amount of information we can include in reports. For example, in our group tests, there is only so much information

Photo 10. AA Roadwatch gives up-to-the-minute reports on road conditions.

Photo 11. Installing AOL from disk.



that makes the cut. Our editorial staff acquire and accumulate considerably more detail than we can ever print and so our area on AOL will be an extension of the printed product", said Ross.

News

AOL has contracted *PA News* to supply real time domestic news and sports feed. PA's online news service carries up to 1,000 reports and updates daily, covering a broad spectrum of stories, from politics to entertainment and from crime to consumer affairs. The spread of stories which the service carries is impressive, and because the system is linked into an international news agency, material is published in real time. For instance, when the IRA bomb exploded in the East London at the beginning of February, AOL carried a report together with photographs as shown in Photo 8, almost 30 minutes before the story hit the TV and radio bulletins.

Weather

AOL allows members to focus in on more than eighty inland and coastal regions for a detailed combination of 6-, 12-, 24-hour and five day local forecasts, as shown in Photo 9. Here, AOL has also included information such as sunrise and sunset, tidal changes, sea swells and temperatures and wind speed and direction, from any part of the UK.

Road Travel

AA Roadwatch is providing AOL with a comprehensive UK service, updated on a 15 minute basis. With AA Roadwatch shown in Photo 10, potential trouble spots such as roadworks and traffic hold ups are identified, so that journeys can be tailored accordingly. On a typical day, more than 2,500 pieces of information are entered into the AA Roadwatch database, which will be continually available to AOL members.

Missing Links

While the services available over AOL are impressive, there are some large holes. For a start, there is no UK shopping facility, and CompuServe users will miss the executive news service. The latter can be forgiven, but if AOL is to hit it off among consumers, an online mall is an absolute must.

At the moment, the AOL network is very fast, but watch out as membership begins to pick up. The computing press in the US slammed AOL last year for its sludgy transmission speeds. However, with a high-speed network already in place, the new online provider should avoid this problem.

AOL is pitching itself as more than a traditional online service. It blends text, audio and images as a matter of course, and looks a lot more like TV than any other service. By entering the UK market with highly graphical easy-to-use client software, the lowest subscription rates, a high-speed network and a broad range of local call points of presence, AOL has placed the emphasis on content. In terms of content, this is the service provider which others will have to follow.

Getting Online with AOL

The minimum systems requirements for AOL 2.5i is a 386 IBM-compatible PC with 4M-bytes of RAM, VGA monitor, a modem, and Windows 3.1 or Windows '95. The cover-disk includes 10 hours of online time which must be used within the first 30 days of online time. Use of AOL requires credit card registration for subsequent billing. The membership fee is £5.95 per month, which includes 5 hours online time each month. Subsequent time is charged at £1.85 per hour.

- To get started, insert the cover disk in your disk drive.
- If you are running Windows 3.1, click on the File Menu of your Program Manager and select Run. If you are running Windows '95, click on the taskbar and select Run.
- Type A:\SETUP and press ENTER. Next, click on the install button, as shown in Photo 11.
- AOL for Windows Setup will boot-up and run through some preliminary hardware tests before installing AOL 2.5i to the hard disk.
- The installation routine takes approximately 5 minutes. Once complete, an AOL icon will be added to your program manager, as shown in Photo 12. To get online, double-click on the AOL icon.
- AOL 2.5i will guide you through a series of initialisation menus to set up the modem connection before signing on to AOL, as shown in Photo 13.
- Once online, insert your registration number and password from the cover disk, as shown in Photo 14.
- Before accessing AOL's online services, you must select a screen name. This can be up to ten characters long and must not conflict with any other AOL user. Consequently, it can take several attempts before a suitable screen name is selected. If you have trouble securing the screen name you want, try adding "UK" or a middle initial.
- Finally, you need to choose a password. This is required each time you go online, so choose something familiar, but not so obvious that somebody else could guess it.

If you are installing AOL on a second machine, follow the same process above, except insert your screen name and screen name password instead of registration number and password when initially logging on.

Photo 12. AOL icon is added to Program Manager.

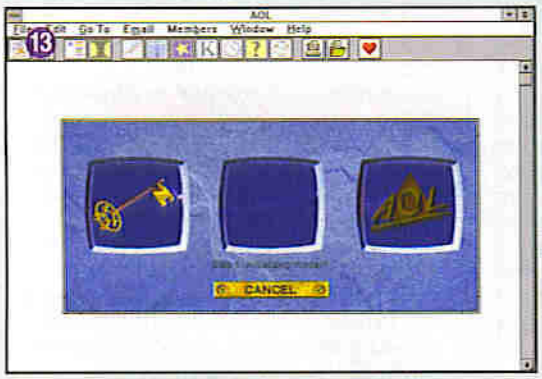


Photo 13. Signing on to the AOL server.

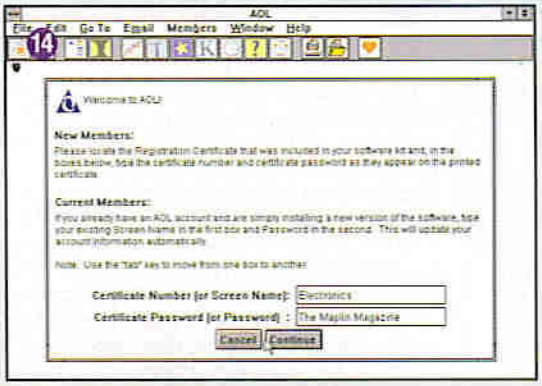
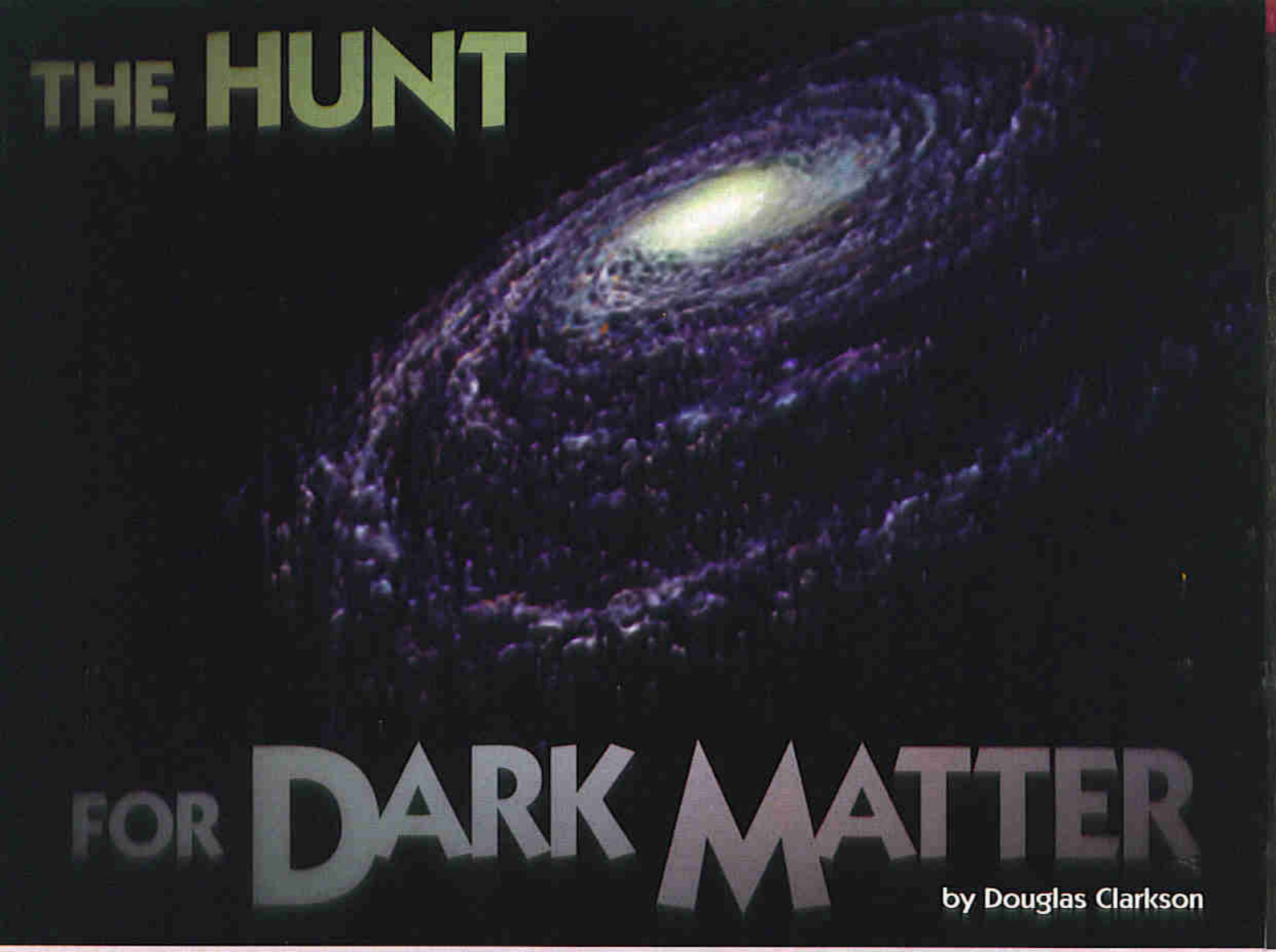


Photo 14. Registration and password details are required.

AOL Contacts

Sales: (0800) 279 1234. General: (0800) 376 5432. Technical: (0800) 279 7444. Billing: (0800) 376 7444.

THE HUNT FOR DARK MATTER



by Douglas Clarkson

The 1980s and 1990s have witnessed a resurgence of interest among the public at large on the topic of Cosmology. The contribution by Stephen Hawking of 'A Brief History of Time' has made many more people wonder about the start and possible end of the Universe. If, based on the best observations of Astronomers, the galaxies in the universe are separating from each other in a distant aftermath of the 'Big Bang', then the Universe will either keep expanding for ever or at some time in the future, reach the limit of its expansion and begin to collapse back on itself.

Some of the basic experiments now being undertaken in astronomy and particle physics are designed to fill some of the significant gaps in our present understanding of the universe.

One of the embarrassments of modern theories of Astronomy is that only around 10% of the mass of the near Galaxies can be directly observed. The so-called 'Dark Matter' of the universe – the matter which from rotation of galaxies, etc. is known to exist but cannot be detected is being investigated by a growing number of research groups. Observational systems such as the Hubble Space Telescope have a significant role to play in searching for very faint objects which may account for some of the missing mass of the Universe. Photo 1 indicates an image obtained by the Hubble Space Telescope in the search for faint objects. It shows an image of a suspected comet nucleus at the fringe of the Solar System, beyond the orbit of Neptune.

There is also the possibility that numerous non-Baryonic particles exist, which, while having mass and participating in gravitational attraction, do not interact with 'normal' Baryonic particles such as neutrons and protons. Such particles are termed 'cold' Dark Matter.

Enter the Neutrino

Neutrinos, by contrast, are termed 'hot' or energetic Dark Matter. The neutrino ('little neutral one') was first proposed by Pauli in 1931 and formulated into theories of radioactive decay by Fermi in 1934. The particle was first detected in 1956 by Reines and Cowan, and is now extensively studied in order to try to resolve the 'Dark Matter' Mystery.

In the initial formulation of the characteristics of the neutrino, it was assumed to have energy and momentum, but little and probably no rest mass. Theorists have shown that there is a critical mass of the neutrino with respect to either an 'open' and expanding universe and a 'closed' and at one time contracting universe. Major scientific projects are currently seeking to detect neutrinos with greater precision and evaluate more of their characteristics – particularly their mass.

Detecting Solar Neutrinos

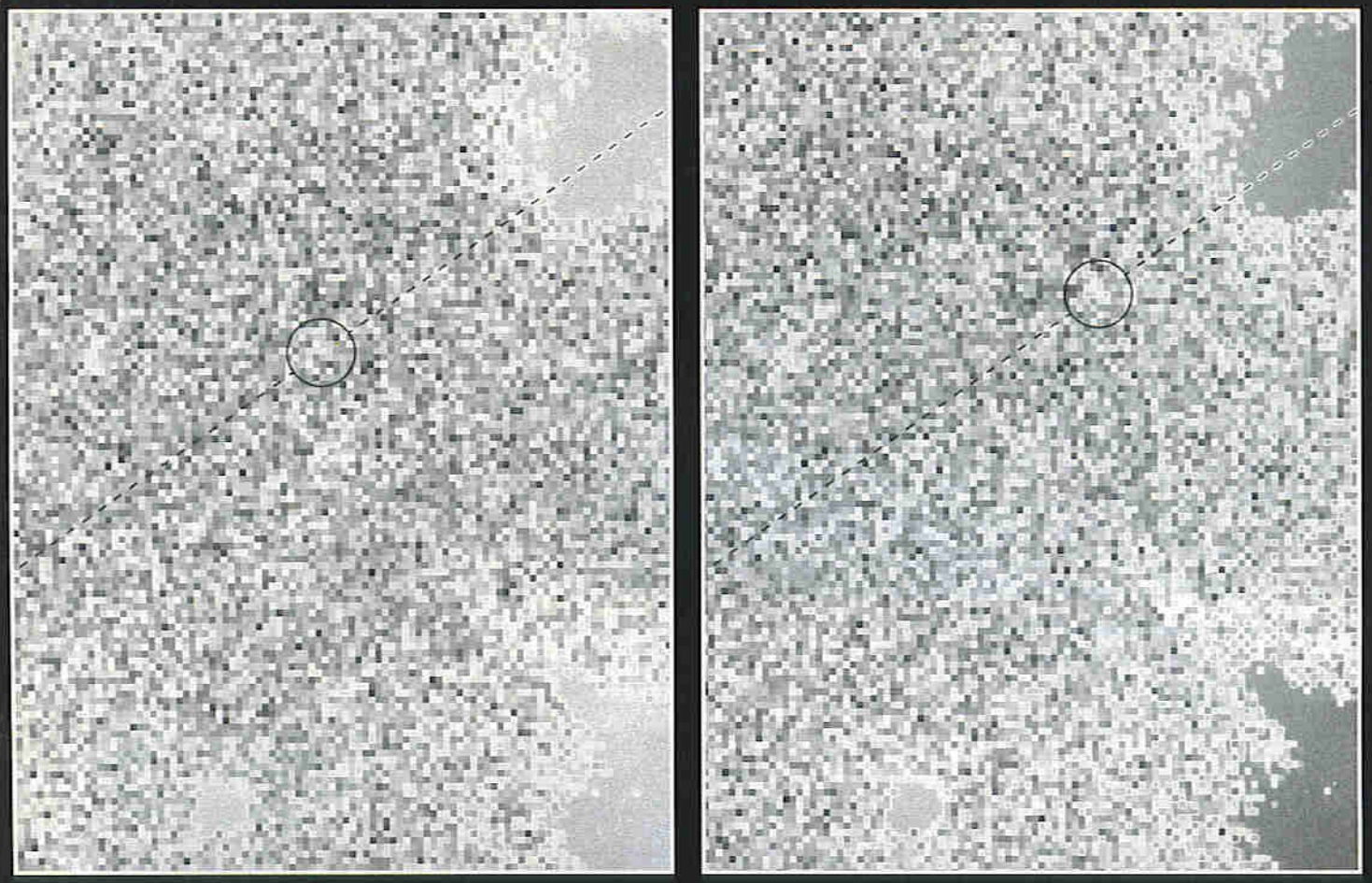
In the solar system, the major source of neutrinos is the sun. A significant percentage of the energy of the sun, as much as 3%, is emitted as energetic neutrinos. It is estimated that at the surface of the earth, the flux of neutrinos is of the order of $10^{10}cm^{-2}s^{-1}$ (per square centimetre per second). These neutrinos are considered to arise due to the nuclear reactions within the sun. While there are a great many neutrinos incident upon the earth, very few of them interact with matter. In nuclear physics, the relative level of interaction is described in terms of cross-section. A typical value of cross-section for a slow neutron, for example, leading to fission, is in the region of $10^{-24}cm^2$. For a neutrino, the cross-section is typically of the order of $10^{-43}cm^2$, though this varies considerably with energy and type of neutrino.

This implies that almost all neutrinos incident on the earth pass right through it without any interaction whatsoever. This poses great difficulties for their detection by scientific experiments. As ever, the intrepid physicist cannot be daunted by apparent difficulty.

There are two basic types of neutrino detector at present – active and radiochemical. The active detector measures events as they happen. This form of detector was especially useful in detecting the neutrino outburst of supernova SN1987A. Such active detectors can also determine aspects of the directionality and energy of the incident neutrino. As neutrino studies develop, the active type of detector is playing an increasingly important role.

In a radiochemical detector, the incident neutrino interacts with an atom in the detection medium to form a radioactive isotope. Usually, such radioactive atoms can be collected from the detector in gas form. Such detectors have to be left for some appreciable time (e.g., 100 days) in order to allow the radioactivity to build up to detectable levels. While such experiments are cheaper to implement compared with the active detectors, they only provide information about 'how many' neutrinos were observed.

One of the longest established cosmic neutrino



Candidate Kuiper Belt Object

Hubble Space Telescope • Wide Field Planetary Camera 2

detectors is run by the Brookhaven National Laboratory and is located in the Homestake Gold Mine in South Dakota, some 1·5km underground. In this radiochemical detector, the core of the system is a tank of 400,000 litres of extremely pure perchlorethylene – a dry cleaning fluid.

Neutrinos interact with Chlorine atoms of the perchlorethylene to form an isotope of Argon – Argon 37 with a half life of 35 days. Every 100 days, the system is flushed with Helium to extract the Argon and the radioactivity of the sample is measured.

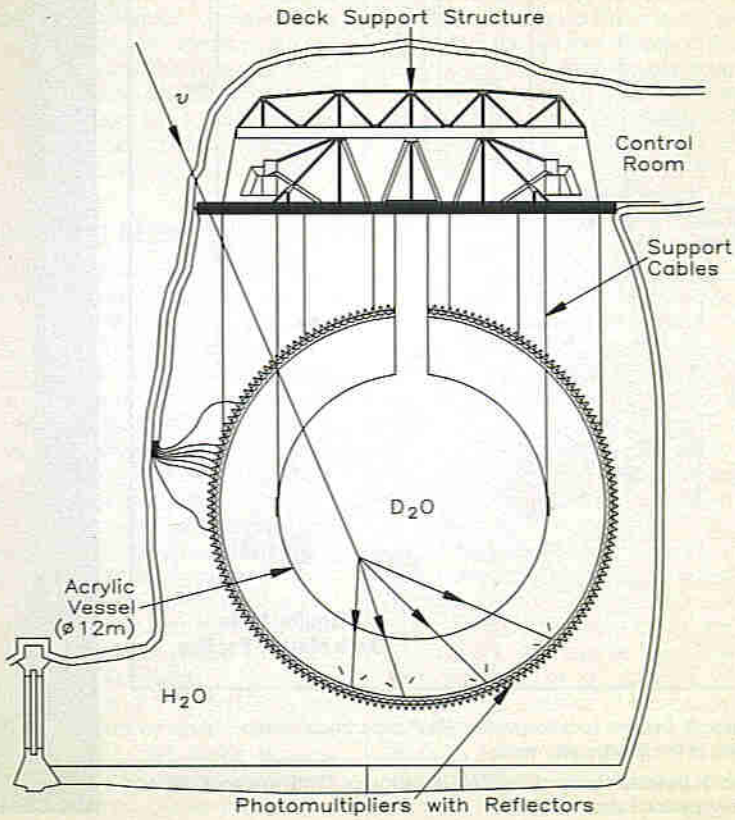
The solar neutrino unit (SNU) is defined as the number of captured neutrinos per 10^{36} target atoms. Based on the Standard Solar Model (SSM) of solar activity, the number of target atoms and the energy threshold of the Chlorine atom for neutrino capture, the predicted counting rate was estimated at around 7·6 SNUs and corresponded to around 3 atoms per week. The level detected at the Homestake Mine detector, however, has been consistently measured at under 2 SNU. This significant discrepancy has posed serious problems for theorists ever since.

The Japanese Detector: Kamiokande-II (K-II)

In the late 1980s, the K-II detector began to generate data on detection of neutrinos using a different detection technique. The detector measures the Cerenkov light produced by 'knock-on' electrons in a large water tank as a result of neutrino-electron scattering.

The smaller than expected value of neutrino detection is replicated by the K-II detector. The ratios of the signal, however, are not identical.

Above: Photo 1. Image obtained by the Hubble Space Telescope in the search for faint objects.
Below: Figure 1. Design of the Sudbury Neutrino Observatory (Courtesy Hamamatsu Photonics).



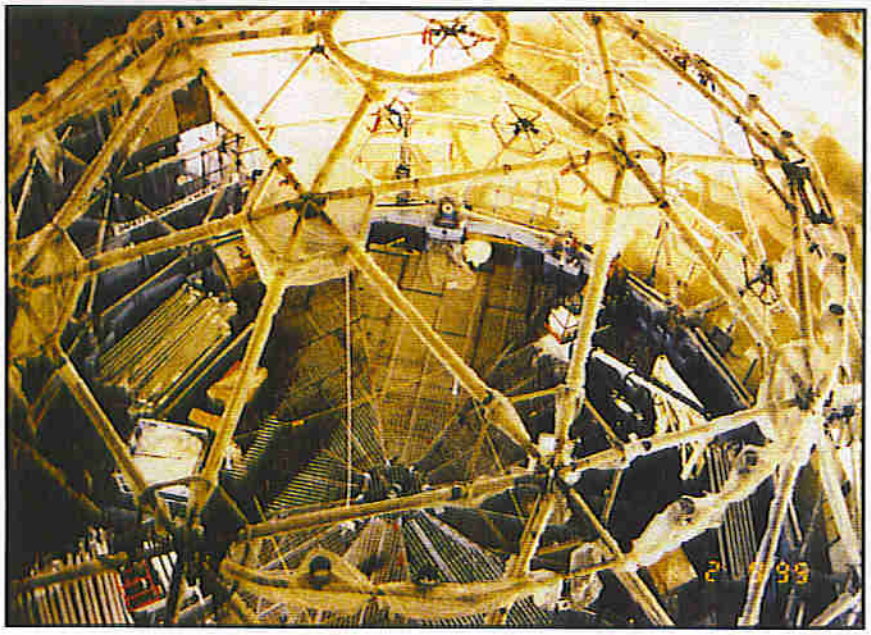


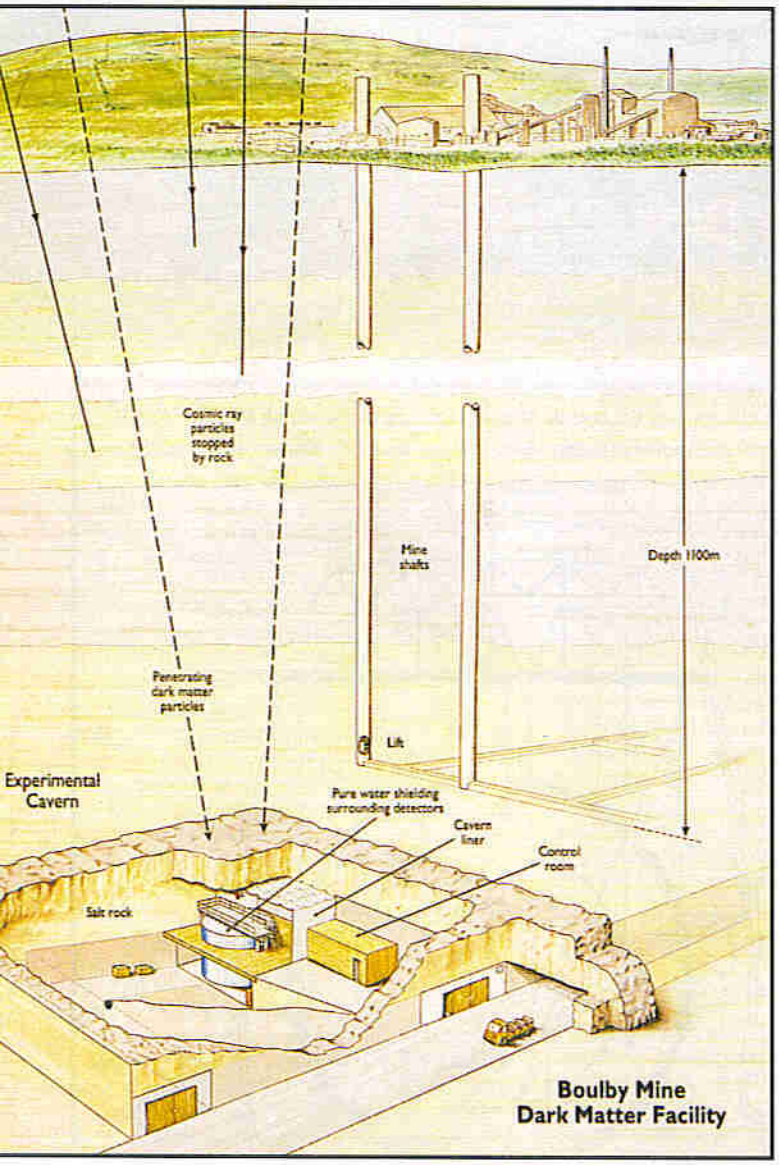
Photo 2. A stage of development of the SNO facility.

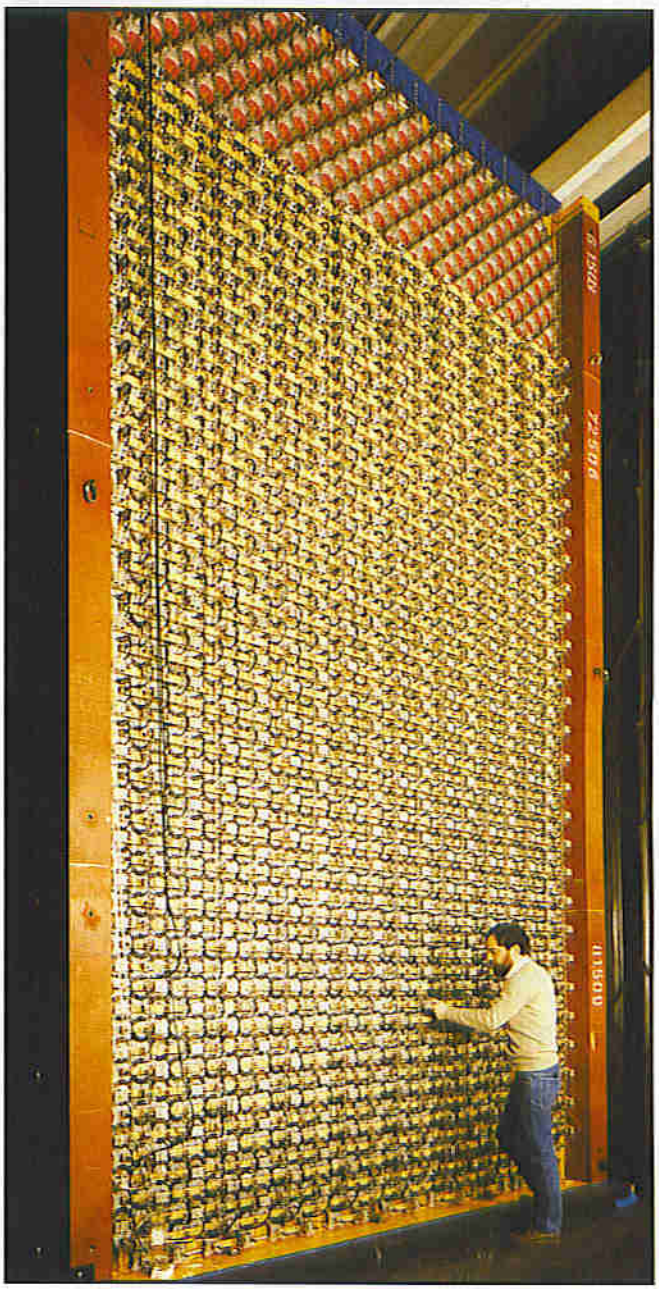
This may in turn be explained by the difference in sensitivity of the detectors to the different 'flavours' of neutrinos. Neutrinos originating from the sun start off as 'electron' type neutrinos, though weak interactions may convert these to 'tau' and 'muon' types, which are not able to be detected by the Chlorine detector and at reduced sensitivity by the K-II system.

Resolving the Solar Neutrino Problem

Part of the complexity about understanding the Solar Neutrino puzzle relates to appreciating the exact natures of the solar neutrinos which are emitted from the sun.

The lowest energy neutrino, the proton-proton, can emerge with an energy between 0 and 420keV, and is estimated to account for around 90% of the total solar flux. The Beryllium neutrino is considered to be emitted at peaks around 384keV and 861keV, and account for around 8% of the total solar flux. The highest energy neutrino, the Boron-8, is considered to be emitted with energies up to 14MeV. While the Boron-8 neutrino accounts for a tiny fraction of the total flux, around 0·01%, its much higher characteristic energy implies that it is much more readily detected.





Above: Figure 2. Relative location of the WIMP experiment, deep underground in the Boulby salt mine.

Right: Photo 3. Detector array of the KARMEN project. (Both images Courtesy Rutherford Appleton Laboratory).

The energy of the emitted neutrinos, however, has implications for the type of detector used. The Chlorine detector of the Holmstake Gold mine has a threshold energy of 820keV, which implies that the more numerous proton-proton neutrons are not able to be detected. For the Be_7 neutrinos, only the more energetic set at 861keV will be able to be detected.

Gallium, however, with a threshold of 233keV, provides sensitivity to a wider range of particle energies. While the Gallium detector has a higher detecting efficiency than Chlorine, there is very high dependence on neutrino energy. A 10MeV neutrino has around 1,000 times greater chance of interacting with a Gallium atom compared with a 400keV neutrino. The observed reaction detection rate is, therefore, just as dependent on the energy spectrum of neutrinos as the total number in the solar neutrino flux.

Data from the Holmstake Mine and the initial results from the Japanese detector, Kamiokande-II, indicated that the flux of Boron-8 neutrinos is around half that predicted by the standard solar model, and that the numbers from Beryllium-7 are reduced by a factor greater than four. If this deficit of detection is to be made up by proton-proton neutrinos, then gallium detectors should detect in the range 80-105 SNU. This calculation is based on estimates of total numbers of neutrinos emerging from the sun.

The SAGE project utilises a liquid gallium target, and is located deep underground at Baksan, Russia. Neutrinos convert Gallium atoms to an isotope Germanium-71, which decays with a half life of 11 days. The Gallium is, in fact, mixed with a trace of inactive stable germanium. Periodically, the Germanium atoms (stable and radioactive atoms) are flushed out with hydrogen, and the resulting gas (GeH_4) monitored in a proportional counter to detect the level of radioactivity. The SAGE experiment currently uses 60 tonnes of Gallium. In the GALLEX experiment at Gran Sasso, Italy, the Gallium exists as an acidic aqueous solution of gallium chloride.

The results from both systems, however, detect fewer events than would be expected. The SAGE experiment currently detects (74+14) SNU while the GALLEX experiment detects (79+12) SNU. Such values are significantly below the SSM values of (132+7) SNU for Gallium detectors. This still indicates that the understanding of the neutrino and especially, the mechanisms creating them in the sun, are poorly understood.

The present experimental data indicates that the various detectors are faithfully measuring the neutrino fluxes. Rather than alter the Standard Solar Model for neutrino production, it is more likely that the discrepancy between the model and the data relates to the fundamental property of the neutrino. The data would be explained, for example, if the neutrino had a small mass of about 0·003eV and if some electron neutrinos became transformed to u and t neutrinos in their flight through the sun.

The next key stage in the saga of the solar neutrino is the Sudbury Neutrino Observatory in Ontario, Canada, which will be able to measure the energy of the neutrinos detected above a threshold energy of 5MeV. This detection system will use 1000 tonnes of heavy water, some 2,700m below ground. This is expected to produce results during 1996. The detector design is shown in Figure 1. A series of photographs from the installation are shown in Photo 2.

The SNO detector will be able to detect all three types of neutrinos; e, u and t. The main detection mechanisms are electron neutrino capture by Deuterium to form two protons and an electron, and e,u and t neutrino capture to form proton, neutron and neutrino. The relative count rates for the two reactions will be able to be determined if transformation of neutrinos is taking place. Because of the large size of the detector, up to 10 counts per day should be obtained.

The SNO should also be able to detect all three families of neutrino and so valuable information to determine the types of neutrino present should be available. This should be able to determine, for example, if oscillations take place in neutrino types as they stream out from the sun.

The Superkamiokande experiment, planned to come on stream during 1996, will provide an increase by a factor of 30 in the detection rate of neutron-electron scattering based on the original Japanese system. Like the SNO, this detector will only be able to detect neutrinos above 5MeV.

Meanwhile, back at the Holmstake Mine, a 100 tonne Iodine radiochemical detector is being implemented alongside the Chlorine detector.

Also, to complement the GALLEX system at Gran Sasso, in Italy, the ICARUS detector is planned to be operational by 1998. This detector will be sensitive to inverse B-process like the conventional radiochemical Chlorine detector, and will be an active detector. The main detector will be liquid Argon with detection of recoil electrons and decay gamma rays being possible.

The scale of interest in neutrino detection is now so widespread, however, that it is not possible to reference all the projects planned, and in the process of being implemented.

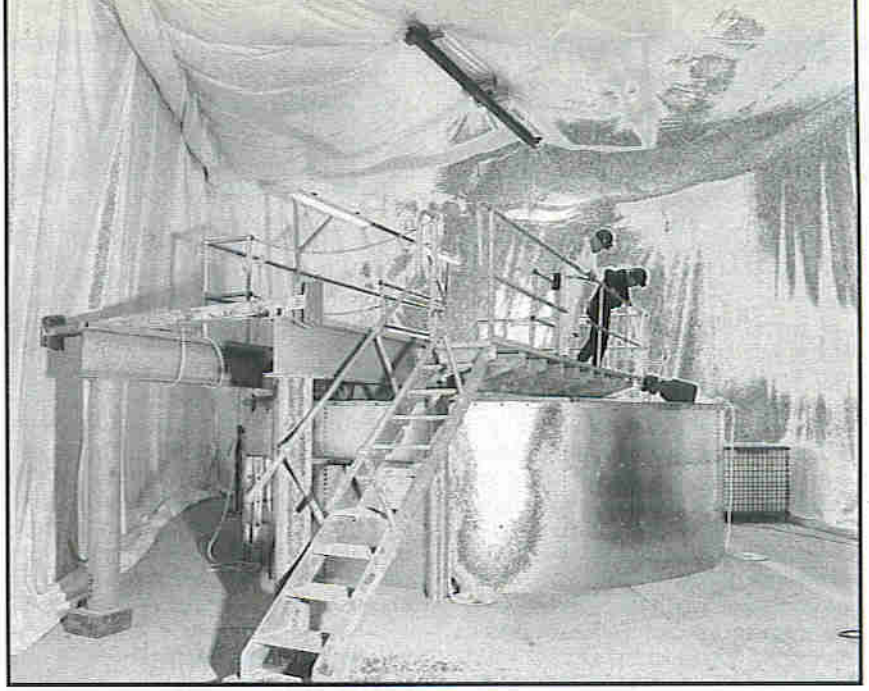


Photo 4. From the Boulby detector, showing the tank of ultra-pure water which surronds the main detector system (Courtesy Rutherford Appleton Laboratory).

Weighing the Neutrino

Theorists suspect that the characteristics of the neutrino, like some grain of sand on a pair of scales which keeps the balance of two pans, provides a key link between all the known interactions of physics – strong, electromagnetic and weak. In particular, the mass of the neutrino could end up as a direct measure of relative linkage of the basic forces in the universe. This is why the mass of the neutrino is being investigated using a broad range of approaches.

Supernova explosions are considered to be a rich source of neutrinos. Theories predict that in such a cataclysmic event, the neutrinos are given off within a relatively short time scale of around 1 second. If the neutrinos, in fact, have zero mass, then they should arrive 'in unison' at distant objects such as the solar system.

The supernova event of 1987 SN1987A was independently observed by neutrino detectors in Japan and Cleveland, USA. In the Japanese system, 11 neutrinos were detected in an interval of around a few seconds. A total of 8 neutrinos were detected by the Cleveland system. Based on these initial findings, theorists estimated that the mass of the neutrino was less than $1/_{50,000}$ of that of an electron – not enough to 'close' the universe in the models of cosmology.

The significance of the supernova event, SN1987A, in terms of neutrino detection cannot be over-emphasised. In such a collapse, believed to be caused by the collapse of a star after the completion of its cycles of nuclear burning, it is estimated that up to 99% of the energy released is emitted in the form of neutrinos.

Preliminary work recently reported at the Los Alamos National Laboratory at New Mexico, Meson Physics Facility indicated that the mass of the neutrino was between 0·5 and 5eV. On this basis, the neutrino could account for as much as 20% of the mass of the universe. This calculation assumes that each cubic metre of space contains about a million neutrinos.

It is interesting to do some simple calculations relating to possible neutrino masses. Taking a value of 1eV for the rest mass energy of the neutrino, a cubic metre of space would contain the mass equivalent of 1MeV (million electron volts) of energy. A volume approximately $10m^3$ would contain an energy equivalent to a proton or a neutron (931MeV).

In Europe, the KARMEN project – a joint UK-German neutrino experiment at the Rutherford Appleton Laboratory, is also investigating the properties of the elusive neutrino. Using a pulsed neutron source (ISIS), neutrons are directed into 60 tonnes of liquid hydrocarbon contained in a steel vessel. Scattering of the neutrinos from carbon nuclei results in the emission of gamma rays which are detected by light-sensitive electronic tubes surrounding the liquid. By ensuring that the neutrinos observed are produced by a tight pulse structure, non-pulse events can be separated. The detector array is shown in Photo 3.

Such basic work at KARMEN while providing information about the properties of neutrinos has, however, given rise to a puzzle. Some 3 to 8μs after the neutrinos were detected, a separate set of detection pulses were observed. Such work, will take at least two years to complete in order to capture sufficient events to verify the statistics of the experiment. One possible explanation is that the signal is derived from an as yet unobserved and unexpected particle which weighs around 60 times as much as the electron. So far, however, KARMEN has not identified that the neutrino has any appreciable mass.

The Search for Very High Energy (VHE) Neutrinos

It has long been recognised that while the sun is an active source of neutrinos, there are probably VHE neutrinos with large and extremely large energies which range from 100GeV and upwards (1GeV = 1,000MeV). Neutrino energies are also quoted at values considerably in excess of 100GeV.

There has long been intense interest in the origin of cosmic rays with ultra-high energies. While these very high energy protons can be detected, they are deflected by magnetic fields on their way to Earth, and so information on their place of origin is difficult to determine. It is assumed that highly energetic processes which give rise to such cosmic rays are likely also to give rise to very high energy neutrinos. Unlike cosmic rays, however, such neutrinos do not interact to a significant degree to the physical world and so will maintain their original 'flightpath'.

Astronomers have for some time endeavoured to develop telescope systems which, in addition to detecting such high energy neutrinos, would also be able to obtain information about possible sources.

One system is being implemented in Lake Baikal in Russia, in Russian-German collaboration. Another, DUMAND (Deep Underwater Muon and Neutrino Detector), is located off the island of Hawaii and involves a team of scientists from the US, Japan, Germany and Switzerland. The NESTOR system is being developed in the waters of south west Greece and involves researchers from Greece, Italy and Russia. Finally, AMANDA (Antarctic Muon and Neutrino Detector Array) involves US and Swedish scientists at the geographic south pole.

For such experiments to be successfully undertaken, they must be placed remote from the Earth's surface, to reduce the flux of particles from cosmic ray interactions – such as muons. The Lake Baikal, DUMAND and NESTOR systems consist of an assembly of photomultiplier tubes suspended in an array at depth in the sea. The DUMAND II neutrino telescope is located at a depth of 4,470m, and is 230m high and 106m in diameter.

It is expected that VHE neutrinos will be detected from 'local' events associated with high energy cosmic rays encountering the earth's atmosphere. This will provide a means of 'calibrating' the telescope system against specific interaction events. Of key interest, however, is the possibility of the detection of VHE neutrinos from extraterrestrial sources, which include X-ray pulsars in our galaxy and the nuclei of so-called Active Galaxies (including Quasars), which radiate immense amounts of energy.

It is anticipated, however, that it will be several years until sufficient data has been obtained to allow appraisal of VHE neutrinos. These four systems are the first generation of such VHE neutrino detectors. Plans are already on the drawing board for the next phase of detection system – within an area of a square kilometre. The value of the active neutrino detector is that neutrino bursts from supernova in our galaxy can be detected, even if the light is obscured by dust clouds.

Consideration also needs to be given to any possible decay of the neutrino to other particles. Is the level of neutrinos in a steady state where their decay to other forms is replaced with new particles or are levels of neutrinos slowly building up with time? Experiments are even now being devised to try and measure the half-life of protons – the stalwarts of Baryonic matter.

Hunting the WIMP: Cold Dark Matter

A particle physicist would describe our world as Baryonic – made up of protons and neutrons. Neutrinos are considered as 'hot' non-Baryonic dark matter particles. It is possible that the missing matter in the universe is formed of 'cold' dark matter particles called WIMPs (weakly interacting massive particles). In the present state of research, the parameters of the neutrino are, as yet, poorly defined and initiatives to detect WIMPs have yet to produce validated results. This is, therefore, one of these periods in particle research where groups are unwilling to predict what experiments are likely to reveal, and also which experiments are likely to be more successful.

The Boulby Salt Mine

In the UK, a project funded by PPARC (Particle Physics and Astronomy Research Council) is preparing to gather information on WIMP collisions 1,000m below the surface in a salt mine at Boulby, near Whitby in Yorkshire. Theorists predict that around 10^{12} WIMPs pass through each kilogram of material every day, with only a tiny fraction interacting with Baryonic matter. When a WIMP interacts with an atom, the atom is knocked forward and this energy can be detected. Where the absorbing material is a crystal such as sodium iodide, this energy is released as light photons which can in turn, be detected by highly sensitive light detectors. In an appropriate crystal lattice held at very low temperatures, this energy can be translated into phonons, which result in transient increases in temperature which can in turn, be detected.

Figure 2 shows the relative location of the WIMP experiment deep underground. Experiments to detect WIMPs need as far as possible to be conducted deep underground, where interference from particles created by cosmic ray bombardment is reduced to acceptable levels. In the Boulby mine, the overhead rock absorbs almost all of the cosmic ray particle activity and shielding from high purity water absorbs residual gamma rays from the walls of the cavern.

The approach at Boulby is to use sodium iodide crystals as detectors. This is a standard technology in the nuclear medicine industry, where levels of radioactive trace chemicals are scanned to produce clinical images.

There is considerable uncertainty as to the levels of counts per kilogram of matter which should be observed. Estimates vary from 0·01 events per day to 100 events per day. This ranges in frequency from one event every 100 days to one event every half hour. Photo 4 shows the tank of ultra-pure water which surrounds the main detector system, while Photo 5 shows work being undertaken for the Dark Matter experiment.

By mid-Spring of 1995, the UK team at Boulby had improved the sensitivity of their system from 100 events per day to 10 per day. It is anticipated that a further increase in sensitivity of 10 can be achieved. A recent drastic reduction in the funding, however, has resulted in 'severe difficulties' for the UK-based project. This comes, however, at a time when the importance of experiments for detection of WIMPs is rapidly being acknowledged.

One group in the USA at Berkeley is utilising germanium crystal cooled to 0·02K above absolute zero. A similar group at the Gran Sasso laboratory beneath the Apennines in Northern Italy plans to install a detector developed at the Max Plank Institute in Munich, which uses a sapphire crystal cooled to 0·015K. At this stage in WIMP detection, however, there is benefit in the use of a range of type of detectors, since the precise mechanisms of interaction of WIMPs with Baryonic matter are not fully understood.

Photo 5. Working on the instrument for the Dark Matter experiment.

Summary

Scientists are keenly aware of the extensive gap in their understanding of the physical world. The Dark Matter mystery is being followed up on a broad range of initiatives (ranging from surveys undertaken by the Hubble Space Telescope to locate ultra-faint objects to the hunt for WIMPs) heavy non-Baryonic particles which interact weakly with our visible world of neutrons and protons. The work, however, on the life and times of the neutrino is a key facet of this line of research.

Whatever the origin of the Universe, the work of scientists in the search for Dark Matter is certainly providing more information to help 'explain' the Universe as it is now and provide greater clarity for outcomes of the 'Big Bang' scenario.

So, when relaxing out of doors, spare a thought for the thousands of millions of neutrinos which stream through our bodies every second. These emanate mostly from the sun, but others have travelled endless distances across the universe. . . .

Further Reading

Neutrino Astrophysics, J. N. Bahcall, 1989, Cambridge University Press.

Progress and prospects in neutrino astrophysics, J. N. Bahcall, Nature, volume 375, May 1995, pp. 29 to 34.

HIGH BANDWIDTH MEMORY

by Frank Booty

THE demand for higher bandwidth memories in systems from multiprocessing to multimedia has designers working overtime. The problems of matching fast processors with the slower memory chips they have to use are legion. Processors need more data per unit time than many standard memory chips have been designed to provide. Indeed, signals encounter delays in the board traces and connections to the surrounding system, as well as in the memory chip and package.

As a result, memory bandwidth sufficient for an application's needs calls for the right combination of system architecture, and processor and memory type. To assist in solving the problem in various applications, the manufacturers of memory ICs have responded with a line up of fast, innovative architectures, technologies and hierarchies.

The biggest bandwidth discrepancy is between dynamic RAMs (DRAMs) and microprocessors. As the gap between them widens, it becomes more difficult and more expensive to fill. However, the static RAM (SRAM) has generally managed to maintain pace with processor speeds by resorting to wider buses, alternative technologies and special interfaces. Nevertheless, there is an inherently shorter cycle time here than with a DRAM, as the two have different types of memory cell. An SRAM stores data in a flip-flop comprising normal logic transistors, and is ready for the next read cycle as soon as one is complete, but the DRAM's capacitor cell is read by having current drained from it. This means that time has to be spent on writing the data back into the cell after a read access and precharging the bit lines before the next attempt is made to read the device.

The cost of a memory is determined in a large part by the chip size. All other things being equal, SRAMs have about a quarter the capacity of DRAMs and therefore, tend to cost about four times as much per bit. This economic disparity caused many suppliers in the '80s to offer SRAMs tailored to a specific application, so that the devices enhanced system performance enough to justify a higher price.

As the main justification for the existence of the DRAM is its lower cost, the focus in the DRAM industry is primarily on cost reduction. It is the chips' lower cost and higher density that keeps them in demand. A faster DRAM or a cheaper SRAM could eliminate the expense of having to use both to obtain the advantages of both, for some systems.

The two types continue to co-exist meanwhile. The majority of computer systems are based on a cache hierarchy architecture, in which a small SRAM is inserted between the microprocessor and a main memory constituted from large banks of DRAMs – see Figure 1(a). The SRAM holds data that has a high probability of being the next to be wanted by the processor, so less time is spent accessing the main memory's slower banks of DRAMs.

Solutions to the bandwidth mismatch can usually be viewed as attempts to improve the performance of the system cache hierarchy, make it less expensive, or to eliminate the cache altogether. The design choices involve embedding the SRAM in the processor, in main memory and between the processor and main memory, as well as more elaborate configurations, shown in Figure 1.

With the first variation, integrating the SRAM into the processor gets over the bottleneck of the input and output buffers and enables the memory bus to be tailored to the (wide) width the processor needs. The first microprocessors with embedded instruction caches emerged in 1987. The caches were small, comprising 1 to 2K-bytes of embedded SRAM. Today, most microprocessors contain complex first-level SRAM caches, one each for data and instructions, and they tend to be partially to fully associative. Now, the most memory that can be embedded in a microprocessor chip cost effectively is 64K-bytes. For many high-performance systems, that means adding a second-level cache.

A second variation is to take the SRAM into the DRAM, once more unblocking performance through access to the wider internal bus of the DRAM, e.g., the video DRAM (VDRAM) introduced in the early '80s. However, adding circuitry to the standard DRAM also adds to its cost as the chip and package size increase, and as testing becomes more expensive.

A subset of this last case is to modify the output architecture of the DRAM, so that rapid bursts of data may issue from the wide internal DRAM bus without having to wait for the access cycle to finish. This feature is to be found in the synchronous DRAM from the Joint Electron Devices Engineering Council (Jedec).

Fast Tracks

There are many ways to speed up the RAM itself, including dividing up the internal architecture, switching to a different process, using wider outputs, and employing output modes that access data faster.

A divided architecture uses a tree-like hierarchical structure, in which lines with global access lead to lines with local access to specific sections of the RAM array. This shortens the data path to the cells and reduces the capacitive load so that on both counts, the devices switch faster. However, the price paid for a divided architecture is extra wire routing, entailing either more silicon or more layers of interconnects. Even so, use of the architecture is increasing, together with the density and chip size of DRAMs and SRAMs. Typically, the memory array of a 16M-byte DRAM is laid out in 4 to 8 major divisions and 32 subdivisions.

In fast SRAMs, extra speed can be gained by using alternative technologies to MOS, such as bipolar transistor-transistor logic (TTL) and emitter coupled logic (ECL) or alternative materials to silicon, such as gallium arsenide and silicon on sapphire. An SRAM, for example, can be completely bipolar or BiCMOS, in which the circuit elements requiring high drive current, such as outputs and line drivers, are bipolar and the rest of the circuits are CMOS. Incidentally, MOS SRAMs also operate faster at a low temperature, as does CMOS logic.

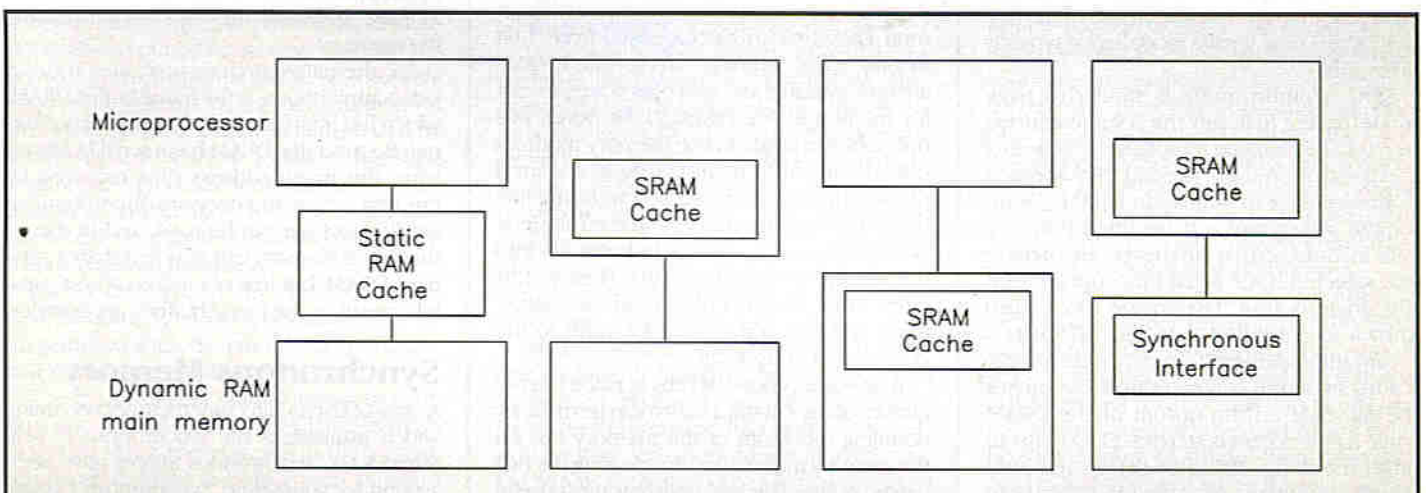


Figure 1. Computer memory hierarchies for high-speed systems.

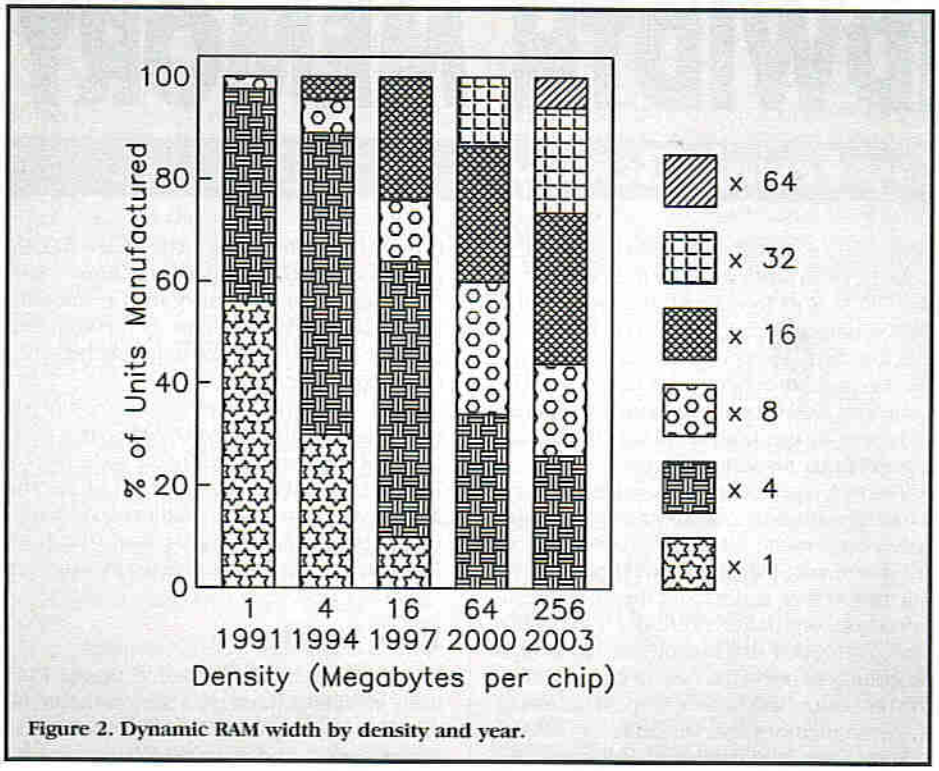


Figure 2. Dynamic RAM width by density and year.

It is not all glory though, as bipolar and BiCMOS technologies consume more power on standby and occupy a larger silicon area, raising costs. For gigahertz speeds, where the costs of cooling techniques are not prohibitively great, high-speed alternative technology processors and memories are an option. Alternative output modes access fast bursts of data from the wide internal structure of the RAMs. DRAM examples are the fast page mode and others such as static column and nibble modes.

The different DRAM read operations are an illustration of the various modes. When a row is selected by strobing in its address with the appropriate strobe pin, all the data on that row (page) appears on the sense amplifiers. In random access mode, only one column address is strobed in, and the corresponding data bits appear on the output pins. In a page mode read operation, the data from the selected row is held on the sense amplifiers while new column addresses are selected and strobed in. No time is spent on writing the information from the sense amplifiers back into the memory cells and precharging before another address in the same row can be accessed. In a 4M-byte DRAM with 70ns random access time, a page mode access typically takes 35ns.

Static column mode is similar to page mode, except that only the column address needs to be changed to obtain the new data and no strobe pulse is needed. Nibble mode (a predecessor of 4-bit wide DRAMs) is no longer widely used. It grouped memory cells in fours, so that whenever one of them was selected, four serial bits appeared on the single output. Hyperpage mode, also known as extended data out (EDO) is a recent improvement to page mode timing. It adds an output control option that latches the old data on the output of the DRAM while a new access is started. EDO helps to offset the delay caused by set up and hold timing restrictions on page mode, and can shorten the effective page mode cycle by 5 to 10ns.

Width

Matching the widths of a system's memory bus and a RAM's output will optimise the component's speed in the system by maximising the amount of data transferred at one time. Byte-wide SRAMs have been paired with byte-wide buses for some time, and 36-bit wide SRAMs are already available for use with 32-bit microprocessors. SRAMs moved to wider buses early on, as they are frequently used in applications in which a little memory must still match the width of the memory bus in the system. These are often battery operated systems, where the SRAM's low standby power is an advantage.

Consider as an example, a hand-held electronic diary that has an 8-bit bus and only 256K-bytes of memory. A single 256K-byte wide memory chip should suffice. Since it would be extravagant to add control overhead for a DRAM to support only one chip and since battery back-up in such a system relies on low standby power dissipation, the most economical chip to use would be an SRAM.

The width of the DRAM, meanwhile, has not increased as fast as the memory bus width or its own bit density. Since 1980, the most common DRAM width has increased from 1-bit to only 4 bits, although 16-bit wide DRAMs are now available and wider parts are forecast for the future (see Figure 2). However, PCs normally use single in-line memory modules (SIMMs) for main memory. These are small printed circuit boards stocked with multiple DRAMs arranged in parallel and used like individual components, being fitted vertically into the main printed circuit board. Their widths range from 32 to 144 bits in various applications, and match the memory width to the PC's memory bus width.

Where the processor runs at twice the frequency of the DRAM, a match can be made by doubling the width of the memory bus on the memory module and interleaving the two banks of data. This manoeuvre is most useful in larger systems that require the extra memory, but if the granularities (granularity is the minimum increment of memory that may be added to a system) of the available memories exceed the amount of system memory required, interleaving can increase the cost of the system memory.

Granularity can be a problem, as the output widths of the DRAMs have not been increasing at the same pace as their bit density. The granularity increases as the width of the memory becomes narrower with respect to the memory bus. An illustration is a system with a 16-bit wide bus that uses 4M-byte DRAMs. If the chips are organised as 1M-byte×4 bits, then it takes four of them to fill out the 16-bit bus with a minimum granularity of 4×4M-byte = 2M-bytes of memory. However, if the organisation is 4M-byte×1 bit, then 16 of them are needed to fill out a 16-bit bus with a minimum granularity of 16×4M-byte = 8M-bytes of memory.

Application Specifics

Specialised memory architectures match the RAM output to the application, so that the effective speed is maximised. An early example of this approach to bandwidth matching is the video DRAM (VDRAM) which after processing the data, feeds it very rapidly to a video display. The VDRAM has two access ports, one random and one serial. The random port interfaces with the processor or controller. The serial one is fed data from a 256- or 512-bit register, which is loaded by an internal transfer from the sense amplifiers. The register data flows out through the port at the speed required by the video display.

The VDRAM is excellent for very fast graphics manipulation in many high end PCs, low end workstations and other applications that require great performance but only modest memory. In these circumstances, it would be impractical to boost speed by interleaving banks of standard DRAMs.

The disadvantage of the VDRAM is the larger chip and package size. The serial register needs space and increases the cost. The package expands to cope with the added control pins and serial port I/O pins, which require more space on the printed circuit board. For example, a 1M-byte DRAM organised as 256×4 has 20 pins including nine address pins and four multiplexed I/O pins, whereas a 1M-byte 256×4 multiport VDRAM needs a 28-pin package to accommodate four serial I/O and four control pins. The testing procedure is also more complex for the VDRAM, increasing the cost of manufacturing the memory.

An alternative architecture, also used in video applications, is the frame buffer DRAM, which has interfaces only in the display channel. Because this DRAM has a serial I/O structure, the many address pins required by random access memory are superfluous. A smaller package can be used, and in theory, the frame memory can cost less than a standard DRAM, but loss of random access capability restricts the frame buffer's applications.

Synchronous Memory

A class of fast architecture memory becoming widely available is the synchronous or self-timed RAM. Synchronous SRAMs have been around for some time. Synchronous DRAMs are being discussed, and a few early versions have appeared (e.g., Mitsubishi's cache

DRAM, NEC, Fujitsu and Toshiba's Rambus DRAM, and the Jedec standard synchronous DRAM from companies like NEC, Fujitsu, Toshiba, Texas Instruments, Hitachi, Samsung, Mitsubishi, Micron Technology and Oki).

In synchronous memories, dual latches called registers guard some or all the inputs and outputs. They serve to shorten or get rid of wait states in a system with a fast microprocessor – wait states are the extra cycles the processor spends waiting for the data it has requested from the RAM. A synchronous RAM can have the input addresses latched into it in one cycle by the microprocessor, which is then freed to perform other tasks until, a known number of cycles later, the memory has the required data ready on the output. While the intrinsic speed of the RAM has not increased, its effective speed in the system is greater, because the processor need not idly wait for the data to come out of the RAM.

The use of multiple banks on a single memory chip further augments the speed of the Jedec standard synchronous DRAM. Random access is faster when one bank may be precharged or refreshed while the other is being accessed. Multiple rows on a Jedec synchronous DRAM can be simultaneously open, and accesses of the two banks can be interleaved on the chip. A multiplicity of internal banks also helps small fast systems with the memory granularity problem. Speed can be increased by interleaving the banks on one chip, saving the expense of memory required to interleave multiple banks in the system.

Both the synchronous DRAMs and the synchronous SRAMs feature burst mode accesses that are compatible with the Intel 80486 and later generations of processors. These are swift accesses to a small amount of data, following an initial access at normal memory speed. The addresses of the subsequent bits of data in the burst are generated automatically by the RAM.

Like page mode, these burst mode accesses exploit the fact that the RAM's internal bus is wider than the external bus. Accordingly, all the data from a series of burst mode addresses can be fetched to the RAM outputs from its databank on the entry of the first address. This data can then be fed out of the RAM at the clock speed.

The system clock edge is the only timing strobe that must be provided by the system to a synchronous memory. The need to propagate multiple timing strobes around the printed circuit board or module is therefore lessened. In the synchronous DRAM, all internal strobes required for its operation are referenced to this external clock. At the rising edge of the system clock, a mode register on the synchronous DRAM is sampled. The mode register is set to indicate the burst length, burst type, latency mode and combination of commands for the operation requested. A simplified truth table of commands is shown in Table 1.

Also of concern, are the electrical characteristics of the RAM I/O gates, as well as the transmission lines, the pinouts and packages, and system timing tolerances.

The characteristics of RAM inputs and outputs are standardised, as they have to interface with other components in the system. Interfaces capable of higher than standard speeds are not new. Historically, the 5V TTL interface was faster than the CMOS interface, in that it limited the output swing of the circuit. The 3·3V low-voltage TTL (LVTTL) interface characteristics are the same as those of 5V TTL, but the gain over CMOS is not so great as with 5V TTL, as the full rail swing of CMOS is less at the lower operating voltage. For higher speed at 3·3V, a smaller swing interface is needed. Several have been standardised: Gunning transceiver logic (GTL) and centre tap terminated (CTT) logic by Jedec; backplane transceiver logic (BTL) by the Futurebus committee; and a low swing differential interface by the IEEE RamLink standards committee (IEEE 1596.4). Rambus also uses a proprietary low swing interface.

Command	Chip Select Cs\	Address Strobes		Write Enable W\
		Row RAs\	Column CAs\	
Mode register (set or read)	L	L	L	L
Row address entry/bank activate	L	L	H	H
Column address entry and write	L	H	L	L
Column address entry and read	L	H	L	H
Bank deactivate/precharge	L	L	H	L
Command inhibit	H	X	X	X
Burst stop L	H	H	L	
Self refresh L	L	L	H	
L = logic low H = logic high X = don't care				

Table 1. The Jedec synchronous dynamic RAM: a simplified command truth table.

At clock frequencies beyond 66MHz, the system's transmission line characteristics come into play. In all the high-speed interfaces mentioned, the answer is a reference voltage level supplied either on the RAM or externally, plus careful design of the output buffers. Their design needs to take into account whether the RAM is operating in a point-to-point environment or on a parallel bus, and whether the bus is terminated or not. An example here is a synchronous×36 organised BiCMOS SRAM, with a×36 organisation from Motorola, which has GTL-type output buffer options for point-to-point operation as well as parallel terminated and unterminated buses.

Another way to gain speed is to access the memory on both the rising and falling edge of the clock pulse. This requires more control of the clock, but appears to be necessary to attain speeds of over 200MHz. This differential clock technique is used in both the Rambus and Ramlink schemes to reach 500MHz and over.

The pinout and the package also affect the speed of the component. For the synchronous SRAM, Jedec has standardised a revolutionary pinout designed to minimise the self-inductance of the package lead frame. An increase in the number and placement of power and ground pins reduces the ground bounce that slows down the device when wide outputs switch. The Jedec standard synchronous DRAM also uses a larger number of power and ground pins than usual.

Smaller packages such as the thin small outline package II (TSOII) with its lower lead inductance are also being used to improve speed for the synchronous DRAM. Small, vertical packages are used for the Rambus, and fast SRAMs are being housed in new packages such as thin quad flat packs and even pin grid arrays.

Simulation helps with another important factor: the timing tolerances of the various parts in a system running at 100MHz. At both the system and the component level, simulation tools help model the components in the transmission line environment of the system. Over the past year, the process of developing models of the system components as well as the whole system has become an integral part of designing high-speed components such as the synchronous DRAM into systems.

Conclusion

In the SRAM area, various architectures of cache SRAMs all increase the bandwidth between the processor and main memory by holding small amounts of frequently requested data in a small, fast SRAM near the processor. The trade-off here is the cost of the fast SRAM, due both to its elaborate four or six transistor memory cell and to the divided architectures required to obtain high-speed.

As the effective speed of the processor can be multiplied many times if the SRAM cache hit rate can be improved, architectural changes are being made to the older, direct-mapped SRAM caches, in which each address corresponds to an address in main memory. So, a larger cache has a higher hit rate.

The newer, associative cache stores the same bit of data at several locations. In practice, fully associative caches are seldom used, since the controllers are very complex and SRAM content addressable memories (CAMs) are very expensive. However, much of the benefit from the increased bit rate of an associative cache can be obtained instead from a two- or four-way partitioning of the memory, a layout that requires a far simpler controller. In a two-way set associative cache, for example, the data can be stored at either of two possible locations in the cache.

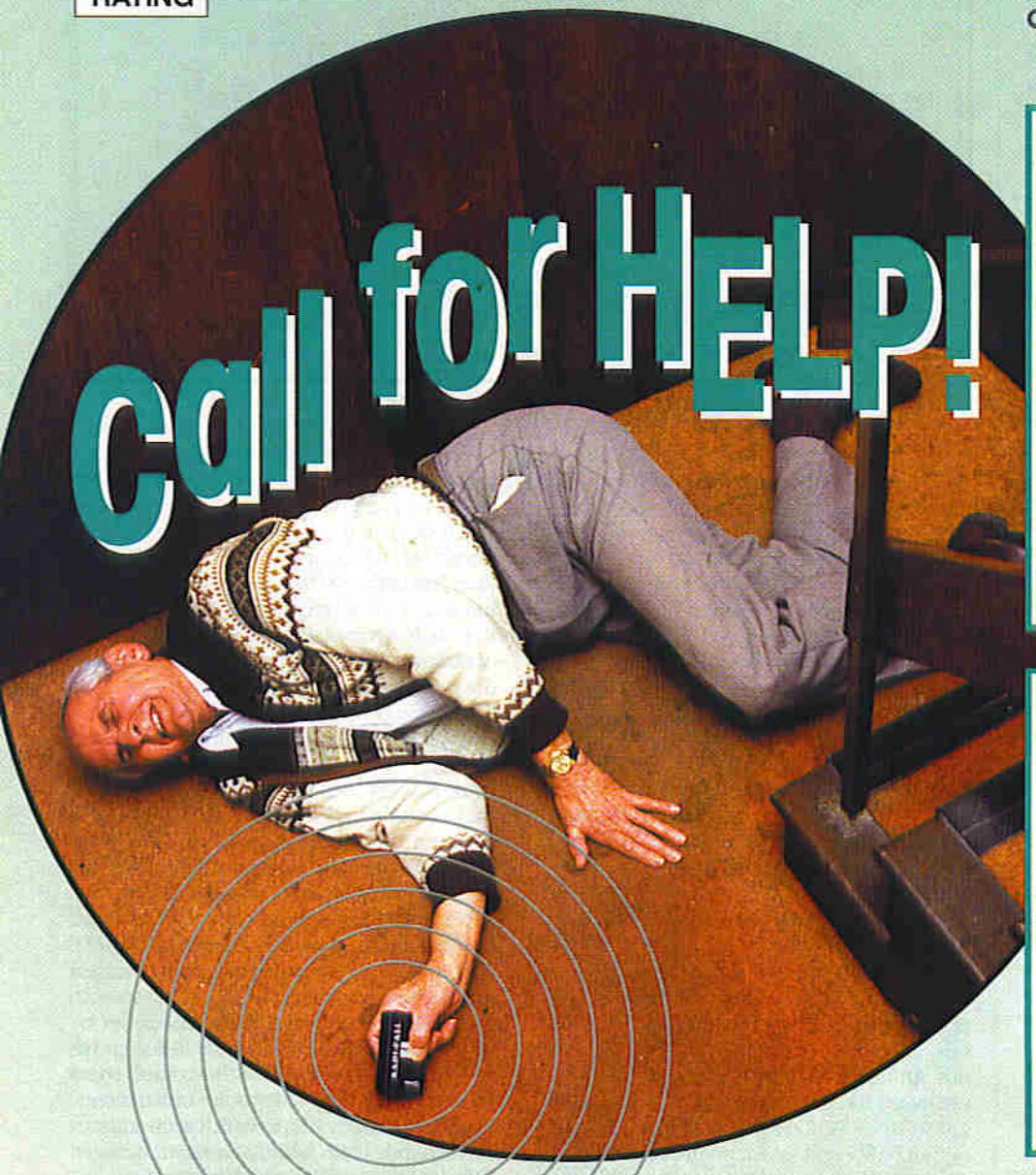
While most fast processors find a direct-mapped cache adequate, future high-speed processors may seek a more complex cache organisation, to avoid losing an even higher number of cycles during a cache miss.

Certainly, processor speeds are not stagnating. Two further demands on the SRAM cache are already coming. Intel's Pentium and Texas Instruments' Multi Video Processor (MVP) contain multiple execution units, and systems with multiple external processors are becoming more common. With many processors attempting to access the cache at ever higher data rates, the bandwidth demand on the memory can only grow. E

2
PROJECT RATING

Designed by
Alan Williamson

Text by Alan Williamson
and Maurice Hunt



418MHz RADI-CALL TRANSMITTER

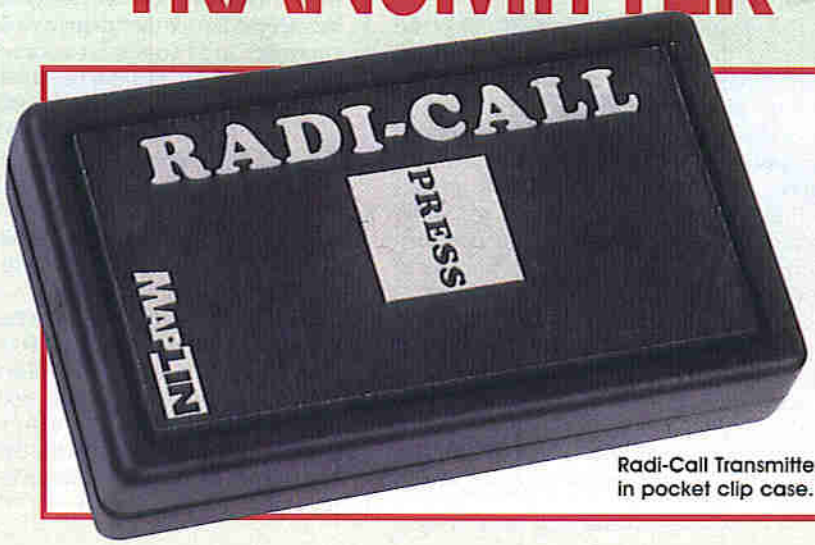
FEATURES

- ★ Easy to build and use
- ★ Compact and lightweight
- ★ Wide supply range
- ★ Very low standby current consumption
- ★ Ready-made and aligned RF module
- ★ 4,096 Codes
- ★ FM Operation
- ★ DTI approved to MPT 1340

APPLICATIONS

- ★ Domestic/commercial security
- ★ Guard patrol protection
- ★ Lone worker protection
- ★ Medical alert
- ★ Nurse call systems
- ★ Site paging receivers
- ★ Paging car alarms
- ★ Fire alarms
- ★ Remote control systems
- ★ Door bell

The 418MHz Radi-Call Transmitter project presented in this article and its companion, the 418MHz Radi-Call Receiver project (to be featured in next month's issue) are a boon for the frail, infirm, sick and elderly and their carers. However, the system may also be used for many other security and remote-control applications – enabling stand-alone or wire-interconnected equipment to be linked to good effect by totally wireless means.



Radi-Call Transmitter in pocket clip case.

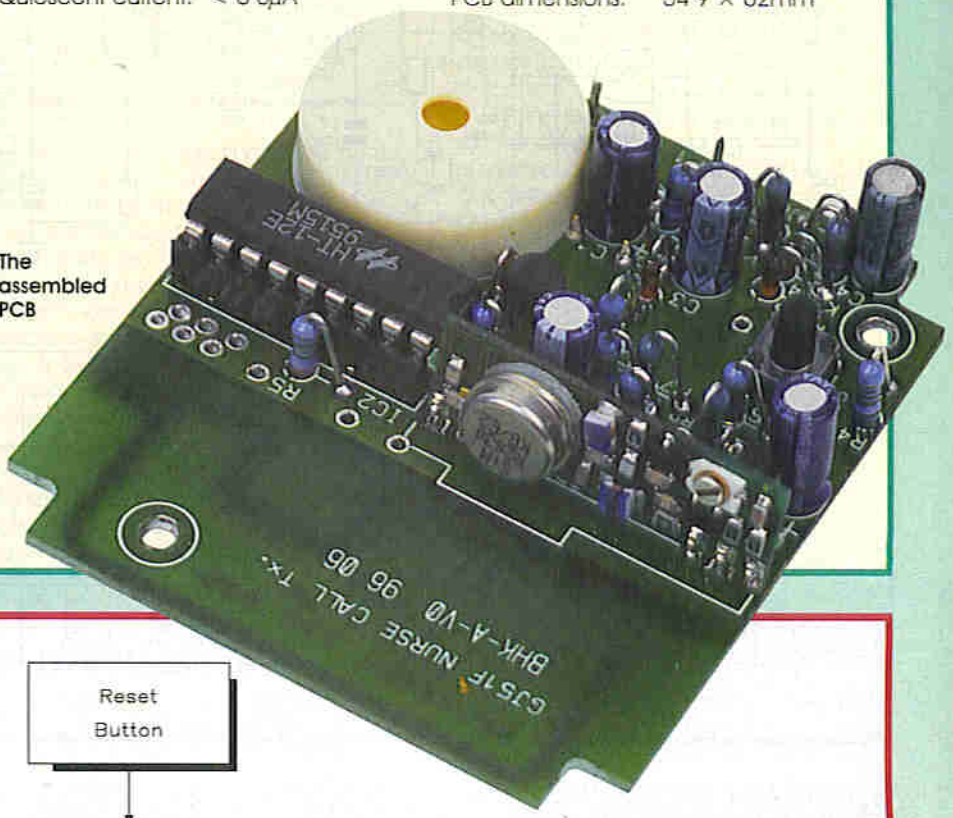
KIT AVAILABLE (95080) PRICE £39.99 A1

PREVIOUSLY, it has been difficult for the electronics enthusiast to build, and legally use, UHF radio transmitters and receivers. However, this project uses a ready-built and aligned radio transmitter module TMX-418-A (AM27E), and similarly, the Radi-Call Receiver project also uses a ready-built and aligned radio receiver module SILRX-418-A (AM28F). Refer to issues 73 and 83 of *Electronics* for further information on these modules. With suitable antennae, the modules are capable of transferring data reliably up to a distance of 50m in buildings and over 200m under open field conditions.

The transmitter is type approved to Department of Trade and Industry (DTI) Radiocommunications Agency (RA) specification MPT 1340, thus avoiding the need to submit the finished project for further approval. The 418MHz modules have been optimized for battery powered operation and both are designed for reliability and performance in the field. They perform well with very small antennas and require no alignment whatsoever.

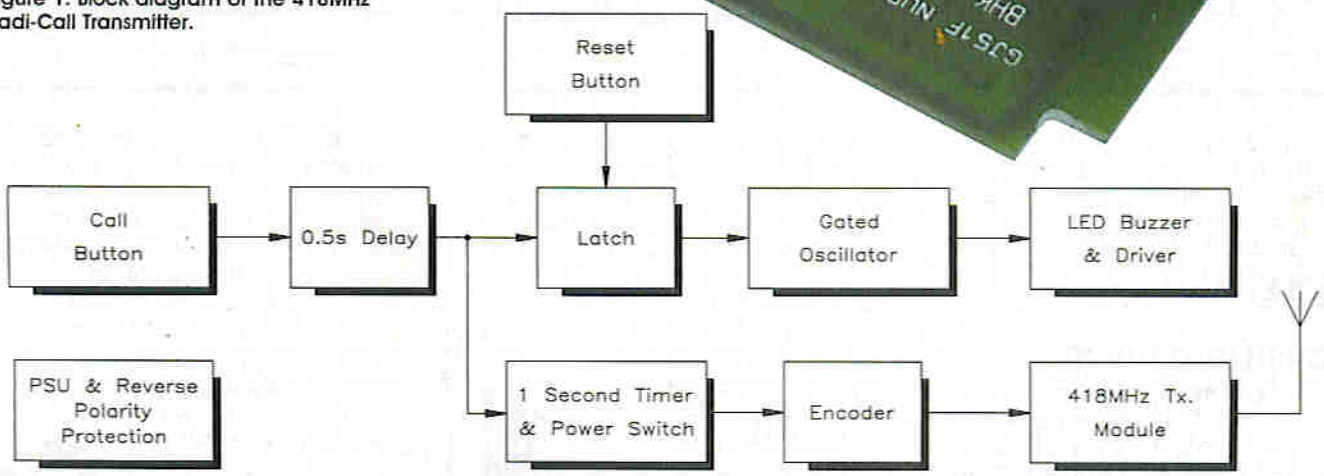
Specification

Power supply voltage:	6 to 12V DC (9V nominal)	Operating current:	< 25mA
Quiescent current:	< 0·5µA	Sound output:	= 75dB @ 30cm
		PCB dimensions:	54·9 × 62mm



The assembled PCB

Figure 1. Block diagram of the 418MHz Radi-Call Transmitter.



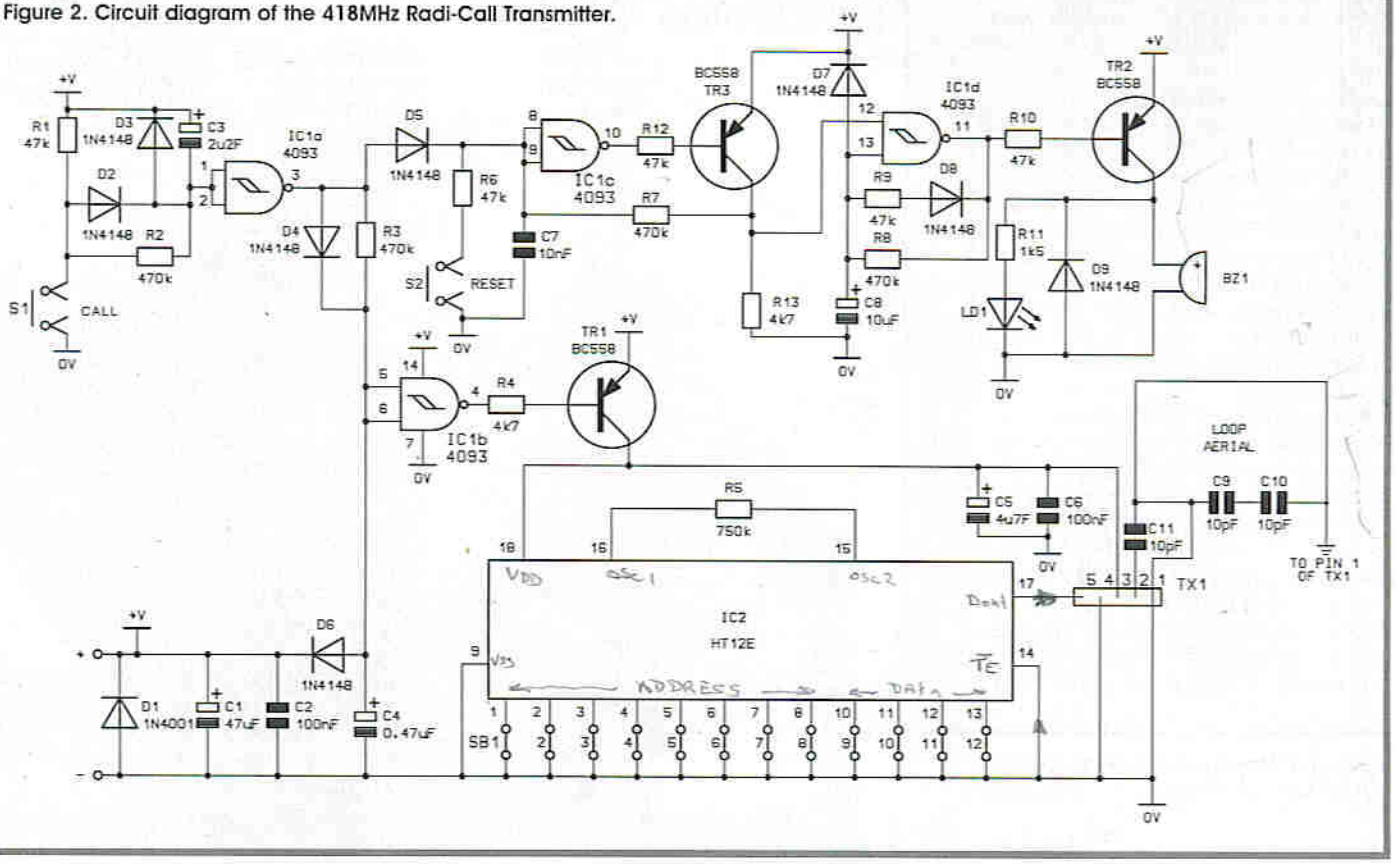
IMPORTANT NOTE:
Commercial use may require additional type approval; in case of doubt, contact the Radio Communications Agency at the Department of Trade and Industry – contact details are given at the end of this article.

The transmitter circuit features very low power consumption to allow a long battery life. The operation of the transmitter is such that when activated, it will transmit an encoded 418MHz signal containing the four complete word frames required to activate the receiver. The transmission will then cease (unless the panic button is pressed again or held down), but the LED will continue to flash and the buzzer will sound in piercing bleeps until either the reset button is pressed, or the battery becomes drained (a fresh battery will maintain the unit in an activated state for hours).

The panic button is a large and easily pushed 'activation pad' on the front panel of the unit. The reset button, however, is concealed, so that the activated transmitter can only be reset by persons notified of its position,

The assembled PCB in case.

Figure 2. Circuit diagram of the 418MHz Radi-Call Transmitter.



eliminating the possibility of it being prematurely switched off before help has been summoned. The transmitter is fitted into a compact, lightweight enclosure, so that it is convenient for keeping upon one's person, and close at hand should help need summoning.

Circuit Description

Figure 1 shows the block diagram of the 418MHz Radi-Call Transmitter project, and Figure 2 shows the circuit diagram.

Diode D1 prevents expensive damage to the circuit from accidental reverse polarity connection; capacitor C1 acts as a reservoir, and capacitor C2 provides the high-frequency decoupling.

IC1a is configured as a delay timer of approximately 0·5s, preventing false triggering in case of accidental pressing of the switch.

Pushing S1 will begin to charge C3 via R2, and these components determine the switch delay; the fast discharge of C3 is via R1 & D2. When the input of IC1a falls below the threshold for logic 0, IC1a will output logic 1; this will quickly charge C4 via D4 and trigger the latch formed by IC1c & TR3. The charge on C4 will cause IC1b to switch on TR1, and this in turn powers up the encoder (IC2) and the 418MHz transmitter module TX1.

When the output of IC1a returns to logic 0, the time constant set by R3 & C4 will maintain power to the encoder and transmit module for approximately 1 second; this ensures that if C4 only receives a short pulse from IC1a, a minimum transmission of 1 second is achieved, more than sufficient time to transmit the 4 complete word frames required by the receiver decoder.

D5 prevents the latch from being reset by IC1a, this being manually reset using the switch S2. A logic 1 output from TR3 reverse biases D7, which then allows IC1d to oscillate; C8 & R8 set the oscillator 'space' duration and R9 & D8 in parallel with R8 with C8 set the 'mark'. TR2 is used to drive the LED and buzzer.

The mark duration is set far shorter than the space duration in the interests of prolonging battery life, since the buzzer and LED will then have a correspondingly short duty cycle, thus drawing less power.

Code Setting

IC2 is the HT12E single chip encoder. The code pattern is set by making solder bridges on the track side of the PCB (spanning pins 1 to 12 of IC2); a total of 4,096 different codes are possible (2^{12} = 4,096). The timing of the system is set using a single resistor, R5. The resulting

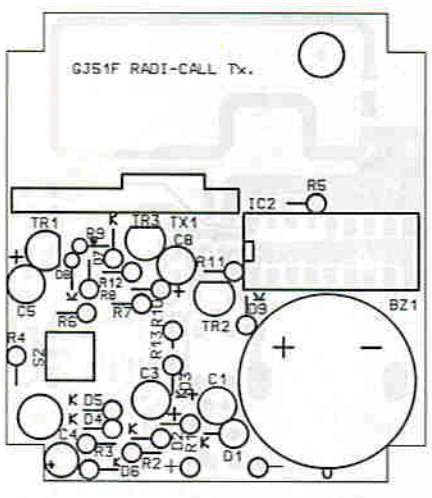


Figure 3. PCB legend and track.

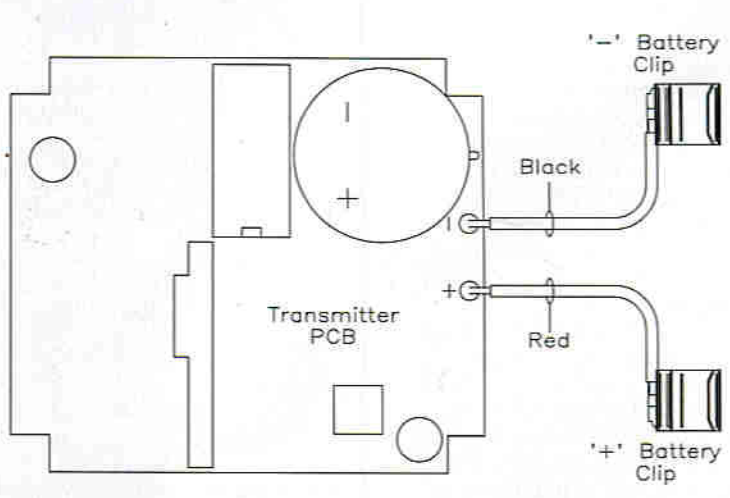


Figure 4. Wiring diagram.

digital code appearing on pin 17 is fed to the modulation input pin 5 of the transmitter module TX1.

PCB Construction

The PCB legend and track are shown in Figure 3, and will assist in the construction of the PCB. A ready-made PCB is included in the kit and is also available separately (see Parts List). Construction is fairly straightforward and the following general advice applies; begin with the smallest components first, working up in size to the largest; be careful to correctly orientate the polarized devices, i.e., electrolytic capacitors, diodes, LEDs and ICs. Do NOT fit the 418MHz transmitter module, TX1, at this stage. Note, however, that a soldering iron fitted with a fine point (SMD) bit should be used for installing the SMD components. Revert to a normal sized bit for installing the regular-sized parts.

Fit the LED with the shortest lead to the hole marked cathode (K). Next, correctly orientate and insert the IC2 into its socket – aligning the end notch with that of the holder. Take suitable antistatic precautions when handling the ICs, since CMOS devices are used.

A more detailed explanation of component recognition and construction techniques may be found in the Constructors' Guide, which is included in the kit (also available separately, XH79L).

Thoroughly check your work for misplaced components, solder whiskers, bridges and dry joints. Finally, clean all the flux off the PCB using a suitable environmentally friendly solvent.

Testing

Refer to Figure 4, showing the wiring diagram and PSU. Power up the module by inserting a fresh PP3 into the battery compartment, ensuring that it is fitted the correct way round. Alternatively, connect a PSU with an output voltage between +6V to +12V DC (9V nominal) to the +V and 0V terminals.

Push S1 (the panic button), and approximately half a second later, the LED should illuminate and a long initial bleep from the sounder should be heard, followed by a pause then short bleeps, LED flashes and pauses. Push S2, and the circuit should immediately reset. Note that the specified box design requires that a suitable pointed instrument (e.g., a pen tip) must be used in order to press the reset button, to prevent accidental deactivation.

Now set the code by means of the solder bridges on the underside of the PCB – see Figure 5. Ensure that both the transmitter and receiver have been set up to use the same code. Note that the transmitter code must be set BEFORE soldering in the 418MHz transmitter module.

Disconnect the power supply, then very carefully fit the 418MHz transmitter module into the PCB and solder it in position.

To test the 418MHz Radi-Call Transmitter, a matching 418MHz Radi-Call Receiver is required. Turn on the receiver; the receiver module's LED should illuminate and the relay should energize when the

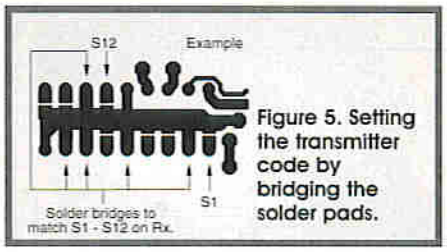


Figure 5. Setting the transmitter code by bridging the solder pads.

transmitter is powered up and the panic button pushed.

If you possess any RF test equipment, this will enable you to test the transmitter output power level and thus assist you to fine-tune the receiving antenna to achieve maximum range in difficult locations. Even without RF test equipment, range tests can still be easily carried out, by gradually increasing the distance between transmitter and receiver, noting the point at which reception becomes unreliable. Such experiments will allow optimization of the system and antenna configuration. Avoid the temptation to adjust the trimmer on the transmitter, as it has already been set correctly during manufacture!

Box Construction

Refer to Figure 6, showing the drilling details for the specified box, and Figure 7, showing the exploded assembly diagram. The specified enclosure is ideally suited (after all, the PCB was designed to go in it!), but you may wish to use an alternative. However, it must be pointed out that a metal enclosure should not be used, as it will act as an RF shield around the project, seriously reducing the unit's transmitting capability!

Drill the box according to the diagram and chamfer off any burrs. Note that a square 'activation pad' must be cut out of the front panel – don't throw it away! Once cut out, it should be held in the position from whence it came by means of a small piece of sticky tape on the inside of the box. Check that the activation pad moves freely when pressed with moderate pressure.

Refer again to the wiring diagram shown in Figure 4. The battery clips should then be fitted into their respective positions in the battery compartment, and then connected to the PCB (+) and (–) terminals using suitable lengths of red and black wire, respectively. The PCB can then be fitted into the box and held in place with the two M2·5 countersunk screws, shakeproof washers, nuts and M3 spacers, ensuring that they are tightened securely.

Next, wipe the box clean and carefully apply the labels, shown in Figure 8 (note that the supplied label must first be

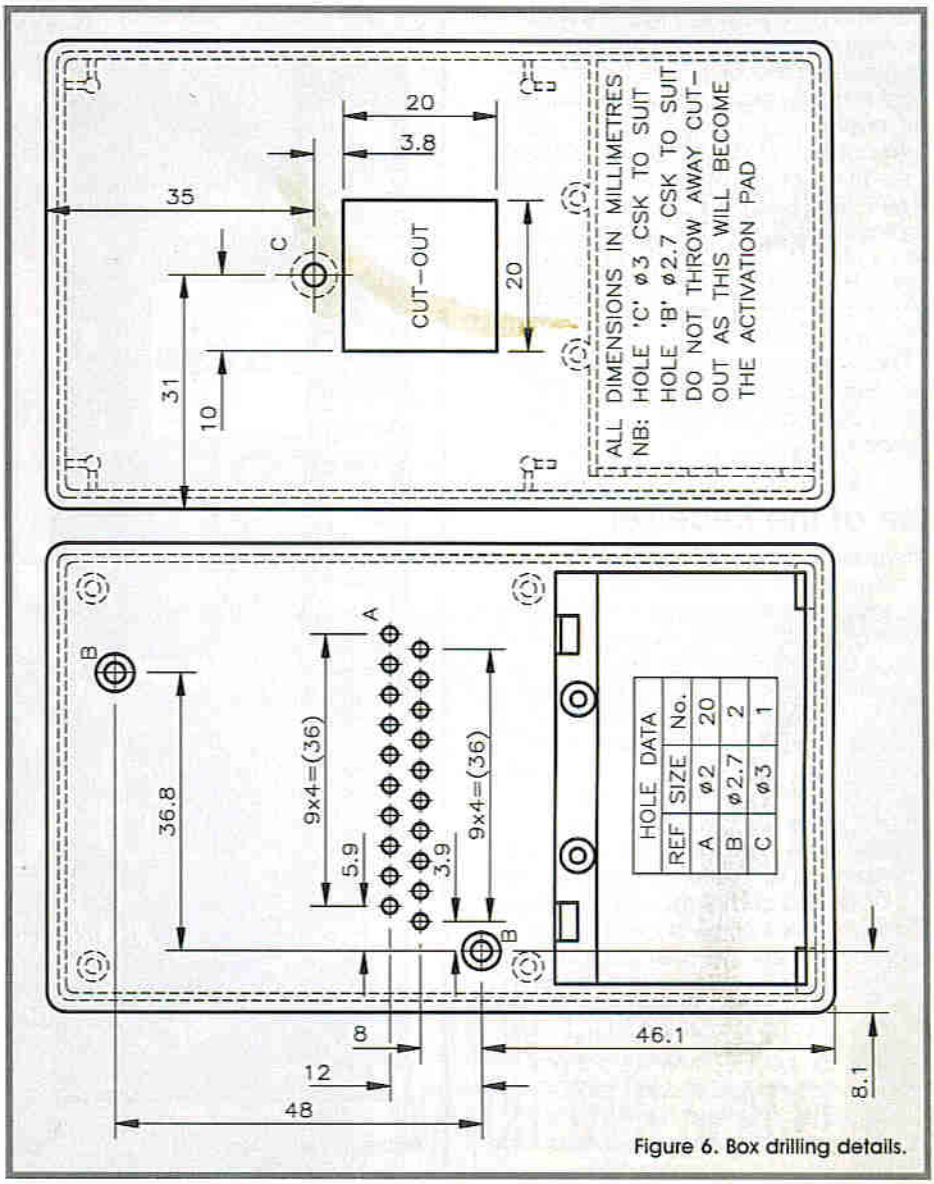


Figure 6. Box drilling details.

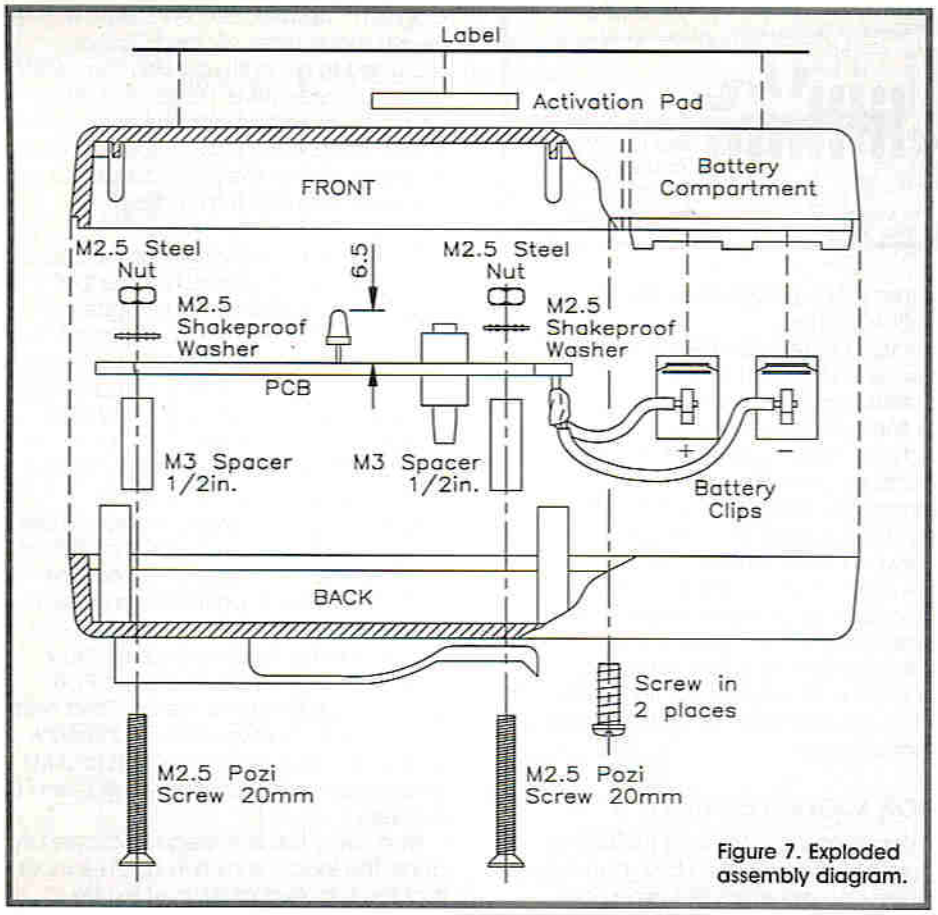


Figure 7. Exploded assembly diagram.

separated into individual sections – for the front panel, battery compartment and receiver module). Store the receiver label in a safe place until you have built the receiver!

An additional label has been included in the kit to comply with the requirements of MPT 1340 (see Figure 9), and it is also available separately. The wording reads 'MPT 1340 W.T. LICENCE EXEMPT' and this should be fitted on the outside of any box or case that the transmitter module is incorporated into.

Finally, secure the back of the box with the screws supplied, clip a fresh battery into its compartment and slide its cover in place.

Use of the Receiver

Construction of the 418MHz Radi-Call Receiver will be covered in next month's issue of *Electronics*.

The 'Radi-Call' system was designed for use by the frail/infirm/elderly. The transmitter is carried by the vulnerable person, so that it can be operated in case of emergency. The receiver can be fitted within an alarm system, or used to control a telephone communicator, such as the unit stocked by Maplin (GL03D). Note, however, that the receiver should not be fitted into a communicator unit, unless the communicator is wired to a private exchange, since doing so would contravene the BABT approval – it should instead be installed in a separate box. If a GL03D-type communicator is used on a private exchange, the receiver can be fitted into the bottom right-hand corner, alongside the 9-0-9V 250mA transformer and 50mA mains fuse. Activating the transmitter would cause the receiver to operate the relay, which in turn, would cause the telephone communicator to dial the preprogrammed number and relay the prerecorded emergency message. The GL03D unit mentioned stores the emergency message in battery backed-up RAM and can be programmed with up to four telephone numbers.

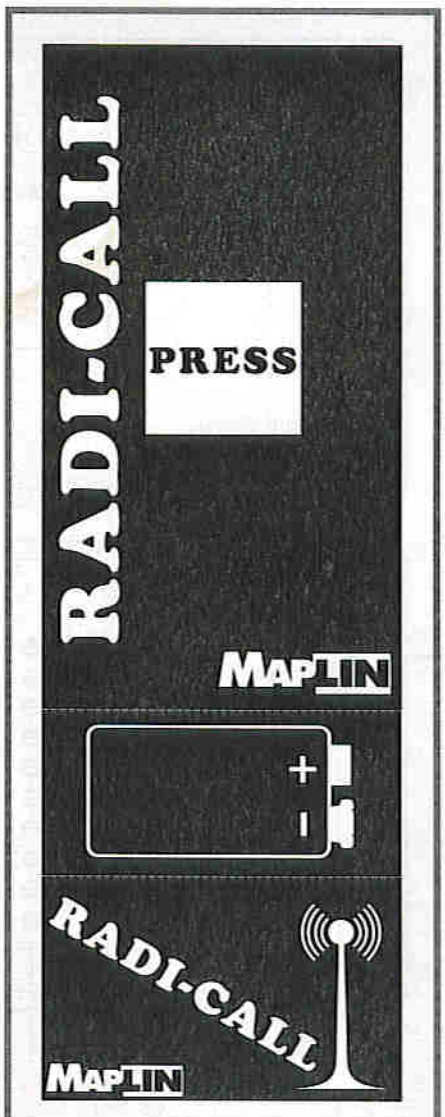


Figure 8. Panel labels.

Note that the equipment in which the transmitter module is fitted must carry a clearly visible label stating 'MPT 1340 W.T. LICENCE EXEMPT'. The minimum dimensions of this mark should be 10 × 15mm and the letter and figure height must not be less than 2mm. A suitable label, complying with these requirements and shown in Figure 9, is included in the 418MHz Radi-Call Transmitter kit, and is also available separately.

IMPORTANT! The trimmer control on the transmitter module is factory set to comply with the DTI (RA) specification MPT 1340, and therefore, must *never* be altered.

Other Applications

There are many other applications for the 418MHz Radi-Call system, such as part of a security system.

The transmitter/receiver projects could be used as a means of connecting a remote sensor to an alarm system without having to install wiring in a building. A remote sensor can be connected to the transmitter by means of normally open contacts, such that when the sensor is triggered, the transmitter is activated. Interfacing the receiver to an alarm system can be achieved by simply connecting to the appropriate contacts of the low power relay. The relay contacts would be connected to either a normally open or normally closed loop on the alarm system, so that when a valid code is received, the relay is operated and the alarm system triggered.

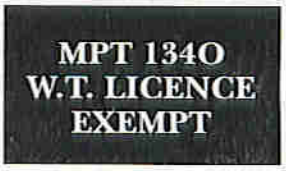


Figure 9. MPT 1340 label.

By connecting the transmitter to a car or house alarm system, a paging system would be created such that when the alarm is triggered, the transmitter is activated. When a valid code is received, the relay on the receiver would activate, triggering the alarm and alerting the owner to a theft attempt.

By interfacing the transmitter to a sensor or to an alarm system, when the sensor or alarm is activated, the transmitter would be triggered as well. As long as the range is not exceeded, it is possible to use it on a boat, caravan, garage, shed, etc. at the bottom of the garden (protect your tools and ladders – burglars find them very useful!)

Another application could be a

'watchdog' for remote machinery not often checked, where unexpected down time could be expensive.

With a total of 4,096 codes to choose from, there is a plenty of scope for using multiple units in many different applications. In all cases, it is wise to perform range tests to ensure adequate coverage is obtained. With security applications or emergency call systems, correct operation should be checked regularly (at least once a month) and batteries replaced periodically as a matter of course.

The 418MHz low-power transmitter module used in this project was covered in a DATA FILE in Issue 73 of *Electronics*, which contains additional applications information.

Contacts

Radiocommunications Agency,
Waterloo Bridge House,
Waterloo Road,
London, SE1 8UA.

Switchboard, Tel: (0171) 215 5000
Radio communications, Tel: (0171) 215 2150
MPT 1340 Enquiries, Tel: (0171) 215 2129

Copies of MPT 1340 are available from the Radiocommunications Agency.

RADI-CALL TRANSMITTER PARTS LIST

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

R1,6,9, 10,12	47k	5	(M47K)
R2,3,7,8	470k	4	(M470K)
R4,13	4k7	2	(M4K7)
R5	750k	1	(M750K)
R11	1k5	1	(M1K5)

CAPACITORS

C1	47µF 16V Radial Electrolytic	1	(AT39N)
C2,6	100nF Surface-mounted Ceramic	2	(DJ00A)
C3	2µ2F 63V Radial Electrolytic	1	(AT75S)
C4	470nF 63V Radial Electrolytic	1	(AT73Q)
C5	4µ7F 63V Radial Electrolytic	1	(AT76H)
C7	10nF Surface-mounted Ceramic	1	(DH97F)
C8	10µF 63V Radial Electrolytic	1	(AT77J)
C9-11	10pF Surface-mounted Ceramic	3	(DH86T)

SEMICONDUCTORS

D1	1N4001	1	(QL73Q)
D2-9	1N4148	8	(QL80B)
TR1-3	BC558	3	(QQ17T)
IC1	HCF4093BM1 Surface-mounted	1	(AB08J)
IC2	HT12E	1	(AE17T)
LD1	Miniature Low Current High-brightness Red LED	1	(CZ28F)

MISCELLANEOUS

S1	PCB-mounted Push Switch Type 105	1	(KR88V)
S2	PCB-mounted Push Switch Type 105B	1	(KR90X)
TX1	418MHz Transmitter Module	1	(AM27E)
	PCB-mounted Piezo Buzzer	1	(KU58N)
	18-pin DIL Socket	1	(HQ76H)
	10m 16/0·2mm Wire, Red	1 Pkt	(FA33L)
	10m 16/0·2mm Wire, Black	1 Pkt	(FA26D)
	Pocket Clip Case	1	(KC95D)
	M2·5 × 20mm Pozi-drive Screw	1 Pkt	(JC69A)
	M2·5 Steel Nut	1 Pkt	(JD62S)
	M2·5 Shakeproof Washer	1 Pkt	(JD97F)
	M3 × 0·5in. Spacer	1 Pkt	(FG34M)
	Single-ended 1mm PCB Pins	1 Pkt	(FL24B)
	PCB	1	(95081)
	Label	1	(95082)
	MPT1340 Exempt Label	1	(KP72P)
	Instruction Leaflet	1	(XZ11M)
	Constructors' Guide	1	(XH79L)

OPTIONAL

	Duracell PP3 9V Battery	1	(JY49D)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

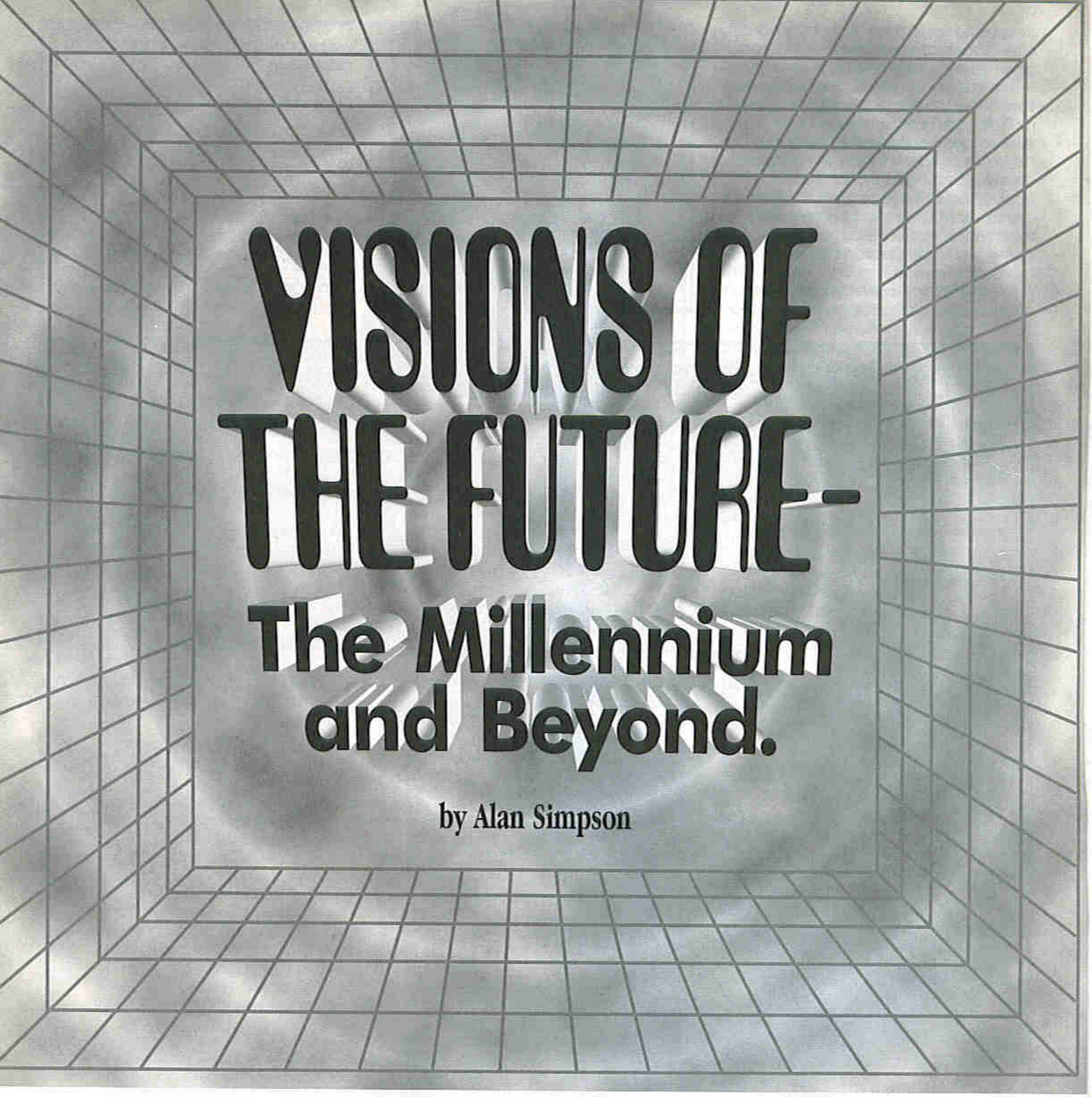
The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As 95080 (Radi-Call Transmitter) Price £39.99 A1

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1996 Maplin Catalogue.

Radi-Call Transmitter PCB **Order As 95081 Price £5.49**
Radi-Call Transmitter Label **Order As 95082 Price £4.29**



VISIONS OF THE FUTURE-

The Millennium and Beyond.

by Alan Simpson

To mark this the 101st issue of *Electronics*, the editor has invited Mystic Alan to peer into the future and reveal his findings. In an industry where even looking one month ahead is somewhat hazardous, he has come up with some startling predictions.

It doesn't take a crystal ball (or even a silicon chip) to forecast that by the end of the decade, computers will be as powerful as the human brain, churning out some 10 million billion calculations a second. But don't take my word for it. For example, Professor Cochrane from BT's Martlesham research laboratories confirms that early in the next century computers will be over 1,000 times faster than they are now. Feasible? Certainly as industry pundits regularly assure us that every six month period sees computer power doubling while size and costs halve.

"Computers are already influencing our everyday life and by the year 2000, they will probably become a major part of our social culture. People will have the technology to 'meet' through shared-interest Internet sites, towns and villages will be connected via local servers. Banks will operate via the Internet, and users will be able to shop entirely through 'net order'. The high street cannot exist as we know it today, and what future for the Post Office? Even video hire shops will be a thing of the past with the rise of video on demand, a service that will become widely available thanks to the increased number of high-end parallel servers. Computers are already affecting us in ways that we could never imagine, and increasingly will be changing the face of the world we live in. The intelligent computers, previously of science fiction, will become consumer fact", said Julie Woods, UK Marketing Manager, IBM.

Curtains on Hi-tech Today

Science fiction also features in the crystal-gazing by Paul Cave, of AMP GB, who said, "Technology and gadgetry that we thought were locked securely in the realms of sci-fi, will become quite a commonplace reality. A likely development will be the creation of a complete communications infrastructure for your home through your TV via a modified keyboard which will hold all the processing capabilities of today's PC – everything from closing the curtains through to regulating the heating to videoconferencing, will be done from the armchair at the touch of a button."

But when it comes to future-gazing and predicting, there is none greater than Bill Gates (the guy who put the 'bill' in billionaire). He

describes the Internet as being some kind of gold-rush, but a gold-rush where there really is gold. "It may be buried a little deeper than some people think, but the drop in the price of communication, the fact that PC's everywhere will eventually have very high-speed data rates allowing them to work together, really will have a fundamental impact. In fact, it will mean that our industry will be changing the way people do business, the way they learn, and even the way they entertain themselves, far more than I think people are expecting."

At the UK launch of his new book *The Road Ahead*, Bill Gates who, thanks to his company Microsoft is estimated to be worth some $14billion, said that he could see the time in the not too distant future when computer screen technology will resemble tablets of paper. Will prices come down? Yes, but a qualified yes. Providing hardware can meet the demands of software, a $2,000 system could cost between $800-$900.

A Journey Into the Future – Courtesy of BT

More crystal-gazing from BT's Professor Cochrane. "In a few years we will be dialling telephone numbers by voice, and the machine will recognise who we are. We have to thank the space race and the cold war for promoting the birth of integrated circuit technology. There are now wrist-watches that wield more computing ability than some 1970s mainframes. Ordinary cars today have more 'intelligence' than the original lunar lander.

A generation hence, BT predicts will see the emergence of Mechatronics, the merging of mechanical and electronic engineering which will be responsible for producing many extraordinary new devices and developments.

Such as: Special glasses for three-dimensional television won't be needed, and video-conferencing will create the impression of 'virtual presence', being three-dimensional and life-sized. We will probably also have discovered a new mechanism for communication, other than radio, electronic and optical transmission."

Thanks for the Memory

Yet more forecasts from the redoubtable IBM. John R. Taylor, Manager of IBM OEM Europe poses the question, "How much personal storage are PC users of the future likely to need? The answer is probably always going to be more than they estimated. New technology and software is encouraging wider use of multimedia, graphics, internet related applications, virtual reality and entertainment of all kinds. To meet this need, storage companies are pushing forward the frontiers at an ever-increasing pace. Today, most online storage is provided with the magnetic hard disk drive – the low price 3·5in. solution for desk-tops or the smaller, lower power, more rugged 2·5in. version for mobile computing. Today, PC manufacturers are offering 1 to 2G-byte drives on their latest PCs. By the year 2000. these same drives will be capable of 10G-byte at similar prices by storing 10G-bits on each square inch of disk surface. Impressive though this is, alternative storage technologies are being researched today that could take over from HDDs early in the century. One such example is 3-dimensional recording on quartz or polymer films using holography. Data can be written with interference patterns produced at the intersection of two laser beams at 150G-bits per square inch and at multiple levels in the material. Just start thinking what you could do with a 100G-byte drive with a data rate of 1G-byte/s."

Without doubt, compact floppy disks will have the capacity to store over 50 novels and probably all the issues of *Electronics*, with space left over for the next ten years.

Global with Everything

Meanwhile, FTP Software envisages a world in which global internetworking and information systems, based on World Wide Web-based networks (the Intranet) will become the *de facto* standard for all business communications. "The need will be intensified and today's core communications tools (PCs and telephones) will be replaced by a comprehensive range of software applications as the worktools of choice for accessing the global network, sorting relevant information efficiently and sharing it with other interested parties", says Vincent James, Marketing Manager,

I Heard it On the Internet

Firefox is one of the few British companies to have made money out of the Internet explosion. Vice President Phil Mercer can see a firm future for the Internet, not only commercially, but as an organisational information resource – that is cornering off a piece of the Internet for a businesses own use).

Right now the race is on to produce a cheap Internet terminal. By 2000, a number of companies will be marketing what in effect are cut-down computers, featuring limited memory and storage facilities together with the ability to dial into the Internet by means of an ordinary telephone. Necessary data and files will be stored on the central network as will of course, most of the national newspapers. (Bet the page 3 feature will be the most heavily surfed).

Internet with Everything

Meanwhile, as Martin Turner, General Manager CompuServe UK said, "What is not in dispute is that whatever form the PC takes in the future, it will be connected in some way to the Internet and the requirement to access it in an easy, secure and reliable fashion from whatever device will be paramount. Obviously a number of improvements, including investment by telecommunications companies in higher-bandwidth ISDN and cable modem links will be necessary to improve the speed of hooking up to the Internet.

Electronics Sparks to Fly

Somewhat closer to our own interest level, Robin Saxby of Advanced RISC Machines, believes that as electronics is set to become the world's largest business by the year 2000, it is important that we focus our energies to create global solutions to global problems. "No longer can we think in terms of 'Fortress Europe'. It is through free markets, open standards and collaboration internationally that we can influence the direction of the world's electronics industry and thus improve our contribution to the global economy."

Similar growth forecasts are being expressed by the world's leading semiconductor companies. Philips states that the market for writable CDs will grow quickly as the cost of drives fall from today's $1,000 to $500 in this year alone.

Meanwhile, Intel says that personal computers for the home will out-sell televisions and are set to become the most popular consumer device. Multimedia rules, it seems.

According to Siemens, the rate of technological innovation is largely driven by microelectronics and computer software. Clearly the world market is in a position to absorb innovation across a wide range of technologies, but there are three in particular which occupy different parts of the technology spectrum – namely, multimedia networking, decentralised energy generation and transportation.

Getting the Message

Thilo Kusch, a manager in Arthur D. Little's consultancy, has also been donning the Mystic Meg mantle. "Personal communicators will include voice-activated 'wearables' integrated into personal organisers and watches, as well as audio-visual communicators with a screen hanging on the wall displaying the users favourite painting when not in use. The critical technologies behind these developments include improved power technologies, for example new battery technologies and hybrid systems, as well as user interfaces, such as flexible polymer screens and improved voice recognition.

Communication within the office will be more personalised through the use of call identifiers for different groups of callers. This will allow us to determine communication profiles for different groups of customers, for example, enabling greater control over call handling and improved customer service. This will require much more sophisticated customer management systems on the network side facilitated by technologies such as computer telephony integration, increased intelligence in communication networks and sufficient customer care systems."

On a more social level, electronic mail will increasingly pose a threat to the Post Office, with PCs and faxes making standard-issue post redundant.

Goodbye – and Hello Paper

"The next few years will see the final acceptance of the Paperless Office as a myth that will never come true." So believes Peter Turner, marketing director of OKI Systems UK., which might bring some measure of comfort to the Post Office. "Whilst the advent of the Internet and the widespread use of e-mail has certainly curtailed the rise of paper usage, they are both a long way from being seen as a viable blanket replacement. There remains a massive role for printers in the offices of the future, but the role of facsimile products face a greater challenge unless they continue evolving at a fast pace. It is conceivable for instance, that the transmission of colour photographs could be standard-issue usage by 1999."

Getting On Board the Superhighway

"It took a century to establish a half-billion terminations on the world's networks – an impressive figure in itself. But it will take just six years or so to double that number to a billion, and half of those terminations will be

Continued on page 31.

THE USE OF LASERS IN OPHTHALMOLOGY

BY DOUGLAS CLARKSON

With the development of technology, we live in an increasingly visual world, and with this has come a greater awareness and understanding of the mechanisms of vision. Optical hazards have also been extensively researched. Development in lasers and optics has also provided new means of treating eye disorders – arising through either injury or disease. Aspects of the use of laser technology in ophthalmology are subsequently outlined. In order to appreciate specific applications, however, some background information of the eye and its structure is presented.

Navigating the Eye

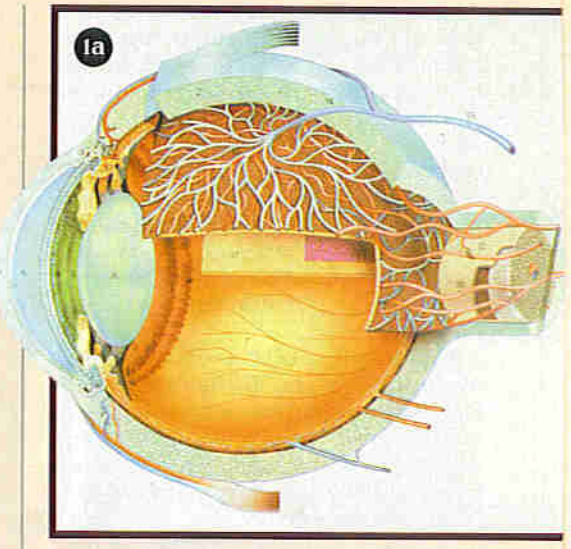
The eye presents a wonderfully adapted and developed biological imaging system. While vision is 'sensed' with the aid of an even more highly developed signal processing and image recognition system in the brain, the starting point for the process of sight begins within the structures of the eye, as indicated in Photo 1a

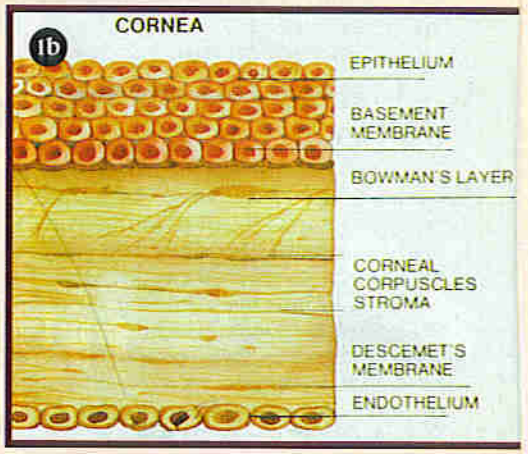
Incoming light is first focused at the air/corneal interface. The relatively large ratio of refractive index between the air and the corneal surface (1·3376) provides most of the total focusing power of the eye. The cornea is featuring increasingly in laser treatment of the eye, and the use of excimer laser surgery is highlighted in a later section. The cornea shown in detail in Photo 1b is itself a complex structure and one which has a significant bearing on some forms of laser treatment undertaken.

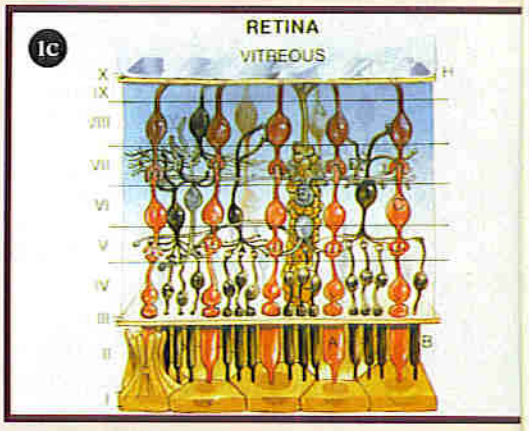
On the exterior, the corneal epithelium acts as a protective sheath which can regenerate in event of injury. Below this is Bowman's membrane about 8-10μm thick. Beneath this structure the stroma forms the main structural tissue of the cornea. In immediate contact with the fluid in the anterior chamber endothelium cells are the most vulnerable component of the cornea and tend not to regrow in event of injury. Most laser wavelengths, with the exception of the ultra-violet excimer wavelengths, are transmitted by these corneal structures.

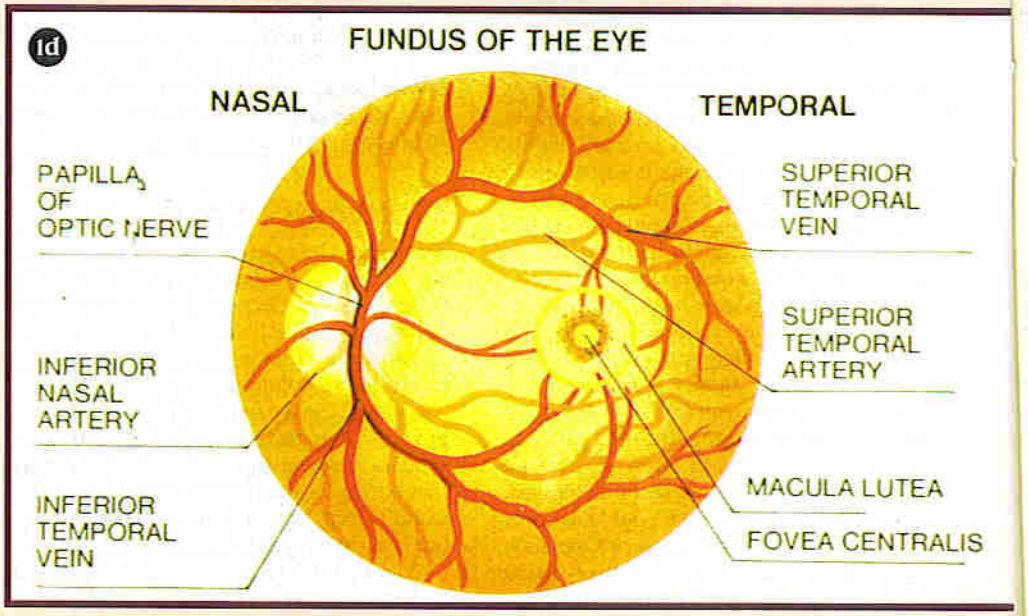
The lens is located in the clear fluid of the anterior chamber with the iris structure located above it. The lens is encased in the lens capsule – a protective membrane which while intact maintains the delicate chemical balance of the cells within the lens to preserve its transparency. Should the lens capsule become damaged through injury or incorrect application of laser energy, then the lens will develop a cataract and require to be removed. This requires great care to be exercised in the delivery of specific types of laser energy in the eye – especially pulsed types, where an intact lens remains in situ.

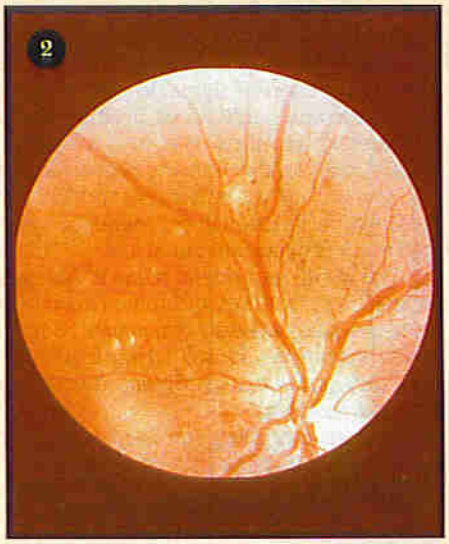
The lens is attached around its periphery by fine ligaments which can be drawn tighter and relaxed by the ciliary muscle. This allows 'fine' focusing on objects at varying distances from the eye. It is this application of variable tension which acts to change the curvature











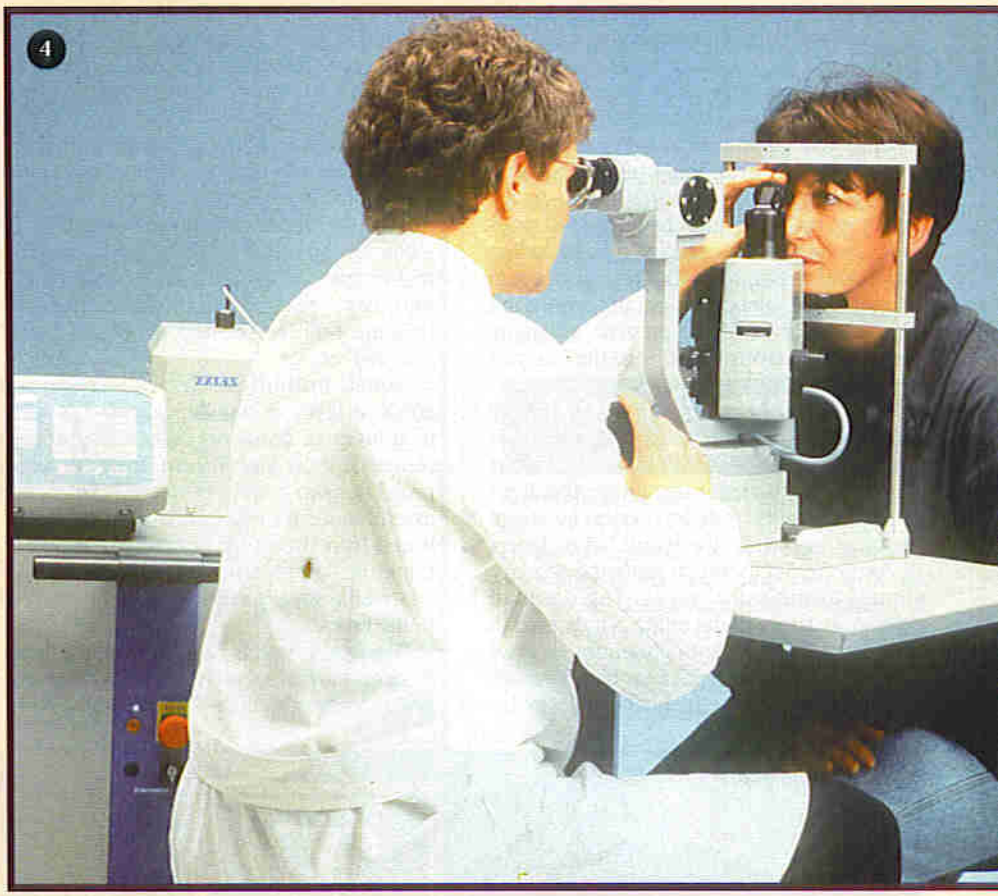
of the lens and hence its focusing ability. With age, the lens loses its accommodation as it becomes more rigid.

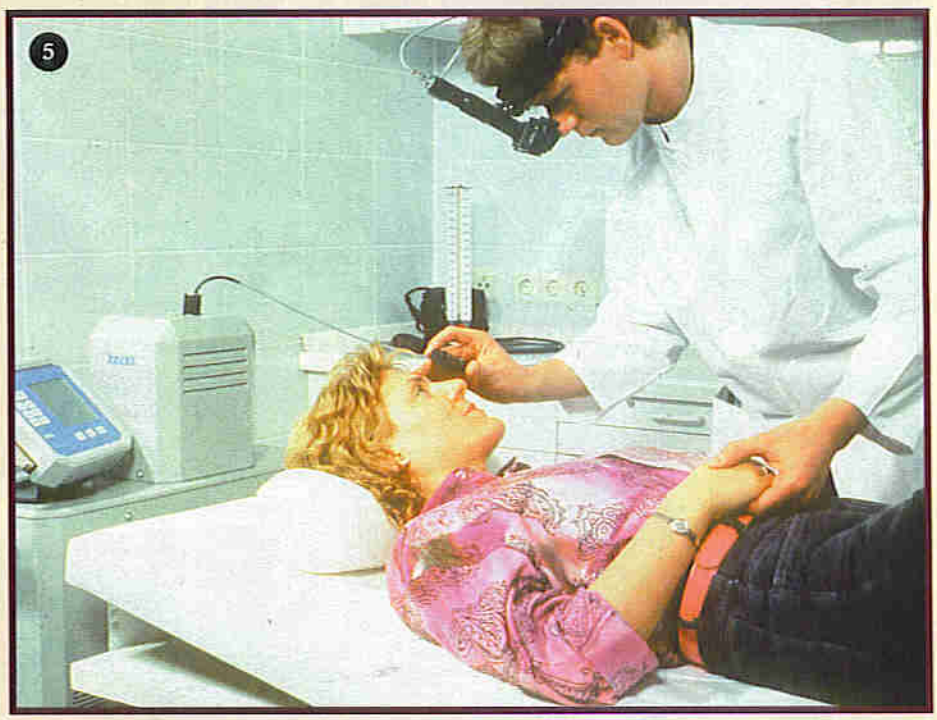
Complications can arise following lens removal during cataract surgery. Flaps of the capsule of the lens can adhere to the iris and result in significant pain and inflammation, requiring rapid intervention. Lasers have been specifically adapted to produce micro-pulses of highly focused energy to disrupt and break apart such linkages in situ. In this way, an additional surgical procedure with attendant risks for the patient is avoided. Most ophthalmic centres where cataract surgery is routinely undertaken will have available pulsed Nd:YAG laser systems.

The iris is like a circular 'curtain' which

opens and closes above the lens – changing the size of the inner circular aperture. Thus in bright conditions, it contracts to about 3mm, while in levels of low light, it expands to around 8mm. The base of the iris when functioning normally has within its structure a system called the trabecular meshwork, which allows fluid to be exchanged from the anterior chamber to the front of the cornea where leakage takes place to relieve ocular pressures. The eye must function above atmosphic pressure in order to provide rigidity to its optical structure.

When this meshwork becomes blocked or restricted, the flow rate of fluid through the trabecular meshwork becomes insufficient and abnormally high pressure builds up





1a Structures of the eye. (Courtesy CUCI(UK) Ltd.)

1b Structure of the cornea. (Courtesy CUCI(UK) Ltd.)

1c Cell structure of the retina. (Courtesy CUCI(UK) Ltd.)

1d Visual appearance of the retina as observed via ophthalmoscope examination. (Courtesy CUCI(UK) Ltd.)

2 Indicates the appearance of the retina in the condition of diabetic retinopathy. (Courtesy Zeiss Medical).

3 One end of laser resonator incorporating totally reflecting mirror and cylindrical air seal unit to protect optical surfaces from contamination.

4 Conventional slit lamp system used for delivery of photocoagulation energy. (Courtesy Zeiss Medical).

5 Indirect slit lamp used for greater convenience in delivery of photo-coagulation energy. This is a preferred method of treatment in theatre and for patients who otherwise would be difficult to treat with the slit lamp. (Courtesy Zeiss Medical).

in the eye – resulting in 'simple' glaucoma, as the blood supply to the retina becomes insufficient to sustain normal retinal cell function. Lasers have been used in various modes to improve the circulation of fluid through this fine meshwork in the iris. The basic approach is to apply highly localised energy at points around the limbus to try and open up closed fluid pathways. All types of lasers have been used for this, including Argon and pulsed Nd:YAG. The more severe 'closed angle' glaucoma occurs where the lens bulges forwards and prevents adequate transfer of aqueous humour to the anterior chamber.

The retina is the most complex and highly developed and in many ways, the most vulnerable part of the eye. Nature has produced a light sensing structure where the light sensitive cells (the rods and cones) lie above the layer of blood supply and below layers of connected cells which relay the sensory stimuli to the optic nerve. The detailed cellular structure of the retina is indicated in Photo 1c. The pigment epithelium layer of cells acts as a natural block for blood vessels from the choroid (the highly vascular outer membrane) from invading the light sensing layers of cells of the retina.

Many different layers of cells can be identified in the retinal structure. The light sensing elements are the rods and cones. The smaller rods are primarily for sensing at low levels of light in monochrome. Thus, under moderate moonlight, the eye is using the rods to see where objects are rather than be aware in too much detail of their colour. At higher levels of light, the larger cones come into play – sensing colour of the structures through relative sensing of 'blue', 'green' and 'red' cones.

Signals from these elements are passed across a layer of bipolar cells and in turn, to a layer of ganglion cells which accept sensory inputs and in turn, transmit axion projections to a layer of nerve fibres which extend round the eye to where they are combined into the optic nerve. The retina is, therefore, undertaking an extensive signal processing 'locally' before signals are relayed to the brain.

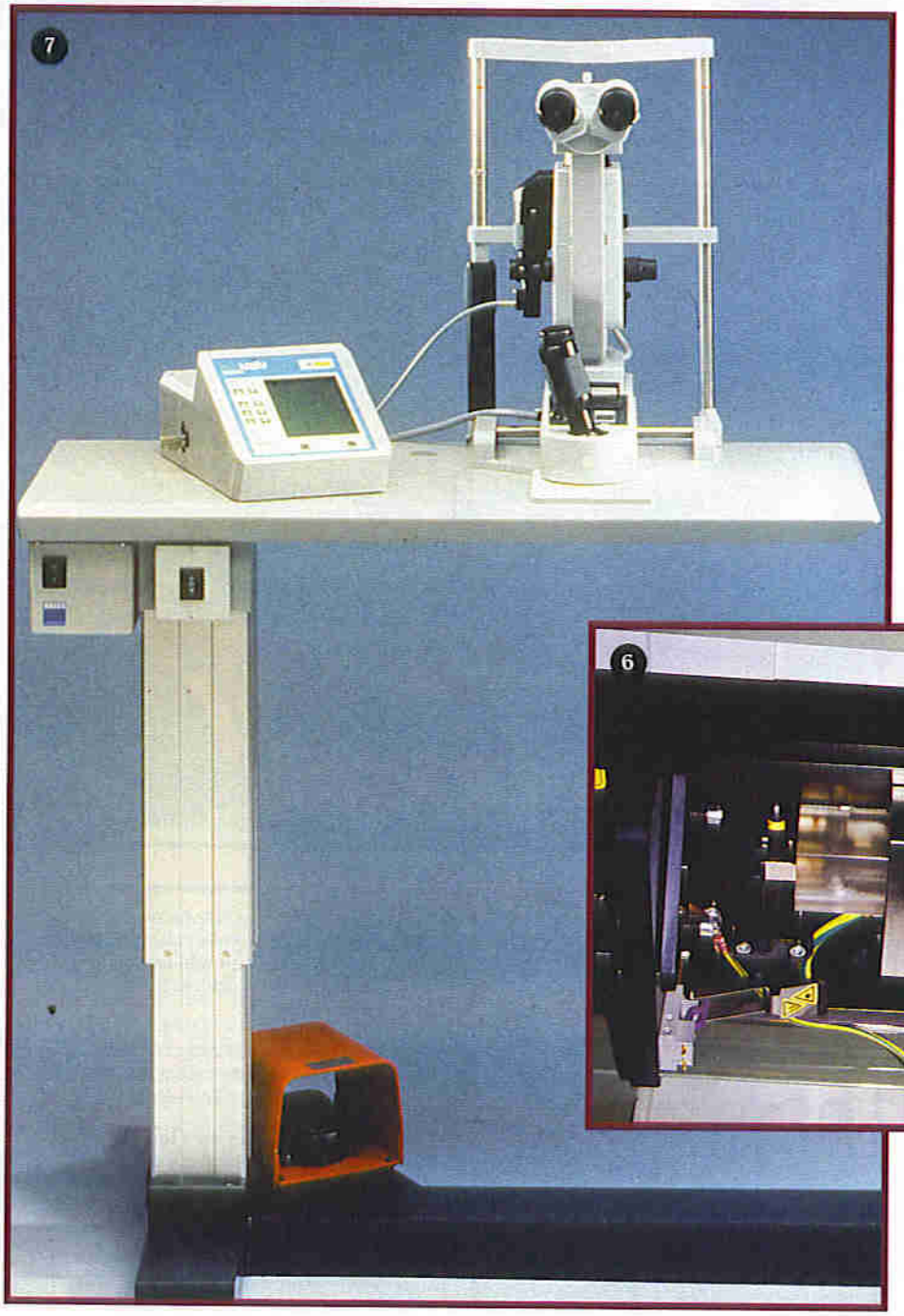
The eye, in adopting this configuration, loses visual sharpness over most of its extent, since the sensory cells – the rods and cones are overlain with bipolar and ganglion cells. At the fovea, a region approximately 3mm in diameter, however, the rods and cones are directly accessed by light. This is the region of the eye that tends to be used for more demanding viewing of tasks, such as reading. Loss of vision in the more peripheral parts of the retina may not be serious, though any loss of visual function in or around the fovea can result is significant visual loss.

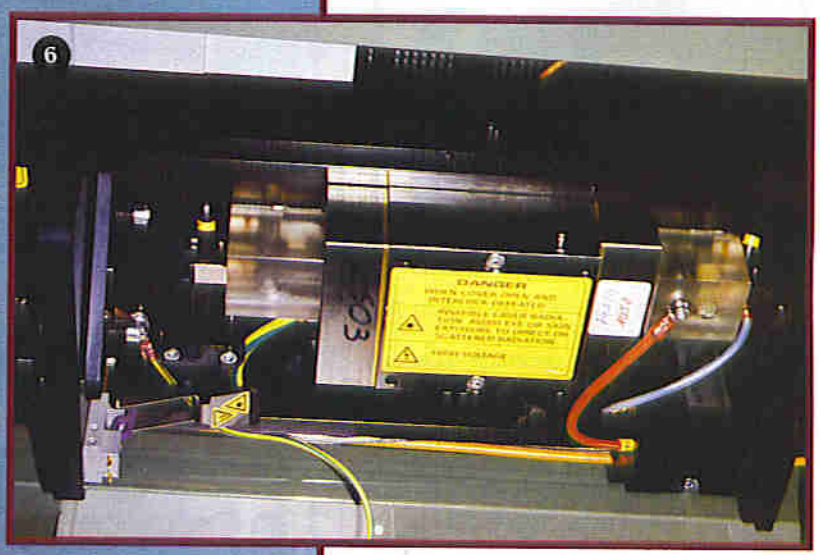
The 'blind' spot on the retina is that area where the nerve fibres transmitted as outputs from the ganglion cells congregate to form the optic nerve. Photo 1d indicates the structure of the eye, as observed using an ophthalmoscope.

In instances of injury and disease, the layer of cells in the retina can develop a 'tear' and become detached from the pigment epithelium. Laser energy can be delivered across the boundary region to coagulate the separating layers and thus 'weld' the two structures together. Where this can be successfully undertaken non-invasively, this is obviously preferable.

There are a range of clinical conditions, including diabetes, where the retinal structure is threatened by the invasion of new blood vessels from the layers below or from haemorrhage of ruptured vessels. The retina of patients prone to this condition have to be monitored at regular intervals. Lasers can be used to control such problems and also minimise the effects of incidents where vessels rupture. Figure 1 shows the different wavelength responses of specific retinal tissues to visible wavelengths of light.

A range of techniques have been developed for delivery of photocoagulation laser pulses. The most common is to apply energy on either side of minute vessels and not directly across them. This has been found to stabilise areas more satisfactorily. In a typical treatment session, however, as many as 500 separate individually aimed laser pulses may be applied. Spot sizes used are typically 100μm from the slit lamp delivery systems. The focusing power of the eye, however, reduces the effective spot size on the retina significantly, so that power densities are significantly increased.





6 Resonant cavity of a pulsed Nd:YAG laser. (Courtesy Zeiss Medical).

7 Clinical Nd:YAG laser system with slit lamp delivery system. (Courtesy Zeiss Medical).

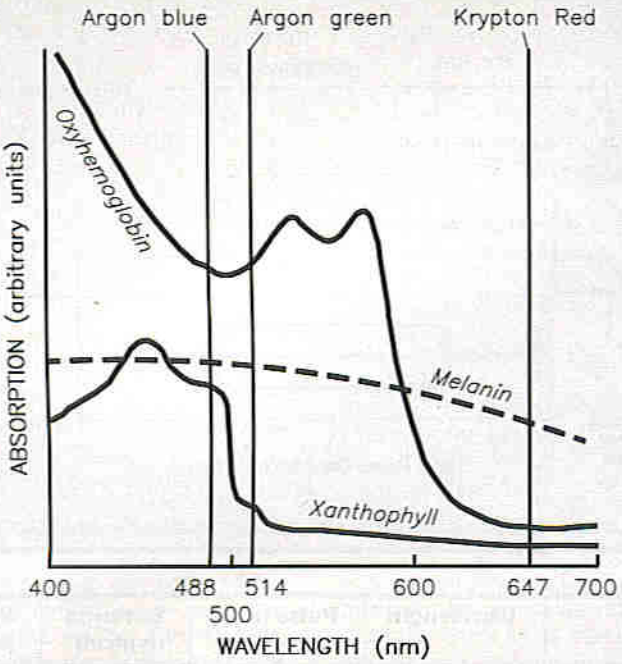


Figure 1. Relative absorption of retinal tissues of visible light.

Photo 2 indicates the appearance of the retina in the condition of diabetic retinopathy. This condition tends to lead to the proliferation of new blood vessels (proliferative retinopathy) and to the 'leaking' of blood from existing vessels. Over 25% of people affected by diabetes will develop some degree of retinopathy. Laser coagulation has been shown to successfully control proliferative retinopathy in around 80% of cases.

Modes of Tissue Interaction

Figure 2 indicates the different types of tissue interaction as a function of pulse energy and duration. In photocoagulation, energy is delivered which results in a temperature increase of the tissue sufficient to change the characteristics of the tissue, but not alter its structure. In vaporisation, the temperature is raised sufficiently to vaporise it. In photo-disruption, energy is delivered so rapidly and at such high levels, that tissue tends to be micro-fragmented. When focused into a small volume within fluid, e.g., in the anterior chamber of the eye, the ultra-high electric field of the laser energy will result in electric breakdown across the volume of fluid at the focus – resulting in a micro-explosion of plasma which in turn, collapses to produce intense local shock waves. These are used principally to dislodge the lens capsule from adhering to the iris.

Figure 3 shows how the energy is brought to a focal zone. A point is reached before the geometric focus, however, where high electric field values result in plasma generation. This can take place in the air, or in the fluid of the anterior chamber of the eye. As the pulse energy is increased, the site at which the breakdown occurs moves away from the geometric focus and towards the observer. This effect is of critical importance in accurate clinical placement of treatment pulses. Some systems compensate the focusing optics as a function of energy, to try to maintain a consistent point of micro-disruption in the zone of treatment.

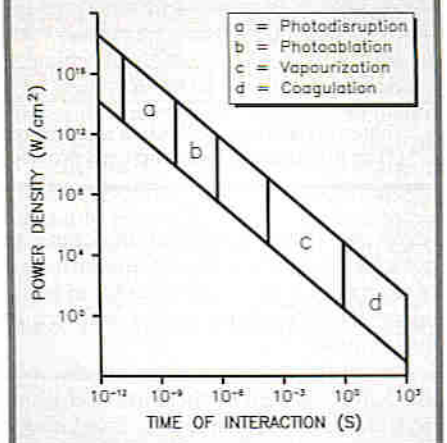


Figure 2. Modes of laser interaction with tissue.

The operator is usually provided with two independent aiming beams which, when coincident, indicate the co-ordinate where energy will be delivered. Precise alignment of the laser beam is essential for effective use.

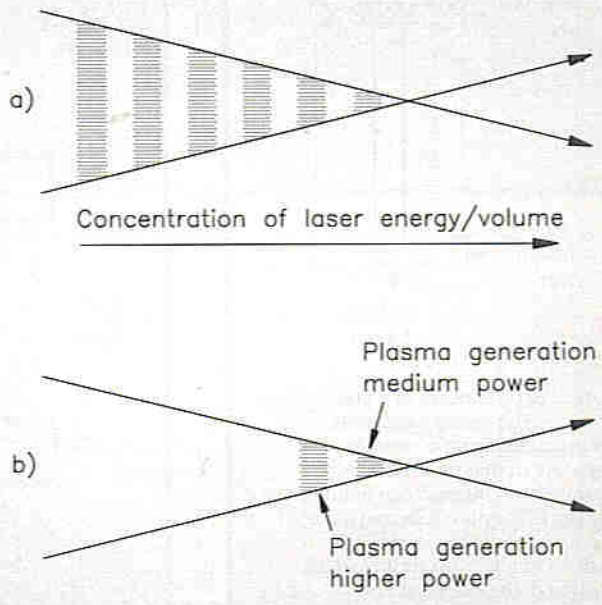
High field levels of ultraviolet wavelength, e.g., an excimer laser at 193nm, will result in disruption of molecular bonds across thin layers, around 0·25μm thick, of the cornea. This provides a means of sculpturing the cornea to a new photorefractive profile to rectify specific types of corneal focusing defects.

Types of Ophthalmic Lasers

Ophthalmic lasers such as the Argon ion have been in active clinical use for decades. However, newer technologies based on solid-state crystals are beginning to emerge and gain wider acceptance. Continued refinement of manufacturing processes in traditional Argon ion lasers has yielded improved reliability, which has tended to extend their product life. Figure 4 indicates the design of a typical Argon laser. The efficiency of an Argon laser is typically very low – around 0·01%, so that for a 30kW mains input, the delivered power is around 3W. This requires either forced air, or water-cooling of the ion tube. Table 1 summarizes some details of ophthalmic laser technology.

Argon/Krypton photocoagulation in the Argon tube in its steady-state conduction mode current of up to 30A is passed across a potential difference of around 250V. The accelerated ions in the plasma pick up energy and via numerous collisions, become promoted to higher energy levels. Energy is released in the form of visible and ultraviolet radiation as the electrons fall to lower energy levels. This can be either by the process of spontaneous emission (a random process) or stimulated emission, where one photon interacts with an atom to release a photon of similar characteristics. This is the key aspect of the LASER (Light Amplification by the Emission of Stimulated Radiation) function. Laser radiation is established within a laser resonator, as shown in Figure 5. Photons of

Figure 3. Pulsed Nd:YAG laser interaction. As energy in the laser pulse is confined to a smaller and smaller volume the very large electric field values in the region of the pulse result in formation of plasma with initial rapid expansion followed by catastrophic collapse of the cavity resulting in localised shock waves.



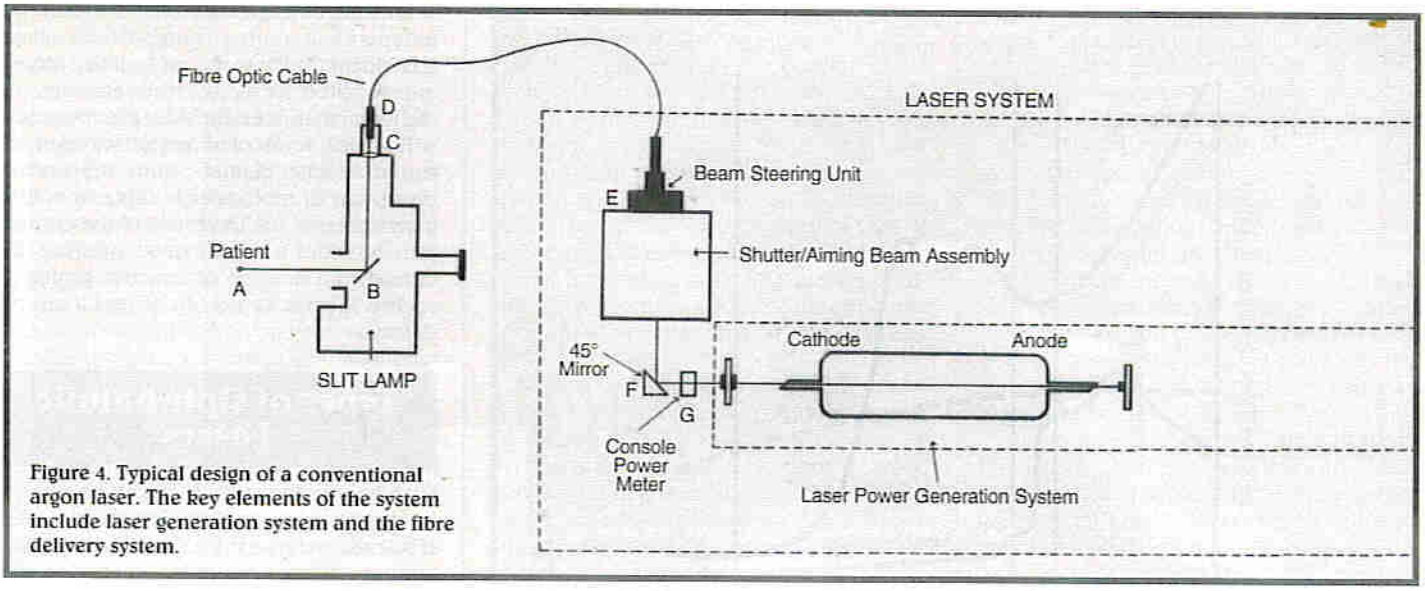


Figure 4. Typical design of a conventional argon laser. The key elements of the system include laser generation system and the fibre delivery system.

light released along the direction between the two end mirrors in turn release photons due to stimulated emission of radiation.

One of the mirrors is partly transmitting, in order to allow part of the light within the laser resonant cavity to enter the laser delivery system. Precise adjustment of the mirrors is essential for such resonance to occur. These features are typical of a broad range of laser systems.

Photo 3 shows one end of the laser resonator, which incorporates the totally reflecting end mirror, housed in an aluminium end block. The cylindrical unit incorporates a device to seal the optical surfaces from air-borne contamination. More recent Argon laser tube technology incorporates sealed optical systems to minimise problems of optical surface contamination and associated output degradation.

In the use of the Argon photocoagulator, typical treatment pulses are of 0·1s duration at power levels of around 0·3W. Where significant opacities exist in the lens, however, higher pulse energy levels may be required to provide effective retinal treatment. In conventional photocoagulation lasers, pulses of this time frame are delivered using mechanical shutter devices. Newer designs of Argon laser instead use electronic controls to pulse the tube current. This has the advantage of running the laser tube at reduced mean power levels, ensuring greater accuracy of pulse timing.

Laser Type	Wavelength	Pulse (mm)	Duration (typical)	Pulse Energy (typical)
Argon	476 to 514*		100ms	30mJ
Krypton	460 to 750*		100ms	30mJ
Nd:YAG	1,064		15ns	10mJ
Excimer	193		18ns	500mJ
Diode	670		10mJ	100mJ
Doubled Nd:YAG	532		50mJ	100mJ
Holmium	2,060		300μs	20mJ

Table 1: Treatment details of a range of types of ophthalmic lasers. (*The Argon and Krypton systems provide a range of discrete line outputs).

One of the most important interfaces in the delivery system is where the laser beam from the laser resonator is coupled into a fibre-optic cable. This allows subsequent coupling to a wide range of delivery systems. The beam as it leaves the laser resonator is typically some 1·5 to 3mm in diameter. After precision alignment, usually achieved by Vernier adjustment in the X and Y directions, the beam is focused using a lens onto a narrow optical fibre – usually some 50μm in diameter. The launching of the beam into the fibre optic requires highly precise control. Excellent positional stability is also required to ensure stable output powers.

While light is shown in a simplistic way being reflected from the inner surfaces of the fibre, light is, in fact, transmitted by means of highly complex modes of 'waveguide'

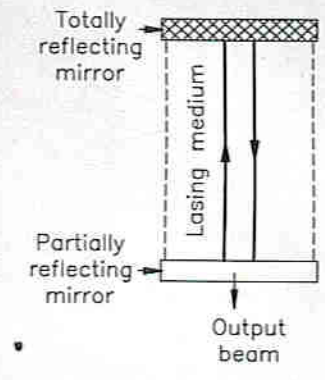


Figure 5. Basic concept of a laser resonator. The lasing medium is contained between two mirror resonators so that photons released by stimulated emission can build up intensity as they are reflected from the end mirrors. One mirror is usually partially transmitting so that a portion of the resonant energy can 'escape' out to the delivery system.

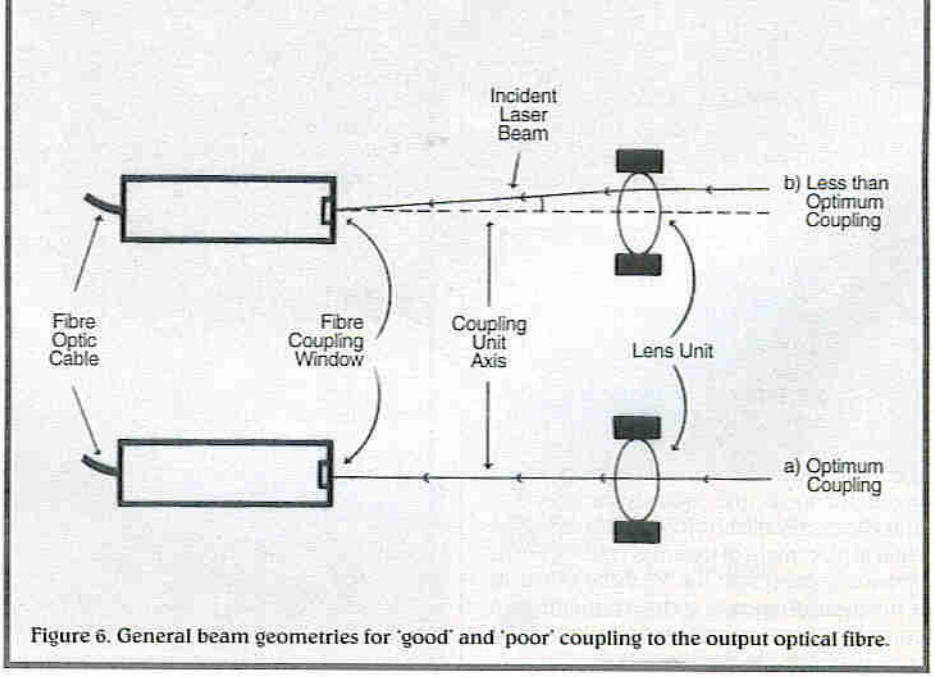


Figure 6. General beam geometries for 'good' and 'poor' coupling to the output optical fibre.

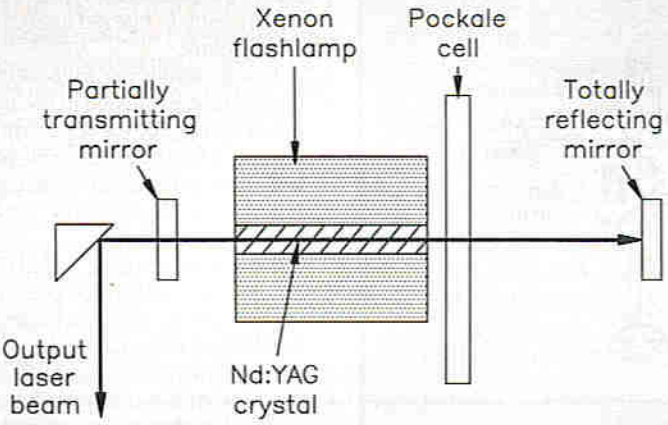


Figure 7. Resonator elements of an ophthalmic pulsed Nd:YAG laser system.

transmission. High losses can occur within the fibre if the light energy is not coupled in an optimum way into the fibre. If, for example, the light is coupled in at an angle to the axis of the fibre, losses in the fibre can be significant. Typical 'good' transmission figures of 90% can fall to as low as 50% or less with poor coupling. Figure 6 summarises the general requirements for good coupling to the fibre unit.

In addition to the conventional slit lamp delivery system shown in Photo 4, the indirect headset has been added, shown in Photo 5. This latter option, worn on the operator's forehead, allows the operator to image the retina of the patient in a 'free field' mode and deliver treatment pulses as appropriate.

In treatments using a laser of this type, it is necessary for the operator to be provided with an aiming beam in order to direct the treatment beam to selected locations on the retina. In conventional photocoagulation systems using Argon ions lasers, the main treatment beam was attenuated by means of aiming beam filters with optical densities typically of 4 or 5 (attenuation by factor of 10,000 or 100,000). More modern systems tend to use an independent aiming beam system, such as the red He-Ne laser.

In all photocoagulation systems, it is important that the safety filters operate in the slit lamp or indirect headset to fully protect the operator's eye from light reflected and scattered from the surface of the patient's eye. The area of the patients's retina containing rods and cones treated by photocoagulation pulses may experience short term impairment, due to temporary bleaching of visual pigments.

The use of the photocoagulation laser is primarily to inhibit vascularisation above the layer of the rods and cones. Green wavelengths, such as that of the Argon laser, are readily absorbed by oxygenated blood (see Figure 1). Longer wavelengths, such as the principal 647nm line of the Krypton laser, are not absorbed significantly by vascular tissue. This allows more deep penetration of laser energy below the pigment epithelium.

The trabeculotomy procedure for the relief of glaucoma undertakes to coagulate the region around the canal of Schlemm, next to the cornea in the anterior chamber. In this procedure, it is essentially the localised heating effect that coagulates tissue and encourages the flow of fluid from the anterior chamber to relieve high ocular pressure. Typically, Argon lasers with a small 50µm diameter spot size are used for this procedure.

Solid-state Photocoagulation Systems

While Argon ions laser systems are still being manufactured and supplied, photocoagulation systems which utilise solid-state lasers are now available. Systems utilising solid-state Nd:YAG at a wavelength of 1·064nm as a pumping energy in a frequency doubling system, produce a wavelength of 532nm – comparable with the main green line of 514nm of the Argon system.

Pulsed Nd:YAG

In the pulsed Nd:YAG, a Xenon flashlamp is used to excite atoms within a Nd:YAG crystal. Photo 6 shows the laser resonator cavity of a pulsed Nd:YAG laser.

Figure 7 shows the elements of the 'Q' switched laser resonator system. In the resonating path, a Pockels cell (an electro-optic device) which when closed, acts as a block to laser resonance. The 'Q' of a laser is a measure of its ability to resonate within its

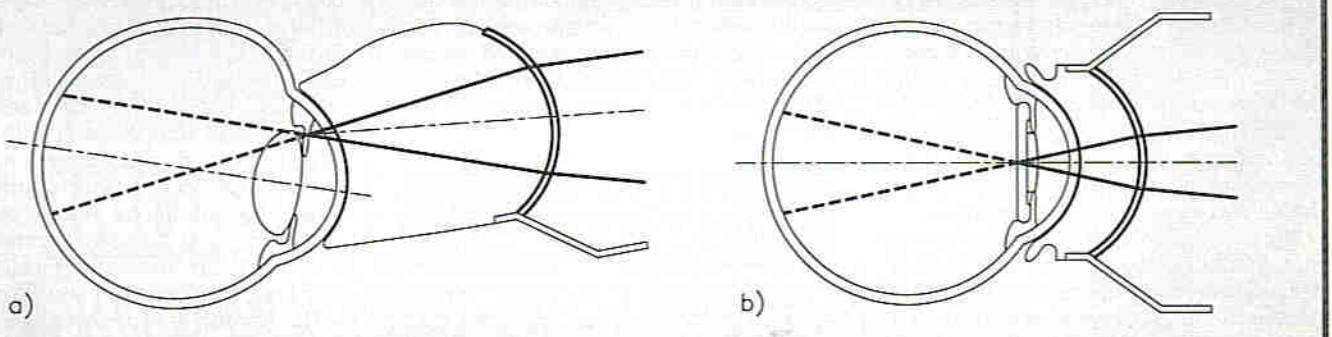


Figure 8. Typical contact lens configurations used with Nd:YAG Laser: (a) iridotomy – punching holes in the iris; (b) working in zone of capsule/vitreous wall after lens extraction.

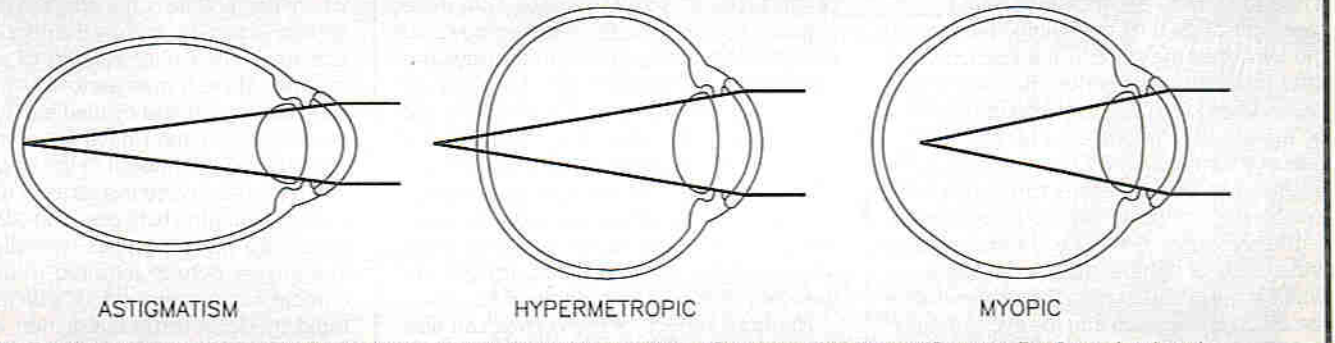


Figure 9. Three basic types of eye conditions which result in blurred images being formed at the cornea. (Courtesy Eye Laser Academy).

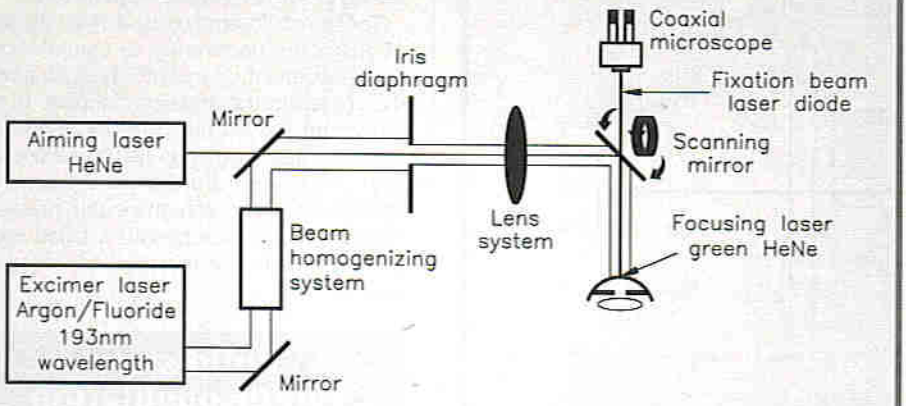


Figure 10. Key elements of the Chiron Technolas excimer laser. Laser radiation is passed through a beam homogeniser and then through a variable aperture unit under computer control. The beam is then passed through various optics interfaces to reduce the beam size. A red He-Ne aiming beam provides location data along the axis of the treatment beam and a green He-Ne beam, when coincident with the red aiming beam, gives accurate location in the vertical plane. (Courtesy Chiron).

Variable	Value
Maximum power at laser site	1W
Maximum pulse energy	450mJ
Wavelength	193nm
Pulse length	18ns
Repetition Rate (max)	30Hz
Fluence test pulse count	63±5
Treatment energy density	120mJ/cm²
Ablation layer per pulse (cornea)	0·25μm

Table 2: Typical output parameters of the Chiron Technolas Keracor 116 Excimer Laser.

cavity. Lasers with high 'Q' values require low levels of excitation energy to resonate. A 'Q' switched laser is one where the laser's resonant properties are altered to encourage the laser to release its stored energy. When the Pockels cell is activated by an electronic pulse, it momentarily changes its direction of polarization and allows stored laser energy to be swept along the resonator path through the Nd:YAG element as a pulse of energy.

The principal value of this form of laser is that energy can be released and utilized within a very small time frame – of the order of 10ns. Photo 7 shows a modern pulsed Nd:YAG system. The main laser power supply, Nd:YAG resonator and aiming beam optics are relatively compact compared with the Argon photocoagulator.

Iridotomy is that procedure for introducing a hole in the iris – e.g., to relieve closed angle glaucoma caused by the bulging forward of the lens onto the iris and the restriction of fluid flow into the anterior chamber. While previously, such a procedure was undertaken by a pulsed Nd:YAG laser, it is now undertaken by a pulsed Nd:YAG laser system. Care is required, however, to minimise any involvement of the lens in such a treatment.

The use of contact lenses is essential to a wide range of ophthalmic laser techniques. With a contact lens in place over the cornea, the eyelid is held back and the eye generally stabilised. Also, the surface of the lens is coated to minimise reflection, and thus reduce losses compared with those that would occur across an air/cornea interface. Such lenses with mirror reflectors can also allow laser energy to be directed to sites within the eye. Figure 8 indicates the function of typical contact lenses used with a Nd:YAG pulsed laser.

Applications of Excimer Lasers

It is quite common for the eye to develop so-called short sightedness, where the eye's optics tend to focus light too strongly. The net result is that the plane of the focused image is presented in front of the retina and the image on the retina is blurred. Standard remedies to date have included the wearing of spectacles and contact lenses. Both these approaches bring benefits of correcting visual defects. About a quarter of all adults are myopic to some degree.

With age, the optical 'fitness' of the eye diminishes. The degree of accommodation provided by the ligaments attached to the lens decreases as the lens becomes increasingly 'stiffer'. So-called long sightedness arises when the eye is not strong enough to focus images on the retina. Instead, images are brought to a focus beyond the retina.

The front surface of the cornea can also develop asymmetry, so that images cannot be focused on the plane of the retina – a condition known as astigmatism. Figure 9 shows the three basic types of eye conditions which result in blurred images being formed at the retina.

It was during the mid-1980s that interest began to be expressed in the use of lasers for direct change of the refractive power of the cornea. It had been determined that excimer lasers have the ability to selectively remove layers of cells from the layer below the surface epithelium.

Once this technique, called PhotoRefractive Keratectomy (PRK), had been demonstrated, the technology began to be developed which would lead towards precise sculpting of the cornea. The procedure of PRK was, however, fundamentally different from the related surgical technique of radial keratotomy, which relied on wound healing to pull the cornea flatter. The laser method, by skimming off layers of prescribed thickness from the cornea, does not weaken the structural integrity of the eye.

The focusing ability of the eye is measured in dioptres (D), which can be expressed in 1/f, where f is the effective focal length of the eye. When vision is perfect, the eye can be described as requiring 0D of correction. Typical values of refractive power of the eye are around 45D. A significant level of correction, of 5D, can be successfully treated in a single PRK procedure. Correction of much greater refractive errors, such as 12D, are typically undertaken in separate procedures several months apart. The corneal surface tends to regress after PRK treatment – i.e. the eye, to some extent, reverts to its former condition. It is, therefore, normal to undertake a slight element of over-correction – typically by 0·5D.

Excimer Laser Technology

In excimer lasers used for PRK, a mixture of a noble gas such as Xenon or Argon and a Halogen such as Fluorine, Chlorine or Bromine are activated by high voltage electric fields, electron beam or microwave excitation. The inactive noble gases tend not to form stable compounds, but the intense activation energy results in the formation of short-lived compounds which, during breakdown to original atoms, release photons of short ultra-violet radiation. Excimer implies 'EXCIted diMER'. The excited molecules exist only for a short time – at most 20ns.

The Argon Fluoride (ArF) laser is used widely in PRK systems to produce laser output at 193nm. The ArF gas is a highly toxic gas mixture, and considerable care must be exercised during gas changes. Also, most medical excimer lasers utilize containment technology, where the module containing the gas supply system is totally enclosed and can safely deactivate the entire contents of a gas mix cylinder. There is now a move to create gas mixtures on demand by the heating of compounds, rather than have large volume of ready-mixed gas present in the system.

Energy is delivered in a series of ultra-short pulses of duration between 10 and 20ns, with maximum pulse energies typically of 0·5J. The energy density required to ablate the corneal tissue is around 120mJ/cm². In the rapid mode of tissue interaction, the laser energy ablates a finite thin layer of corneal tissue. This is typically about 0·25μm per

pulse. The interaction time is so short that there is insufficient time for heat energy to build up in the treated tissues. A typical treatment will correspond to the removal of a given thickness of cornea tissue, and this is undertaken by delivering a specific number of laser pulses over the selected treatment site. Prior to treatment, however, the thickness of the cornea is accurately measured, in order to retain an adequate thickness.

Table 2 summarizes the performance details of the Chiron Technolas Keracor 116 Excimer Laser. The energy density at the treatment site can vary between different manufacturers, so that different thicknesses of cornea are removed with each treatment pulse.

Figure 10 shows the features of a Chiron Technolas Keracor 116 Excimer Laser system. Pulses of energy are delivered over the precisely controlled surface of the cornea. While mainly used to correct over-focusing of the eye caused by over-curvature of the cornea, such a mechanism can also be used to correct astigmatism, where the corneal surface is not symmetrical and leads to blurred focusing on the retina.

The excimer laser can also be used to 'smooth' the cornea where it has become worn due to injury or disease. By removing cornea over the indicated area, fresh epithelial cells will in time grow into the treated area and help smooth the corneal surface.

The refractive changes brought about by PRK can also be provided using conventional spectacles or contact lenses. It is, however, the element of convenience and cosmetic appeal which makes the procedure attractive to groups of individuals. An alternative approach to PRK is use of the Holmium laser (wavelength 2·06nm) for the 'shrinking' of the cornea due to application of the Holmium laser energy.

References

The Laser Guidebook, Jeff Hecht, McGraw-Hill, 1986.

VISIONS OF THE FUTURE – *Continued from page 23.*

wireless – an option that barely existed 10 years ago." So states George C. Smith, President of BNR. "We are building on two decades of breakthroughs in digital systems, fibre optics, network intelligence, radio technology, opto-electronics, miniaturisation, voice recognition, and countless other technologies. In sum, we are creating a world of networks that is directly impacting how our society lives, works, learns and plays.

We have succeeded in making communications more available and convenient through a variety of diverse networks – switching networks, wireless networks, enterprise networks, and broadband networks. Now we are weaving these networks into an integrated infrastructure that can seamlessly carry any type of information anywhere in the world. On this new infrastructure, the most sophisticated multimedia communication will be as easy as dialling a call – even easier, as voice recognition technology leads to the touchless telephone.

Traditional network concepts will change as well. Until recently, functionality resided at centralised focal points – in the switches. Now we are exploring technology that is self-monitoring, self-testing, self-healing, and self-adjusting. As we prepare to manage the 21st-century networks, we continue to explore technological frontiers in such areas as neural networks, new algorithms that replicate biological flexibility, and human/machine interfaces featuring virtual reality". From now on it seems, the technology gloves are fully off in the communications world.

No time or space in this brief canter towards the next century except to forecast the marketing arrival of still and digital video cameras which store images on disks. This could be bad news for the instant print shops but good news for the rest of us. Similarly the broadcasting authorities will have been given the go-ahead to introduce digital terrestrial services, offering viewers not only a wide selection of programmes, but higher quality. No wonder the cable industry are keen to get their digital transmission act together.

High-tech Motoring

Your car will not escape the high-tech revolution. According to Novell, they are working on the NEST concept, a system which will manage the sundry microprocessors already in the vehicle and keep a check on the state it's in. You won't even have to organise the service visit. The car could use the mobile phone to call up the garage and report the problem and make a booking.

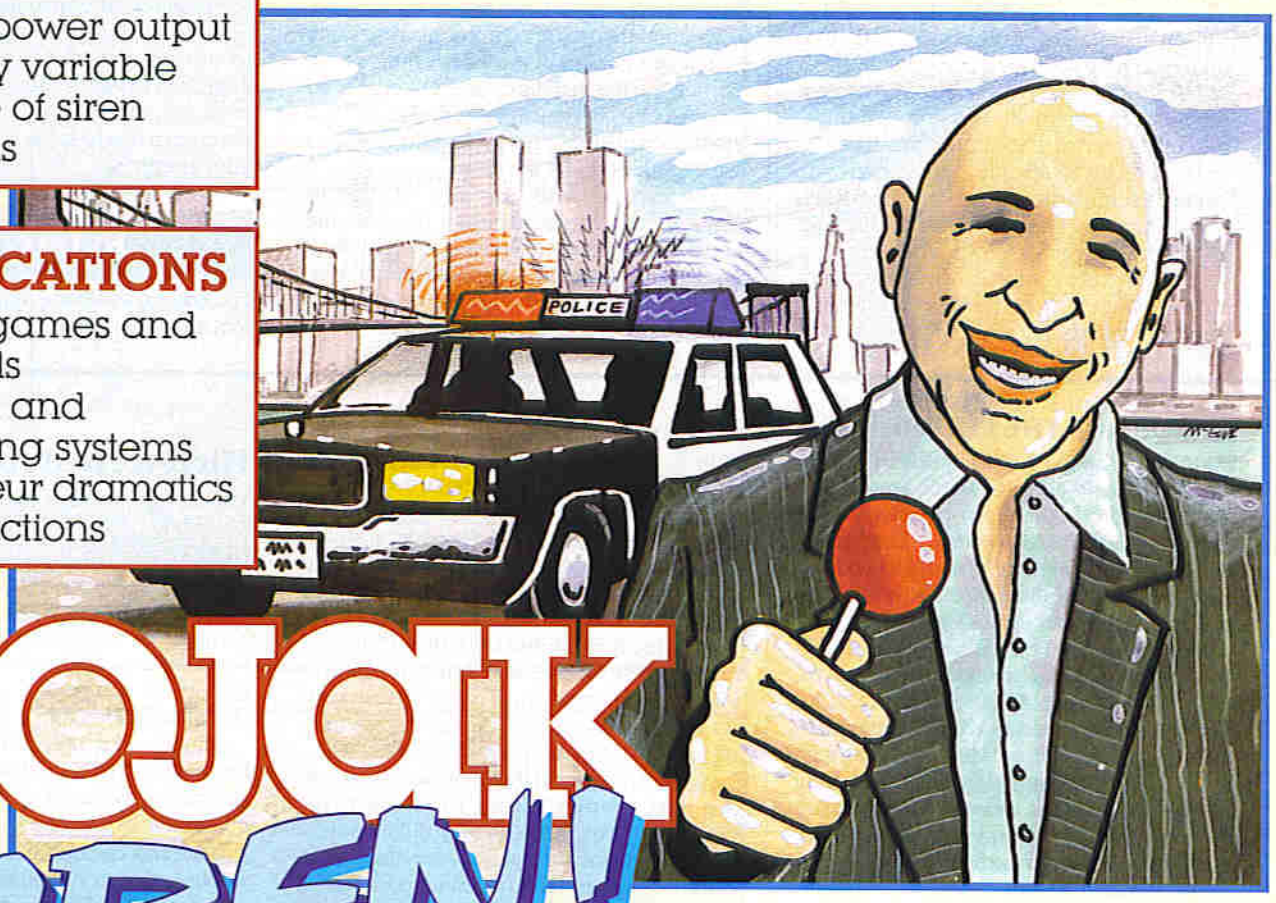
Paul Cave of AMP said, "It will take a very brave man, to forecast exactly what technology we will be using in the future. The only guarantee is that, whatever it is, it will be smaller and cheaper than it is today. Mobile videophones from your wristwatch is probably close to reality", or as Texas Instruments suggests, computer notebooks being driven by infra-red technology. The point is emphasised by Professor Cochrane of BT. "It is plain, looking back through history that PhDs in hindsight are common but PhDs in foresight are in very short supply."

FEATURES

- ★ High power output
- ★ Widely variable range of siren sounds

APPLICATIONS

- ★ Toys, games and models
- ★ Alarm and warning systems
- ★ Amateur dramatics productions



KOJAK SIREN!

1 PROJECT RATING

Text by
Maurice Hunt

KIT AVAILABLE (95116) PRICE £8.99

A very handy and inexpensive module for use in toys, games and models or even alarm systems, the siren circuit is widely adjustable, enabling many different siren sounds to be generated. The emitted sounds can range from a slowly rising and falling American police car siren or 'Kojak'-effect drawl, to a fast-changing whooping sound, plus all manner of siren sounds in between. Additionally, the pitch of the sound is adjustable, and the module contains an on board 2W amplifier to provide a powerful output for directly driving a low-impedance loudspeaker.

THIS is an easy to assemble kit, containing all the parts needed (with the exception of the loudspeaker and power supply) along with straightforward assembly instructions to create a working siren. The components are mounted onto a high quality single-sided glass fibre PCB, with a printed legend to clarify the correct component placement. Connections to the board are made to the six PCB pins, for power supply, loudspeaker and an optional push switch (not supplied).

Circuit Description

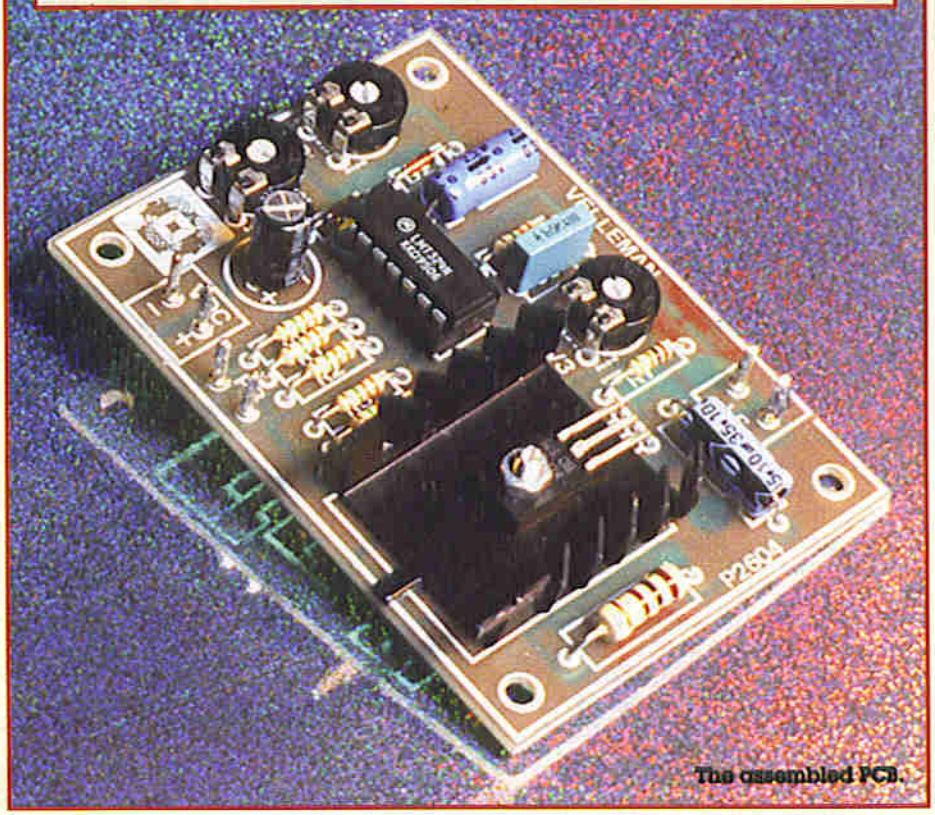
Refer to Figures 1 and 2, showing the block and circuit diagrams, respectively. The circuit is based around IC1, an LM324N or equivalent quad op amp chip, although only two of its four op amps are actually used. The first op amp stage sets the sweep (modulation) frequency, determined by the charge/discharge rate of capacitor C4, which can be varied from between 0·5 and 5Hz by means of preset potentiometer RV1, which sets the positive modulation, and RV2, which sets the negative modulation. R1 and R2 form a potential divider to bias the first op amp stage at half supply voltage.

The second op amp stage generates the audio frequency of between 500 and 2,000Hz, the pitch being adjustable by means of potentiometer RV3. This stage is modulated (altered in amplitude and pitch) by the first stage, via the resistor R4. The audio output of the second stage is then fed via R7 to the audio amplifier, T1, a BD675 or equivalent audio frequency (AF) driver amplifier transistor. The amplified output signal is fed to the loudspeaker via R8 paralleled with coupling capacitor C2. C1 provides supply decoupling.

Note that R8 is a hefty 1W resistor, and that a substantial vaned heatsink is used to dissipate heat from T1. These measures ensure that the module is capable of driving a low impedance (4 to 16Ω) loudspeaker at high volume (up to 2W of output power) without overheating. Additionally, by replacing R8 (100Ω) for a 4Ω/5W resistor (not supplied), the unit is then capable of driving a 3 to 5W loudspeaker, to obtain an even louder siren sound, if desired.

Specification

Operating voltage:	8 to 14V DC
Operating current (activated):	1A Maximum
Standby current:	0mA
Output power:	2W into 8Ω loudspeaker
Output impedance:	4 to 16Ω
Frequency range:	800 to 2,000Hz
Modulation speed:	0·5 to 5s
PCB dimensions (WDH):	79 × 57 × 15mm



The assembled PCB.

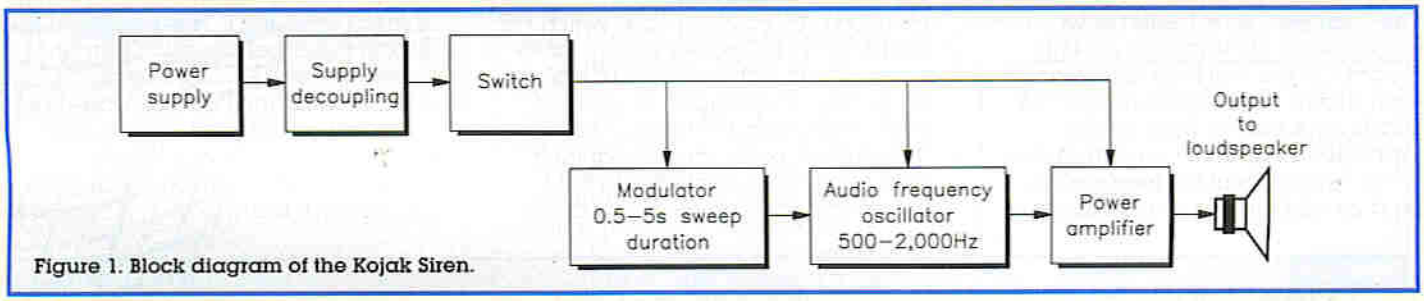


Figure 1. Block diagram of the Kojak Siren.

PCB Assembly

If you are a newcomer to electronics assembly consult the Constructors' Guide (XH97L), and read through the instructions included in the kit prior to building it to familiarise yourself with the component placement.

Tools required will be a soldering iron, wire cutters, pliers and a small flat-bladed screwdriver. The board should be assembled in order of ascending component size. Start with the two diodes, making sure that they are orientated correctly, with their black bands aligning with the bands printed on the legend. Next, install the resistors: R1 to R6 are all 3M3Ω (orange, orange, green), R7 is a 10kΩ (brown, black, orange), while R8 is

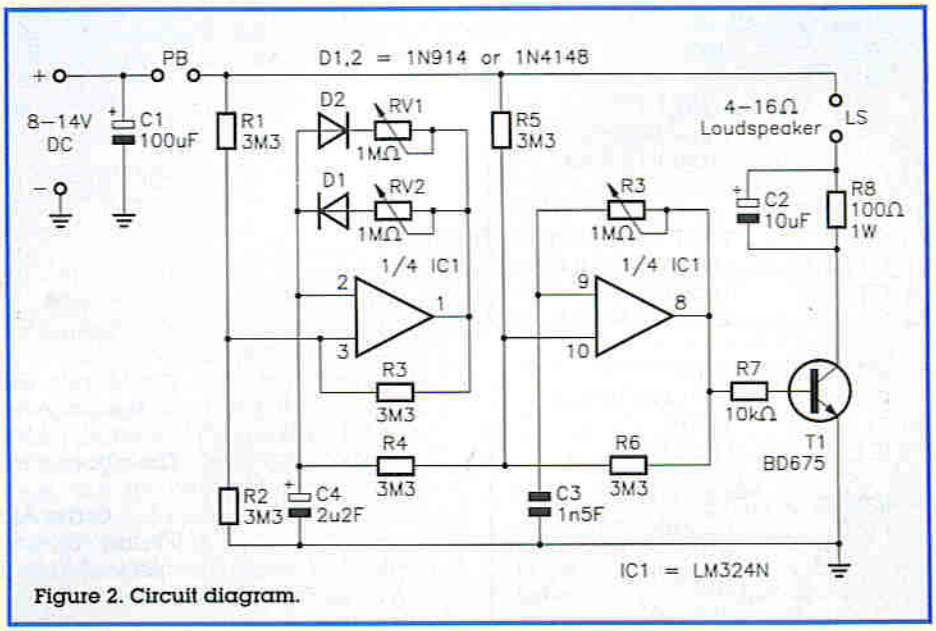
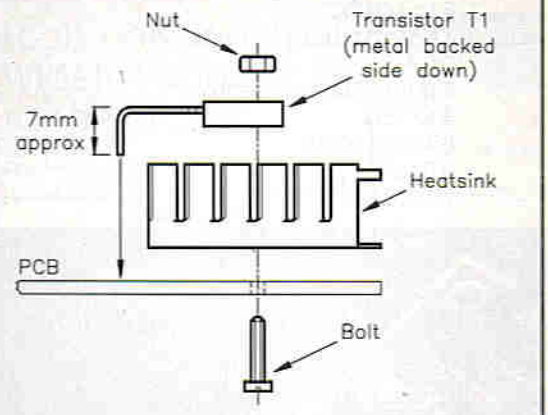
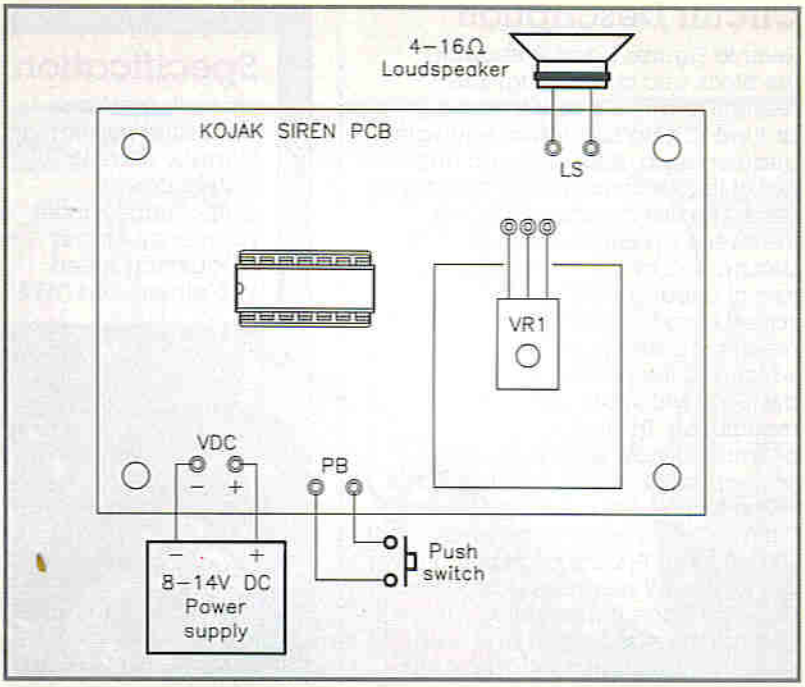


Figure 2. Circuit diagram.



Above: Figure 3. Mounting the transistor T1 and heatsink.



Right: Figure 4. Wiring diagram

the bigger 1W 100Ω (brown, black, brown) resistor. Now fit the IC holder, ensuring that the end notch is aligned with the legend marking. Do not fit the IC at this stage.

Next, install the three preset potentiometers, RV1 to RV3, all 1MΩ types. Go on to fit the capacitors, taking care to install the polarized electrolytic capacitors (C1, C2 and C4) as per the legend. The transistor T1 is fitted next, metal-backed side facing down – see Figure 3. You will need to align the mounting hole in the transistor body with the hole in the PCB, to determine where the transistor leads should be bent, and allow for the thickness of the heatsink, which sits between the transistor and the board. On the unit built for the article and shown in the photographs, the leads were bent at right angles approximately 7mm (¼in.) from their ends. Having bent the leads to suit and placed them in their holes, the transistor should be mounted on the board together with its heatsink, a nut and bolt being used to secure them in position, then the transistor's leads can be soldered. Fit the six PCB pins, and finally, install the IC into its holder, aligning its end notch with that on the holder.

Having completed the assembly, check your work for misplaced components, solder whiskers, bridges, and dry joints, then clean excess flux off the board using a suitable solvent.

Testing and Use

Connect a 4 to 16Ω impedance loudspeaker, push-to-make switch and 8 to 14V DC power supply (or 9V battery) to the appropriate PCB pins on the board, as shown in Figure 4, the wiring diagram. Initially, set all three preset potentiometers at their mid positions, then push and hold the switch, or otherwise connect the terminals marked 'PB' together by bridging them with a metal object. You should then hear a siren sound being emitted, and by altering the settings of the three presets, the sound will be alterable across a wide range. Find potentiometer settings that give the desired siren sound, and the module is then ready for use.

If used as part of an alarm system, the module can be triggered by using a relay with normally open contacts (or equivalent output switching device) in place of the push switch, so that when the relay contacts close (i.e. if the alarm is set off), the siren will sound.

If you wish to mount the board into an enclosure, the PCB is predrilled to accept fixing bolts at each corner. Remember to allow sufficient ventilation for the heatsink/transistor.

Now all you need to do is shave your head, suck on a lollipop or two, and your Kojak imitation is complete. Who luvs ya, baby!

KOJAK SIREN PARTS LIST

RESISTORS: All ¼W 5% Metal Film (Unless stated)			
R1-6	3M3	6	
R7	10k	1	
R8	100Ω 1W	1	
RV1-3	1MΩ Horizontal Preset Potentiometer	3	
CAPACITORS			
C1	100μF 25V Radial Electrolytic	1	
C2	10μF 35V Axial Electrolytic	1	
C3	1n5F Polyester	1	
C4	2μ2F 63V Axial Electrolytic	1	
SEMICONDUCTORS			
D1,2	1N914 or 1N4148	2	
T1	BD675	1	
IC1	LM324N	1	
MISCELLANEOUS			
	Heatsink	1	
	Bolt	1	
	Nut	1	
	14-pin DIL IC Socket	1	
	PCB Pin	6	
	PCB	1	
	Instruction Leaflet	1	(XZ21X)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	8Ω 0·5W Loudspeaker	1	(YW53H)
	Push Switch	1	(FH59P)
	PP3 Battery Clip	1	(HF28F)
	Duracell PP3 Battery	1	(JY49D)
	Extra-flexible Wire, Black	1m	(XR40T)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

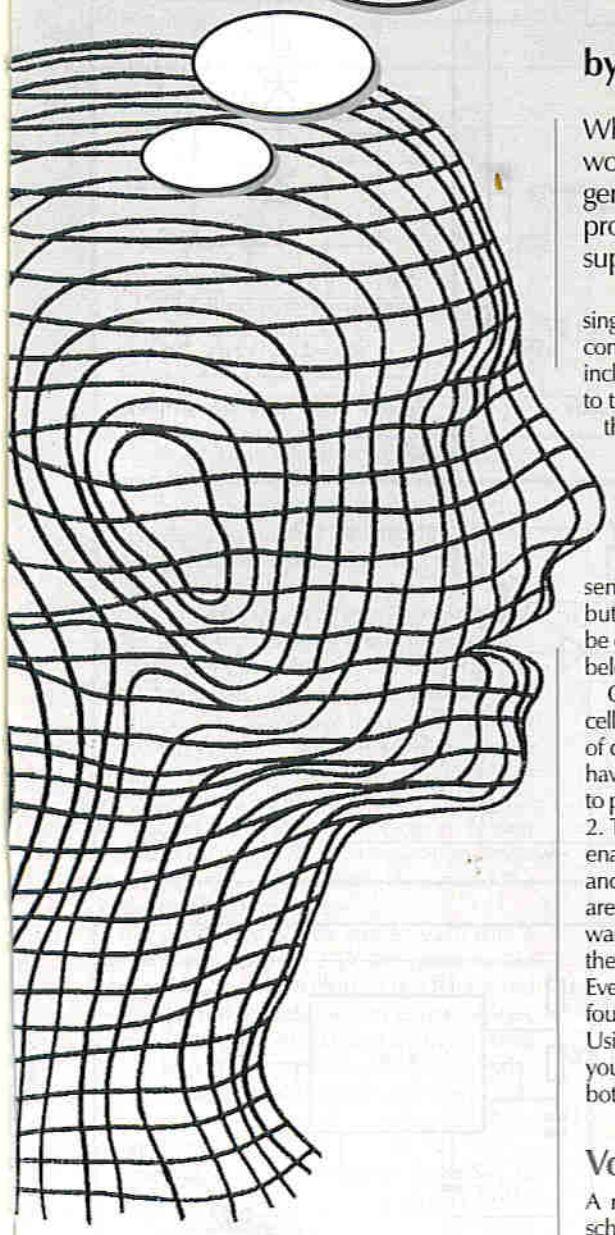
The above items (excluding Optional) are available in kit form only.

Order As 95116 (Kojak Siren) Price £8.99

Please Note: Some parts, which are specific to this project (e.g., PCB), are not availalbe separately.

POSITIVE THINKING

by Stephen Waddington B.Eng.(Hons), MIEEE, AIEE, AITSC



When digital meets analogue, there are always design challenges. Recently, while working on the design of a microprocessor based sprinkler system, I struggled to generate the dual power supply required for a pair of pressure transducers. The problem was further exacerbated by the fact that for safety reasons, the power supply had to be generated from a battery voltage.

THERE are lots of similar examples. Temperature transducers, hall-effect devices, voltage references and operational-amplifiers are all electronic devices that require both a positive and a negative voltage. Normally, a constructor must confine such circuits to the laboratory and be satisfied with a bench power supply. Here, we investigate a number of solutions to the problem of generating a negative voltage from a battery supply.

Batteries

With a little thought, the problem is not really that difficult to resolve. The most basic solution relies on the duplication of batteries. Using a single cell, +1·5V and 0V can be achieved by connecting to either ends of the device. The inclusion of a further cell connected in series to the first provides +1·5, 0 and –1·5V. Here, the centre point between the two cells is used as a ground reference, with +1·5V and –1·5V obtained from the outermost terminals, as shown in Figure 1. A negative voltage is achieved because of the relative position of the ground reference. In this sense, the battery is not producing –1·5V, but the combination enables the value to be obtained because the voltage is taken from below the ground potential.

Of course, this concept is not limited to single cells, indeed, you may opt for any combination of cells or batteries. It is not even necessary to have a balanced arrangement. You may wish to produce +4·5V and –3V, as shown in Figure 2. The benefits of this type of design are that it enables the designer to utilize the full power and efficiency of the battery. Its disadvantages are apparent in terms of cost and size. If you wanted to produce a supply of ±12V DC, then you would need an awful lot of cells. Even if you opted to use two 9V PP3 batteries, four additional 1·5V cells would be required. Using two 12V batteries in series may solve your problem, but in doing so, would increase both cost and space required for housing.

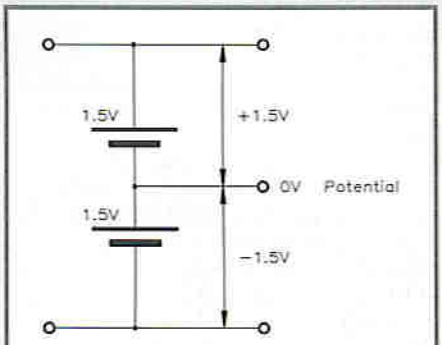


Figure 1. Two 1·5V cells used to generate +1·5, 0 and –1·5V.

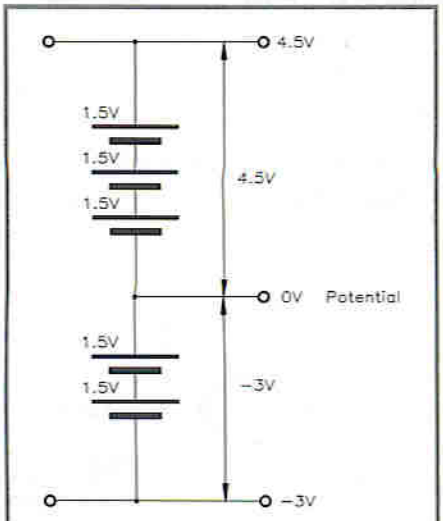


Figure 2. Using a combination of cells to produce +4·5, 0 and –3V.

Voltage Dividers

A natural extension of the multiple battery scheme is to use a potential divider. Here, two resistors are used to split a supply voltage, as shown in Figure 3. Here, a single battery may be used, though the largest swing attainable will only ever be half the battery supply voltage. Again, greater potentials are achieved by connecting a number of batteries in series. The resistors used are chosen to produce the desired voltage drop whilst also meeting the current demands of the intended load. Since we wish to produce ±4·5V, two resistors of equal value are connected across a PP3 9V battery. Initially, for purposes of illustration, we shall use two 100Ω resistors. It is now a relatively straightforward exercise to show, from Ohm's Law, that 4·5V will appear across each resistor.

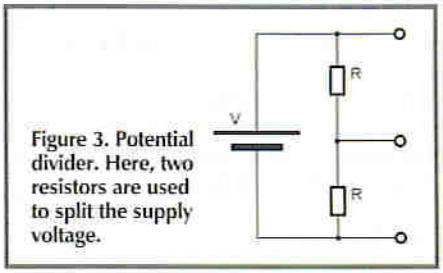


Figure 3. Potential divider. Here, two resistors are used to split the supply voltage.

Ohm's Law states that:

$V = I \times R$

Rearranging gives:

$I = \frac{V}{R}$

Here, V=9V and the combined resistance of R1 and R2 is 200Ω:

$I = \frac{9}{200} = 0{\cdot}045A$

Therefore, the voltage across R1 is:

$V_{R1} = I \times R1 = 0{\cdot}045 \times 100 = 4{\cdot}5V$

Performing exactly the same calculation produces the same value for the voltage across R2. Consequently, if the centre point of the divider is taken as ground, the two extremes will produce +4·5V and –4·5V, as shown in Figure 4. There is no magic here, the negative voltage, as with our first design using batteries, is obtained relative to the newly defined ground.

Instability

Though meeting the initial specification, the potential divider circuit is far from ideal. The major problem with the design is its instability. As soon as a load is placed across either of the resistors, the balance of the divider will be destroyed.

Consider, for example, a 400Ω load placed across R2, as shown in Figure 5. The divider must now be considered as the parallel combination of R2 and the 400Ω load in series with R1. The rationalised circuit is shown in Figure 6, with the combination of R2 and the 400Ω load replaced with an equivalent resistor determined using the formula for resistors in parallel.

$\frac{1}{R_T} = \frac{1}{R2} + \frac{1}{R_{LOAD}}$

$\frac{1}{R_T} = \frac{1}{100} + \frac{1}{400}$

$R_T = 80\Omega$

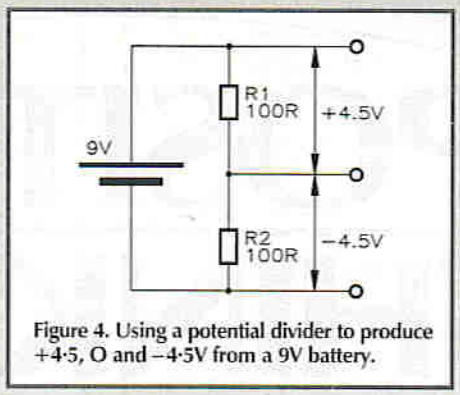


Figure 4. Using a potential divider to produce +4·5, O and –4·5V from a 9V battery.

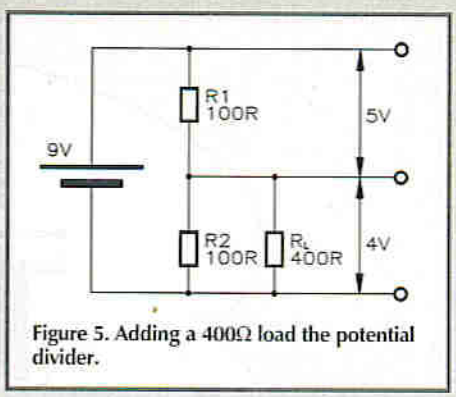


Figure 5. Adding a 400Ω load the potential divider.

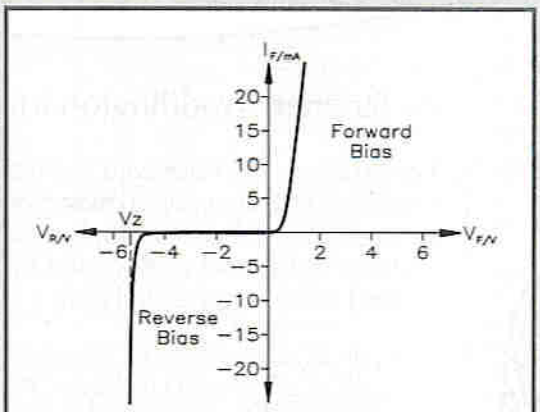
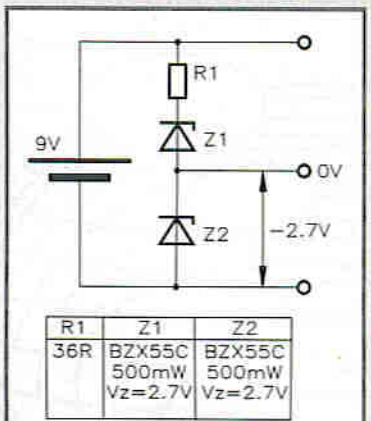


Figure 6. Characteristic curve for a Zener diode.



R1	Z1	Z2
36R	BZX55C 500mW Vz=2.7V	BZX55C 500mW Vz=2.7V

Figure 7. Zener diode voltage divider.

Figure 8. Circuit diagram for diode pump negative voltage generator.

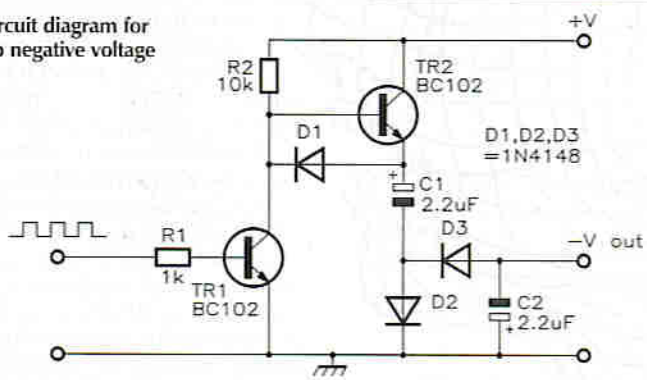
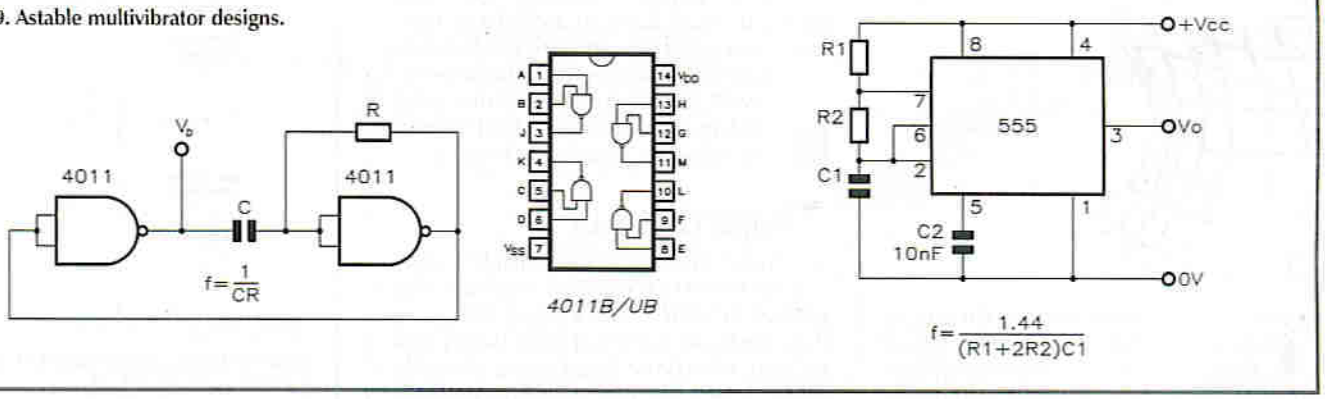


Figure 9. Astable multivibrator designs.



Repeating initial calculations, we are able to see by how much the voltages across R1 and R2 have changed. The circuit resistance is now:

$R = 100 + 80 = 180\Omega$

The supply voltage remains 9V but the circuit resistance is now 180Ω:

$I = \frac{9}{180} = 0{\cdot}05A$

Therefore, the voltage across R1 is:

$V_{R1} = I \times R1 = 100 \times 0{\cdot}05 = 5V$

The corresponding voltage across R2 and the load will be:

$V_{R2||LOAD} = 0{\cdot}05 \times 80 = 4V$

Measured from the 0V line as intended, this will equate to –4V. So we can see that as soon as the circuit is loaded, the initial voltages change. The problem of voltage mismatch is reduced when the value of the load greatly exceeds the values of the resistors in the divider circuit. For example, try performing the calculations for a load of 10kΩ. You will see that the effect on the balance of the circuit is minimal. Conversely, the problem is exaggerated if a load resistance with a value close to, or less than that of the divider resistors is

used. If both sides of the circuit are loaded, the problem is further exacerbated, unless of course, the loading is equal.

Despite the problems described, the voltage divider circuit cannot be discounted. In fact, this type of circuit appears throughout every branch of electronics design, its usefulness is limited only by the ingenuity of the designer. If calculations are performed to account for loading and current demands, then the design is entirely suitable and is a very inexpensive method of producing a negative voltage.

Zener Diodes

Moving away from resistors, let's consider another similar possibility. Zener diodes are semiconductor devices, designed specifically

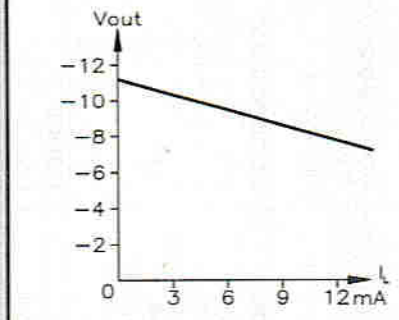


Figure 10. Voltage drop-off as load current is increased for diode pump circuit design.

devices used in this experiment are BZX55C devices, with a maximum dissipation of 500mW. The maximum current is determined using the basic equation for electrical power:

$$P = I \times V$$

Rearranging to determine I_{max}:

$$I = \frac{P}{V}$$

With the voltage across each resistor clamped at 2·7V, the voltage across the resistor is 3·6V. Therefore, I_{max} is:

$$I = \frac{0{\cdot}5}{3{\cdot}6} = 138mA$$

We therefore have a range with I_{min}=5mA, and

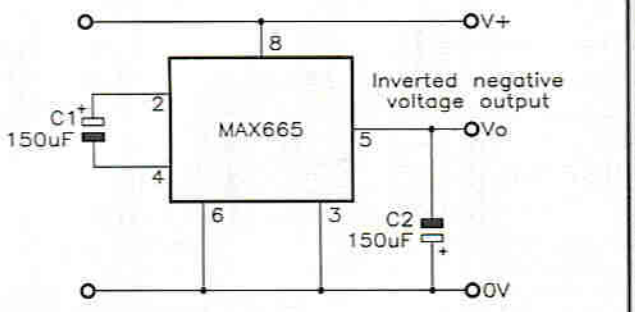


Figure 11. Circuit diagram for MAX665.

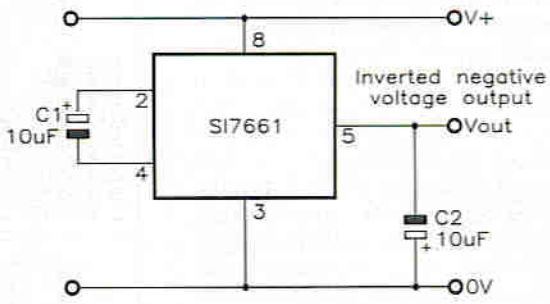


Figure 12. Circuit diagram for Si7661.

to exhibit a consistent reverse breakdown characteristic. A whole range of breakdown voltages are available, making the device ideal for use in voltage reference applications. Zener diodes are generally used to generate a positive reference, and it is this characteristic that is exploited in the next circuit design.

The characteristic curve for a Zener diode is shown in Figure 6. This shows the reverse voltage behaviour. As the reverse voltage V_R is increased, the reverse current is negligible until V_R reaches the breakdown voltage V_Z. I_R then increases dramatically, while the voltage across the diode remains the same. V_Z is called the Zener or clamping voltage.

In Figure 7, two Zener diodes, each with a breakdown voltage of 2·7V, are connected in series with a resistor. A 9V battery is connected across the resistor and the two Zener devices, and the mid-point is taken as a relative ground. With the voltage across each of the diodes clamped at 2·7V, the upper and lower rails provide +2·7V and −2·7V relative to the ground rail.

The value of the resistor is selected to protect each of the diodes from excess current, but to also ensure that the diodes operate in the reverse breakdown region, as shown in Figure 6. The maximum current is determined by the power rating of each of the Zener diodes, and the minimum by the reverse bias characteristic, which is typically 5mA.

With the value of R selected using this process, the circuit should be stable. The final consideration is the load which is to be placed across the negative reference created by the Zener diode arrangement. This must be balanced so that at least 5mA flows through the loaded Zener diode.

Consider the example in Figure 7. Here, R is determined by first fixing the maximum and minimum current, I, as discussed. I_{max} is based on the power rating of each of the diodes. The

Pin 1 (FC)	Pin 7 (OSC)	Oscillator Frequency
Open	Open	10kHz
V+	Open	45kHz
Open	External clock	External clock Frequency

Table 1. The three modes to control the clock frequency of the MAX665.

Pin	Name	Function
1	FC	Frequency control for internal oscillator
2	CAP+	Positive charge-pump capacitor terminal
3	GND	Power supply ground voltage input
4	CAP–	Negative charge-pump capacitor terminal
5	OUT	Negative voltage output
6	LV	Low voltage operation
7	OSC	Oscillator control
8	V+	Power supply positive voltage input

Table 2. Pin description for MAX665.

Pin	Name	Function
1	NC	Not connected
2	CAP+	Positive charge-pump capacitor terminal
3	GND	Power supply ground voltage input
4	CAP–	Negative charge-pump capacitor terminal
5	OUT	Negative voltage output
6	LV	Low voltage operation
7	OSC	Oscillator control
8	V+	Power supply positive voltage input

Table 3. Pin description for Si7661.

I_{max}=138mA. Using Ohm's and opting for I=100mA, the value of R can be determined:

$$R = \frac{V}{I} = \frac{3{\cdot}6}{0{\cdot}1} = 36\Omega$$

Opting for the closest standard device gives a design value of 36Ω. Providing due thought is given to the design process, and care is taken when loading the circuit, this design is far more stable that the potential divider design, while the cost remains in the order of pennies. The circuit's major flaw is the fact that the negative output voltage will always be a discrete fraction of the battery voltage.

Diode Pump

Let's change tack slightly. A rather elegant design, based on a theme often used by digital designers, is shown in Figure 8. Here, a square-wave oscillator is used to drive a transistor and diode arrangement to produce a negative voltage virtually equal to the modulus of the positive supply voltage. Used in conjunction with a battery, the circuit (unlike the others discussed so far) is able to produce a sweep of almost twice the battery voltage.

Consider the circuit in Figure 8. Here, a square-wave signal of 10kHz is used to switch TR1. In logic circuits, if a suitable clock signal is available, it could be used to feed the circuit. Assuming it isn't, then you must additionally construct a 10kHz astable multivibrator. When initially experimenting with this circuit on breadboard, I used the output from a signal generator. When graduating to a breadboard construction, however, I decided to rely instead on a 555 timer. In fact, either of the astable oscillator designs outlined in Figure 9a or 9b may be used. You may prefer to use the two-stage NOT gate design. Remember that it is possible to make a NOT gate from a NAND by connecting the two inputs together. It is a useful point, because NAND gate packages are more common than NOT gates, and are also about half the price.

The square wave effectively turns the circuit on and off perpetually. When T1 is turned off, T2 is turned on and C1 charges via T2 and D2. Conversely, when T1 turns on, T2 turns off, and the positive end of C1 decreases to 0·7V, leaving the opposite end of C1 at a negative potential. The charge across C1 discharges through D3 into C2, leaving a negative potential of roughly 7V DC (assuming you are using a supply voltage of 9V) across C2.

A clocking rate of 10kHz was chosen to correspond with the time constant of the circuit and ensure the capacitor C2 is able to charge and discharge without an appreciable ripple appearing on the output. Of course, if a severe current is demanded from the output, then the capacitor will be unable to maintain its charge. This will result in a 10kHz ripple appearing on the output and a reduction in the effective voltage produced. That said, the circuit should be good for a few milliamps. Figure 10 shows the voltage drop-off as the load current is increased.

Using the battery voltage in conjunction with the output of the circuit, it is possible to achieve a total voltage of 16V (+9 to –7V). Here lies the main advantage of this circuit. It produces a negative voltage close to the actual battery voltage. The main disadvantage is component overhead. The design is relatively expensive, particularly if you have to generate the 10kHz driver circuit.

	Cost	Design Consideration	Versatility	Size	Output voltage as function of input	Efficiency	Stability
Ratings	✪✪✪✪✪✪✪✪✪✪ Low Cost ✪ Expensive	✪✪✪✪✪✪✪✪✪✪ Simple ✪ Lengthy process	✪✪✪✪✪✪✪✪✪✪ High Level ✪ Limited	✪✪✪✪✪✪✪✪✪✪ None ✪ Large overhead	✪✪✪✪✪✪✪✪✪✪ Good ✪ Poor	✪✪✪✪✪✪✪✪✪✪ High ✪ Low	✪✪✪✪✪✪✪✪✪✪ High ✪ Poor
Batteries	Requires double number of batteries	None	Limited by battery availability	Doubles battery overhead	Dependent on battery arrangement	Full battery capacity is utilised	Highly stable
	✪✪✪✪	✪✪✪✪✪✪✪✪✪✪	✪✪	✪✪✪	✪✪✪✪✪	✪✪✪✪✪✪✪✪✪✪	✪✪✪✪✪✪✪✪✪✪
Potential divider	Minimal	Requires careful design based of loading and current demand	Loading and current calculations are critical. Dependent on ingenuity of designer	Minimal – two resistors	Dependent of circuit design – typically half	Divider circuit adds additional loading to circuit typically reducing efficiency by half, although this is largely dependent on circuit design	Very stable if designed correctly otherwise poor
	✪✪✪✪✪✪✪✪✪	✪✪	✪✪✪✪✪	✪✪✪✪✪✪✪✪✪	✪✪✪✪✪	✪✪✪✪	✪✪✪✪✪
Zener diode divider	Minimal	Consideration of current demands required	Limiting factors are available battery supply, and clamping voltage of Zener diodes	Minimal – two Zener diodes and a single resistor	Dependent on clamping voltage of Zener diodes – typically half	Additional loading overhead in form of Zeners and resistors gives typical efficiency of half	Good, but degree of dependence on design and current loading
	✪✪✪✪✪✪✪✪	✪✪✪✪	✪✪✪✪✪✪✪	✪✪✪✪✪✪✪✪	✪✪✪✪✪	✪✪✪✪	✪✪✪✪✪✪
Diode Pump	Six to ten discrete devices required depending if external clock available	High level of integration with other circuits required	Loading is critical issue. Circuit useless beyond output of 20mA	Large number of components required	Typically two volt overhead	Voltage drops rapidly with current. Useless beyond 10 to 20mA	Loading is limited, otherwise good
	✪✪✪✪✪✪	✪✪✪✪✪	✪✪✪✪	✪✪	✪✪✪✪✪✪✪✪	✪✪✪	✪✪✪✪✪✪✪
MAX665	ASIC device is expensive but few other components required	Ripple on output increases with output load	Output voltage scalable from –1·5V to 8·0V	Single device and two capacitors	No voltage overhead	Efficiency of up to 90%	Excellent if capacitors selected compensate output ripple
	0	✪✪✪✪✪✪✪✪	✪✪✪✪✪✪✪✪✪	✪✪✪✪✪	✪✪✪✪✪✪✪✪✪	✪✪✪✪✪✪✪✪✪✪	✪✪✪✪✪✪✪✪✪
Si7661	ASIC device is very expensive but few other components required	Requirement for large capacitors to reduce output ripple must be balanced against	Output voltage scalable from –4·5V to 20V	Single device and two capacitors	No voltage overhead	Efficiency of up to 90%	Excellent if capacitors selected compensate output ripple
	✪✪✪✪✪	✪✪✪✪✪✪✪✪	✪✪✪✪✪✪✪✪✪	✪✪✪✪✪	✪✪✪✪✪✪✪✪✪✪	✪✪✪✪✪✪✪✪✪✪	✪✪✪✪✪✪✪✪✪

Table 4. Comparison of different circuit design approaches.

ASIC Designs

We have considered several designs based on discrete component design from the crude potential divider to the relatively complex square wave driven diode pump. With the trends in integration, it is no surprise that there are integrated circuits that are able to convert a battery voltage into a negative supply rail. In the final section of this article, we examine two such application specific integrated circuit (ASIC) devices. While both devices meet our specification for a negative rail and produce an output voltage which can be tightly controlled in terms of voltage and current using a minimal number of external components, they are expensive compared to some of the other designs.

The MAX665 charge-pump voltage inverter shown in Figure 11 converts a +1·5 to +8V input to a corresponding –1·5V to -8V output. In fact, the device is very similar to our last circuit. The approach is almost identical. The device contains a switchable 10 or 45kHz charge pump clock, while two external components, C1 and C2, perform the charge pump and reservoir functions, respectively.

In comparison with the previous design, the output current of the MAX665 is relatively insensitive to load changes. With an input voltage of +5V, under light load, the output voltage is –5V, falling to –4·35V for a 100mA load. Inevitably, there is an output ripple voltage superimposed on the negative output voltage. This due to the discharge cycle of the capacitor, and is consequently equal to half the frequency of the charge pump cycle:

$$V_{PUMP} = \frac{I_{OUT}}{2(f_{PUMP} \times C2)} + 0{\cdot}2I_{OUT}$$

Running the internal clock at 10kHz gives a nominal f_{PUMP} of 5kHz. With C2=150µF, the ripple is approximately 90mV, for a 100mA load current. If C2 is raised to 390µF, the ripple drops to 45mV. There is scope to alter the frequency of f_{PUMP} using either a standard CMOS external clock or selecting the internal 45kHz clock. Table 1 outlines the three possibilities.

The pin descriptions for the MAX665 are shown in Table 2. If a supply voltage of less than 3V is used or the internal oscillator is being overdriven, pin 6 (LV) must be connected to ground. This bypasses the internal regulator circuitry and provides optimum performance for low voltage applications.

	Catalogue Page No.	Component	Reference	Cost
Batteries	586 to 590	Battery	–	–
Potential divider	768 to 770	Resistors	–	–
Zener diode divider	789	Zener diode	QF45Y	£0.14
	768 to 770	Resistors	–	–
Diode pump	788	1N4148	QL80B	£0.06
	784	BC108	QB32K	£0.28
	768 to 770	Resistors	–	–
	623 to 637	Capacitor	–	–
	795	CMOS4011	QX05F	£0.53
	796	NE555	QH66W	£0.49
MAX665	840	MAX665	AY39N	£7.99
	623 to 637	Capacitor	–	–
Si7661	840	Si7661	AV37S	£2.29
	623 to 627	Capacitor	–	–

Table 5. Buyers' Guidelines.

Greater Voltage Output

The MAX665 is an excellent device. Its only downside is its output voltage range and cost. The device is costly, because it will also function as a voltage doubler.

If a voltage greater than –8V is required, then there is scope to use another device. The Si7661, shown in Figure 12, has the same essential characteristics as the MAX665, but has a greater output voltage specification of –4·5 to –20V. The device is driven by a 10kHz internal clock in the same manner as the MAX665 operating in its standard mode.

Like the voltage output of the MAX665, the Si7661 depends on two external capacitors – a reservoir device, and a charge pump. The value of the capacitors can be increased from the typical values shown of 10µF, up to 1,000µF. This should be considered as an absolute maximum. Capacitors of greater value are likely to cause large surge currents on switch-on, which could exceed the power dissipation of the device, and ultimately result in destruction.

Pin descriptions for the Si7661 are shown in Table 3. The device has an LV (pin 6) like its MAX665 counterpart. This should be grounded for input voltages below 8V. The only other significant difference between the MAX665 and the Si7661 is the level of output current protection afforded by the latter. If the output load becomes too heavy, the device will go into shutdown.

The Si7661 should be considered as a more robust version of the MAX665. Both devices have an excellent specification, and should be considered as the ideal method of generating a negative rail. Finally, Table 4 compares each of the circuits examined within this article. If you are looking for a straightforward design but are not concerned about cost, consider the ASIC devices, otherwise look at one of the other, more design-intensive, but less expensive options.

The circuits described within the context of this article are based on the author's own experiments. Please do not regard any of the examples outlined as self-contained circuits, they are working designs, intended to form the basis of further investigation.

Buyers' Guidelines

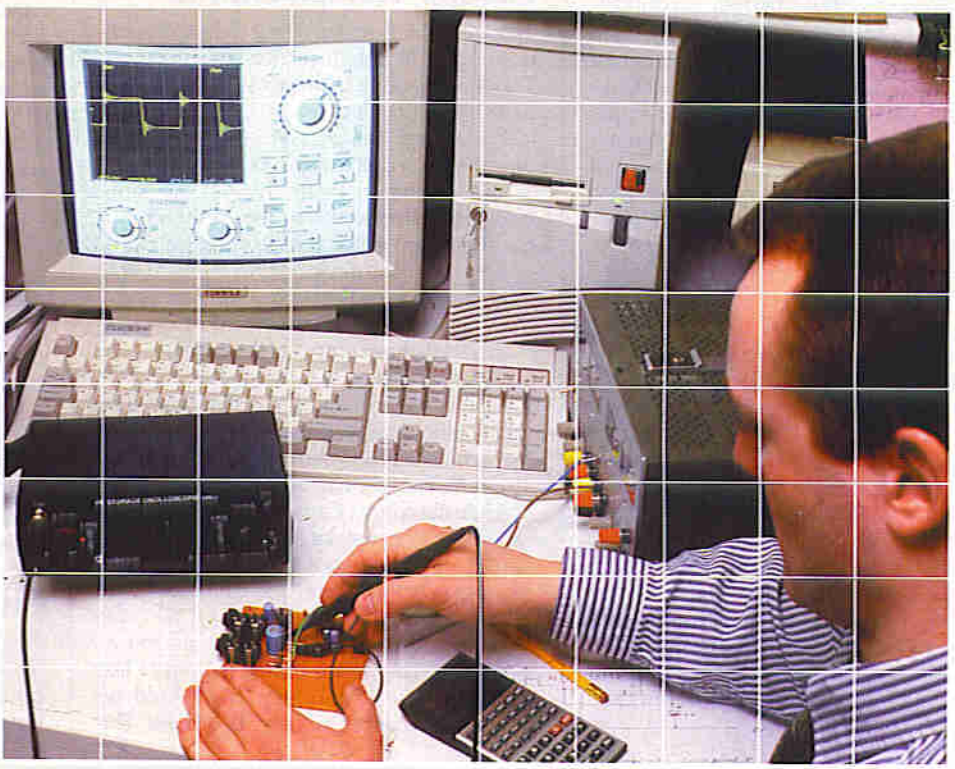
Precise values for discrete components such as resistors and capacitors are not quoted. This is because the values of these devices in each instance are variable. Refer to Table 5. E

3
PROJECT RATING

An oscilloscope is an essential piece of test equipment for anyone who regularly dabbles with electrical or electronic circuit testing and development. Unfortunately, oscilloscopes are invariably expensive (creating a lot of space in your wallet) and bulky (taking up a lot of space on one's workbench). However, if you already own an IBM-compatible PC, a solution to this quandary is provided by this project – it masterfully transforms your PC into a well-specified digital storage oscilloscope, at a fraction of the cost of buying a dedicated instrument with the equivalent features!

DIGITAL STORAGE PC OSCILLOSCOPE

Text by
Maurice Hunt



KIT AVAILABLE (95086) PRICE £169.99 H1

FEATURES

★ REALISTIC OSCILLOSCOPE DISPLAY AND CONTROLS ★ ACCURATE OSCILLOSCOPE OPERATION ★ COMPACT, LIGHTWEIGHT HARDWARE ★ COMPREHENSIVE SOFTWARE ★ EXPANDABLE TO 2-CHANNELS ★ EASY TO OPERATE ★ WAVEFORM STORAGE FACILITY (TIFF – TAGGED IMAGE FILE FORMAT) ★ PRINTABLE WAVEFORM OUTPUT ★ CAPABLE OF DISPLAYING VERY LOW FREQUENCY WAVEFORMS

APPLICATIONS

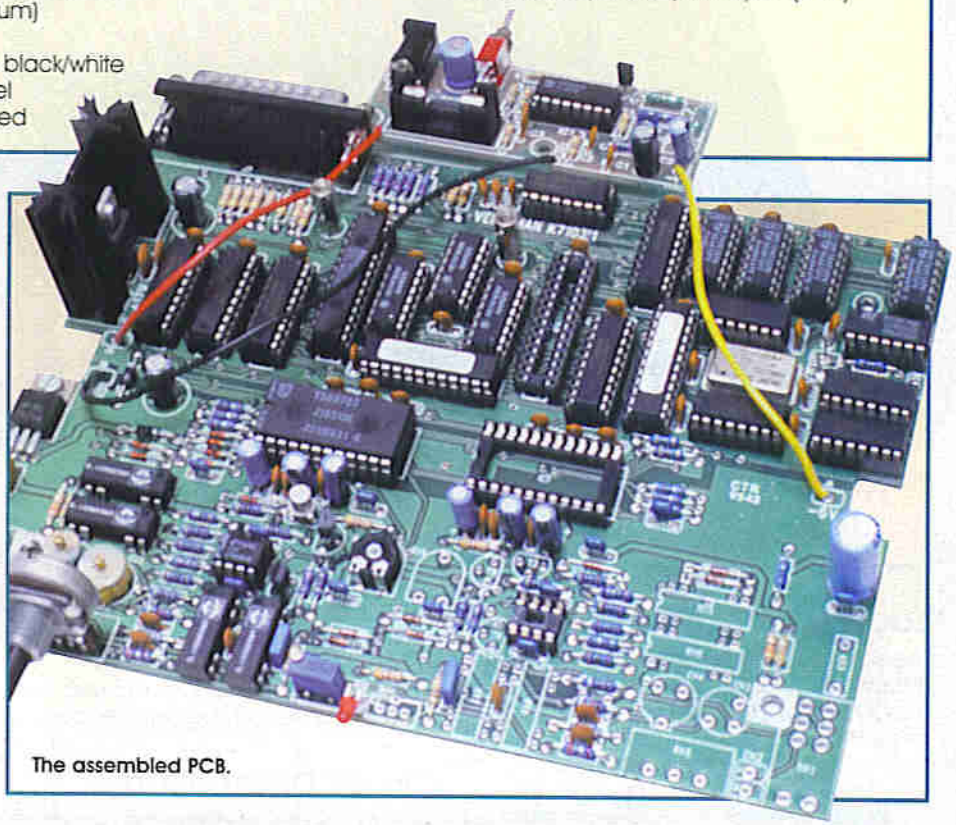
★ HOBBYIST'S WORKBENCH ★ SCHOOLS AND COLLEGES ★ PROJECT REPORTS ★ LABORATORIES ★ GARAGES AND WORKSHOPS ★ REPAIR SHOPS

Specification

Supply voltage:	9 to 12V DC
Supply current:	700mA (maximum)
Channels:	1, expandable to 2
Input sensitivity:	10mV to 5V/division
Input impedance:	1MΩ
Input capacitance:	30pF
Maximum input voltage:	100V (AC/DC)
Timebase:	100ns to 100ms/division
Trigger source:	CH1, CH2 or internal triggering
Triggering slope:	Positive or negative
Trigger level:	Adjustable in ½-division steps
Sampling frequency:	32MHz (maximum)
Vertical resolution:	8-bit
File format:	TIFF 320 × 256 black/white
Memory:	4K-byte/channel
Interpolation:	Linear or rounded
Casing dimensions (WHD):	200 × 65 × 160mm
Minimum system requirements:	IBM compatible PC (286 or higher); 400K-bytes conventional memory available; MS-DOS operating system; MS-Windows 3.1 or higher for accessing assembly instructions; VGA display card; Mouse; An available parallel printer port (LPT1)

All standard oscilloscope functions are provided by the DOS program, and operation seems just like using a real oscilloscope, except that most operations are performed using the mouse. Connection is via the parallel (printer) port of the computer. Additionally, the system provides the facility to be able to save off screen waveforms in TIFF (Tagged Image File) format, which can be processed by readily available graphics software, and also allows the waveforms to be printed out. This is extremely useful for keeping permanent records of measurements and response graphs, etc., as well as providing a ready means of presenting the screen images.

The project consists of a compact boxed hardware unit, parallel port interconnecting lead, and a software disk. The only extras required to use the project are a 9 to 12V DC power supply and a standard oscilloscope probe. In standard form, the kit forms a 1-channel oscilloscope, but this is easily expandable to dual channels by installing the additional components supplied in an optional extra kit. The software provided is capable of providing the dual channel operation if the additional extra components are installed. The project is supplied with all necessary parts including the enclosure, and comprehensive instructions on assembly and use are also provided.



The assembled PCB.

The completed system is very useful as a general-purpose oscilloscope for viewing most types of waveform, but it should be noted that it is not particularly well-suited to viewing complex waveforms, such as video signals, due to the sampling rates of the analogue to digital stage – see Table 1 for further information.

A separate software trial disk is also available for further evaluation of the project – see the Optional list at the end of this article for details. The kit will be available in ready-built form, and there will be additional software available to enable the system to be used as a Spectrum Analyser, providing Fast Fourier Transform functions (details to be announced).

It is advisable to load the software into your PC before building up the hardware, since assembly instructions and diagrams are incorporated into the 'Manual' part of the program to assist with construction and setting up the completed unit. Note that the program must be running within a Windows™ environment to enable the 'Manual' screens to be displayed, although the measurement modes can be operated in DOS or Windows™ environments.

Timebase settings (TIME/DIV)	Shown sampling frequency in RUN mode	Real sampling frequency (Sampling rate)
0·1μs	32MHz	32MHz
0·2μs	32MHz	32MHz
0·5μs	32MHz	32MHz
1μs	32MHz	32MHz
2μs	16MHz	32MHz
5μs	6·4MHz	32MHz
10μs	3·2MHz	16MHz
20μs	1·6MHz	8MHz
50μs	640kHz	3·2MHz
0·1ms	320kHz	1·6MHz
0·2ms	160kHz	800kHz
0·5ms	64kHz	320kHz
1ms	32kHz	160kHz
2ms	16kHz	80kHz
5ms	6·4kHz	32kHz
10ms	3·2kHz	16kHz
20ms	1·6kHz	8kHz
50ms	640Hz	3·2kHz
100ms	320Hz	1·6kHz

Table 1. Relationship between timebase setting and sampling frequency.

The assembled PCB in case.

Loading the Software

The software is supplied on a 3·5in. floppy disk, and is in the form of an MS-DOS program, which will also run in the Windows™ environment. The software will run on any IBM-compatible PC of 286 or higher capacity. A mouse is required to select the various program functions. With the disk inserted in the appropriate drive, at the DOS prompt or in the Windows File Manager, type a:\install to load the program. If you are trying out the demonstration disk, go into the file manager, select the appropriate drive and click on the 'demo.bat' icon. If in DOS, enter the appropriate drive, then type 'demo' to start the program.

Note that the correct mouse driver (IMOUSE or equivalent) must be selected, otherwise problems with graphics corruption or lack of cursor arrow response may be experienced.

Circuit Description

Refer to Figure 1, showing the block diagram of the hardware circuitry. As can be seen, there are two distinct analogue and digital sections to the circuit, which will be dealt with separately to simplify the operation description as far as possible.

Analogue Section

This description describes the operation of the single-channel version of the oscilloscope, although the second channel largely duplicates the first. The signal being measured is passed to the input attenuator via a three-position switch, which is used to select the mode of input connection – AC, DC or GND (ground). In DC mode, the input signal is fed directly to the input attenuator. Both DC and AC components of the signal will then be measured and displayed on the screen.

If AC coupling mode is selected, the input passes through a decoupling stage on its way to the input attenuator, which blocks the DC component of the signal in addition to very low frequency AC signals, the –3dB cutoff frequency being set at 10Hz. In the GND position, the probe connector is isolated from the input attenuator, while the input of the attenuator is grounded – this provides a quick way to check the zero reference line position on the screen without having to disconnect the input signal.

The attenuation selector consists of a frequency-compensated voltage divider, which gives attenuation ratios of 1:1, 1:10 and 1:100. The attenuation is selected by reed relays, and the frequency response of this block is adjustable.

Over-voltage protection is provided for the input amplifier, to limit the maximum voltage levels to the amplifier input FET, preventing damage. The gain of the input amplifier is set to either ×4, ×10 or ×20, controlled by the gain selector stage. The Y-position of the trace is set

Front view of the Digital Storage PC Oscilloscope case.

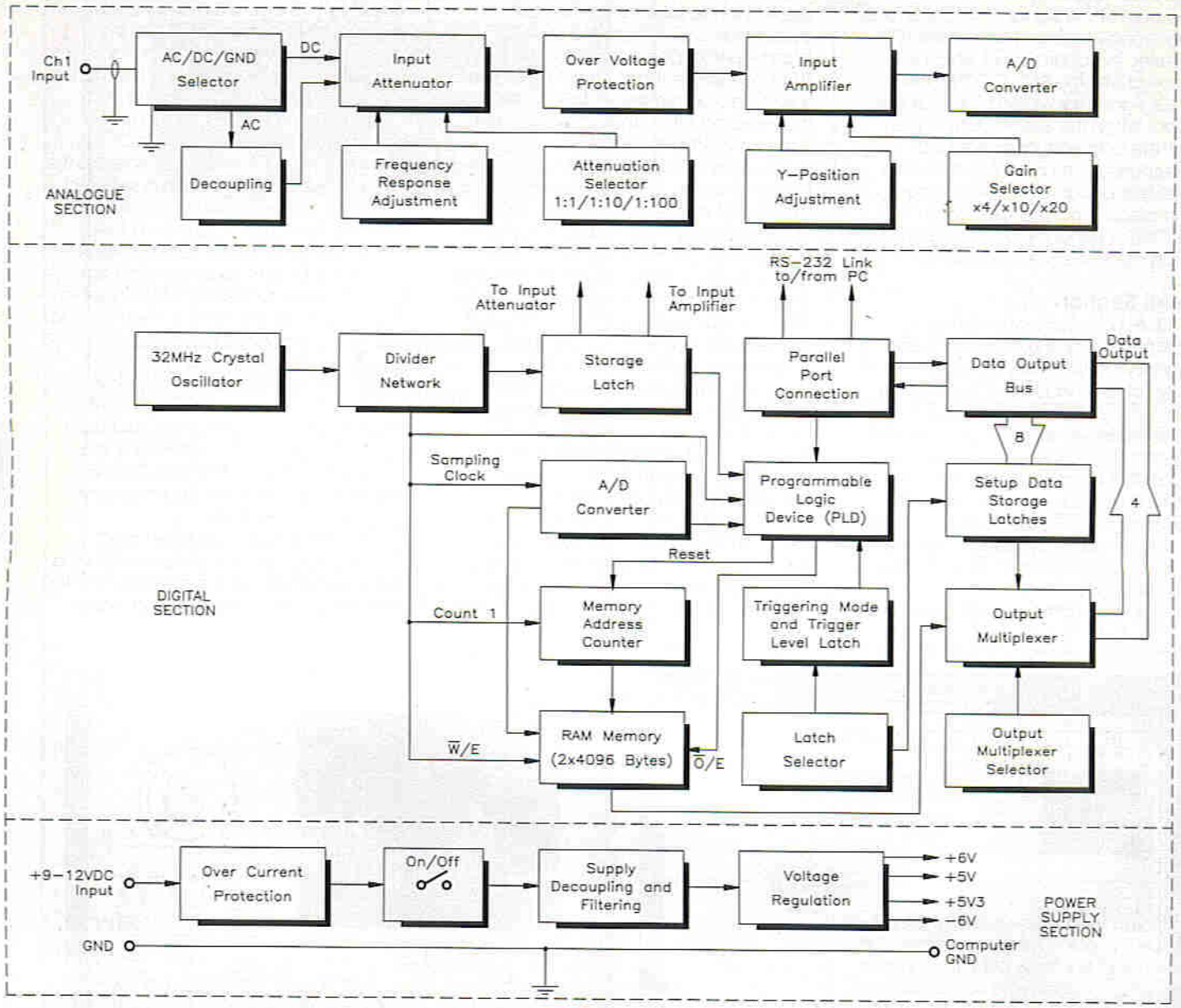


Figure 1. Block diagram of the hardware.

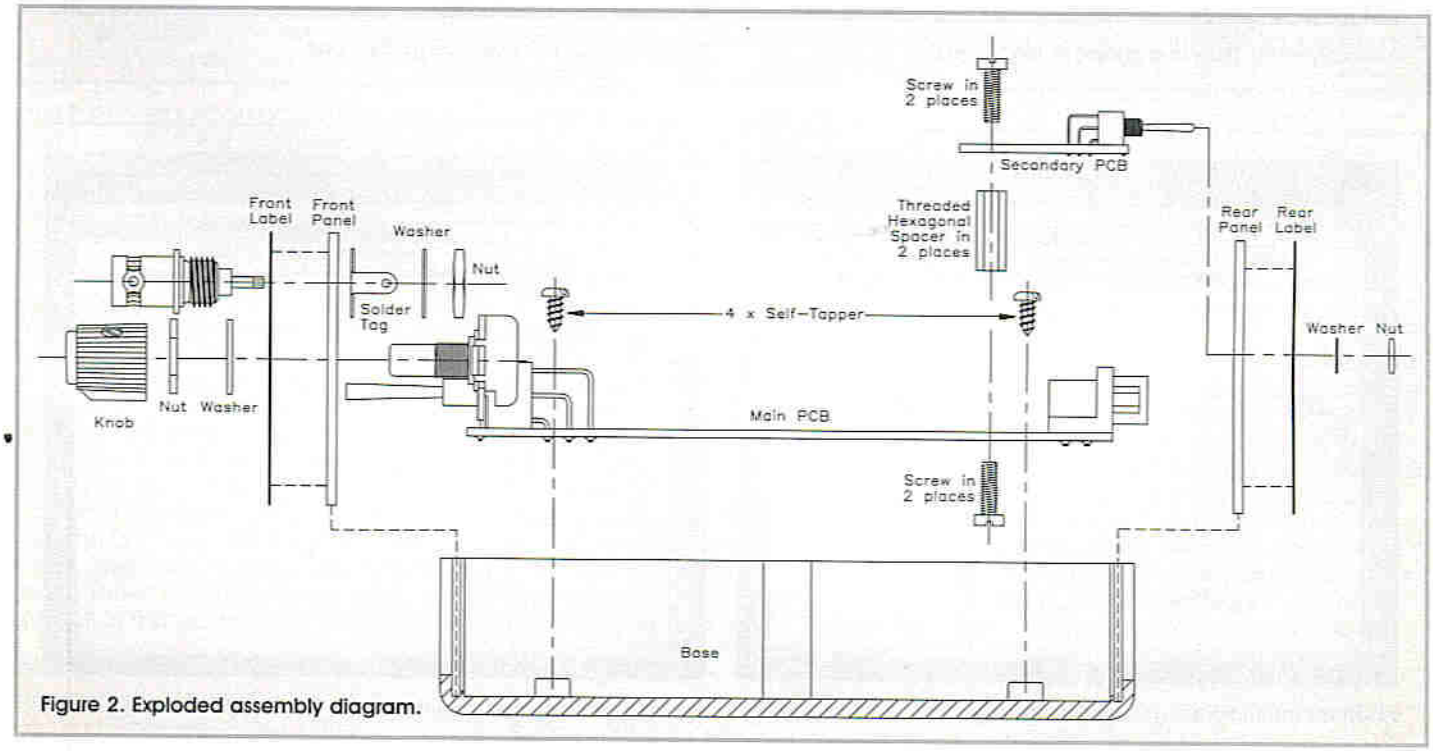


Figure 2. Exploded assembly diagram.

by control of the bias current applied to the input amplifier.

The gain of the signal path determines the reference voltage span of the A/D converter, the operation of which is controlled with the END-COUNT and AD-CLK signals, provided by the digital section. When the END-COUNT signal is low, the converter operates and the outputs are in an active state. The conversion occurs at the rising edge of the clock signal, AD-CLK. When the END-COUNT signal is high, the converter outputs are in the high impedance state.

Digital Section

The 32MHz clock signal is fed via a predivider (÷2) to the programmable frequency divider, which outputs the desired clock frequency. This is fed via the programmable logic device (PLD) as a sampling clock (AD-CLK) to the A/D converter stage. The clock signal also supplies the memory address counters (COUNT1) and the memory, as a write enable signal ($\overline{W/E}$). The PLD additionally controls the memory reading with the $\overline{OE}$ signal and the setup data storage latch selector.

The latches store the setup data controlling all operations of the oscilloscope hardware. The settings are fed to the latches via the data output bus (DB0-7) from the RS-232 parallel printer port connector, J7. The latch where the data will be stored is selected before the data is written to the selected latch. The latch selection data is stored in the PLD.

The desired latch content is transferred by the program to the data output of the RS-232 connector. It is then stored in the selected latch. Correspondingly, the address counters are reset, then begin to count, while the A-to-D converter stage converts the analogue input data into a digital form which is stored in the consecutive addresses of the RAM.

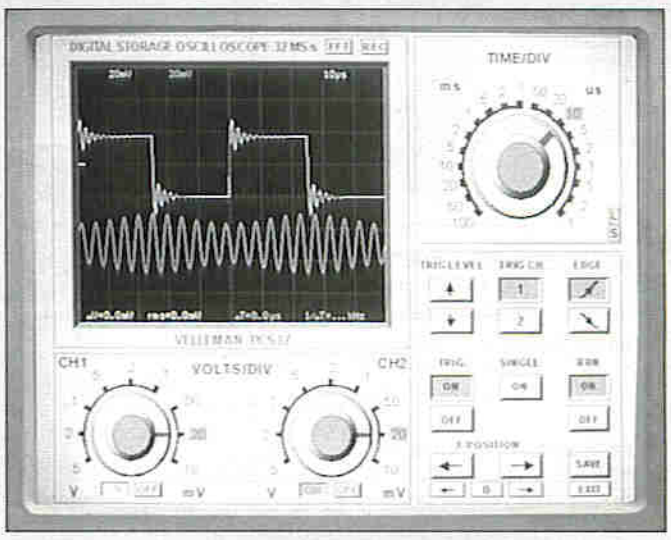
When the address counter has reached 1,024, the PLD is informed that triggering is now allowed because enough data prior to the triggering point is now stored in the memory. If the TRIG-ON screen 'button' is selected, the triggering occurs when the preselected conditions stored to the latch are fulfilled (the signal of the selected channel passes the triggering level in the direction selected). When triggering conditions are met, the counters are allowed to begin counting. This state remains until the END-COUNT signal goes high, at count 3,072, which is the count of samples stored to the memory after triggering. The total amount of samples stored in memory is now 4,096 (= 1,024 + 3,072).

The PLD compares the four most significant bits (MSBs) of the A-to-D converter output to the value stored in the latch. If the TRIG-OFF 'button' is selected, triggering occurs almost immediately after the first 1,024 values from the A-to-D converter are stored in memory.

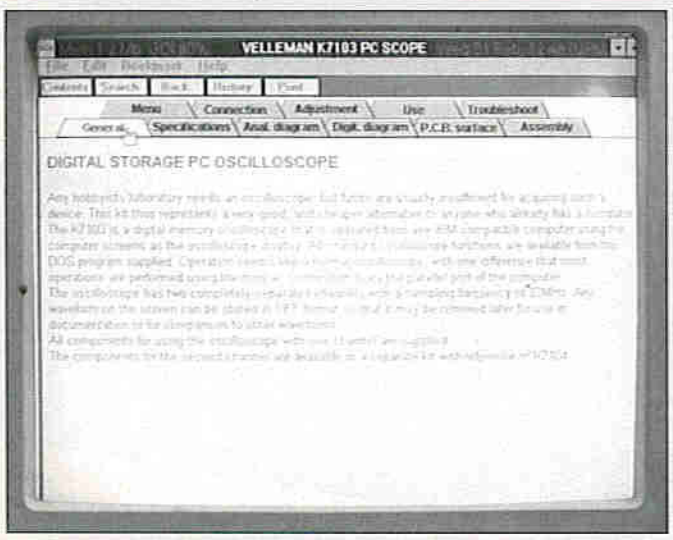
Now it is time to read the data from the memories to the PC, which happens in 4-bit groups. The data is transferred to the RS-232 connector data input. A 2-to-4 line decoder is used to select which 4-bit group is outputted. After reading all four groups from the RAM, input 3 of the PLD goes high and back to low. This pulse also increments the address counters (if the END-COUNT signal is high), and the next memory location can be read.

After all the data has been read (2 × 4,096 bytes), the program sends a RESET command to the address counters and the above operation is repeated.

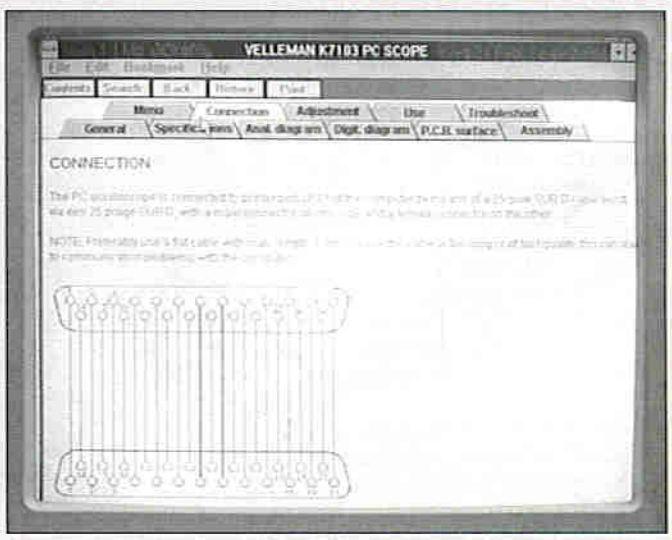
Assembly instructions in a choice of languages.



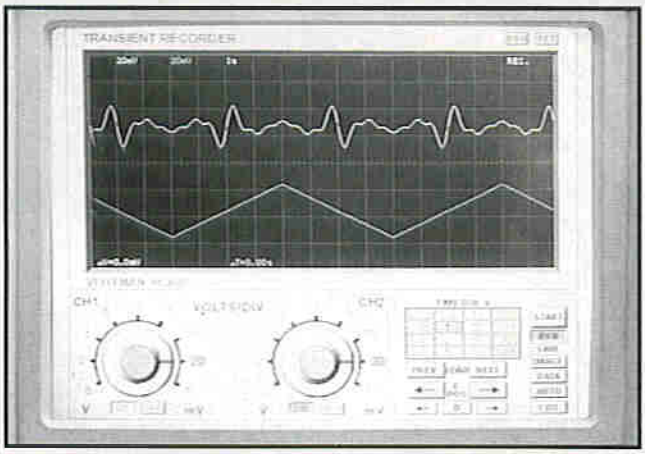
Digital Storage Oscilloscope (DSO) mode.

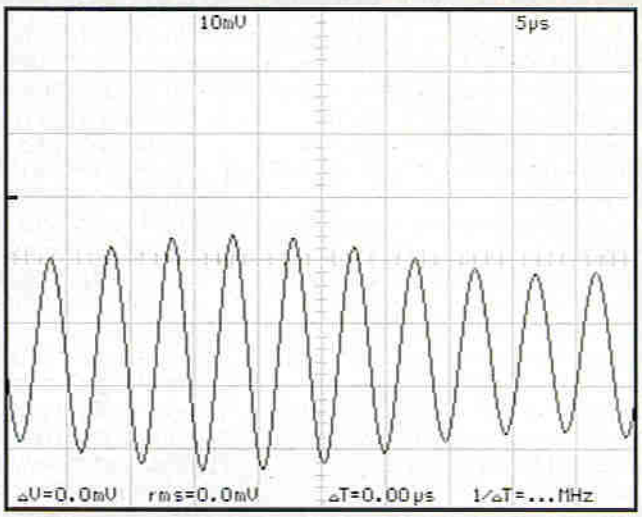


Assembly instructions – general information.

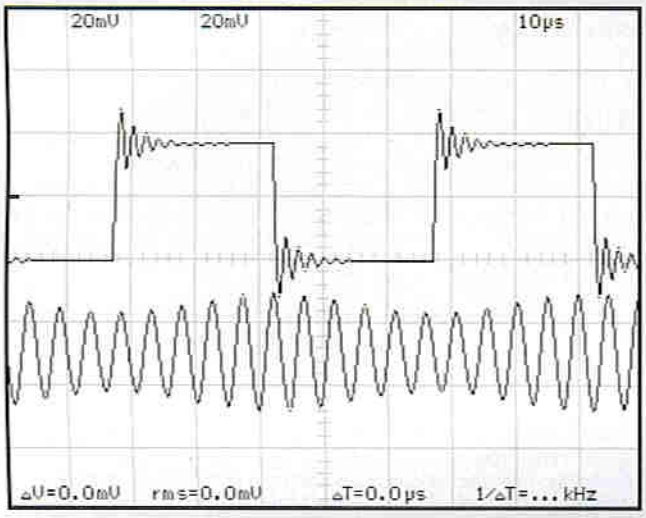


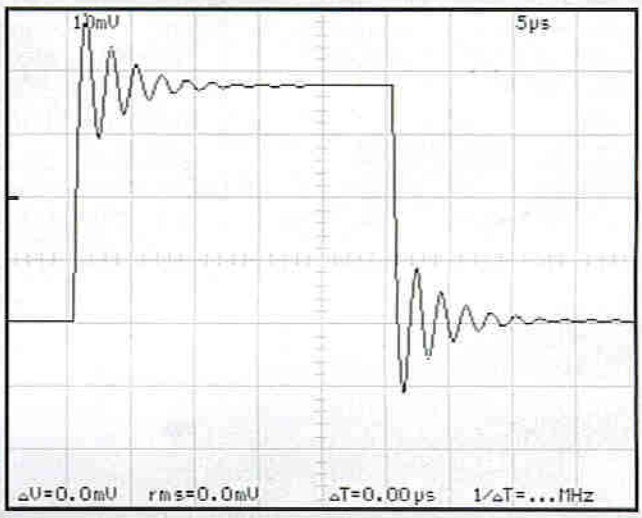
Assembly instructions – connections.





Above: Transient Recorder (REC) mode.
Right and below: Stored waveforms in TIFF form.





Construction

PCB Assembly

The following instructions apply to the construction of a single-channel version of the project. The dual-channel version has the analogue section duplicated, though the digital section and software remain identical. The additional parts for the second channel are available separately – see the Optional Parts List. There are two PCBs in the kit, the main and supply regulation boards. The main PCB is double-sided with plated-through holes, so errors in construction will be difficult to rectify. Double-check that each component is installed in its correct location *before* soldering in place. Ensure that all components are mounted tightly against the board, to prevent stray RF interference affecting the operation of the system.

A small soldering iron rated at no higher than 40W and fitted with a thin tip should be used, along with thin gauge solder, to build up the boards in order of ascending component size. Note that DIL holders are used; leave insertion of the ICs until the PCBs have been assembled. Further instructions are provided with the software and instruction manual supplied with the kit.

Box Construction

Refer to the exploded assembly diagram, shown in Figure 2. The box supplied with the kit is predrilled, however, you will need to apply the labels to the detachable front and rear panels, having first ensured that the panels are clean. Ensure that the labels are fitted in the correct positions. Carefully use a scalpel or similar to cut away the label where it covers the holes. Do not expose the holes for the CH2 switches and sockets unless you are actually building the 2-channel version of the project.

Next, fit the BNC socket (CH1) into its hole in the front panel, using the nut to secure it, then connect the socket to the main board at terminals J1 and J2 using two short (approximately 35mm) lengths of hook-up cable.

Fit the two threaded mounting pillars to the main board, and secure them with two bolts.

Fit the front panel to the main board by means of the RV2 potentiometer and SW2 toggle switch fixings. Hold the rear panel against the rear edge of the main board so that the RS-232 connector fits into its slot, then fit the subassembly into the box base, ensuring the front and rear panels slide into their respective grooves.

Fit the smaller board's toggle switch SW1 into its hole in the rear panel, but don't tighten its locknut yet. Position the board so that its holes align with the two mounting pillars on the main board, and secure it using two bolts. Now tighten SW1's locknut.

Finally, following alignment of the unit as per the instructions in the software 'manual', affix the lid of the box using the four screws provided.

Using the Software

The software is capable of running without the need for the hardware to be connected. In Windows, double-click on the 'K7103 PC SCOPE' icon, which will bring up a further two icons, 'PC SCOPE' and 'MANUAL'. Clicking on 'PC SCOPE' displays the 'virtual oscilloscope', complete with screen and control 'switches'. Clicking on 'MANUAL' provides menu-selectable instructions, available in four languages, and covering details on general information, specification, circuit diagrams, assembly, troubleshooting, connection, adjustment and descriptions of the various functions. The majority of this information can also be found in the instruction manual.

When in the various program modes, use the mouse to move the cursor arrow to the functions that you wish to select, then click on them. Otherwise, most aspects of the virtual instruments' operation are very similar to when using the equivalent real test instrument.

If using the demonstration disk, you will need to access the program via the Windows file manager or in DOS, as described in the section 'Loading the Software'. Note that the demo disk also

provides a demonstration of the (optional extra) Transient Recorder and Fast Fourier Transform programs – refer to the Optional Parts List for details. To select these functions, enter the normal oscilloscope program, and use the 'buttons' above the screen, labelled 'REC' for the Transient Recorder, and 'FFT' for the Fast Fourier Transform. Note that your PC must be fitted with a suitable maths coprocessor to enable the Fast Fourier Transform program to operate. While in either 'REC' or 'FFT' modes, clicking on the 'DSO' button above the screen will return to the Digital Storage Oscilloscope (normal) mode.

To save off screen images, click on the 'SAVE' button, and the image will be stored in TIFF (Tagged Image File Format) files – the name of the file will be shown on the screen.

To return to Windows or the DOS prompt while the program is running, simply click on the 'EXIT' button at the bottom right of the screen.

Using the Hardware

Connect the hardware to the PC's parallel printer port (LPT1), via a 25-way ribbon cable terminated in a 25-way D-type socket at one end, and a 25-way D-type plug at the other. The cable should not be any longer than 1·5m, otherwise there is the possibility of corruption of the data flow between the PC and the hardware.

You will need a standard type oscilloscope probe to connect to the input BNC socket; ensure that its attenuation switch (where fitted) is on the ×1 position. Connect a suitable 9 to 12V DC power supply to the hardware, ensuring that the positive (+) connection is applied to the centre pin of the power socket.

Switch on the unit (by means of the on/off toggle switch on the rear panel), then the front panel LED should light.

The unit will now need to be aligned in accordance with the instructions provided in the software 'manual'. Ensure that this procedure is done correctly, since the level of attention here will determine the accuracy of the finished system.

Further Notes on Use

Because the Digital PC Oscilloscope uses an analogue-to-digital converter to sample the incoming signal, it should be borne in mind when carrying out measurements that Nyquist's theorem must be applied to obtain a meaningful screen waveform. Put simply, the sampling rate must be at least double that of the signal to be measured. To ensure that this is the case, it is advisable to initially set the timebase setting to its maximum setting (100ns/DIV), and then reduce it until the displayed waveform is suitably defined. Note, however, that quantisation steps are visible on certain waveforms, in particular, square waves. Table 1 provides details on how the sampling frequency varies according to the timebase setting.

When saving screen waveforms, the image is stored as a TIFF file with the filename S01.TIF, subsequent save operations incrementing the filename to S02.TIF, S03.TIF, etc. However, if the program is restarted, the sequence is reset, which will thus overwrite stored screen image files without warning. Therefore, if you wish to retain a waveform image permanently, you should exit the program and rename the file, or transfer it into an alternative directory/onto a spare floppy disk – or print out a hardcopy.

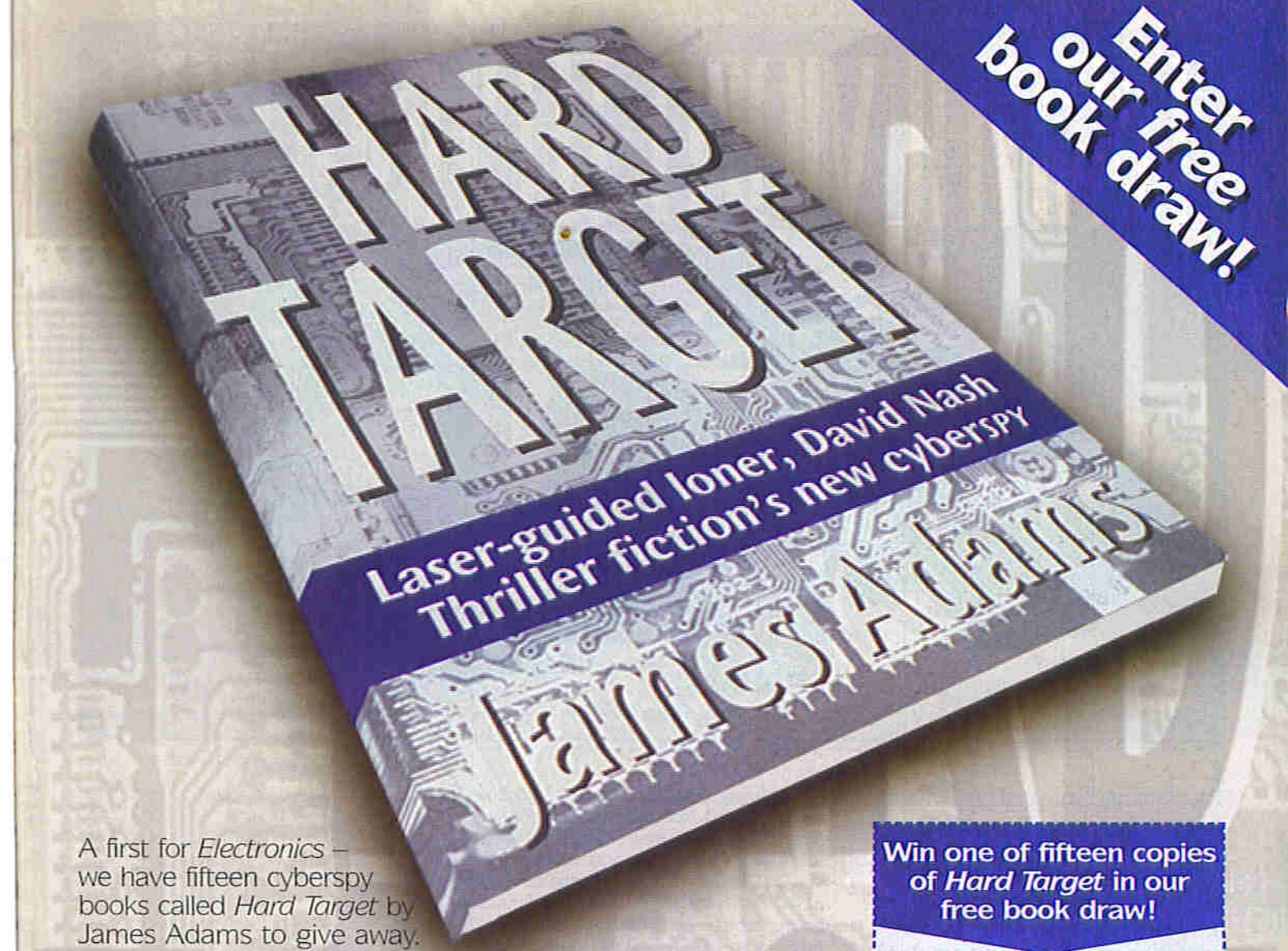
No bandwidth is quoted in the manufacturer's specification, but it is estimated to be approximately 10 to 15MHz.

DIGITAL STORAGE PC OSCILLOSCOPE PARTS LIST

OPTIONAL (Not in Kit)		
Oscilloscope Probe	1	(AQ58N)
Unregulated 800mA Power Supply	1	(YM85G)
Dual Channel Expansion Kit	1	(95117)
Digital PC Oscilloscope Demonstration Disk	1	(95118)
Ready-built 2-channel PC Oscilloscope	1	(*TBA*)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available in kit form only.
Order As 95086 (Digital Storage PC Oscilloscope) Price £169.99 H1

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.



Enter our free book draw!

A first for *Electronics* – we have fifteen cyberspy books called *Hard Target* by James Adams to give away.

James Adams is the journalist known and trusted more than any other by the world's intelligence agencies, and frequently comes across information so secret that publishing it as fact is beyond his power. But that does not stop him from publishing it as fiction.

It is this core of knowledge and understanding that Adams has that makes *Hard Target* as close to a primer on how modern spy agencies operate as any ordinary citizen is liable to get. The weapons, training, technology and 'mindsets' that characterise today's intelligence operations are all to be found in *Hard Target*.

Against this background of unimpeachable authenticity, James Adams has woven a story of human and criminal drama that starkly illustrates the terrifying challenges of the uncertain world we now inhabit. The rules have changed, the old certainties are gone, ancient foes are now friends, and vice versa. No other writer could give us such a clear understanding of the precariousness of our security with such eloquence and nerve-tingling action.

At the heart of the conspiracy of former agents lies the greatest threat to humanity around today: biological weapons. The renegades intend to grab them and market them to the highest bidder. In post Cold War Russia, with uncertain security to protect them, 14 varieties of plague have been developed. They have no antidote. A microscopic portion can wipe out hundreds of thousands of people.

This is not fiction, it is fact, and the scenarios Adams weaves around them are frighteningly possible.

In 1995, Adams learned of a debate being conducted deep in the Pentagon about Iraqi tanks moving under cover of darkness towards the Kuwaiti border. Using techniques as sophisticated as any intelligence tradecraft, Adams got the story, stood it up, and ran it in the *Sunday Times*. Within 24 hours of the story's appearance, British Intelligence reported communications between the tank commanders and Iraq's military rulers that indicated the article had blown the operation wide open. The tanks turned back – the crisis was over.

In the same way that a spy will cultivate agents in sensitive places, so does a journalist like James Adams develop his own secret sources. The people Adams knows are in the highest reaches of the world's most secret agencies, and keeping their identities confidential requires a special bond of trust and integrity.

But James Adams makes clear one important distinction between himself and the inhabitants of the shadowy world he frequents with such ease. "Their job is to uncover the secrets that threaten our world, so is mine. Their inclination is to bury those secrets, as a journalist, mine is to expose them", said Adams.

Hard Target is published on 4 April, priced £9.99.

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ELECTRONICS
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DIGITAL VIDEO TECHNOLOGY

by Reg Miles

Avid/Ikegami hard-disk camcutter.

The digital revolution that has occurred in the audio field is now extending to video. It has already begun in a small way with some of the disc systems, but is set to accelerate with the arrival of new video tape formats, video editing systems using computer technology and, perhaps more importantly, the advent of digital cable, satellite and terrestrial broadcasting. New things are appearing all the time.

THE reason for this enthusiastic conversion from analogue-to-digital is a relatively simple one: the digital signal is highly resistant to degradation because even if it accumulates noise or distortion through the recording and transmission process, it can be simply corrected as long as the binary data can be identified, and any data that is missing can be recovered by error correction techniques. It is also amenable to compression. Which is fortuitous, because using bits to represent voltage levels places a considerable demand on bandwidth.

In the Beginning

Experiments with digital VTRs (DVTR) began in the broadcast domain, where the improvements in quality and flexibility would be worth the high cost. The first DVTR was developed by the Research Department of the BBC in 1974. This recorded a composite video signal, with a sampling frequency twice that of the 4·43MHz PAL colour sub-carrier frequency ($2f_{sc}$) using 8-bit quantisation. The tape was 25mm wide gamma-iron oxide of 1,460m in length, which allowed just 8 minutes of recording time (274m^2/hr). Not surprisingly, it remained experimental, and it was another five years before Ampex and Sony announced prototype DVTRs. Both were NTSC, and sampled at $3f_{sc}$ with 8-bit quantisation. The Ampex reduced tape consumption to 69·7m^2/hr, and the Sony to 22·4. However, the recording density was still too low; commercialisation had to wait for the introduction of high density tape and heads capable of recording submicrometre wavelengths.

It was not until 1987 that the technology finally caught up with the ideas, and Sony launched a DVTR conforming to the internationally agreed D-1 standard. This uses 19mm high-coercivity cobalt iron oxide tape, at a rate of 19·6m^2/hr. Unlike its forebears, D-1 uses a component video signal, and the machine can be switched between PAL and NTSC. The signal consists of luminance (Y) and colour difference signals (R-Y/B-Y); these being sampled at a ratio of 4:2:2 – Y at 13·5MHz, R-Y and B-Y at 6·75MHz. This halves the horizontal resolution of the colour, but because it is the luminance that provides all the picture detail, this compromise is acceptable to reduce the data rate. Quantisation is again 8-bit. The recording and playback system is shown in Figure 1. The signal is recorded in time division multiplex (TDM) form, with the individual bits recorded as changes in magnetic direction – 0 = S-N, 1 = N-S. Because the volume of data is 226M-bit/s, each field is divided into twelve tracks (PAL), and

Sony DV camcorder.

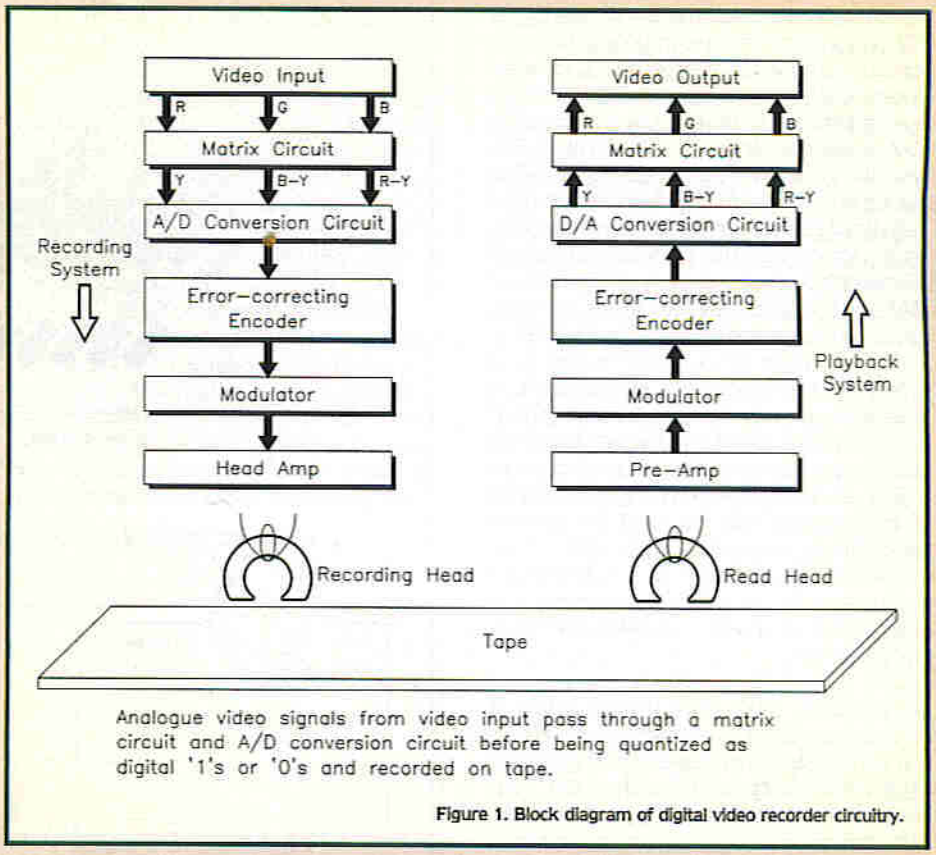
subdivided into video and audio sectors (see Figure 2), with the four audio channels sampled at 48kHz/16 bits. Its cost, however, has limited it to top-end niche markets where quality is paramount.

Thus, in the following year, Ampex and Sony launched machines conforming to the more affordable D-2 composite video standard. This samples at $4f_{sc}$, with 8-bit quantisation, and has a data volume of 154M-bit/s. The recording principles are essentially the same as D-1. However, the use of 19mm metal particle (MP) tape has allowed minimum wavelengths down to 0·79μm (PAL) by comparison with 0·89μm for D-1; and azimuth recording has reduced track pitch to 35·2μm (PAL) by comparison with 45·0μm, reducing tape consumption to 9m²/hr.

Then in 1991, Panasonic launched its composite D-3 format machine which further cut the cost. This is based on work by the Japanese broadcasting company NHK, and uses 12·7mm MP tape, recording tracks of 18μm pitch with minimum wavelengths of 0·71μm – halving tape consumption. The D-3 format also allowed smaller cassettes, and smaller and less expensive hardware to be used.

Nevertheless, it was the last composite format DVTR to be introduced. The increasingly complex production and post-production systems then being installed by broadcasters worked more effectively and at higher quality with component signals. Separate processing of the luminance and colour difference signals gives a wider colour bandwidth and eliminates cross-colour and cross-luminance artifacts. It also removes the need to decode the signals for some post-production processes and subsequently re-encode them for recording, and it is more flexible with regard to TV standards.

1993 proved to be a bonanza year for DVTRs, with three 4:2:2 component formats being launched: D-5 from Panasonic (based on D-3) Digital Betacam from Sony (based on analogue Betacam) and DCT (Digital Component Technology) from Ampex (based on D-2 and data recording machines). If you're wondering what has happened to the D-4 format, there isn't one: four is apparently an unlucky number in Japan, and no manufacturer is going to risk the possibility of buyers being superstitious. D-5 and Digital Betacam use 12·7mm MP tape, while DCT uses 19mm MP tape. All three employ 10-bit quantisation to further improve the video quality. Also, for the first time in the broadcast market, Digital Betacam and DCT apply bit rate reduction to reduce tape consumption. This employs Discrete Cosine Transforms and Variable Length Coding, which operate by first dividing each field into discrete blocks of pixels and transforming those into horizontal and vertical energy components of increasing frequency, then assigning the shortest codes to the most repetitive signal levels and the longest codes to those which occur the least – achieving a compression ratio of 2:1. Because it is an intrafield system, there are none of the motion artifacts that can mar some other compression systems.



Analogue video signals from video input pass through a matrix circuit and A/D conversion circuit before being quantized as digital '1's or '0's and recorded on tape.

Figure 1. Block diagram of digital video recorder circuitry.

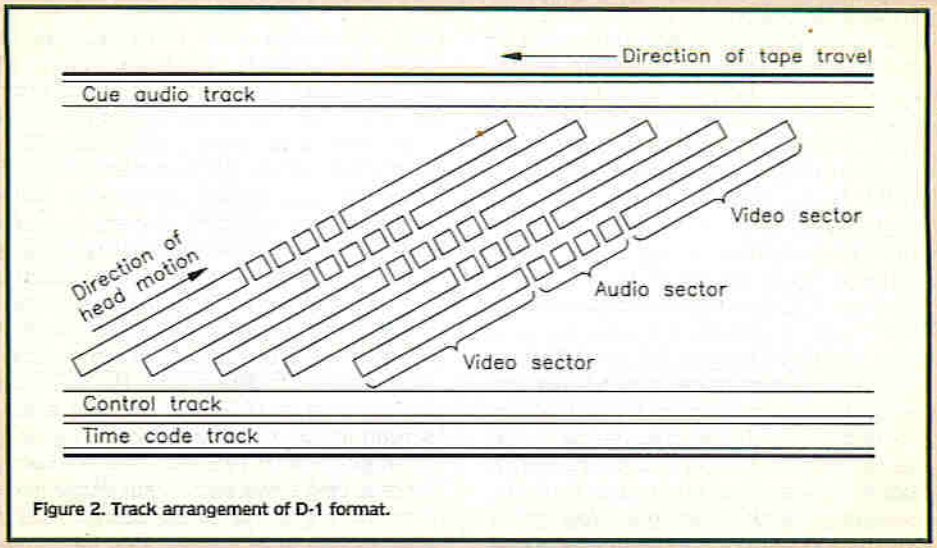


Figure 2. Track arrangement of D-1 format.

Panasonic DVCPRO range.

Digital Video (DV)

Despite expanding the DVTR market, these formats are still only relevant to broadcast and top professional users; those lower down the professional scale, such as consumers, have had to continue using analogue formats. Until now, that is. In my article 'Digital VHS Explained' in Issue 97, I described D-VHS, which can record a bitstream from a cable or satellite receiver, and component Digital S for the lower-end professional user. The latter has just been launched, but we're still waiting for D-VHS.

I also briefly referred to the component Digital Video cassette format intended for both consumer (where it is known as just Digital Video or DV) and professional uses. Sony has now launched two consumer/semi-professional DV camcorders: the DCR-VX1000 at £3,500 and the slightly more affordable DCR-VX700 at £2,800. While JVC and Panasonic have exhibited camcorders – the former an ultra-compact model. The professional side of Panasonic has also shown a full range of DVCPro products – camcorders, a portable, a field editing machine and a studio VTR.

The standard for DV was devised by a committee of electronics companies and has the support of many more, together with some well-known names from the computer, photographic and tape industries – 52 in all. Their intention has been to create a format that can be used for camera acquisition and post-production, both consumer and professional, and for recording present PAL and NTSC broadcasts, with the built-in facility for upgrading to future video systems.

DV uses 6·35mm double-layer metal evaporated (ME) tape in two sizes of cassette: a Mini DV cassette which allows up to one 1 hour of recording and the larger standard DV cassette with a 4·5 hour capacity, with the tape running at 18·8mm/s. The former will be used for camcorders, but both will be accepted by VTRs without an adaptor being required. An optional IC cassette memory will provide a table of contents list to facilitate rapid searches; but even without the memory, high-speed access is still possible in the VTR by using subcode data. Recordings are made by two heads on a 21·7mm diameter drum rotating at 9,000rpm, laying down 12 tracks per frame (PAL), each of which is just 10μm wide and divided into sectors (see Figure 3).

The sampling ratio is 4:2:0 for PAL and 4:1:1 for NTSC – both using 8-bit quantisation. The PAL ratio maintains the colour sampling rate of 6·75MHz, but R-Y and B-Y are sampled on alternate lines which halves the vertical colour resolution as well as the horizontal; with NTSC, the vertical colour resolution is maintained but the horizontal resolution is reduced to one quarter. However, in both cases, the colour bandwidth is still greater than consumer analogue formats – about 3MHz for PAL and 1·5MHz for NTSC. Bit rate reduction is employed, using intra-frame operation at a 5:1 ratio.

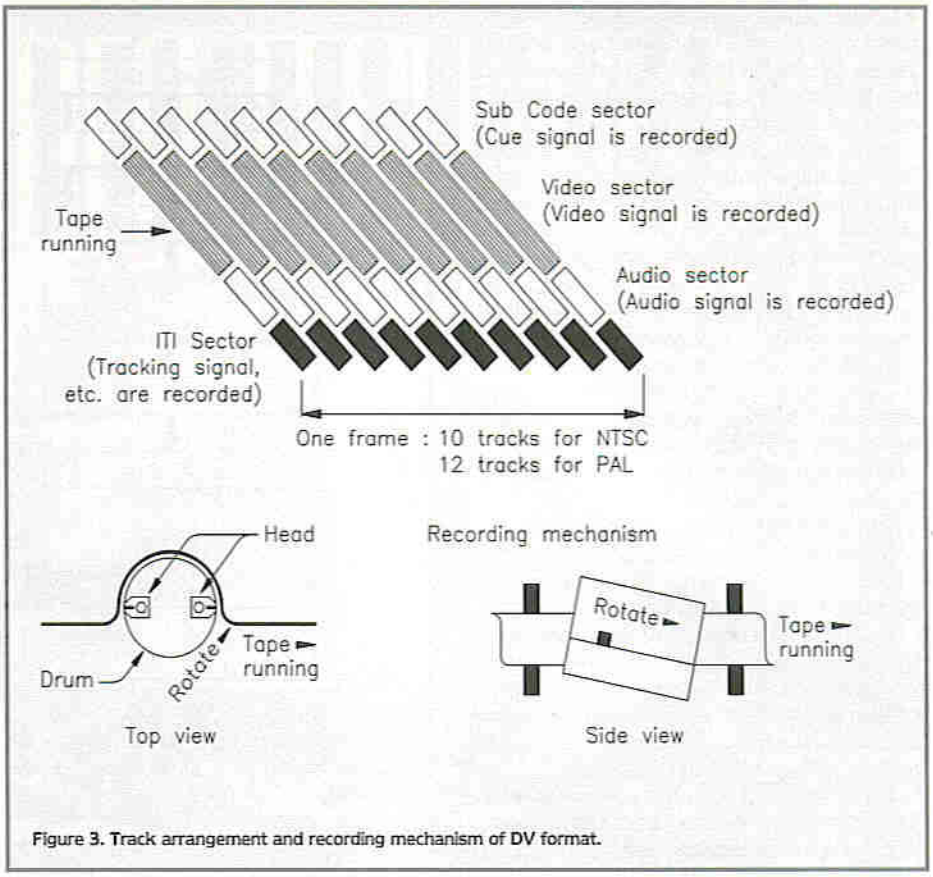


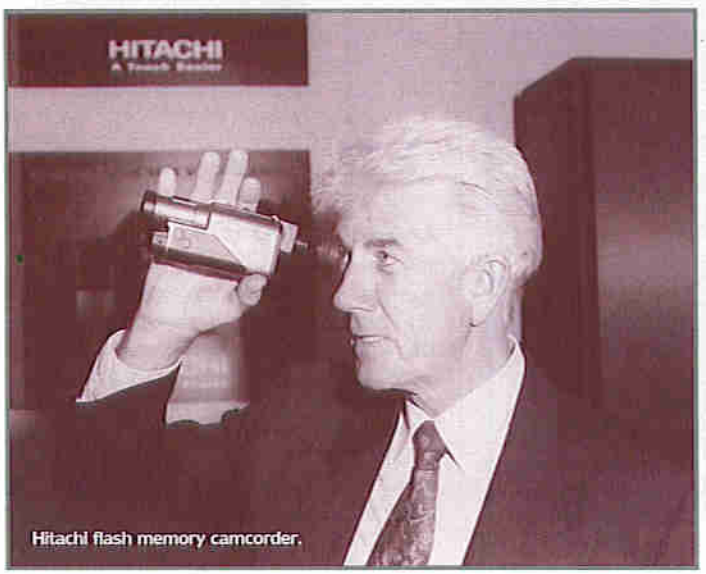
Figure 3. Track arrangement and recording mechanism of DV format.

This allows video data to be recorded at 25M-bit/s, with a total data volume of 41·85M-bit/s, which includes audio, error correction, etc. The horizontal video resolution is claimed to be around 500 lines – 25% greater than Hi8 and S-VHS, and almost double that of 8mm and VHS. Two digital audio standards are provided: one stereo track using 16-bit linear quantisation with sampling frequencies of 48, 44·1 or 32kHz, and two stereo tracks using 12-bit non-linear quantisation and 32kHz sampling for audio dubbing.

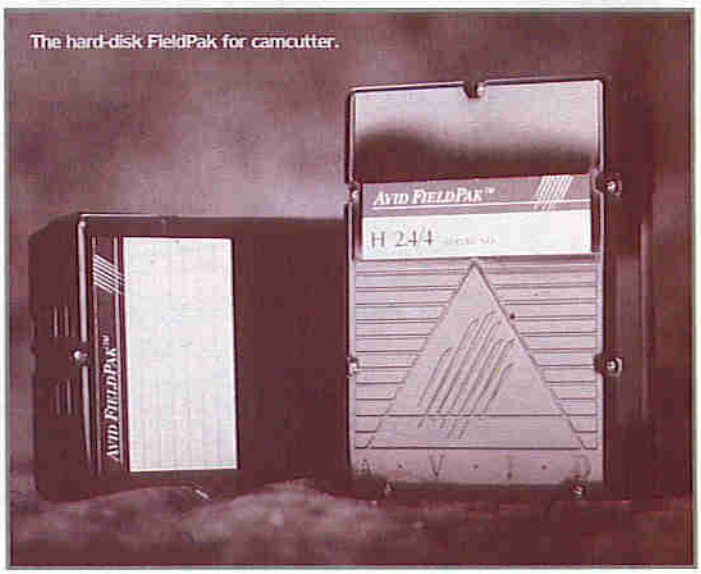
The standard also includes a number of additional facilities. The PAL version incorporates a 16:9 mode, giving a full-screen image on a widescreen TV or a letterbox image on a 4:3 set. There is provision for recording a five second still image from a memory store (a 'photo search' facility enables stills to be found among the movie recordings). There is also timebase correction to minimise jitter, a video printer output and a digital interface to retain quality during editing and copying (but with a copy management system used for commercial and prerecorded tapes). It also allows up to 64 DVTRs to be networked.

DVCPro is essentially the same, but more robust MP tape is used, and it is run at 33·813mm/s to increase track pitch to 18μm. A control track and cue channel are also added, and PAL and NTSC both use 4:1:1 sampling. However, it will still be possible for the professional equipment to play normal DV tapes. Because modern post-production is rapidly becoming a hybrid world of tape and disk, a player will be available to download material to a server at 4× speed, and a DVCPro compatible Digital Disk Recorder (DDR) is under development.

Besides the Standard Definition version of DV and its professional offshoot, there are three other variants for future use. One is High Definition to record the Japanese 1,125 line broadcasts, together with future HD systems and specialised industrial and med-



Hitachi flash memory camcorder.



The hard-disk FieldPak for camcutter.

ical recording. This will use ME tape, but running at 37·594mm/s to record 20 tracks per frame using four heads on the drum. The sampling frequency will be 40·5MHz for luminance and 13·5MHz for the colour difference signals, giving a horizontal resolution of about 600 lines. The other two are intended to record the Advanced TV high definition digital broadcasting system in the USA and the Digital Video Broadcasting system that will be introduced into Europe. These recording standards have yet to be finalised.

Tapeless Video Recording

Tape has undeniable attractions for users, with its ability to store large amounts of data at low cost. Unfortunately, it does take a comparatively long time to access that data, and the hardware requires a lot of high-precision moving parts.

For this reason, Hitachi is developing a camcorder without moving parts that uses a 400M-byte multilayered flash memory to record for thirty minutes. A digital input/output allows the data to be downloaded to a storage device or transmitted over a phone line, as well as recording from an external source, and it has an output from the DSP for TV viewing (see Figure 4). However, it is not expected to become a commercial reality for another five or six years.

In the meantime, there is the CamCutter – the first camcorder to use hard disks. It has been jointly developed by Avid (who make hard disk editing systems) and Ikegami (who make professional video cameras), and it should now be available for professional news gathering. There are no moving parts in the camera itself, these are all in a slot-in FieldPak containing two 1·2G-byte hard disks. This is hermetically sealed and claimed to be shock-proofed to 5G over 2ms without data loss and over 2,000G when not operational (they know what news gathering crews can do to equipment). Sampling is 4:2:2, 8-bit, and the video is compressed at 7:1 for 15 to 20 minutes recording (future developments will include variable compression). Four channels of 48kHz/16-bit audio are also provided.

It has all the normal controls, plus facilities such as 'RetroLoop' for constant recording in a predefined loop of time, and time-lapse recording. However, its main advantage over a tape-based camcorder is that it is also a nonlinear editing system. Once the shots are on disk, they can be randomly accessed using the LCD panel and controls (see Figure 5). All clips are automatically numbered, and timecode is recorded for each frame. Any frame or clip can be viewed in the electronic viewfinder, assembled in any order, rearranged, trimmed or deleted, to build up sequences without loosing any material on the disks. The sequences can then be transmitted by microwave or satellite link back to the studio for immediate broadcasting. Alternatively, FieldPak's can be returned to the studio and inserted into a MediaDock to feed a studio nonlinear editor, insert segments into an on-air server for broadcasting or a network server for multiple access.

So it's versatile, but on the downside, a FieldPak costs over £1,000. However, it is classed as capital equipment for tax purposes, and it is expected to last for about 30,000 hours, whereas tape is disposed of after only a few uses – and professional cassettes are more expensive than consumer ones, so Avid and Ikegami would like potential users to think of it as an investment. But, even so, an alternative to expensive hard disks would obviously be welcomed – particularly if such a camcorder is ever going to gain broad acceptance and perhaps move into more cost-conscious markets. The same applies to rack-mount/desktop DDRs, which are steadily gaining acceptance in the broadcast field as alternatives to DVTRs where quick, random access to the data is desirable.

Figure 4. Block diagrams of Hitachi flash memory camcorder.

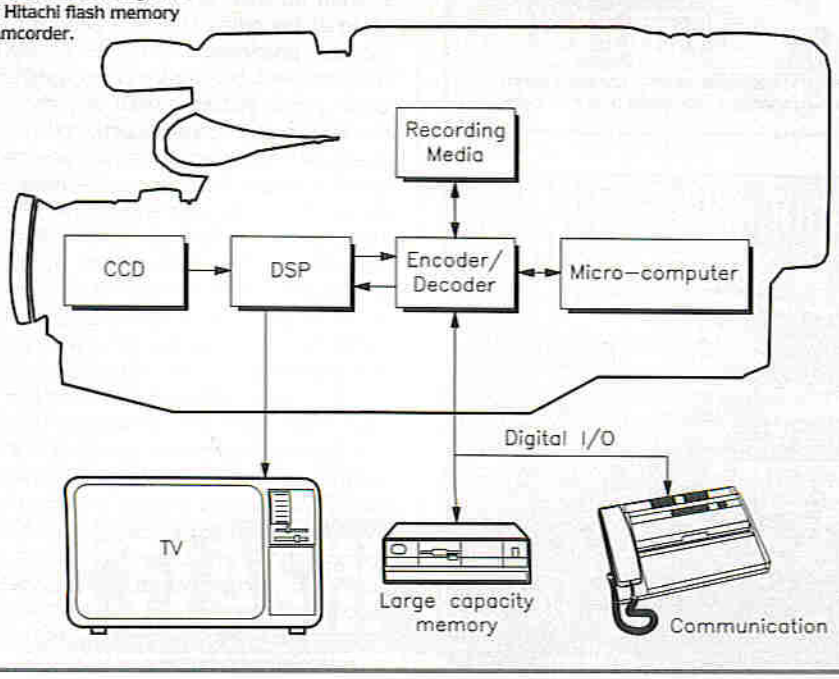
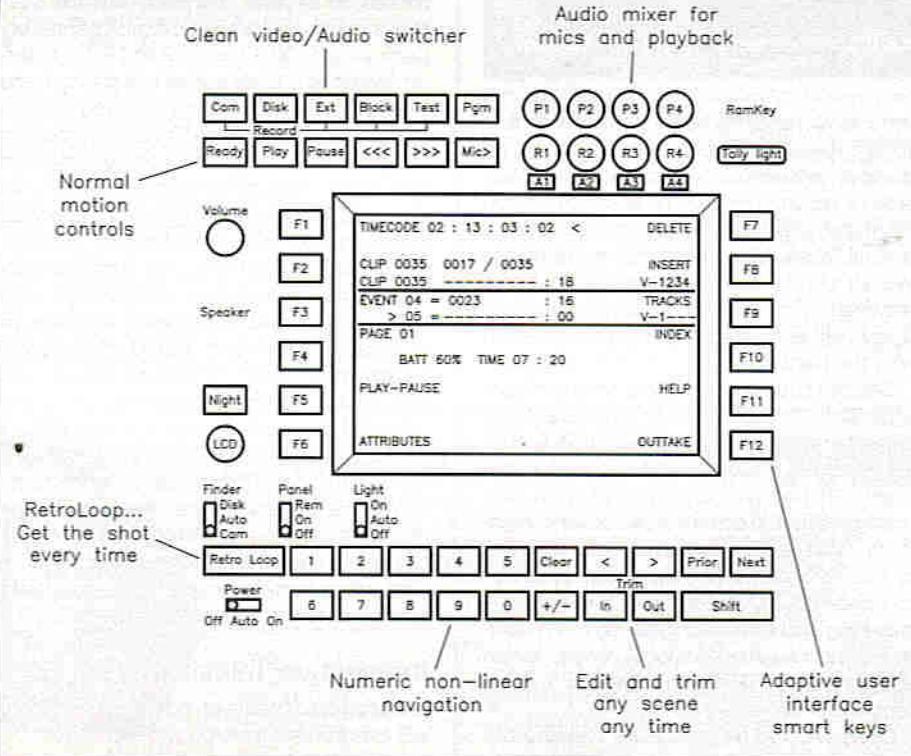


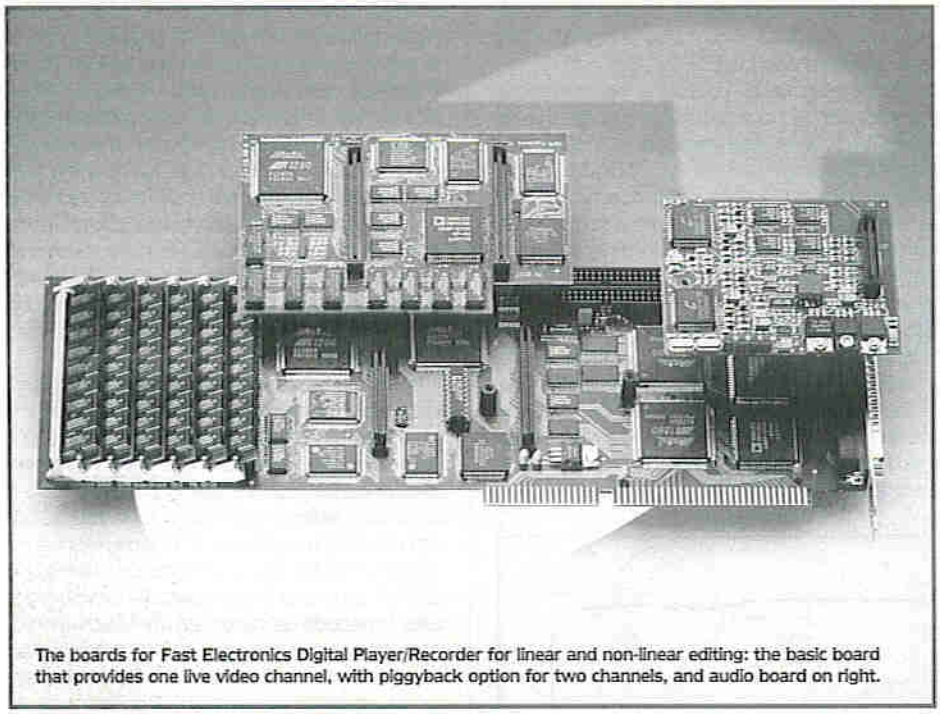
Figure 5. The control panel and LCD screen display of camcutter.



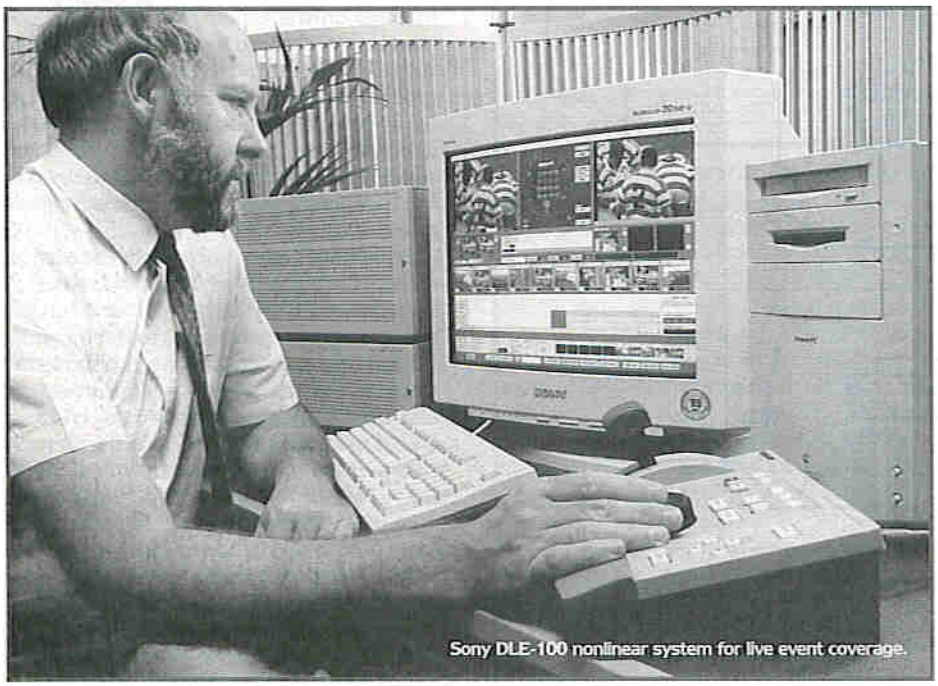
Magneto-optical (MO) Disks

One possible solution is to use rewriteable magneto-optical (MO) disks, which are about one-fifth the price of hard disks and have the advantage of being removable – but the disadvantage of being comparatively slow. However, this is exactly what Eidos has done with its new Optima nonlinear editing system for desktop use. This uses both a hard disk and 1·3G-byte MO disks. The latter's lack of speed is compensated for by Eidos' digital video compression system, 'Optimizer', which is more efficient than the commonly used Motion-JPEG (a standard developed by the Joint Photographic Experts Group, which compresses frames individually using Discrete Cosine Transforms).

As with DVTRs, nonlinear editing was originally developed for broadcast use, with systems being launched in the early 80s by companies like Avid and Quantel, and has



The boards for Fast Electronics Digital Player/Recorder for linear and non-linear editing: the basic board that provides one live video channel, with piggyback option for two channels, and audio board on right.



Sony DLE-100 nonlinear system for live event coverage.

quickly moved down the affordability scale, all the way to the consumer market. These studio and desktop video (DTV) systems employ computer hardware and software to control the post-production processes. A large capacity disk is necessary, together with plenty of RAM and a fast processor to store and manipulate the large volume of data in real time. Once the audio and video has been copied onto the hard disk(s), it can be edited randomly like the CamCutter. However, in this case, the operator has the convenience of a monitor to see what is going on, plus a keyboard and mouse for control.

Each scene can be represented by a small still image for quick identification. The position and duration of each edit in a sequence is displayed as a graphical representation on an interactive timeline, which enables rapid changes to be made to both video and audio, as well as facilitating the addition of titles, graphics and effects. And if changes don't live up to expectations, the work can be instantly returned to a previous undo level, ready to begin again. Once it is acceptable, the piece can be sent to an on-air or network server, copied onto video tape or recordable disk, or an edit decision list generated for automatic editing of original tapes. Many nonlinear systems are hybrid types that can control editing between two or more VTRs (analogue or digital), either on their own or in combination with the hard disk.

Besides their general uses, and particular application for news, other uses are being found for them, too. Sony's new DLE-100, for example, will be used for covering live events. It has two channels of hard disk storage: one for editing and showing highlights, with variable-speed control provided by the dynamic motion controller, the other to continuously record the live action – recording and rerecording for up to an hour, or five hours with additional drives. It can also control a VTR via the dynamic motion controller.

Disks will also be necessary to store the digitised video and audio for Video On Demand (VOD) services. VOD is applicable to cable services which have a high degree of interactivity with their users. A video programme chosen from a menu will be sent directly to their home, with the subscriber having the same degree of control over its running as they would when using a video recorder. To achieve this, the online server must be backed by a vast array of high capacity disks, and the signals must be compressed or the service would become unmanageable – it would also be impossible to get it down coaxial cables.

Compression will be either MPEG-1 or MPEG-2. Unlike JPEG, conceived for still image compression, the Moving Pictures Experts Group had only motion on their collective mind. With MPEG-1, compression to 1·5M-bit/s begins by reducing an interlaced frame to a noninterlaced frame of one-quarter size; intra-frame JPEG compression is then applied, and that intra-frame (or I-frame) becomes the reference for other frames; predicted frames (P-frames) are then created to predict changes that will occur in the picture – with only the actual changes being stored. Lastly, bidirectional interpolation frames (B-frames) are created, which average the changes based on information from previous and forward frames. The frequency at which the I-, P- and B-frames occur is determined during the encoding process. MPEG-1 is already used in the consumer market on disc formats like Video CD, and achieves a quality that approximates to VHS, with audio similar to DCC/Mini Disc. MPEG-2 has a higher data rate (from 2M-bit/s upwards), providing the quality necessary to cater for 16:9 widescreen and high definition (plus the facility for carrying several channels multiplexed into a single bitstream), and multiple audio channels of CD quality. It is the same as MPEG-1 in principle, so an MPEG-2 decoder can handle both, but the MPEG-2 I-frame is a full resolution interlaced frame.

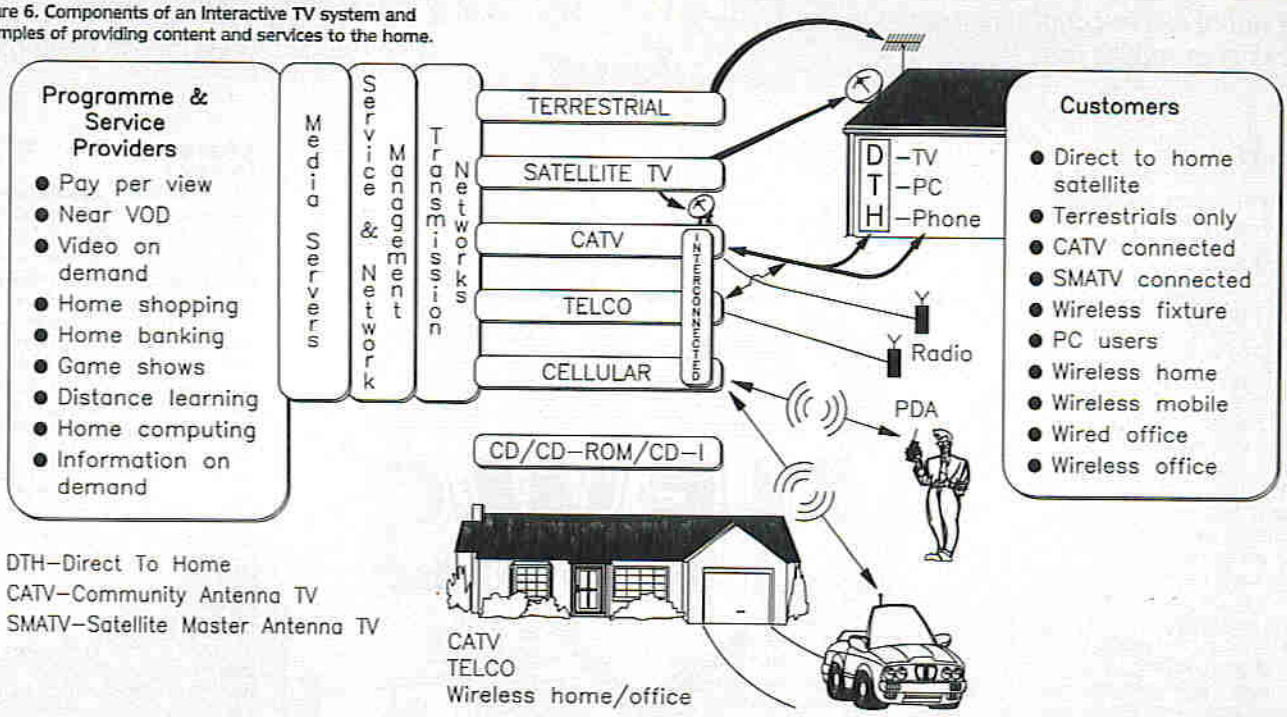
The logistical problems of VOD has rather tempered suppliers' enthusiasm, and they are now talking about Near VOD (NVOD), where the same programme can be transmitted on several channels with the start times staggered on each, e.g.,: Channel one begins at 19:00, Channel 2 at 19:15, and so on (which is equally suited to satellite transmissions). Recently, Sony showed a prototype NVOD system: the film is recorded onto MO disks, with each drive being capable of supplying 16 data streams, which when decoded, provide the 16 time-offset copies. It is expected to be available this year.

So too, is Digital Video Broadcasting (DVB), the European standard that employs MPEG-2. The first digital Astra satellite, 1E, is already in orbit and should soon be fully operational, and 1F should have been launched into orbit by the time you read this, while 1G may be launched towards the end of this year. DVB will also be the standard for digital broadband cable and digital terrestrial transmissions. Analogue transmissions are expected to continue alongside digital for the next fifteen to twenty years. First with set-top boxes for the digital video, and then dual standard TV receivers.

Interactive Television

It is predicted that such boxes and receivers will eventually converge with computers, to turn the TV into a communications centre to

Figure 6. Components of an Interactive TV system and examples of providing content and services to the home.



provide a wide range of interactive services, as well as normal and pay viewing (see Figure 6). These services will include home banking and shopping, downloading computer programmes and games, sending and receiving data and e-mail and surfing the Internet, all via a built-in or PC card modem. Optional peripherals will include printers, and optical disc drives capable of playing all the CD-based standards – including the new Digital Video Disc format. As the number of services increase, the providers of these will be able to transmit new software that will automatically upgrade the box or receiver. A number of companies have already demonstrated such set-top boxes, integrated receivers and receivers that can accept RGB signals from a computer. An alternative method is to have a central super-computer, with digital boxes and receivers being treated as network terminals. In this way, the cost would be less, and those consumers who are unfamiliar with computers will not be put off.

But it still begs the question of whether a sufficient number of people will want, or be able to afford, all these new possibilities? The future for digital video looks bright, but precisely what form it will take remains to be seen.

NEWS FLASH! NEWS FLASH! NEWS FLASH!

The Worshipful Company of Turners 1995 Design Awards

The Silver medal plus £1,000 was awarded to ex Rolls Royce engineer Leslie Dilks of DLK Design Derby for the low-cost, compact, portable potters wheel named the 'Discus'.

The design of the Discus takes advantage of modern technology, and is claimed to be the greatest advance in potters wheel design for 100 years.

The wheel is driven by the very latest electric motor technology, an extremely powerful flat 'pancake' motor only one third the height of a conventional motor.

For further information contact Leslie Dilks DLK Design Associates, Tel: (0332) 371635.

The Bronze medal plus £500 was awarded to Philip Davies and John Emmett of Design Agree, Llandarey for a cost-effective High Torque Metal Fastener System.

The High Torque Fastener System is composed of a computer generated sheet metal thread form, pierce punch and die, and a complementary buttress thread design that allows the material thickness to be matched exactly to the pitch of the screw.

The High Torque system can be used to ensure positive earthing of electrical products to a standard needed for BEAB certification, and assist compliance with current EMC regulations.

For further information contact High Torque Fastener Systems Ltd., Tel: (01792) 817800.

The Bronze medal plus £500 was also awarded to Stuart Burgess and Jonathan Khang of the Engineering Design Centre, Cambridge University for a novel rotary damper using material hysteresis.

This new type of rotary damper is primarily intended for speed control in aerospace applications and is the first to use the working principle of material hysteresis to dissipate energy.

The first prototype has been manufactured and tested with very good results. It is planned to carry out qualification tests with Matra Marconi (UK).

Entry forms for the 1996 awards can be obtained from: The Worshipful Company of Turners, c/o 27 Newbold Terrace East, Leamington Spa, Warwickshire, CV32 4ES. Contact: Nicola Linguard Tel: (01926) 336423.

Chips Are Down for Intel Users – Again

As we head for print, we receive news that Intel has admitted that its latest CPU, the Pentium Pro contains a data processing bug which greatly reduces overall processing speed. This is the second time in 18 months that Intel has had to admit to error in its processors. A floating point error in the Pentium cost the company £306 million in replacement devices.

Intel has sold around 100,000 Pentium Pro chip sets to PC manufacturers. The company reckons 1,000 to 2,000 of those may need replacing. But analysts have reacted quickly saying that Intel made similar claims about the flawed Pentium, but was later forced to exchange the chip for any user that demanded a replacement.

This is in the same week that Oracle CEO Larry Ellison showcased a prototype version of the Oracle Network Computer (NC) in front of 2,000 press on the West Coast. The NC is expected to hit the UK high street in September with a price tag of £300. Could we be about to see a shift away from the Windows/Intel dominance of the world?

A readers' forum for your views and comments. If you would like to contribute, please address your replies to:

The Editor, Electronics – The Maplin Magazine *P.O. Box 3, Rayleigh, Essex SS6 8LR, or send an e-mail to:* AYV@maplin.demon.co.uk

Dear Editor

AIR YOUR VIEWS

S·T·A·R L·E·T·T·E·R

In this issue, John Noble of Rainham in Kent, wins the Star Letter Award of a Maplin £5 Gift Token for his well-received letter.

★★★★★★★★★★★★★★★★★★★★

Dear Sir,
A friend recently gave me a couple of old issues of *Electronics* – Nos. 29 and 32, in which were articles entitled 'Exploring Radio' by Graham Dixie, together with a circuit for a simple short wave receiver. I might add here that I have been an ardent reader of the magazine since 1991. I'm 69 now, and was a very keen SWL back in the '60s and '70s, and on retiring, I have restarted this hobby. I have been using an old portable which left much to be desired, and have been on the lookout for a simple set to build – construction also being one of my hobbies in the dim past. I have always been interested in the more basic receivers, to be able to scrape the last bit out of the ether and finally succeed in deciphering a signal deep in the murk is to me, success. Radio hamming these days seems to depend more on one's depth of wallet than on capability and skill. I must admit though, I was not overly impressed when I studied the circuit, but being pushed for cash, I decided to have a bash at building it. Amazingly, it worked first time (which was rather unusual with anything I built in the past!) Admittedly, I did have to do a lot of fiddling about winding coils, but finally got it working successfully over two bands, 3 to 5MHz and 5 to 10MHz, and the results were outstanding when you consider what this little receiver consists of. I have fond memories of one-valvers in the old days, but this set leaves them standing. However, I have two complaints. First, I cannot get the full claimed 2W audio output, although the earphone side works a treat. Second, though I've wound dozens of coils, I cannot get my favourite band, the old 160m Top Band. Is it possible that there was a mistake made in the original circuit to explain the lack of power? I would be very interested to hear from other people who have built this circuit, to hear their comments and compare notes. I decided I would try an S-meter on it, and bought Howes' DCS2 S-meter kit. Though this works quite well, I find the current drain very heavy – can anyone provide a simple alternative circuit I could use, please? So far, I have received France, Canada, America, Austria, Radio Prague, Radio Finland, Kol Israel, Radio Sofia, Radio Korea, Radio Beijing, Radio Sweden, Deutsche Welle, Brussels, Netherlands Vatican, Norway, Russia, Bosnia, Radio Japan, Radio Budapest, Voice of Free China, Turkey, and a load of American religious programs. My antenna is a 60ft. long wire, 25ft. high, and I'm presently building an ATU. Not a bad collection for a simple set, eh? Whoever designed it should be very proud of their efforts, and I thought I'd let you know you have a satisfied reader!

Good to hear that you have managed to obtain such an impressive reception coverage from this simple receiver. The audio amplifier output stage of this circuit, based on the TBA820M 2W (into 8Ω) amplifier IC, is printed as per the manufacturer's data sheet building block circuit, with the only difference being the addition of the volume control on the input to this stage. A lack of output power, assuming the power supply to be adequate, could be because of a faulty IC, or perhaps the volume potentiometer. You could try directly connecting the input of the audio amplifier (pin 3) to the junction between R2 and L3, via a suitable decoupling capacitor (e.g., 100nF), which would identify whether the problem was down to the potentiometer or the IC. If any readers can help with Mr Noble's requests, we will gladly pass on your information.

★★★★★★★★★★★★★★★★★★★★

Chaos Theory

Dear Sir,
My cheap RS-BX404, bought with my student grant (that's what the grant is really for!) is playing the misaligned game with the tapes! However, an idea just came to me regarding the dispute about CDs, tapes and records, i.e. how CDs are inferior (or so they say) in sound quality to the other two. Notice how a pure sine wave is painful to the ears, and also how old synthesizers were judged on how many oscillators they used? Notice also how most musical instruments (including the human voice) employ some sort of pitch bending. Additionally, people complain about electronic music, and how it is just *too* perfect. The thing about tapes and records is that they have mechanical sources of 'pitch bending'. You will never get a tape transport mechanism that will have zero flutter, or a turntable and stylus which are 100% correct; the turntable for speed and the stylus for the correct reading of the grooves in a record. Now I think that the perfection of CDs make them sound too perfect. By all means, a recording medium should be 'flat', in that what goes in must come out exactly the same. However, humans have non-perfect ears – our hearing is nonlinear. There has to be some additional properties involved (which I would term 'psycho-sonic'). I would also add that people who really love CDs (not for their ease of use, but for purely sonic qualities) are not as warm in personality as human beings should be. They like things to be predictable, precise and clear. No chaos, now wrinkles, no humanity, no LIFE! They have such hatred of all things old and/or imperfect – well, I'm sure you know the sort! What I suggest is that the next generation of CD players have what I would term 'warmth generators'; just some form of very complex harmonic generator circuit. The CD itself should be left as it is, since we want the information to be as 'perfect' as possible. And no, it's not the bandwidth that is the problem; most tape decks only get up to 10kHz flat, and they sound fine. Ironically, I am suggesting that we actually put distortion back into CDs, albeit of the right sort.
V. Ago, Stanley, County Durham.

The issue of the relative pros and cons of alternative forms of sound recording media is a highly subjective one, though many have criticised CDs of giving a sound that is too clinical, but then those paying for the extra cost of a CD generally expect perfection! A switchable 'warmth generator' circuit built into the playback machine would be a very worthwhile feature. In the meantime, the Sound Check CD is worth looking at in order to see just what your CD player, amplifier and loudspeakers are capable of. True high-fidelity is all too often lost in the reverberations and the mixing process of commercial recordings.

Charge!

Dear Sir,
With regard to the feature 'New Battery Technology' in the March issue, I must dispute some of the information in the article. Firstly, the 'fact' that primary cells cannot be recharged and will explode if any attempt is made to do so. If this is the case, why are several chargers available commercially? With pulse charging techniques, primary cells can be recharged or perhaps regenerated to a limited extent. Dry cells can be recharged, but only a few times, up to 10 times seems to be an accepted figure. Secondly, the stated self-discharge rate for Ni-MH cells of 2 weeks sounds rather severe, though I have seen a figure of a month being suggested. Last year, I purchased eight Ni-MH cells and charged them using my constant current Ni-Cd charger for 16 hours at 120mA. Nearly 2 months later, having been used for fairly short periods at irregular intervals, they are still in use without a recharge. The cells in question are 'Super Synchro 1100', which as their name suggests, are 1100mAh capacity. One final comment on 'dry cell' charging, I have seen reports that it is ILLEGAL in Japan to claim that they cannot be recharged, and that they will explode.
M. L. Peake, Bilston, West Midlands.

Regarding the self-discharge rate of Nickel-Metal Hydride (Ni-MH) cells, the article states that "it might be expected that a fully charged cell might self-discharge over a period of about two weeks". This indicates that this would be the worst case that is likely to be found with this type of cell – the majority will retain their charge for longer than this, as in your case. Interesting to hear of the Japanese law regarding warnings on batteries; as the saying goes, not a lot of people know that – with exception of battery manufacturers themselves, perhaps!

Swiss Watch

Dear Sir,
I borrowed a couple of last year's *Electronics* magazines from a friend (Jan/Feb 1995 issues), and was pleasantly surprised when reading through them, particularly the awareness of light pollution. As an amateur astronomer and electronics engineer, it is nice to see the blend in your magazines that others don't do. As a member of the 'Campaign for Dark Skies' and various Astronomical Associations, and with 25 years of astronomy experience, it is apparent that much seeing has been lost by uneducated and inconsiderate illumination spill. It is good that you make the point clear to others who are not so conversant with the laws of physics. Your message does reach other parts, not just within the contiguous UK. Let's hope that others can take note for a worthwhile cause that doesn't pollute, disturb or make noise. I say with remorse and regret that whilst living here in Switzerland, it is surprising that nothing has been done about sky glare, only to say that "where money speaks, ignorance and selfishness glare". Eventually, the word will get across.
R. Walters, Ebikon, Switzerland.

Hopefully, publication of your letter will help 'get the word across' about light pollution and its effects.

Hot Tip

Dear Sir,
Firstly, I would like to say how great the magazine is (it must be, because I've been a subscriber for about two and a half years), although I would like to make a few comments on the Maplin Catalogue. Firstly, I do not like the way you have got rid of all the pinout diagrams for the logic, timer and computer ICs. These are very useful, and I have had to keep my previous catalogue for this information. Secondly, you boast that the catalogue has a few hundred more pages than last time, but I have noticed several things repeated many times throughout the catalogue which could easily take up the room. Moving on to a totally different subject, the other day when I was making a PCB, I noticed that once the board is etched, you can wipe a hot, tinned soldering iron over the etch resist, which burns off the etch resist and leaves you with a 'tinned' board, just like professional boards, and then any residue can be cleaned away with a solvent. This can take time, but adds that extra bit of quality and durability to the board. Another thing is that I cannot afford an oscilloscope, and I would be very pleased if you could develop a kit, costing around £50, that you could connect up to a standard television. I expect this would be appreciated by many people, and rate highly in the kit chart (if you bring it back that is).
Oliver Lindley, Buckfastleigh, Devon.

Thank you for your allegiance to the magazine. We have received many comments about the latest Catalogue, some extremely favourable, while others, like yourself, bemoan the removal of the IC pinout data to make room for a wider product range. However, the good news is that for the next Catalogue, it is highly likely that this information will be replaced at the end of the semiconductors section. The more commonly employed, and perhaps easier method of tinning a PCB, is to use a polishing block (e.g., HX04E) or etch resist remover (such as HX03D) to remove the remaining etch resist from the tracks, then to dip the board in tinning solution for a minute or so (depending on the concentration of the solution) – this gives a very even, albeit thin coating. An oscilloscope operating on a TV set is a good idea for a project, although problems are presented in achieving sufficient resolution and accuracy of the waveform trace and division grid, compared to using a dedicated screen built into the 'scope. However, used single-trace 'scopes are available at around the £50 mark from surplus stores or through classified adverts, which are fine for many general-purpose measurement applications. There are no plans, as yet, to resurrect the kit chart!

Geiger Counter

I was disappointed to see that Ian Poole still insists on perpetuating the myth that 'primary cells' are not rechargeable. This is not the case. The fact that "chargers are not on sale" is a half-truth, since they are readily available in Japan. The reason they are not widely available here is that a primary cell can be recharged up to twenty times. If chargers were on sale, battery sales would plummet by a factor of 15, say. Since batteries are big business, it is in companies' interests not to let on that they are rechargeable, so they print warnings on the batteries themselves, trying to dissuade you from this practice. Anyone who inadvertently left a pair of old batteries in a personal stereo, and then powered it from a battery eliminator, would find that the batteries had been recharged, provided they were not discharged too severely or for too long. I am not advocating that this is the way o recharge these batteries, but it shows it is possible. Most batteries these days have safety vents, etc., which means an explosion is highly unlikely in any case, and the warning is just scaremongering.
I hope in future that you will stop perpetuating the myth yourselves, and come up with a project that charges *all* batteries, not just the Ni-Cd type.
A. Geiger, Cambridge.

It is true that there are chargers on the market specifically designed to recharge primary cells, and that most of these batteries are, in fact, rechargeable, though usually only a couple of times before they become incapable of storing a charge for long – twenty times seems rather optimistic. However, not all primary cells will withstand recharging – some are quite likely to explode, even on the first attempt at recharging them, or at least burst their seals with resulting discharge of corrosive chemicals, and possibly toxic gasses. This seems particularly applicable, for some reason, to the smaller cells, such as watch or penlight batteries. The majority of appliances that feature battery or mains adaptor operation have a jack plug arrangement that disconnects the batteries purposely to prevent charging via the adaptor, so perhaps your personal stereo has a fault! It is inadvisable to use a normal charger, or battery eliminator for the purpose of charging these batteries, and certainly never leave them unattended if attempting to recharge them, as it is not unknown for them to react in a way which could initiate a fire. For safety reasons, if attempting to recharge primary cells, charge them in a well-ventilated environment far away from anything flammable, check them regularly for signs of distress – and be prepared to switch off the charger quickly if the need arises!

NEWS Report

Exclusive PDA Design

Psion has introduced a limited edition of its Series 3a PDA for the more discerning user. The word on the street is that the machine has a smooth, wood-effect finish and is available in a 2M-byte version only.

The look and feel of the new machine is designed to raise eyebrows, but if you want one, don't hang around. The limited edition machine will be available in the UK now through usual Psion stockists, including Dixons, Duty Free outlets, Widget Software and Harrods, priced at a cool £449.95 including VAT.

Contact: Psion, Tel: (0990) 143050.

Magellan GPS 3000

Magellan Systems was founded on the vision of 'Bringing GPS Down to Earth', their mission to create affordable GPS positioning and navigation products for people the world over. Over the past six years, Magellan have refined and expanded their range of GPS equipment (while also making it ever more affordable), and have a new product line for 1996.

For a dedicated marine unit, with all the features, the new GPS 3000 (Stock Code BV45Y) is an ideal choice. It offers everything a navigator needs in one easy to use, pocket-sized unit.

The optional power/data/external antenna kit (EL10L) enables you to connect to a 12V DC external power supply, and to output NMEA data to drive an autopilot or other NMEA-compatible equipment.

Rugged, durable and weatherproof, the GPS 3000 is differential ready. It features an internal antenna, and runs for up to 17 continuous hours on just 4 × 'AA' alkaline batteries (JY48C).

Contact: Maplin Technical Sales, Tel: (01702) 554161.

Engineering Awards

The Engineering Council Young Engineers for Britain contest is open for entries from teams of project engineers for 1996. The teams that reach the national finals in London in September will compete for prizes totalling £20,000.

Meanwhile, a top prize of £5,000 is at stake in this year's Engineering Council Environmental Award for Engineers. The award is open to registered Chartered Engineers, Incorporated Engineers and Engineering technicians, or to teams which include a registered member. Entrants must have been responsible for the design, manufacture, or construction of an engineering project or process which provides a solution to an environmental problem.

Further details and entry forms for both competitions can be obtained from the Engineering Council.

Contact: Engineering Council, Tel: (0171) 240 7891.

Mobile Market to Boom

If you are trying to get individuals within your household to spend less time on the phone, you might as well forget it. According to a Euromonitor report, it will soon be mobile phone bills that you'll be concerned with.

Euromonitor estimates that by the year 2000, there will be around 271·4 million mobile phone subscribers in the world, representing a staggering growth of 226·5 million between 1995 and 2000.

In year 2000, Euromonitor estimates the global mobile phone industry will be worth US$141·7 billion, a growth of 65·9% since 1995. Between 1995 and 2000, the market will be increasingly dominated by service revenues over equipment sales.

Contact: Euromonitor, (0171) 251 0814.

Home PC Users Want More Power than Business

There is an unusual shift taking place in the home market. Home users are beginning to demand more power and functionality than in business, and if Apricot's latest multimedia PC is anything to go by, it is a trend which is set to continue.

The Apricot MS530 has been developed in conjunction with Apricot's parent company, Mitusbishi.

The machine includes a Pentium 133MHz processor, 17in. Mitusbishi monitor, 16M-byte RAM, 1·3G-byte hard disk, v.32bis modem, 16-bit sound card, quad-speed CD-ROM, stereo speakers, and integrated TV with remote control. Also bundled with this top specification PC is stacks of software – but that's the least you'd expect with a price tag of £2,495 plus VAT.

The MS530 is available from PC World. For further details, check: **http://www.apricot.co.uk**.

Contact: Apricot, Tel: (0121) 717 0132.

Chip Set to Improve Disk Drive Times

Philips Semiconductors has launched a family of devices for the disk drive industry that applies the decision feedback equalisation (DFE) approach to signal processing. The TDA99XX family detects and interprets, and if necessary, corrects signals recorded on magnetic media from the disk drive head. Philips claim the devices will enable faster read/write times by intelligently compensating for non-linearities inherent in disk drive recording.

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

Fourth Quarter Complaints

The Radio Authority (RA) has published its Complaints Bulletin for the fourth quarter of 1995. The Bulletin gives details of the 135 programming and advertising issues which gave rise to written complaints during this quarter, of these, the RA upheld 15 programming complaints and 13 advertising complaints.

Contact: Radio Authority, Tel: (0171) 430 2724.

Game Over for Computer Thieves

Computer theft is the UK's fastest growing crime, affecting over one in four companies. Last year, it cost British firms over £200million, twice as much as in 1993, and the figure is still rising fast.

The thieves know what they are after, and often target computer memory boards and processor chips, leaving behind a trail of smashed computers. Stolen memory chips retain 80% of their legitimate saleable value on the black market, resulting in a stolen 4M-byte chip fetching around £80.

Game Over, a Buckinghamshire-based company, is looking to buck these trends, and has introduced a series of full encasement units, manufactured in 2mm thick steel sheet which is designed to deter and delay the would-be theft. The encasement units are suitable for tower and desktop computers, and are designed to blend in with modern office furniture.

But beware – protection does not come cheap. Prices for the Game Over cases start at £195 for a single unit. Contact the company for specification details and costs.

Contact: Game Over, Tel: (01628) 486999.

Cyrix Moves Ahead of Intel

Cyrix has rolled out three new members of its Intel P6 killer, 6x86 processor family: the 6x86-P133+, the 6x86-P150+ and the 6x86-P166+. Bench tests of the 6x86-P150+ and the 6x86-P166+ by analyst firm MDR Labs at MicroDesign Resources, place the 6x86 processor approximately 5% ahead of its rival Intel Pentium processor in terms of performance.

For further details of the 6x86 report, check: **http://www.chipanalyst.com**. For further details of the Cyrix range, check: **http://www.cyrix.com**.

Contact: Cyrix, Tel: (01793) 417777

Digital ARMs Next Generation PDAs

Digital this month announced the availability of its SA-110 StrongARM microprocessor, billed as the first processor to combine the performance of a supercomputer with power dissipation low enough to run on 'AA' batteries.

The SA-110 microprocessor is the first member of the StrongARM family resulting from the architecture licence agreement between Digital and Advanced RISC Machines (ARM), developer of the ARM 32-bit RISC architecture. "Combining ARM's low-power architecture with Digital's high-performance processor design expertise and CMOS process leadership has created a new paradigm for embedded consumer electronics products", said Robin Saxby, president and CEO, ARM.

Industry watchers see a bright future for the StrongARM technology According to Jim Turley, senior analyst, Microprocessor Report, "The SA-110 StrongARM processor is a technical tour de force and a milestone for both Digital Semiconductor and the ARM architecture. It offers a nearly unbeatable combination of performance, price and power consumption."

"The design of the SA-110 StrongARM chip has clearly involved PDA developers, smart phone manufacturers, set-top box suppliers, and even companies exploring the Internet computer. This type of foresight heralds a new wave of mobile products which meet consumers' real needs", said Tim Bajarin, president, Creative Strategies International.

For further details of the StrongARM technology, check: **http://www.digital.com/info/semiconductor or http://www.arm.com**.

Contact: Digital, Tel: (01743) 868711; Advanced RISC Machines, Tel: (01223) 400400.

CD-ROM Sales Rocket

Worldwide CD-ROM drive sales totalled 38·7 million units across all computer and TV set-top platforms in 1995, up 140% over 1994. This represents the fifth straight year of triple-digit year-over-year sell through growth, according to preliminary figures released by InfoTech. Europe had the highest regional growth rate in 1995, up 273% over 1994, but more than 50% of CD-ROM drive units were sold in America.

The single greatest contributor to growth was the high rate of CD-ROM incorporation in desktop PCs, with OEM sales accounting for almost 70% of total CD-ROM units in 1995. The attachment rate of CD-ROM on new consumer PCs is now approaching 95%, while remaining well under 50% for business PCs. Through year-end 1995, the combined worldwide installed base of CD-ROM drives on PC desktop, server, and workstation platforms is 54·7 million.

Contact: InfoTech, Tel: (+1) 802 763 2097.

Chip Cooling Improves Performance

Superconductor Technologies has announced a US$3million order from Commercial Data Servers (CDS) for the company's cryogenic cooling subsystem. The coolers will be used to cool the central processing unit (CPU) and related circuitry of CDS's servers to provide clock speeds up to 50% higher than other methods.

Superconductor Technologies claim that its cryogenic cooling device can increase workstation and server speeds by up to 50%. The improved performance is achieved by cooling the CPU and associated circuitry to at least –55°C.

Current systems utilise forced-air convection to provide heat dissipation. However, as systems increase to the 250 to 300MHz range, they can require as much as 50W of dissipation, which is difficult to achieve using conventional methods.

Contact: Superconductor Technologies, Tel: (+1) 805 683 7646.

Rugged PC

The design of a new PC from Bytech Systems is based an original US army prototype. The 1·4kg HARDBODY hand-held PC is intended to bring high-technology capabilities to traditionally low-tech environments, such as mining or offshore drilling.

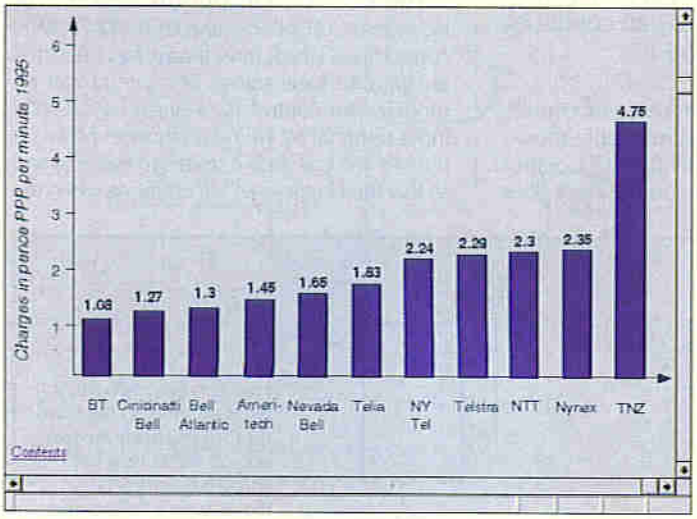
The machine features a 75MHz Intel 486 DX4 processor, a 260M-byte hard disk drive and 8 to 32M-byte of random access memory. It will run for up to 8 hours on standard Duracell rechargeable batteries.

Contact: Bytech Systems, Tel: (01344) 55333.

International Telecom Report

BT is top of the pack in terms of cost when it comes international telephone calls. This is the conclusion of a study of international interconnect prices from analysts Ovum. BT commissioned the study as a defensive action against Oftel's forthcoming revision of the BT price cap regime. The study compared international charges across six countries: Australia, Japan, New Zealand, Sweden, UK and USA. For further details of the study, check: **http://www.ovum.com**.

Contact: Ovum, Tel: (0171) 255 2670.



Paperless Office Moves Closer to Reality

Compaq has launched a combined scanner and keyboard. The keyboard will come as a standard feature with Compaq's Presario model 7226 PC, and will also be offered as an option for use with other industry standards.

The scanner-keyboard integrates a high performance scanner with a high-quality keyboard, featuring Windows '95 keys. The scanner supports an optical resolution of 200dpi horizontally and 400dpi vertically. The scanner keyboard is compatible with 486-based PCs or higher, Windows 3.1, Windows for Workgroups 3.11, or Windows '95, and requires a minimum of 8M-byte of RAM. The scanner keyboard connects to the serial port; no ISA card is required.

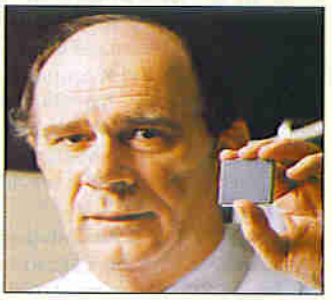
The Scanner-keyboard is available immediately for £275. For further details, check: **http://www.compaq.com**.

Contact: Compaq, Tel: (0181) 332 3000.

Voice, Fax and Data Modem

A 28·8K-bit/s v.34 version of US Robotic's Sportster modem is now available, priced £199 plus VAT. The modem includes voicemail and fax on demand features.

Contact: US Robotics, Tel: (01734) 228200.



Unattended PC Power Switch

The Rhea Group has launched a power switch designed to allow you to turn off your PC overnight and at weekends, and yet be certain of receiving faxes whatever the time of the day or night. Bundled with the proprietary EcoFax software package, the Power-Switch will detect an incoming call, determine whether it is a fax or phone call, power-up the PC, receive the fax, and power-down the PC on completion.

Contact: The Rhea Group, Tel: (01626) 331510.

PC Buyers' Guide

In what must be a deliberate sales ploy, Carrera Technology has released a Home and Office PC Guide, containing advice on what to look for when buying a PC. The guide has been produced as part of Carrera's campaign to educate and support customers in all aspects of PC technology, from purchase to day-to-day use, and increase sales, we have no doubt.

Contact: Carrera Technology, Tel: (0171) 830 0486.

Cambridge Bedfellows Target Education

Acorn and the ailing Apple are climbing into bed together, to develop products for the UK education market. The Cambridge-based joint venture will kick-off in April, with the initial priority to develop products and technologies that increase the interoperability of RISC OS and Apple technology. For further details, check **http://www.apple.com** or **http://www.acorn.co.uk**.

Contact: Acorn, Tel: (01223) 254254; Apple, Tel: (0181) 569 1199.

GPT Giant

The largest microchip being used anywhere in the telecommunications industry has been designed and incorporated into Synchronous Digital Hierarchy (SDH) equipment now being supplied to telecom providers by GPT.

The device is used by the company's SMA multiplexers – part of the SDH family, which sends and receives vast amounts of digital information across the copper or optical fibre lines in a telecommunications network.

The applications specific integrated circuit (ASIC) device has 376 connecting pins and measures 40 × 40mm. At its heart is a circuit containing over half a million electronic gates.

Each of the chip's pins are soldered to corresponding positions on the printed circuit board (PCB) at the company's New Horizon Park site in Coventry. However, because of the number of pins and the minute spacing between each one (only 0·4mm) the manufacturing process had to be completely reworked to accommodate the new component.

A combined development project headed by GPT drew together the Japanese chip manufacturers NEC and Toshiba and the makers of the printed circuit boards ISL, based in South Shields, to respond to the challenge.

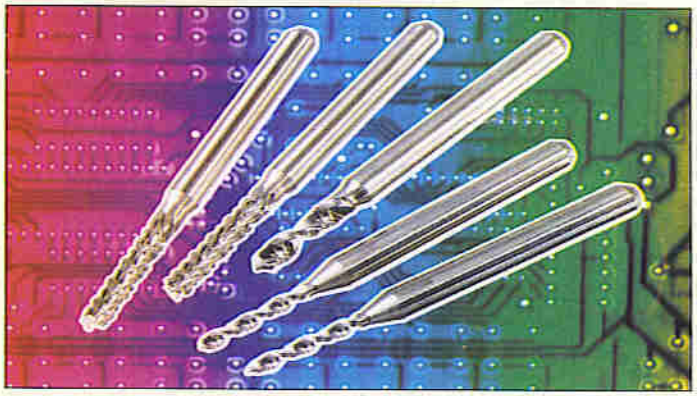
Contact: GPT, Tel: (0115) 9430300.

Toughened Drills

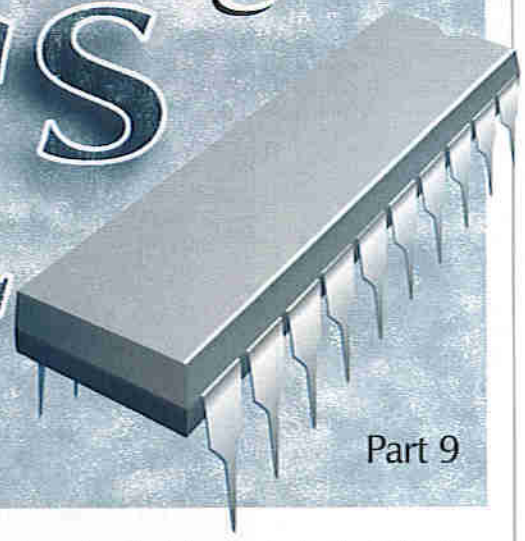
Anybody that has attempted to produce prototype printed circuit boards (PCBs) will know that drilling out the component holes can be a frustrating process. Unless you opt for high quality drill bits, they will continually snap mid-hole. Even tungsten tipped drills will become weak after approximately 100 holes.

Following a deal between US firm Sphinx and Peak Test Services, it is now possible to purchase solid tungsten carbide drills in the UK. The drills are available in standard flute length of 10mm, and drill sizes from 0·2 to 7mm in steps of 0·05mm.

Contact: Peak Test Services, Tel: (01799) 520022.



A Practical Guide to Modern Digital ICs



by Ray Marston

Part 9

Last month, Part 8 of this series took a detailed look at clocked flip-flop principles and at some practical flip-flop and 'counter' circuits. This part continues this theme by looking at special 'Down' and 'Up/Down' counter ICs.

Back to Basics

Last month's part also explained how D-type and JK-type flip-flops work and described how a D-type can be made to act as a binary divide-by-two stage by connecting its D and $\overline{Q}$ terminals together, as shown in Figure 1(a), and a JK-type can be made to act in the same way by tying its J and K terminals to logic-1, as shown in Figure 1(b). Note, from the symbols of these diagrams, that the D-type's actions are triggered by the rising-edges of the clock signals, and the JK's are triggered by falling-edges.

Figure 2 shows how D-type or JK-type divider stages can be cascaded to make ripple-mode binary counters, in which the output of the first stage is used to clock the input of the second stage, and so on, for however many stages there are. In rising-edge triggered D-type circuits, the clock pulses are taken from $\overline{Q}$ outputs, as shown in (a), but in falling-edge triggered JK-type circuits, they are taken from Q outputs, as in (b). Both circuits have the same Q-output truth table, which for a 2-stage ripple counter is as shown in (c); note that the 4-step Q2-Q1 sequential binary coded outputs correspond with normal binary coded decimal (BCD) coding, and run 0-1-2-3-0-etc., as the clock goes through cycles 0-1-2-3-0-etc.

Thus, the Figure 2 type of counter gives a sequentially upwards-counting clocking cycle, which repeatedly runs from 0 to 3 in a 2-bit counter, or 0 to 7 in a 3-bit counter, and so on. Consequently, all circuits of this basic type are known as 'up' counters, irrespective of their bit-count or whether they give a synchronous or asynchronous type of clocking action.

The counting action of a ripple counter can be reversed, so that it counts 'downwards' rather than 'upwards' by using the basic connections shown in Figure 3, in which the clocking output of each stage is taken from the complement of that used in Figure 2 (i.e. from Q rather than $\overline{Q}$, or *vice versa*). A 2-bit counter of this type generates the truth table shown in (c), in which the sequential BCD output coding runs 3-2-1-0-3-etc., as the clock goes through cycles 0-1-2-3-0-etc. This type of counter gives a sequentially downwards-counting clocking cycle, which repeatedly runs from 3 to 0 in a 2-bit counter, or 7 to 0 in a 3-bit counter, and so on. Therefore, all circuits of this basic type are known as 'down' counters, irrespective of their bit-count or whether they give a synchronous or asynchronous type of clocking action.

A ripple counter can be configured to count in either direction by fitting it with gate-controlled clock-source options, as shown in the JK-type example of Figure 4. Here, when the COUNT-UP line is biased to logic-1 and the COUNT-DOWN line is biased to logic-0, the G1 and G4 AND gates are enabled and pass 'Q' clock signals to FF2 and FF3 (etc.), but gates G2 and G5 are disabled and block the $\overline{Q}$ signals; the circuit thus acts like that of Figure 2(b) under this condition, and gives an 'up' counting action. However, when the COUNT-DOWN line is biased to logic-1 and COUNT-UP is at logic-0, the G1 and G4 gates are disabled and G2 and G5 are enabled. These pass $\overline{Q}$ clock signals, and under this condition, the circuit acts like that of Figure 3(b) and gives a 'down' counting action. All circuits of this basic type are known as 'up/down' counters, irrespective of their bit-count or their precise form of construction, etc.

The Figure 4 UP/DOWN circuit uses individual COUNT-UP and COUNT-DOWN control lines, which must always be connected in opposite logic states. The circuit can be modified for control via a single UP/DOWN input terminal by wiring an inverter between the two lines, as shown dotted in the diagram, so that the circuit gives UP counting when the

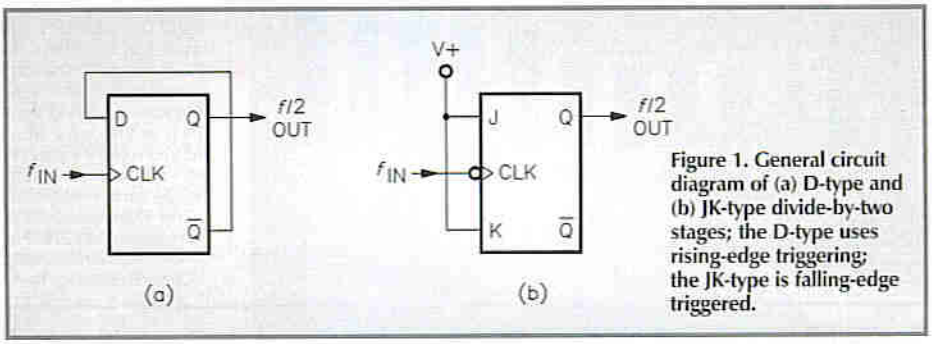


Figure 1. General circuit diagram of (a) D-type and (b) JK-type divide-by-two stages; the D-type uses rising-edge triggering; the JK-type is falling-edge triggered.

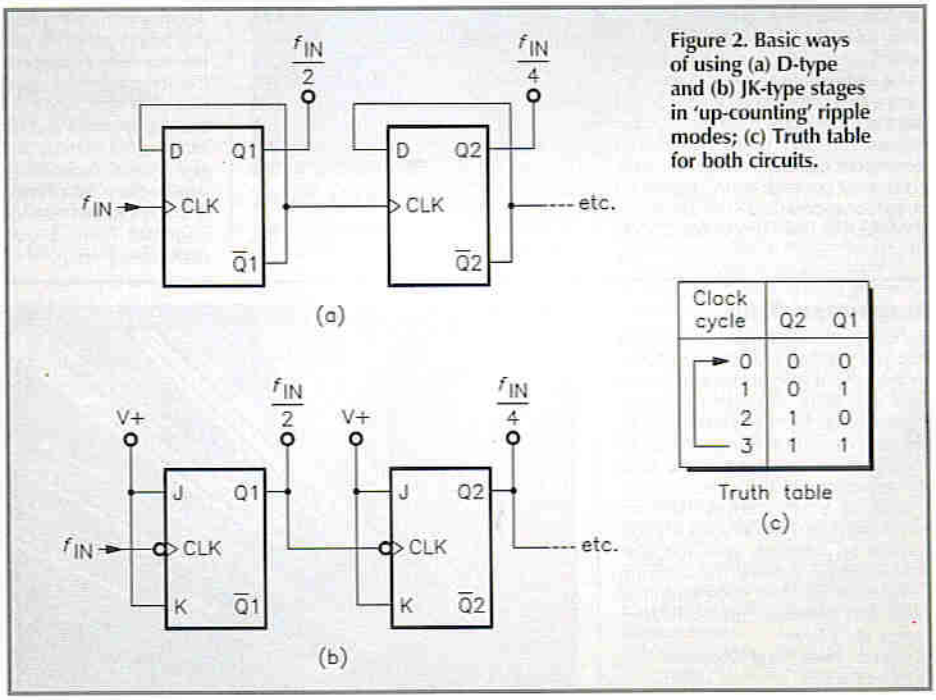


Figure 2. Basic ways of using (a) D-type and (b) JK-type stages in 'up-counting' ripple modes; (c) Truth table for both circuits.

Clock cycle	Q2	Q1
0	0	0
1	0	1
2	1	0
3	1	1

Truth table

(c)

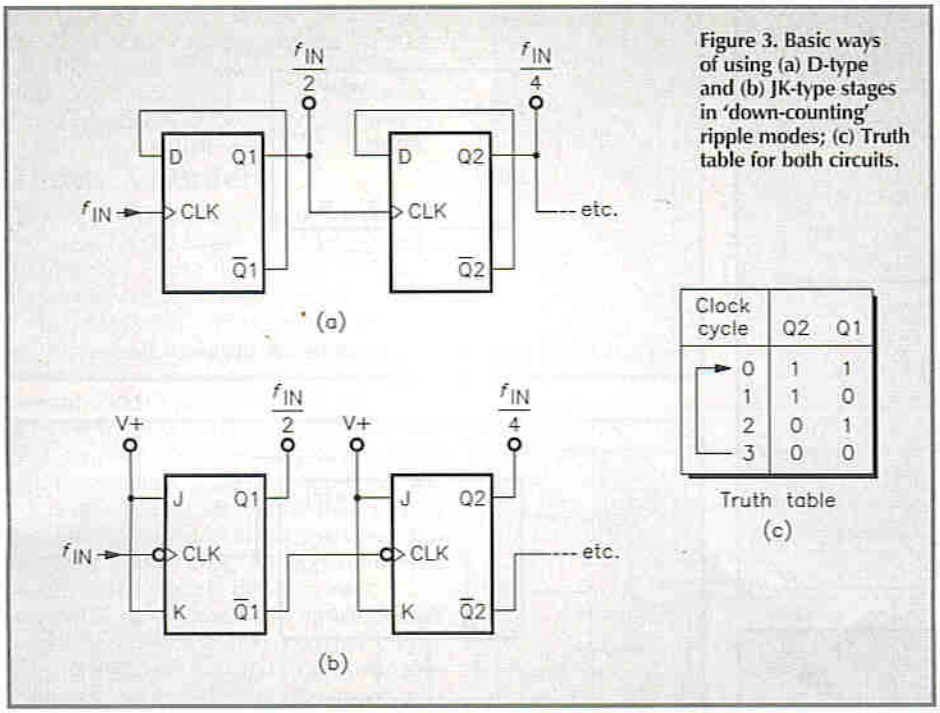


Figure 3. Basic ways of using (a) D-type and (b) JK-type stages in 'down-counting' ripple modes; (c) Truth table for both circuits.

Clock cycle	Q2	Q1
0	1	1
1	1	0
2	0	1
3	0	0

Truth table
(c)

upper line is biased to logic-1, and DOWN counting when it is biased to logic-0. Some UP/DOWN counters use two clock lines, one for UP counting and the other for DOWN counting; these counters are internally similar to the type shown in Figure 4, but have the clock and direction-control lines effectively combined via logic networks that control the clock feed to FF1 and all other flip-flop stages.

Thus, the electronics engineer has many options when designing modern counter/divider circuits. The usual option is to use a conventional synchronous or asynchronous up-counting IC, and many of the finer points of this subject were covered last month. There are also the options of using DOWN or UP/DOWN counters; both of these options are dealt with later in this article, but first it is necessary to look at yet another option, that of using 'programmable' counter/divider ICs.

'Programmable' Counters

All conventional 'up' counters are provided with a RESET facility that enables their 'Q' outputs to be set to zero at any time, thus giving a BCD '0' output. This facility is (as described last month) also useful in enabling the counter's 'divide-by' figure to be preset to any desired value, *N*, by connecting the outputs back to the RESET terminal. The outputs then reset to the BCD '0' state on the arrival of every *N*th clock pulse, but a weakness here is that the IC has to be hardwired to give a specific divide-by figure, and this sometimes involves the use of external gating circuitry, etc. One way around this snag is to provide the IC with an additional PROGRAMMING control that enables its outputs to be set to any desired binary values when the control is activated.

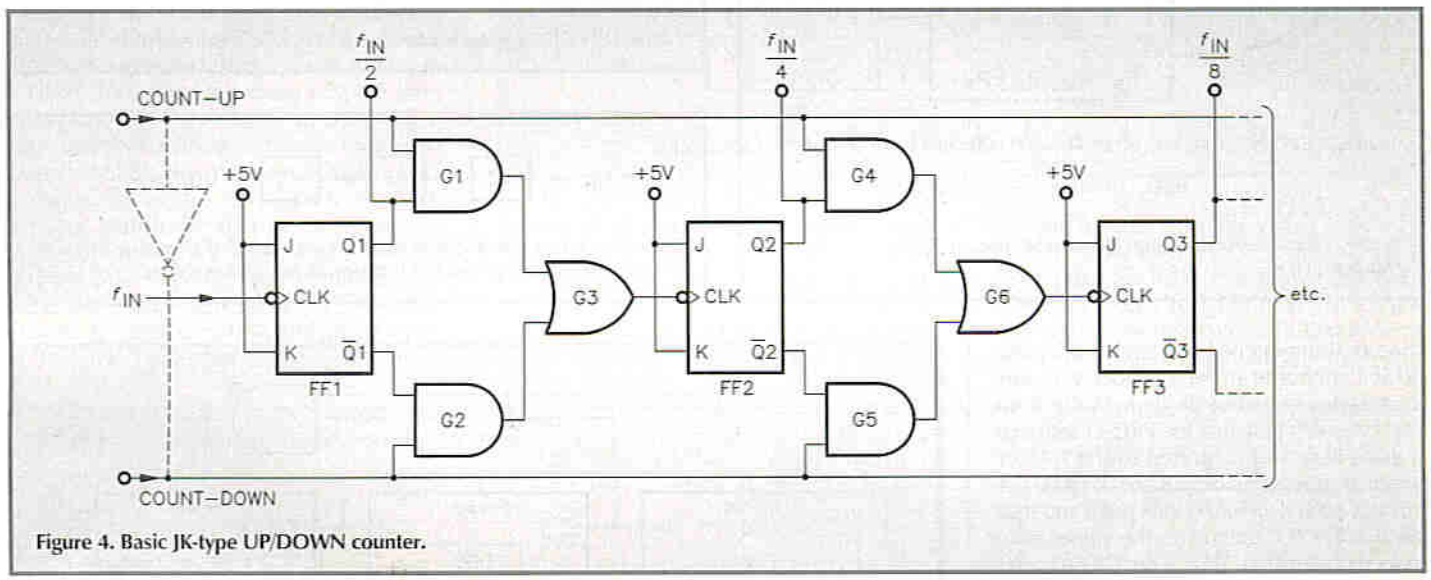


Figure 4. Basic JK-type UP/DOWN counter.

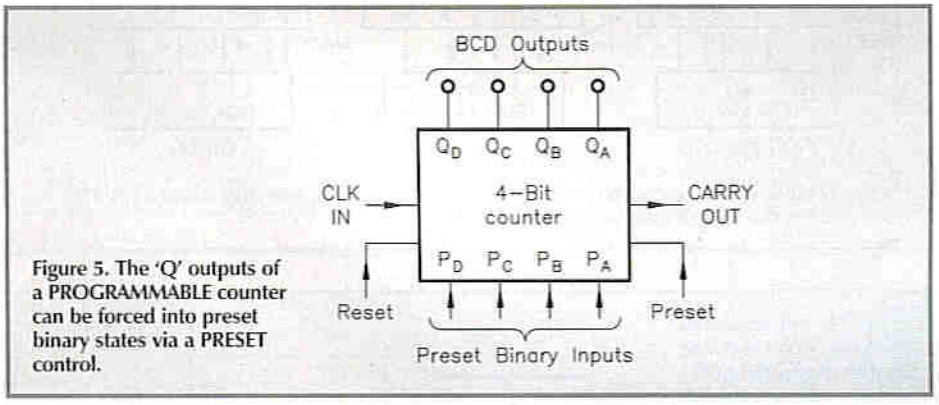


Figure 5. The 'Q' outputs of a PROGRAMMABLE counter can be forced into preset binary states via a PRESET control.

Figure 5 illustrates the basic idea behind the programmable counter. Here, any desired 4-bit binary code can be applied to the IC's four 'P' terminals, and the IC's 4-bit output is forced to agree with this code whenever the PRESET control is activated. In practice, this type of IC may be known as a 'programmable' or 'presettable' counter, its input facilities may be named PRESET, PARALLEL LOAD or JAM controls, and the controls may be activated by a logic-0 or logic-1 input, or by rising or falling clock edges, etc., depending on the individual device and its manufacturer. In all cases, however, these devices operate in the basic way described earlier.

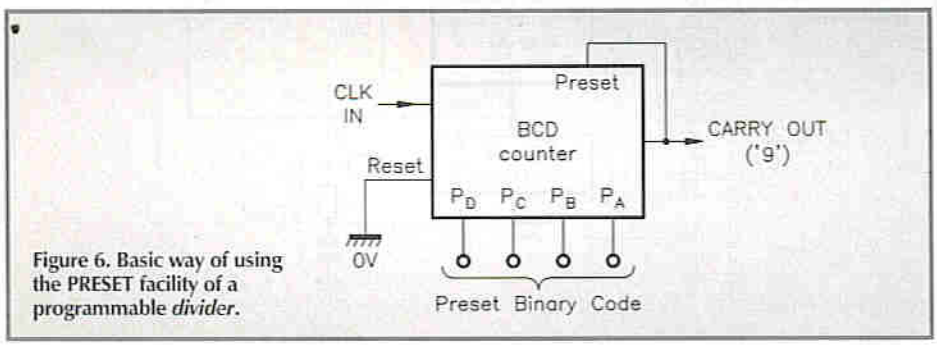


Figure 6. Basic way of using the PRESET facility of a programmable *divider*.

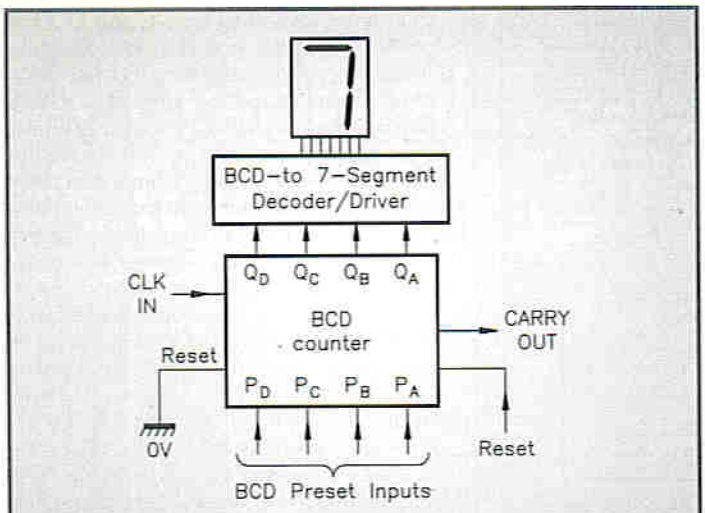


Figure 7. Basic way of using the PRESET facility of a programmable *counter*.

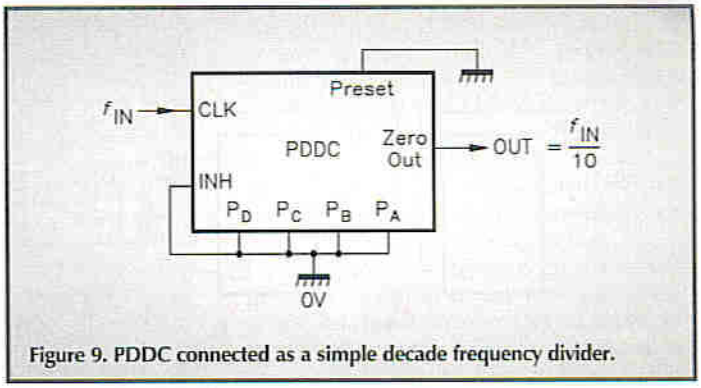


Figure 9. PDDC connected as a simple decade frequency divider.

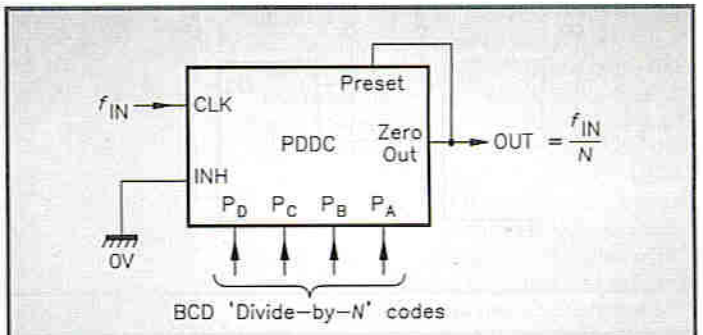


Figure 10. PDDC connected as a programmable frequency divider.

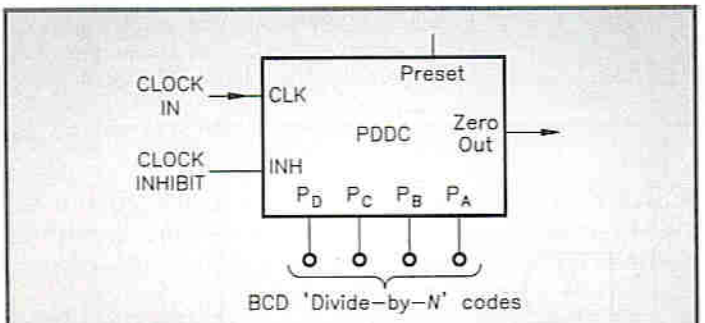


Figure 8. Basic features of a programmable decade 'down' counter (PDDC).

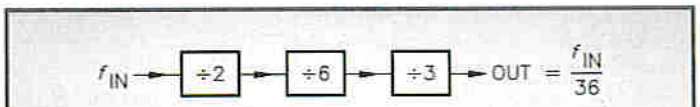


Figure 11. When conventional counters are cascaded they give a final output equal to the product of the individual division values.

Figure 6 shows one basic way of using the PRESET control to make a divider with any desired whole-number 'divide-by' value from 2 to 9. Assume here that the PRESET terminal is active-high and is shorted to the CARRY output as shown; this output goes high on the arrival of each decimal-9 clock pulse and thus sets the IC's 'Q' outputs to the preset state under this condition. Thus, if the DCBA preset inputs are set to '0000' the IC will go through a 0-1-2-3-4-5-6-7-8-0-etc. counting cycle and thus give a divide-by-9 action, but if they are preset to '0010' (decimal-2), the IC will go through a 2-3-4-5-6-7-8-2-etc. counting cycle and thus give a divide-by-7 action, and so on. This type of divider thus goes through X-to-8 counting cycles, where X is the number set on the DCBA preset inputs; note that this action is useful in a divider, but of little value in a decade counter (in which counting usually starts from zero).

Figure 7 shows one basic way of using the PRESET function in a counter. Here, the 7-segment readout displays the current preset BCD number while the PRESET control is activated, and the counter then counts up from that number when the PRESET control is deactivated; the BCD inputs may be derived from special switches, or may be taken from the BCD outputs of a slowly clocked up/down counter, etc. This latter technique is of special value in time-setting electronic clocks, etc.

Yet another use of the PRESET facility is as a master RESET control if the normal RESET is in permanent use as a 'divide-by' controller; in this case, the preset binary code is simply set to '0000'.

Several 74LS-series 'up' counter ICs are provided with 'programmable' PRESET facilities.

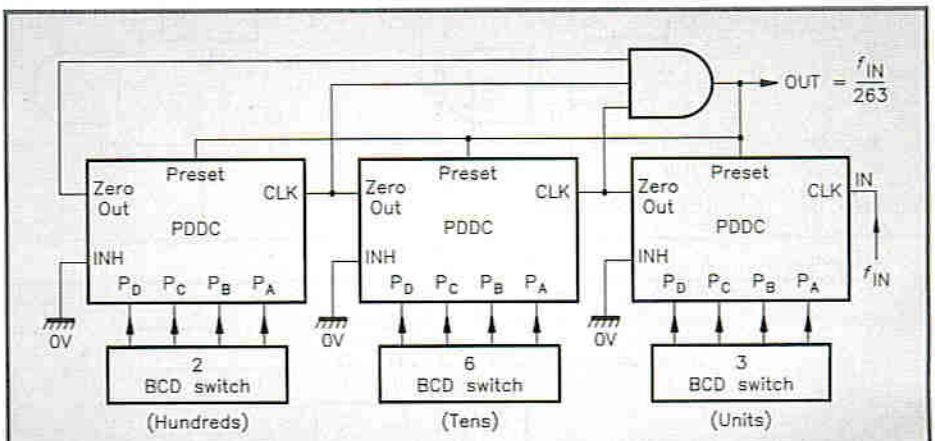
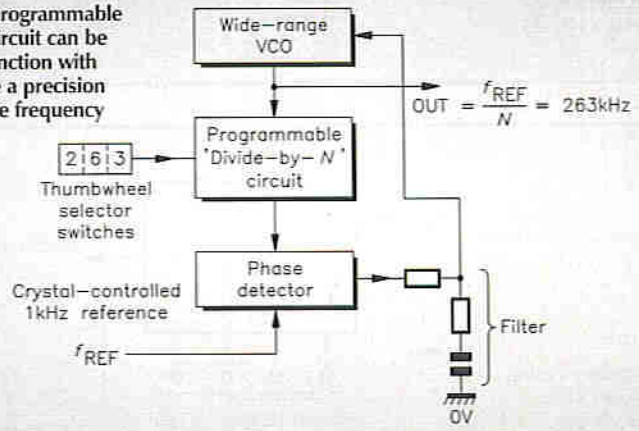


Figure 12. When PDDCs are wired in the 'decade cascaded' mode, they give a final 'divide-by' value equal to the SUM of their individual DECADE values.

Figure 13. A programmable divide-by-*N* circuit can be used in conjunction with a PLL to make a precision programmable frequency synthesizer.



Amongst them are the 74LS160, 74LS162 and 74LS196 decade counters, and the 74LS161, 74LS163 and 74LS197 4-bit binary counters. Most 'down' and 'up/down' counter/divider ICs are provided with 'programming' facilities.

'Down' Counters

'Down' counters are very specialised devices, and *ideally* should have the basic facilities illustrated in Figure 8. Namely, they must be programmable (presettable) and have a special output that activates when the 'zero' count is reached, plus an input that inhibits the clocking action when activated. In the diagram, PRESET and INH (clock inhibit) are assumed to be active-high, and the ZERO OUT terminal goes high only when ZERO count is reached. In the following text and diagrams only, decade (rather than binary) versions of these devices are considered, and the abbreviation 'PDDC' is used to indicate a programmable decade down counter.

A PDDC can be used as a simple decade divider by connecting it as shown in Figure 9, with its PRESET and INH controls, etc. grounded, so that the counter repeatedly cycles through its basic BCD count, from 9 to 0 and then back to 9 again, and so on. The output, taken from the ZERO OUT terminal, goes high for one full clock cycle in every ten.

Figure 10 shows how to use a PDDC in its most important mode, as a programmable frequency divider. Here, the divide-by-*N* code is applied to the preset terminals and PRESET is controlled by the ZERO OUT terminal. Suppose that at the start of the count, the BCD number 4 has been preset into the counter. On the arrival of the first clock pulse, the counter decrements to 3, on the second pulse to 2, on the third to 1, and on the fourth to 0, at which point the ZERO OUT terminal goes high and presets the BCD number 4 back into the counter, so the whole sequence starts over again and ZERO OUT goes back low. Thus, the PDDC repeatedly counts by the number (4) set on the preset inputs, and the output (from the ZERO OUT terminal) takes the form of a narrow pulse with a width of a few tens on nanoseconds.

Note that the really important thing about the circuit shown in Figure 10 is that it automatically divides by whatever BCD number is set on the preset terminals (compare this

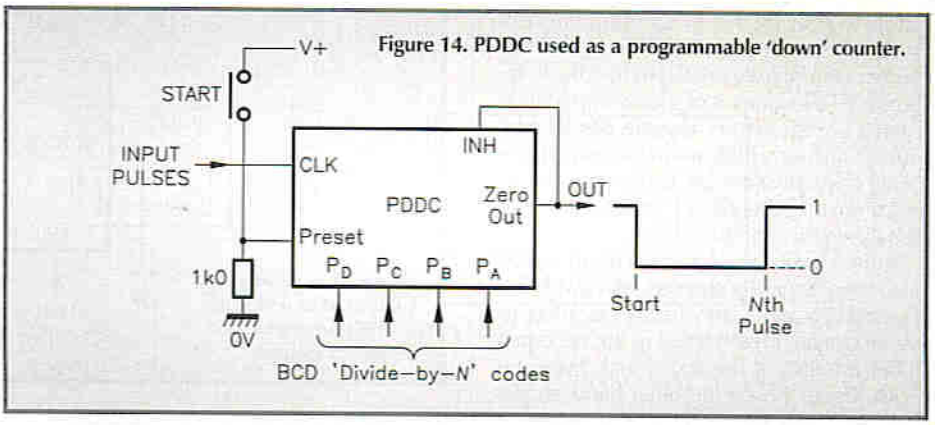


Figure 14. PDDC used as a programmable 'down' counter.

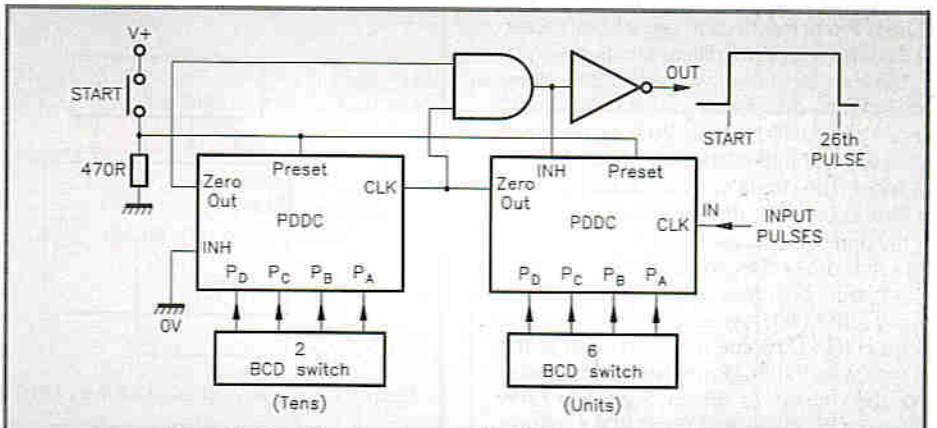


Figure 15. Two-decade programmable 'down' counter, set for count-26 operation.

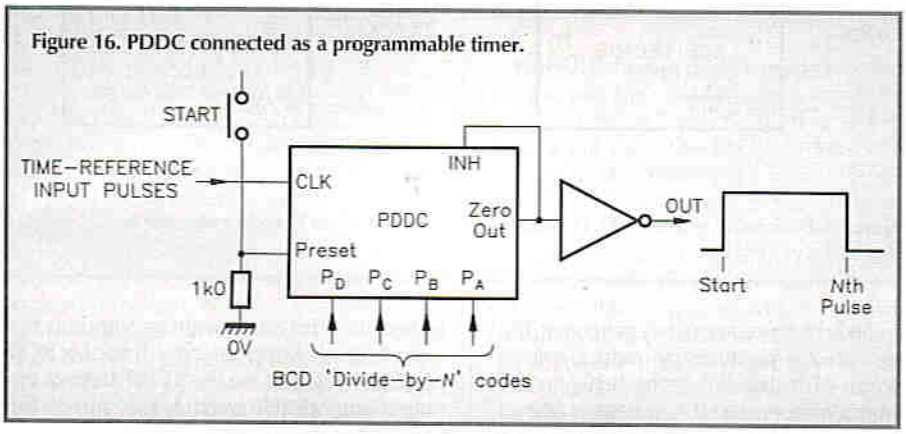


Figure 16. PDDC connected as a programmable timer.

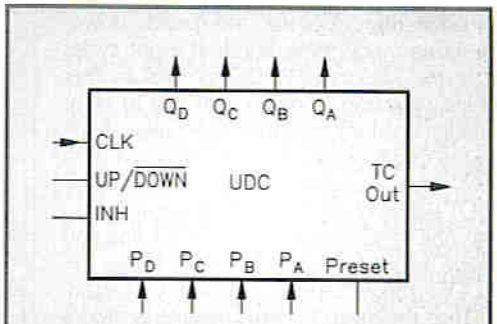


Figure 17. Basic features of a conventional UP/DOWN counter (UDC).

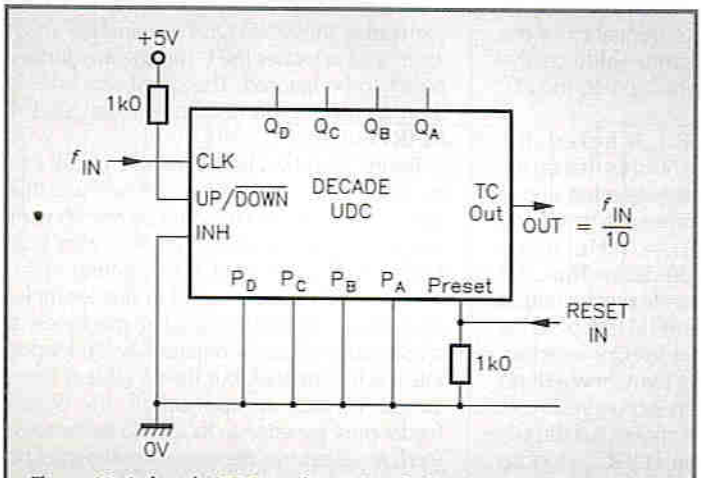


Figure 18. A decade UDC used as a simple decade 'up'-counter/divider.

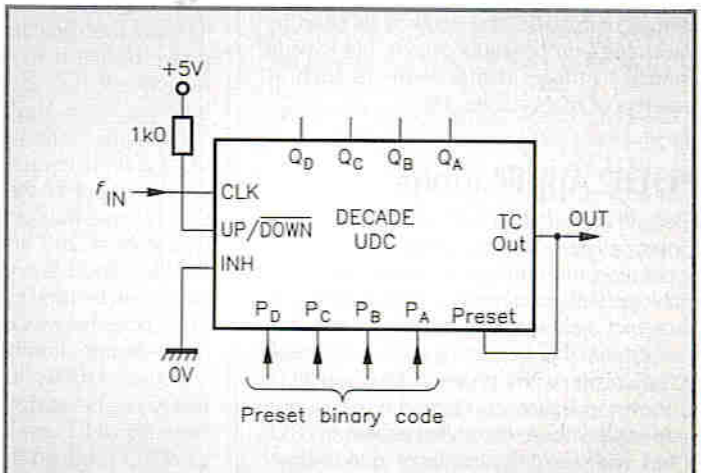


Figure 19. A decade UDC used as a programmable 'up'-divider.

action to that of the programmable 'up' divider of Figure 6, in which the preset BCD number is complexly related to the divide-by number). This feature is of special importance in what are known as 'decade cascadable' counter/divider applications, in which the overall division values are easily and directly programmable; Figures 11 and 12 illustrate the salient points of the subject.

Figure 11 shows a basic circuit in which three conventional 'up' counters, with 'divide-by' values of 2, 6 and 3, are directly cascaded, to give an overall division value of 36, i.e. equal to the *product* of the individual divide-by values. Figure 12, on the other hand, shows what happens when PDDCs with divide-by values of (reading from left to right) 2, 6 and 3 are wired in the 'decade cascadable' mode; in this case, the overall divide-by value is equal to the *sum* of the individual *decade* values, and (since the decades are graded in 'hundreds', 'tens', and 'units') equals 263, or whatever other 3-digit number is set up on the PRESET switches. The circuit operates as follows:

Note in Figure 12, that the ZERO OUT signals of the three PDDCs are fed to a 3-input AND gate that drives the PRESET and OUT lines, which thus becomes active only when all three ZERO OUT signals coincide. With this point in mind, assume that at the start of the count cycle, the BCD number 263 is loaded into the counters as shown. For the first few counts in the cycle, the 'units' PDDC counts from 3 down to 0 and then goes into the normal '9-to-0' decade down-counting mode, passing a clock pulse on to the 'tens' PDDC each time the '0' state is reached. Thus, the 'tens' PDDC receives its first clock pulse after three input cycles and counts down from 6 to 5, but from then on, is clocked down one step for every ten input cycles, until its own count falls to zero, at which point, it passes a clock pulse on to the 'hundreds' counter and simultaneously goes into the decade down-counting mode. One hundred input cycles later, the 'hundreds' PDDC receives another clock pulse and its own count falls to zero; another one hundred input cycles later (on the 263rd count of the cycle) it receives a third clock pulse, and at that instant, the ZERO OUT signals of all three PDDCs are active, so the AND gate activates the PRESET line and loads the BCD number 263 back into the PDDCs, the whole sequence starts over again.

Thus, the Figure 12 circuit repeatedly divides by 263 or whatever other three-decade number is programmed in, and produces a narrow output pulse (from the AND gate) on completion of each 'divide-by-263' counting cycle. This output pulse is only a few tens of nanoseconds wide (the width is dictated by the circuit's propagation delays), but is wide enough to trigger digital elements such as counters or monostables, etc.

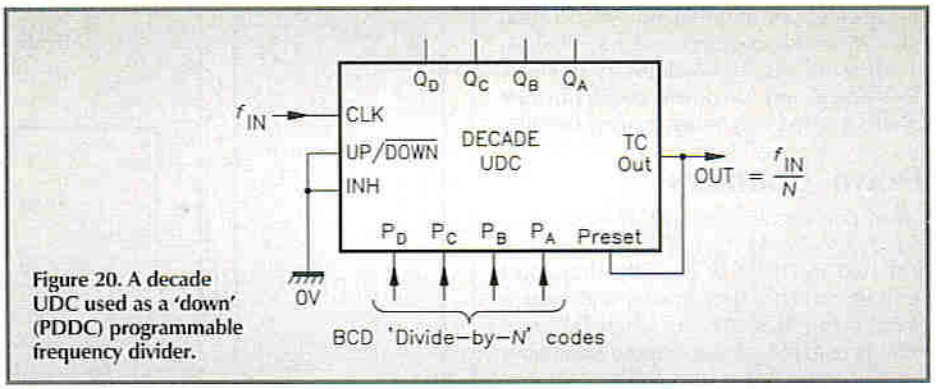


Figure 20. A decade UDC used as a 'down' (PDDC) programmable frequency divider.

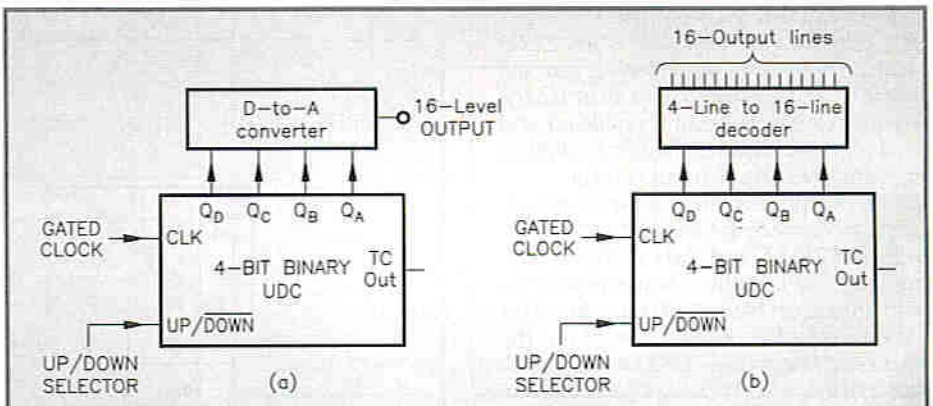


Figure 21. Basic ways of using a Binary UDC as (a) a DAC driver or (b) a multiline selector.

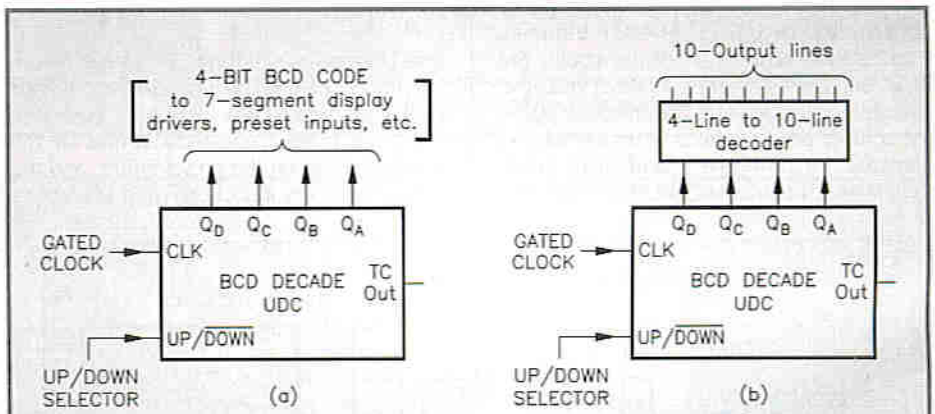


Figure 22. Basic ways of using a BCD decade UDC as (a) a 4-Bit BCD code generator or (b) a multiline selector.

PDDC Applications

'Decade cascaded' PDDC circuits of the type shown in Figure 12 have important practical application in frequency synthesis, programmable counting, and programmable timing. In frequency synthesis, the PDDCs are wired as a programmable frequency divider and used in conjunction with a phase-locked loop (PLL), as shown in Figure 13. Here, the output of a wide-range voltage-controlled oscillator (VCO) is fed, via the programmable divide-by-*N* counter, to one input of a phase detector, which has its other input taken from a crystal-controlled reference frequency generator. The phase detector produces an output voltage proportional to the difference between the two input frequencies; this voltage is filtered and fed back to the VCO control in such a way that the VCO automatically self-adjusts to bring the variable input frequency of the phase detector to the same value as the reference frequency, at which point, the PLL is said to be 'locked'.

Note that when the PLL is locked, the VCO's output frequency is *N* times that on the variable input of the phase detector, and is thus *N* times that of the reference generator, e.g., if $N = 263$ and $f_{REF} = 1kHz$, $f_{OUT} = 263kHz$, and has crystal precision. Thus, this circuit can be used to generate precise output frequencies that are variable in 1kHz steps via the three-decade thumbwheel selector switches.

Figure 14 shows, in basic form, how a single PDDC can be used as a 1-to-9 counting circuit. Here, the INH terminal is connected directly to ZERO OUT, so that the PDDC's clocking action is inhibited when the PDDC is in the '0' counting state; normally, the circuit is locked into this state, with its output at the logic-1 level. Suppose now that the BCD number 6 is preset via the START button; the output immediately switches low, and on the arrival of each clock pulse, the PDDC counts down one step until finally, on the arrival of the sixth pulse, the ZERO OUT terminal goes high again and activates INH, causing any further pulses to be ignored. The count sequence is then complete, but can be restarted via the START button.

Figure 15 shows how the basic circuit can be turned into a useful two-decade unit that can be programmed to count by any number up to 99 and has an output that goes high for the full duration of the counting cycle. This type of circuit is useful in (for example) controlling automatic packing machines in applications where *N* objects have to loaded into each container, but the *N* value is often varied. In such an application, the object feeder must generate a clock pulse each time it feeds an object into the container, and must be so arranged that it directs its feed to the next container when the first one is registered 'full'.

Finally, Figure 16 shows, in basic form, how the simple Figure 14 circuit can be made to act as a programmable timer with an output that goes high as the START button is pressed but then goes low again a preset time later. Here, the clock signal (which ideally should be synchronized with the START signal) is taken from a time-reference source (e.g., 1 pulse per second or minute, etc.) This basic circuit can be expanded to two-decades by using connections similar to those of Figure 15.

If you want to build a PDDC circuit in TTL form, you will have to do so using an 'up/down' counter in its 'down' mode, for the simple reason that no dedicated 'down' counters are available in the TTL range. They are, however, available in CMOS forms, as the 4522B 'Single' and the 40102B and 74HC40102 'Dual' ICs.

'Up/Down' Counters

'Up/down' counters are the most versatile of all counter types. They are invariably programmable and synchronous in operation, are available in both BCD decade and 4-bit binary counting forms, and in most cases, have the basic facilities shown in Figure 17. That is, they have PRESET inputs and a full set of 'Q' outputs, can be set to clock 'up' or 'down' via a single UP/$\overline{\text{DOWN}}$ terminal, have a clock inhibit (INH) facility, and a 'TC OUT' output that becomes active when the counter reaches its Terminal Count ('0' in down-counting mode, '9' in decade up-counting mode). The 74LS192 (BCD decade) and 74LS193 (4-bit binary) up/down counters differ from this norm in that they use separate 'up' and 'down' clocks and have no master INH facility, but are otherwise similar. Individual IC types differ mainly in their pin terminology (the $\overline{\text{INH}}$ terminal may, for example, be named $\overline{\text{ENABLE}}$ or CARRY IN, etc.) and in their details of use, i.e. INH or TC OUT may be active-high on one IC type and active-low on another, etc.

Up/down counter ICs are often available at such low cost that they can be used instead of normal or programmable 'up' or 'down' counters in many applications; they are also, of course, invaluable in many add/subtract and up/down differential counting applications, etc. Figures 18 to 25 show a selection of different ways of using the basic Figure 17 up/down counter; in these diagrams, it is assumed that the INH, PRESET and TC OUT controls are active-high, and that the IC counts 'up' when the UP/not-DOWN control is biased high, and 'down' when it is biased low.

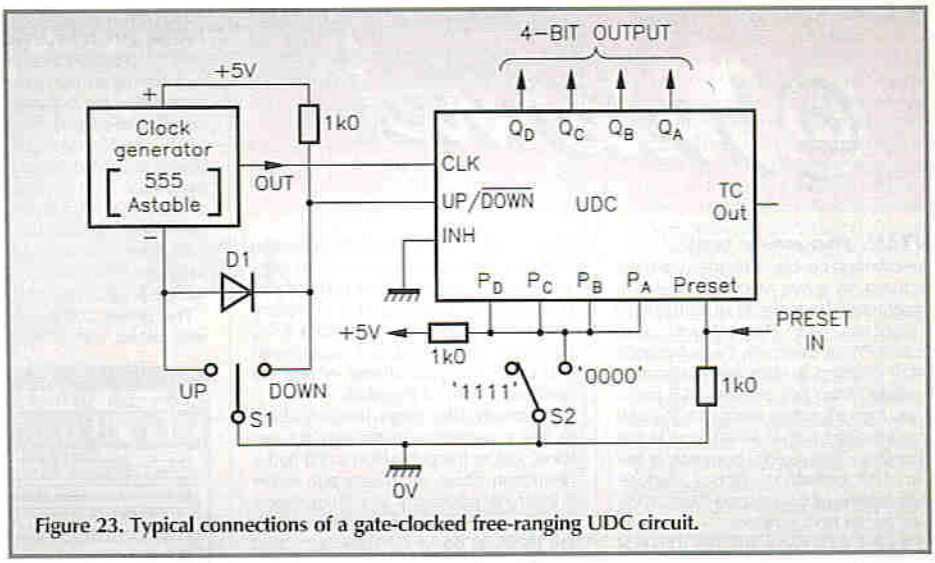


Figure 23. Typical connections of a gate-clocked free-ranging UDC circuit.

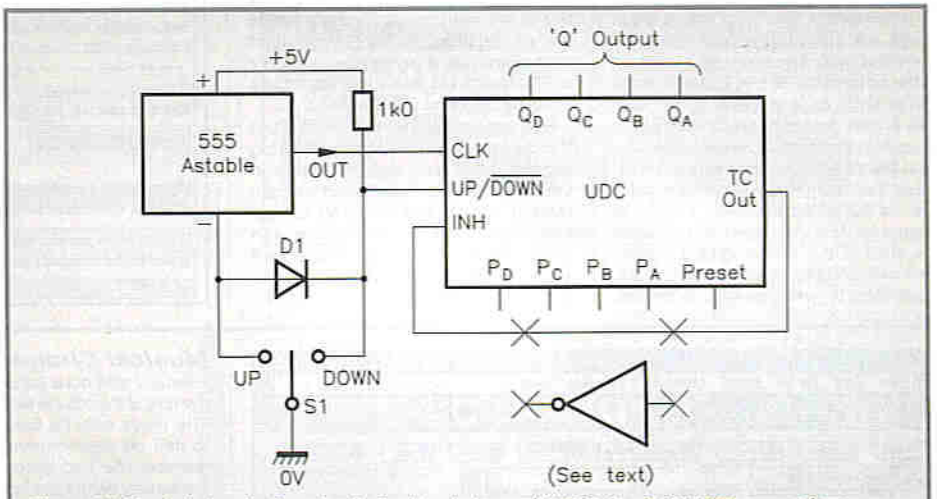


Figure 24. Typical circuit of a gate-clocked 'end-stopped' UDC circuit (PRESET connections not shown).

Figure 18 shows a decade up/down counter used as a simple decade 'up' counter/divider; note that PRESET can be used as a RESET control that forces the outputs into the '0000' state when it is taken high. Figure 19 shows the up/down counter used as a programmable 'up' divider of the Figure 6 type, and Figure 20 shows it wired as a programmable frequency divider of the far more useful Figure 10 down-counting PDDC type, in which the divide-by value equals the BCD value set on the programming terminals; this basic down-counter circuit can easily be used in the decade cascaded modes show in Figures 12and 15, etc.

Figure 21 shows, in basic form, how a 4-bit Binary UDC can be used as (a) a digital-to-analogue converter (DAC) driver or (b) a multiline selector. In the case of the DAC driver, this produces sixteen selectable output voltage levels when driven by the 4-bit Binary UDC as shown, or 256 levels if two UDCs are cascaded to give 8-bit DAC drive; these output voltage levels can easily be used to control sound levels or lamp brightness, etc., via suitable adaptor circuitry. The circuit shown in (b) can be used as a multiline selector, in which only one of the sixteen output lines is active (usually active-low) at any one time, by using the UDC to drive a 4-line to 16-line decoder as shown, or it can be used like a single-pole 16-way switch by using it to drive a CMOS analogue switch IC such as the 4067B, etc.

Figure 22 shows, in basic form, how a BCD decade UDC can be used as (a) a 4-bit BCD code generator or (b) a multiline selector. In the case of the BCD code generator, note that the BCD code can be used to drive PRESET inputs and/or 7-segment digital displays, etc., and is thus useful in the time-setting of clocks and presetting of counters or dividers, etc. Circuit (b) can be used in the same ways as the multiline selector of Figure 21, but gives only ten outputs; note, however, that its BCD output can be used to simultaneously drive a digital display that shows the prevailing output number. Also, by using multiplexing or AND gating techniques, two of these basic circuits

Continued on page 67.

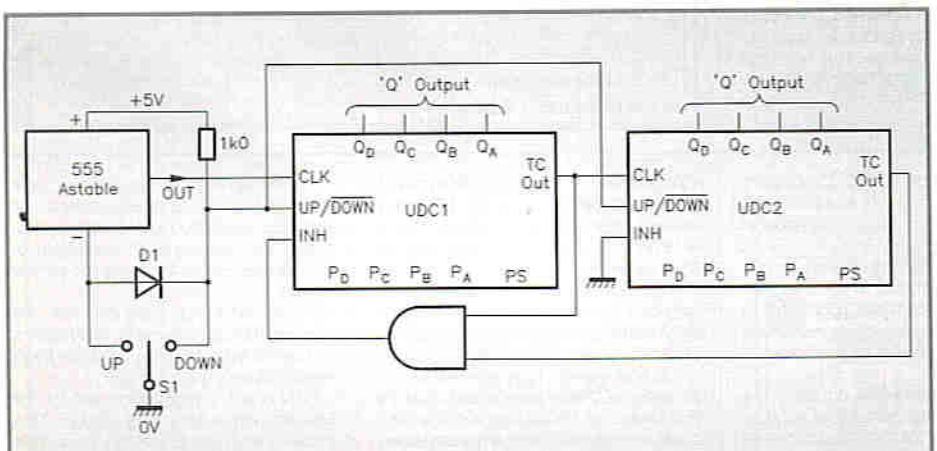


Figure 25. Basic method of expanding the Figure 24 'end-stopped' UDC circuit to give an 8-bit output.

@Internet

HTML the easy way

Over the last couple of months we have focused on ways of creating HTML documents from desktop publishing programs like PageMaker and QuarkXPress. Basically, these methods entail creating a standard publication in either of the two popular DTP packages, then exporting them with the use of specialised plug-in extensions to the programs. This month, however, is the turn of an application which is intended to do nothing else but create World Wide Web pages from scratch.

PageMill is the name and, yes, it sounds a little like PageMaker and, yes, it's from the same company Adobe, its beauty is its simplicity. You start with a blank page, add text and graphic elements, together with any links you want to other documents or URLs, and special items such as forms and so on, and hey presto, you've created a Web page; it really is that simple. So simple in fact, that there's serious talk around the business that many Web page designers will be out of work shortly. Design of pages to date has been complicated because of the very language (hypertext markup language — HTML) which make Web browsing so easy for the rest of us to get to grips with. A program like PageMill makes page makeup so easy that anyone can do it. As a result, if you have money invested in a company which makes up Web pages for a living by old-fashioned means, I recommend you either sell your shares or buy the designer a copy of PageMill.

Effectively, Web page design is about to see a revolution in the way it functions, just as the publishing world had a revolution about ten years ago when publishing packages like PageMaker and QuarkXPress themselves first hit the personal computer desktop. If you want to see a fine example of Web design using PageMill, point your browser towards Mac Today's home and related pages in Site Survey. Apart from giving you a giggle (if you are not a PC user) it will make you appreciate what can be done with PageMill.

Remember where you heard the rumour from first, but it wouldn't be a big surprise if Microsoft might muscle in on the graphical Web page design program market, too. If and when Mr Gates' mob does hit the market-place with such a beast you can guarantee we'll show you it here. Meanwhile, PageMill's is the only stall.

IEE Library Catalogue Now on the Internet

Users of the IEE Library can now search its catalogue over the Internet, at: **http://www.iee.org.uk/Library/Catalogue/simple-search.html**. Founded in 1880, the library holds some 65,000 books and pamphlets and over 3,000 periodical runs. It covers all aspects of electrical engineering, electronics, manufacturing and control engineering, computing, information technology, telecommunications and related subjects such as physics, management and history.

The British Computer Society Library was joined with the IEE collection in 1977, and full services are offered to members of both organisations. The collections of the Institution of Electronic and Radio Engineers and the Institution of Manufacturing Engineers were incorporated into the library when the Institutions merged in 1988 and 1991, respectively.

The IEE Library Online Catalogue contains the title, author, publisher, publication date and keywords for each book, report, pamphlet and conference proceeding held in the library. Entries for the periodicals held are not yet available, but the IEE hopes to add these shortly.

One Pint or Two?

How would you like to surf the WWW anywhere offline, and cease your frustration over WWW pages that take forever to download? That is what Milktruck says its new offline browser, called Milktruck Delivery, can deliver. A beta version is available for free downloading at its WWW site, at: **http://www.milktruck.com**.

Milktruck CEO, You Mon Tsang, claims the program is compatible with other browsers and Winsocks, and improves response time on WWW sites for users with modems, letting them browse sites offline and track favourite sites.

And if you are concerned that downloading WWW pages will lose the interaction for which the Internet is renowned, the program can be configured to download graphics, Java files, or plug-ins such as Shockwave.

Musical Choice

February was not a good month for one member of the editorial team at *Electronics*. The news editor's fiancé threatened to call off their impending wedding, claiming she had become an Internet widow way before she had even had the chance to exchange nuptial vows.

In response, our erstwhile newsman has started to compile a list of Internet sites for regular well-balanced individuals, and for his rock fan fiancé, first on the list is a really neat site created by a bunch of ex-MIT music Media Laboratory people at: **http://www.agents-inc.com**. It asks you to rate your favourite music and bands, and then recommends other bands you might like.

Next time you're concerned about balancing both sides of your brain, give it a try – you will find its responses eerily accurate.

CompuServe Supports Growth on Back of AOL Launch

Good news from CompuServe. Obviously feeling the pressure from AOL with its recent launch in the UK, the company is phasing out communications access surcharges for access to its networks from over 300 cities across Europe. These charges were previously levied when using third party access points. Additionally, all CompuServe nodes will be upgraded to support 28·8K-bit/s and selected nodes will also support ISDN.

"The removal of surcharges makes our service even better value for many of our members. 95% of the British public can access CompuServe for the price of a local call, which is only one pence per minute during off-peak hours", said Martin Turner, general manager at CompuServe UK.

In addition, CompuServe has announced significant investments in its European operations. It is currently upgrading its information network, adding numerous local dial up ports and new points-of-presence.

"We are committed to doubling the number of local dial ports in our network and providing 28·8 access on all CompuServe nodes by May", Turner added.

Contact: CompuServe, Tel: (0800) 000400.

Register Domain Names

WWW site design company, PPN, has warned companies who do not yet have a WWW site that they should register their name now.

"The Domain name is the simplest way for those accessing the Internet and WWW to locate information on companies. Domain names are currently registered on a first come, first served basis. At present, there are no enforceable restrictions on the domain name a business can register, so many companies may find they are unable to register their preferred name because it has already been registered by someone else", said Nigel Lomas, managing director of PPN.

The format of a commercial domain name is straightforward – *company name.co.uk*, but this simplicity means many companies with the name of the owner or founder will be competing for similar names.

In the last five months of 1995, the number of UK-registered Domain names increased from 1,000 to 5,000, a trend which will only grow in 1996.

PPN offers a registration service for Domain names for a cost of £175. This protects that name for one year. This gives companies time to develop a WWW site, either independently or with assistance from a specialist designer.

Contact: PPN, Tel: (0171) 436 3855.

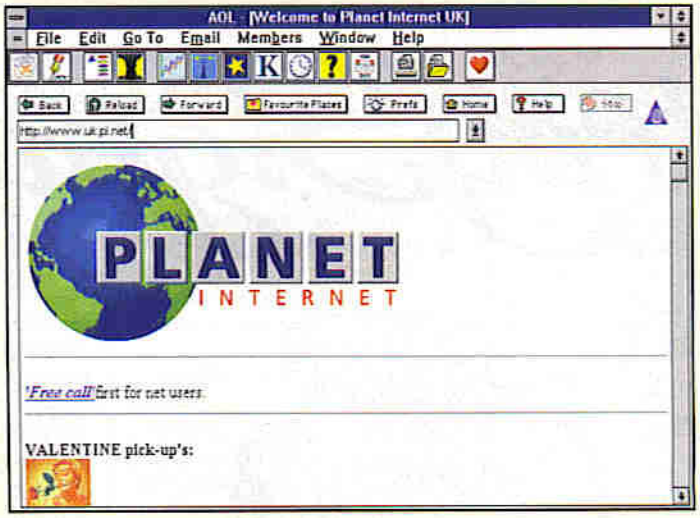
Free Call First

It was inevitable that before long, an Internet provider would offer free 'phone access to the Internet. First to the post is a new player, Planet Internet, who plan to eliminate telephone charges currently incurred by users of most UK Internet service providers.

The Internet service provider unveiled its revolutionary plans this month at its London launch. The bold move, made possible through the use of the national 0800 network, will be in place for Planet Internet's full national launch this May. The service, which is currently limited to London, costs £9.99 excluding VAT per month, which includes 5 hours usage and then four pence per minute thereafter.

The question is, how long before the other Internet providers follow Planet Internet's example? For further details of Planet Internet, check: **http://www.uk. pi.net**.

Contact: Planet Internet, Tel: (171) 345 4040.



CompuServe Introduces Parental Controls

CompuServe has introduced a number of parental controls and content restriction tools, and will discontinue suspension of access to more than 200 Internet newsgroups. The announcement comes after the company temporarily suspended access to the newsgroups as a result of a German investigation into Internet content.

CompuServe's Parental Controls Centre (Go Controls) enables parents to restrict access to Internet services accessible through the CompuServe Information Service, consisting of Newsgroups, File Transfer Protocol, and Telnet.

In addition, it is possible to control browser access by using Cyber Patrol Internet filtering software. Cyber Patrol is available for download from the CompuServe WWW site at: **http://www.compuserve.com**.

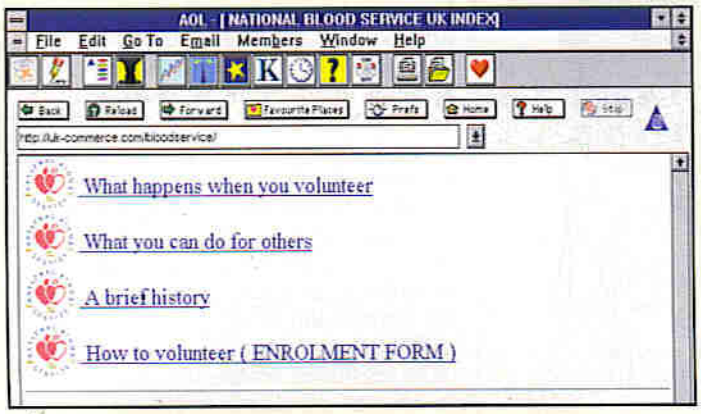
Contact: CompuServe, Tel: (0800) 000200.

Blood Donors on the Internet

The National Blood Service, now in its centenary year, has taken a leap into the future by launching the first ever Blood Donation Information pages on the Internet's WWW.

The site, at **http://www.uk-commerce.com/bloodservice**, is designed to both inform and capture the interest of would be blood donors, giving information on the history of the service, the donation process and the uses that are made of blood donations.

Also included, is an enrolment page, which, at the click of a button, is e-mailed direct to the Bristol Centre for registration on to the computerised donor information system.



Personalised Search Engines from Linkstar

Any WWW site can have its own free personalised Internet search directory by registering in the LinkStar Internet Directory to receive software that creates a hot link to a personalised version of the directory.

"Since the LinkStar Internet Directory was established earlier this year, thousands of WWW sites have taken advantage of our free HTML code to create their own personal search directories", said Stewart Padveen, president of LinkStar Communications.

Any individual or organisation with a home page can also insert a series of hypertext markup language (HTML) code to create a hot link to a personalised version of the directory.

If you want to check it out, here are some examples of WWW sites that have incorporated the LinkStar director: Little Caesars Pizza; **http://pages.prodigy.com/littlecaesars/index.html**, Musician; **http://www.hawaiian.net/~sparrow**, Investment Banking; **http://www.webcom.com/geneva/ggihp.html**.

Site Survey

The month's destinations

Readers who use a Macintosh may be a little perplexed this month at the cover disk, which features a Windows version of AOL software. However, a Macintosh version can be downloaded directly from the AOL World Wide Web site, at: **http://www.aol.com/about/try/** Note though, that this is a US version, so is totally unlocalised for UK use. It works fine, and gives most of the features the soon-to-be released UK Macintosh version will give, but any services you access have a distinctly North American feel to them. Be warned, however, the file is over 2M-bytes, complete with browser.

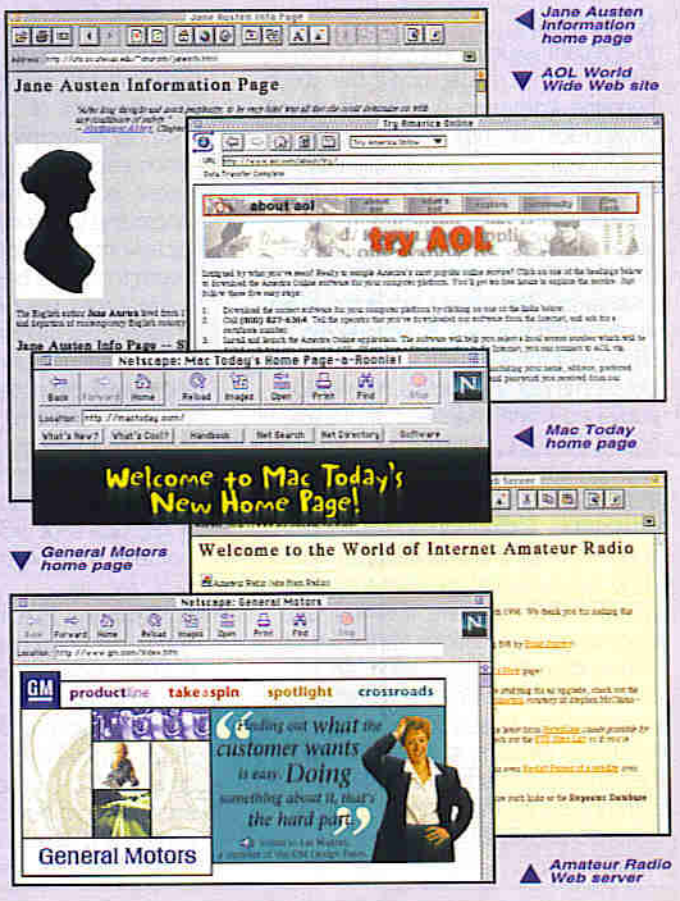
While we are on the Macintosh bandwagon, check out **http://mactoday.com/**, where you will find the home page of Mac Today. It is a magazine unlike most others, and sums up the irreverent and fun-loving attitude which Mac users in general have. The magazine is published in traditional dead tree format out of Florida, but is readable online, and downloadable in Adobe Acrobat portable document format (PDF). If you're a Mac-lover, it's a treat. Particularly cool is the link *I don't get these jokes* off the home page – you probably won't understand it if you are not a Mac user.

And if you do understand it but you don't use a Mac, you are using the wrong computer! For interest, and as an extra to the item elsewhere on these pages, the whole site is designed using Adobe PageMill.

Literature-phobes run and hide, because you won't want to know anything about this next one. It is a gourmet's guide to everything and anything related to Jane Austen. Available at **http://uts.cc.utexas.edu/~churchh/janeinfo.html** it's certainly a change from our normal offerings.

Back to more like normal now, with the Amateur Radio Web server, at: **http://www.acs.ncsu.edu/HamRadio/**. It is not the fact that there is a home page for such a subject, but it is the wealth of links which make this such a good site.

Finally, a brand new site, set up by General Motors, with all the latest Web technologies and gizmos. You will need the latest Netscape Navigator (version 2), together with Macromedia's Shockwave plug-in and Apple's QuickTime VR. You can pickup links to download all three (for Windows or Mac platforms) from the home page. Then you can see Web multimedia at its peak.



Stray Signals

by Point Contact

Radio Power

In a recent issue of the *I.E.E. News*, a letter from a reader, under the above headline, commented on the clockwork-driven radio recently featured in the national press and on television. He remarked that the chore of rewinding could be eliminated by deriving the power from a thermopile (a stack of series-connected thermocouples) heated by a flame. Apparently, the arrangement was used in the '20s to provide the HT current for a gas-driven wireless set. He seems not to have seen an article published some years ago (in, I think, one of the I.E.E. publications), showing such an arrangement in use in the then USSR. The transistor radio set was powered by a thermopile built into the glass chimney of the ubiquitous paraffin lamp (used in rural areas of that vast country, wherever there was no mains electricity), hot junctions on the inside, cold junctions on the outside. An arrangement whereby the paraffin provided light, heat and sound was felicitously efficient, since listening to the wireless was strictly an after dark activity – during the hours of daylight, comrade peasantry would be labouring in the fields.

PC would be interested to hear from any reader who may have tried the scheme with any degree of success. The problem, of course, is the large number of thermocouples required, since each hot junction-cold junction pair is only going to provide a few millivolts. According to my copy of Kaye and Laby, nickel-chromium/copper-nickel would seem to be the best bet, providing, for example, 6·317mV for a 100°C temperature difference, or 21·033mV for a 300°C differential (the output of a thermocouple does not quite vary linearly with temperature). Ordinary copper wire plus nichrome from a bowl-fire replacement element should do the trick, though making good joints is probably a job for a spot welder – nichrome will not take soft solder.

A Shocking Business

You might get a nasty bum from the lamp chimney when listening to a thermopile-powered radio, but you won't get a shock from it, or from a clockwork powered radio, either. Which is just as well, for an electric shock can easily prove fatal – even a few milliamps can kill. The real danger is that, coming into contact with a live conductor, the muscles can go into spasm, making it impossible for the victim to let go again. Continued exposure to the current upsets the heart's rhythm, leading to death. The 'news from forty years ago' page, in a recent issue of a well-known American electronics magazine, included an item about this subject, reporting that the results of a 17 year study showed the average 'let-go threshold' to be 10·5mA for women and 15·87mA for men. PC suspects that four significant figures suggests a greater degree of accuracy in the findings than is warranted. However, the results are not greatly different from those quoted by an H.M. Inspector of Factories, in a lecture to us undergrads when PC was at college in the early '50s. He reckoned that 10mA for men and 5mA for women represented the 1% mortality levels. Bearing in mind that the average ECLB or RCCB trips at around 35mA, one can presumably expect quite a jolt when it trips, but as it generally does so within half a cycle of the mains, the damaging effects of continued exposure to the current are avoided. But what happens if, unfortunately, one presents rather more resistance, limiting the current to a half or one quarter of this value?

Microminiaturisation

A recent news item in *Electronics Times* leaves PC baffled, excited and amused by turns. It describes 20-bit audio DACs of the delta-sigma variety. Describing their performance and extolling their virtues, the piece goes on to describe how small they are, achieving up to a 400% reduction in board space. A 50% reduction would be good going, and a 75% reduction even better, leaving three quarters of the space that would otherwise have been occupied, free for other components or for board size reduction. A 99% reduction in the board space required by the component would be fantastic, but a 400% reduction? If you are running out of space for your layout and cannot increase the board size, just incorporate a few of these devices, even if you leave them unused – for each of them will provide you with three times net their own size of extra space!

Yours sincerely,

Point Contact

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

can be cascaded to make up to one hundred individual outputs available.

Figure 23 shows typical connections that may be used in practical versions of the Figure 21 or 22 gate-clocked circuits. Here, a 555 timer IC is used in the astable mode as a clock-waveform generator, and is normally disabled but can be gated on by grounding its negative supply line via centre-biased toggle switch S1, which also controls the UDC's up/down direction. The UDC's preset inputs are shown configured so that they give codes of '0000' (= BCD '0') when S2 is closed or '1111' (= terminal count in Binary up-counting mode) when S2 is open, enabling a Binary UDC to be instantly set to either end of its counting range.

Note that the circuit shown in Figure 23 gives a 'free-ranging' clocking action, i.e. when it reaches the terminal count in a clocking cycle, it automatically jumps back to the 'start' count in the arrival of the next clock pulse. A popular alternative to this is an 'end-stopped' counting action, in which counting automatically ceases when the terminal count is reached, and can only be restored by reversing the count direction, i.e. so that a lower number can only be reached by clocking down, and a higher number can only be reached by clocking up. If the UDC's INH and TC OUT terminals have the same active states (both active-high or active-low), this action can be obtained by simply shorting these two terminals together as shown in Figure 24, but if they have opposite active states an inverter stage must be wired between TC OUT and INH, as indicated in the diagram (the UDC's 'preset' connections are not shown in the diagram).

Note that the Figure 23 free-ranging circuit can be expanded to give an 8-bit output by cascading it with another UDC, with both INH terminals grounded and with both UP/$\overline{\text{DOWN}}$ terminals shorted together, and with the TC OUT of the first UDC providing the CLK signal of the second IC. The procedure for expanding the end-stopped version is a little more complex.

Figure 25 shows how to expand the Figure 23 circuit so that it gives 8-bit end-stopped clocking operation. In this case, both UP/$\overline{\text{DOWN}}$ terminals are again shorted together, and the TC OUT of UDC1 provides the CLK signal for UDC2, but the TC OUTs of both counters are AND gated and fed to INH of UDC1, thus providing bidirectional end-stopping, and INH of UDC2 is grounded. Note in these expanded circuits, that the first UDC (UDC1) provides the four least-significant bits of the 8-bit output. Also note that a UDC can be made to perform add/subtract actions by simply switching it to the 'up' mode for addition or the 'down' mode for subtraction and clocking-in one input pulse per add or subtract unit; this type of action is useful in applications such as car-park monitoring, etc.

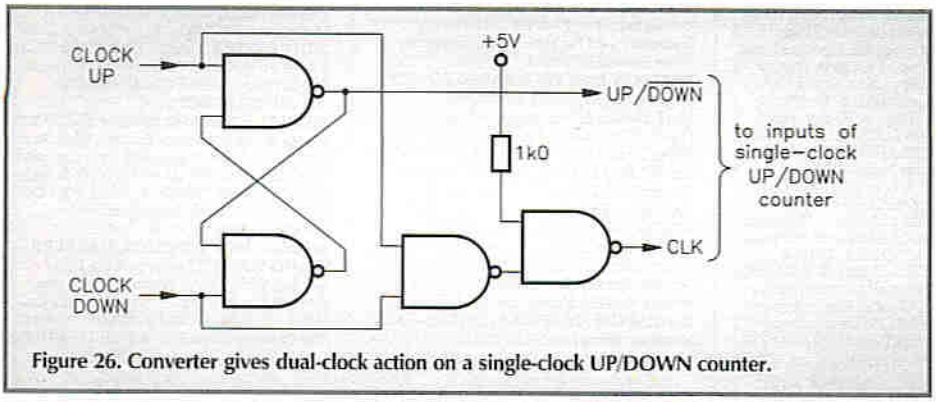


Figure 26. Converter gives dual-clock action on a single-clock UP/DOWN counter.

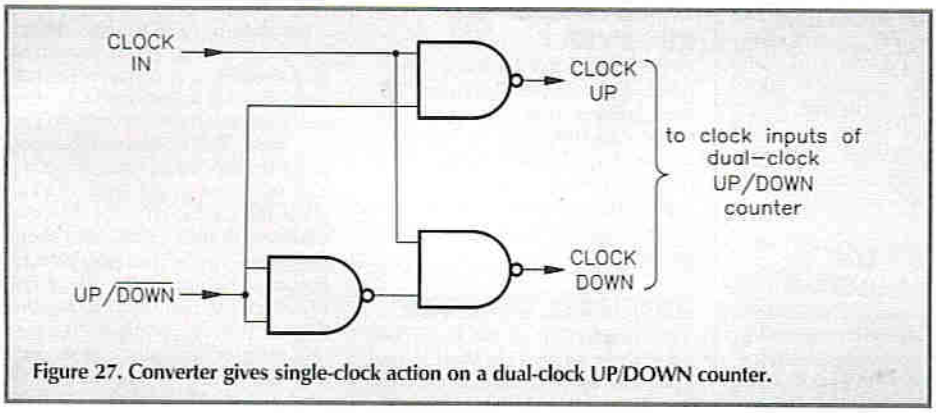


Figure 27. Converter gives single-clock action on a dual-clock UP/DOWN counter.

'Up/Down' Counter ICs

Several different 'Up/Down' counter ICs are readily available in CMOS and TTL IC forms. In ordinary CMOS, the 4029B, 4510B, 4516B, 40192B and 40193B are very popular. The 4029B is unusual in that it has a control terminal that enables it to count in either decade or binary mode; the 4510B decade and 4516B binary counters are single-clock ICs with identical pin notations, and the 40192B decade and 40193B binary counters are dual-clock ICs with identical pin notations. Four of these CMOS ICs are also available in the 74HC-series as the 74HC4510, 74HC4516, 74HC40192, and 74HC40193.

In the 74LS- TTL series, the most popular 'Up/Down' counters are the 74LS190 and 74LS192 'decade' types and the 74LS191 and 74LS193 'binary' types. Of these, the '190' and '191' are single-clock ICs with identical pin-outs and control functions, and the '192' and '193' are dual-clock types with identical pin-outs and control functions (these four counters are also available in 74HC-series CMOS versions, as the 74HC190, 74HC191, 74HC192, and 74HC193).

Note that a dual-clock UP/DOWN counter has no special advantage over a single-clock type, nor *vice versa*, and one type can easily be made to act like the other by using suitable input conversion logic circuitry. Figure 26 shows a converter that enables a single-clock counter to be driven in the dual-clock mode, and Figure 27 shows a converter that makes a dual-clock counter act like a single-clock type; in multistage counters, these converters must be applied to the input(s) of the first stage only. If the counter's Up/Down 'active' levels are the reverse of those shown in the diagrams, simply reverse the input connections to the circuit of Figure 26, or reverse the output connections from the circuit shown in Figure 27.

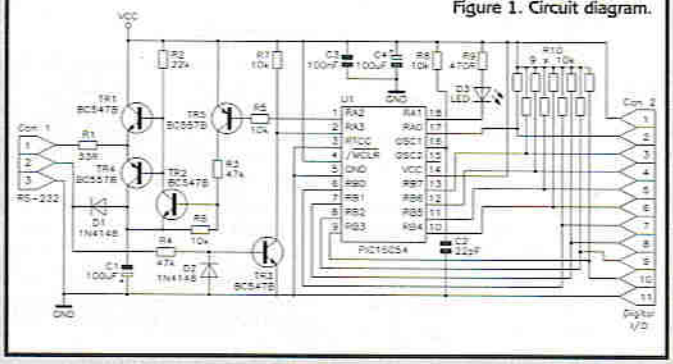
Next month, Part 10 describes digital latches, registers, and comparator circuits.

CORRIGENDA

ISSUE 97 JANUARY 1996

RS232 to 8-bit Converter Module, page 41. Please note that in the circuit diagram (Figure 1), C1 is shown with its (+) to the anode of D1, and its (–) to 0V – this is the wrong way round. See amended drawing, right.

Figure 1. Circuit diagram.



ISSUE 100 APRIL 1996

RS232 Serial Line Tester, page 81. The Baud Rate Select RB1 positions in Table 3 (Test Modes) are wrong and should be as follows:

Baud Rate Select	RB0	RB1	Baud Rate
	LOW	LOW	1,200
	HIGH	LOW	2,400
	LOW	HIGH	4,800
	HIGH	HIGH	9,600

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COMPUTERS

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VARIOUS

64K 8-bit EPROMs for sale. AM27512-25 type, used once, £2 each inc. P&P. Contact: M. Knight, 10 Daniel Road, Mancetter, Atherstone, Warks. CV9 1PA.

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PROFESSIONAL GUN MIC. Sennheiser MKH804, superb quality, £75. 2 Professional radio microphone channels, complete with all accessories including 2 Sony tie clip microphones, £100 per channel. AVO 8 multimeter with leather case, £30. Thandar TF200 Frequency Counter, 10Hz-200MHz, £75. Professional 50W power amplifier, £75. 25W, £30. Realistic 12-band stereo graphic equalizer, £30. Farnell film synchronization equipment: FT1/FT2/FT5. Offers. All the above – buyer to pay P&P. Tel: (01603) 759339.

WANTED

C.O. CARBON MONOXIDE SENSOR HEADS, small PCB mounting, 6-pin plastic case, approx. 10mm in height by 15mm in diameter, as used in commercial units that are on the market. Someone must be selling them from some outlet somewhere. The ones that I have been shown have (SP31) stamped on the top and 01/G on the side. Electromail do one, but it is too large and expensive. Cirkit sell a gas sensor kit which must employ a sensor of the same physical size but different circuit. Maplin, Greenweld, Cirkit, Omni Electronics, Farnell, Bull, Electrovalue, I.M.O. and Base Electronics do not do them, so who does? Any information or leads on the above mini (CO) sensors, please write or telephone: B. Marshall, 32 Fairfield Approach, Wraysbury, Nr. Staines, Middlesex, TW19 5DS. Tel: (01784) 482289. All mail costs will be refunded.

BBS CORNER

APPLE CRACKERS. FirstClass Client BBS, mainly for AppleMac and PC users. Baud rate 2·4K-bit/s to 28·6K-bit/s, 8 data bits, no parity, 1 stop bit. Tel: (01268) 781318/780724.

MACTEL METRO/ICONEX. FirstClass Client BBS, AppleMac and PC users. E-mail address on Internet for registered users. Baud rate 2·4K-bit/s to 28·6K-bit/s, 8 data bits, no parity, 1 stop bit. Tel: (0181) 543 8017 (Metro) or (0115) 9455417 (Iconex).

SPIDER! AMIGA BBS. The lighter alternative. Mainly Amiga and some PC files. Fidonet, Mercurynet and Mufonet. Online games. Speeds up to 19200. Tel: (01568) 613520.

CLUB CORNER

AARS (Aberdeen Amateur Radio Society) meets on Friday evenings in the RC Hall, 70 Cairngorm Crescent, Kincorth. For details contact: Martin, (CM0JCN), Tel (01569) 731177.

THE BRITISH AMATEUR ELECTRONICS CLUB (founded in 1966), for all interested in electronics. Four newsletters a year, help for members and more! UK subscription £8 a year (Junior members £4, overseas members £13.50). For further details send S.A.E. to: The Secretary, Mr. J. F. Davies, 70 Ash Road, Cuddington, Northwich, Cheshire CW8 2PB.

BURY ST. EDMUNDS AMATEUR RADIO SOCIETY. Meetings held at Culford School, 7.30pm for 8.00pm on the third Tuesday of each month, unless otherwise stated. Further details from Kevin Waterson, (G1GVI), 20 Cadogan Road, Bury St. Edmunds, Suffolk IP33 3QJ. Tel: (01284) 764804.

CRYSTAL PALACE & DISTRICT RADIO CLUB. Meets on the third Saturday of each month at All Saints Church Parish Rooms, Beulah Hill, London SE19. Details from Wilf Taylor, (G3DSC), Tel: (0181) 699 5732.

DERBY AND DISTRICT AMATEUR RADIO SOCIETY meets every Wednesday at 7.30pm, at 119 Green Lane, Derby. Further details from: Richard Buckby, (G3VGW), 20 Eden Bank, Ambergate DE56 2GG. Tel: (01773) 852475.

ELECTRONIC ORGAN CONSTRUCTORS SOCIETY. For details of meetings, Tel: (0181) 902 3390 or write to 87 Oakington Manor Drive, Wembley, Middlesex HA9 6LX.

E.U.G. User group for all 8-bit Acorn Micros, since 1991. Still going strong. Programming, news, information, sales. Contact: E.U.G., 25 Bertie Road, Southsea, Hants. PO4 8JX. Tel: (01705) 781168.

THE LINCOLN SHORT WAVE CLUB meets every Wednesday night at the City Engineers' Club, Waterside South, Lincoln at 8pm. All welcome. For further details contact Pam, (G4STO) (Secretary). Tel: (01427) 788356.

MODEL RAILWAY ENTHUSIAST? How about joining 'MERG', the Model Electronic Railway Group. For more details contact: Paul King (Honorary Secretary), 25 Fir Tree Way, Hassocks, West Sussex BN6 8BU.

PRESTON AMATEUR RADIO SOCIETY meets every Thursday evening at The Lonsdale Sports and Social Club, Fulwood Hall Lane, Fulwood, (off Watling Street Road), Preston, Lancashire PR2 4DC. Tel: (01772) 794465. Secretary: Mr Eric Eastwood, (G1WCQ), 56 The Mede, Freckleton PR4 1JB, Tel: (01772) 686708.

SCIENCE AT YOUR FINGERTIPS, for 'hands-on' science experiences and experiments, *Science at Your Fingertips Science Review*, Membership £2.50. For further details, please contact Daniel and Caroline Gee, The S.A.Y.F., 37 South Road, Watchet, Somerset TA23 0HG.

SEEMUG (South East Essex Mac User Group), meet in Southend, every second Monday of each month. For details Tel: Michael Foy (01702) 468062, or e-mail to mac@mikefoy.demon.co.uk.

SOUTHEND & DISTRICT RADIO SOCIETY meets at the Druid Venture Scout Centre, Southend, Essex every Thursday at 8pm. For further details, contact: P.O. Box 88, Rayleigh, Essex SS6 6NZ.

SUDBURY AND DISTRICT RADIO AMATEURS (SanDRA) meet in Gt. Comard, Sudbury, Suffolk at 8.00pm. Visitors and new members are very welcome. Refreshments are available. For details please contact Tony, (G8LTY), Tel: (01787) 313212 before 10.00pm.

TESUG (The European Satellite User Group) for all satellite TV enthusiasts! Totally independent. TESUG provides the most up-to-date news available (through its monthly 'Footprint' newsletter, and a teletext service on the pan-European 'Super Channel'). It also provides a wide variety of help and information. Contact: Eric N. Wiltsher, TESUG, P.O. Box 576 Orpington, Kent BR6 9WY.

THANET ELECTRONICS CLUB. For school age Ham Radio and Electronics enthusiasts, enters its 16th Year. Meetings held every Monday evening from 7.30pm at The Quarterdeck, Zion Place, Margate, Kent. For further details contact: Dr. Ken I. Smith, (G3JIX), Tel: (01304) 812723.

WAKEFIELD AND DISTRICT RADIO SOCIETY meet at 8.00pm on Tuesdays at the Community Centre, Prospect Road, Ossett, West Yorkshire. Contact Bob Firth, (G3WWF), (QTHR), Tel: (0113) 282 5519.

THE (WIGAN) DOUGLAS VALLEY AMATEUR RADIO SOCIETY meets on the first and third Thursdays of the month from 8.00pm at the Wigan Sea Cadet HQ, Training Ship Sceptre, Brookhouse Terrace, off Warrington Lane, Wigan. Contact: D. Snape, (G4GWG), Tel: (01942) 211397.

WINCHESTER AMATEUR RADIO CLUB meets on the third Friday of each month. For full programme contact: G4AXO, Tel: (01962) 860807.

WIRRAL AMATEUR RADIO SOCIETY meets at the Ivy Farm, Arrowe Park Road, Birkenhead every Tuesday evening, and formally on the the 1st and 3rd Wednesday of every month. Details: A. Seed, (G3FOO), 31 Withert Avenue, Bebington, Wirral L63 5NE.

WIRRAL AND DISTRICT AMATEUR RADIO SOCIETY meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF hunts, demonstrations and junk sales. For further details, please contact: Paul Robinson, (G0JZP) on (0151) 648 5892.

In the June 1996 issue (No. 102) of *Electronics – The Maplin Magazine*, we have a blazing assortment of fabulous projects to build and features to read, including:

PROJECTS

GPS DEVELOPMENT SYSTEM PART 2

The second part of this project covers the installation of the VP Oncore GPS software along with the codes for setting up and controlling the GPS Development Receiver, QBASIC program codes and algorithms for converting Lat/Long output from the GPS receiver to Ordnance Survey National Grid References, and information on suitable GPS software which enables GPS receivers to show the position on a digital map.

EARTH-LIFT BOX

Essential equipment for musicians using electronic instruments, this project uses 3-way switching to safely interconnect instruments with either floating, half- or full-earthing to ground, to conveniently eliminate earth loops and the consequent hum from appearing at the amplifier inputs.

OVER-REV/PEAK POWER INDICATOR

Found on most racing cars, and an equally useful aid to consistently achieving the optimum performance from your road vehicle, this easy to build and install project uses an LED and buzzer to indicate to the driver when the engine has reached a preset speed, at which point, for example, it is generating maximum power or torque, so that gear changes can be tailored to increase overall driving efficiency.

PASSIVE DIRECT INJECTION BOX

An essential item for the performing or recording musician, this easy to build project efficiently banishes noise and hum often experienced when using electronic musical equipment on stage, and being a passive device, there are no batteries to worry about, leaving you to concentrate all your efforts on producing sweet music!

SHORTWAVE RECEIVER

Keep your finger on the pulse of worldwide events, be first to hear the latest overseas news, and get to grips with foreign languages by becoming a short wave listener (SWL)! This receiver enables you to comfortably apply your ears to the world to tune into stations and broadcasters spread far and wide.

RADI-CALL RECEIVER

The complement to the Radi-Call Transmitter featured elsewhere in this issue, this 418MHz receiver decodes the transmitted encoded signal, providing an open-ended switched relay output to activate your chosen alarm system, or a telephone auto-dialler, for example, as part of a nurse call system.

FEATURES

New Standards in Logic, by Ian Davidson discusses the reasons for straying from the long-standing 5V logic formats to the new 3·3V logic, and why such a seemingly odd voltage level standard should have arisen. Flexible Business Revolutions Ahead by Frank Booty predicts how the structure of firms will alter in response to increasing availability of affordable worldwide communications systems, while Holography: Theory and Practice by Laura Ryden, describes how the phenomenon of 3D virtual image holograms occurs, and demonstrates how to produce amazing holograms yourself, using a laser in conjunction with common household 'junk'. In Part 2 of Value Added Internet Services, Keith Brindley advises how to get the best value out of the Internet. The Hunt for Dark Matter by Douglas Clarkson reveals information about mysterious 'cold' dark matter particles known as Neutrinos. Part 10 of Ray Marston's Practical Guide to Modern Digital ICs covers digital latches, shift registers, logic comparators, code converters and driving multi-digit displays. Sound Reinforcement Systems for Gigging Bands by Andy Rimmell, is a practical guide to setting up a sound system for your band, to enable you to go gigging with confidence!

All this, plus all your favourite regulars as well!

ELECTRONICS
The Maplin Magazine

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE

What's On?

Window on Desktop World

For PC users the Windows Show is the key event of the Year. Now in its sixth year, the show acts as a showcase for the latest innovations on the desktop. As we go to press this month, the Windows '96 show at London's Olympia Grand Hall is closing. Literally hundreds of companies demonstrated hardware and software innovations and products. Here we take a look at some of the major announcements at the show:

You didn't need to go to the show to see IBM's official web site for the 1996 Centennial Olympic Games at Atlanta, but the site was being showcased on the IBM stand. Located at **http://www.atlanta.olympic.org** it already contains a wealth of information and during the games will contain information on all the athletes, results, photos, videos and interviews. The good news for Olympic fans is that it is robust and scalable enough to handle over 10,000 hits a minute.

BT announced plans to launch a mass market, dial-up Internet service at the end of March. The service called BT Internet will be aimed at residential and small business customers as well as users new to the Internet. To get unlimited online time with BT will cost a one off registration of £20 and a flat monthly subscription fee of £15. Calls to the service will be charged at local rates nation-wide at speeds from 9600-bit/s up to 28,800-bit/s.

Internet users now have the power to publish their data directly to the Internet with an application showcased by Corel. CorelWEB.DATA, a 32-bit database publisher for the Internet supports most major formats including Access, Excel, Foxpro, dBASE, Paradox, 123 and any ODBC compliant SQL data source. Text files in fixed-width or delimited format can also be processed. The application can be downloaded from Corel's web site at **http://www.corel.com** for a 30 day evaluation.

The forthcoming version of Dr Solomon's Anti-Virus Toolkit due out this summer was previewed on the S&S International stand. The latest addition to the new toolkit is Magic Bullet. Except there is nothing magic here. Magic Bullet is simply a clean bootable DOS disk which S&S International claim is the one thing few users have to hand when PC systems are infected by a virus. The Magic Bullet will, however, enable users to boot Anti-Virus software direct from the disk.

Quarterdeck demonstrated the personal user version of WebCompass, an Internet application which enables simultaneous searches of multiple Web engines, enabling the user to accurately track down data or information on a particular topic. A beta version of WebCompass Personal Edition can be downloaded from Quarterdeck's web site at **http://www.quarterdeck.com**. The product will be available commercially in the summer priced around £25.

Springfields Show

The Lincolnshire All Micro Show takes place on 14 April at the Springfields Exhibition Centre, Spalding in Lincolnshire. According to the organisers, this new computer and electronics event will include accessories, electronics components, software and computer hardware. The event will also include a bring and buy sale for visitors to buy and exchange second hand equipment.

Running throughout the day, the entrance fee is £2.50 for adults, and is free for children under 14. Entry to the 25 acre Springfields Gardens site and parking is included in the entrance fee.

Contact: Springfields Exhibition Centre, Tel: (01775) 724843.

DIARY DATES

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

25 March. Surplus Equipment Sale, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

28 March. Agile Manufacturing, IEE, Cranfield Conference Centre, Cranfield University. Tel: (0171) 344 5428.

29 March. Club Shack Open Evening, Mid Sussex Amateur Radio Society. Tel: (01) 444 241 407.

31 March. Radio Rally, Magnum, Scotland. Tel: (01707) 659015.

31 March. 2m Fox Hunt at Ditchling Common, Mid Sussex Amateur Radio Society. Tel: (01) 444 241 407.

8 April. Annual General Meeting, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

11 April. Surplus Equipment Sale, 7.30pm Sharp, Mid Sussex Amateur Radio Society. Tel: (01) 444 241 407.

14 April. Radio Rally, Launceston, Cornwall. Tel: (01707) 659015.

19 April. Annual Construction Contest, Mid Sussex Amateur Radio Society. Tel: (01) 444 241 407.

21 April. White Rose Rally, Leeds Tel: (01707) 659015.

22 April. The First Century of Sound Recording, Brian Hayward G8VXQ, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

23 to 25 April. Eighth International Conference on Road Traffic Monitoring and Control, IEE, London. Tel: (0171) 344 8425.

23 to 25 April. The Institute of Physics Annual Conference, Telford International Centre, Telford. Tel: (0171) 235 6111.

29 April to 3 May. Sixth International Conference on AC and DC Transmission, IEE, London. Tel: (0171) 344 5472.

4 May. RSGB Open Day, Potters Bar. Tel: (01707) 659015.

13 May. Astronomy, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

16 May. World Class Manufacturing for SMEs – Some of the Issues, IEE, The Dudley Centre for Competitive Manufacturing, West Midlands. Tel: (0171) 344 5446.

17 to 19 May. Mac Shopper Show, Wembley Centre, London. Tel: (0171) 831 9252.

20 May. Visit to Nickelodeon, Ashorne, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

21 to 22 May. International Conference on Public Transport Electronics Systems, IEE, London, Tel: (0171) 344 8432.

21 to 23 May. Internet World, Olympia, London. Tel: (01865) 730275.

27 May. Open Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

10 June. 2m Direction Finding Contest, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

15 June. RNARS, HMS Collingwood, Hants. Tel: (01707) 659015.

18 to 20 June. Multimedia, Business Design Centre, London. Tel: (0171) 359 3535.

24 June. Repeater Management Group Chairman, Geof Dover G4AFJ, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

26 to 27 June. Electrical Engineering Exhibition, Airport Skean Dhu, Aberdeen. Tel: (01732) 359990.

30 June. Radio Rally, Longleat, Wiltshire. Tel: (01707) 659015.

6 July. Summer Social Event, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

8 July. 160m. Direction Finding Contest, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

8 July to 30 September. Science Museum Superhighway UK Tour, Exploris, Northern Ireland. Tel: (0171) 938 8192.

22 July. Construction Competition, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

4 August. RSGB National Mobile Rally, Woburn, Beds. Tel: (01707) 659015.

18 August. Radio Rally, Manchester. Tel: (01707) 659015.

18 August. Radio Rally, Great Eastern, Kings Lynn. Tel: (01707) 659015.

1 September. Radio Rally, Telford, Shropshire. Tel: (01707) 659015.

4 to 5 September. Internet, Wembley Centre, London. Tel: (01923) 261663.

8 September. The Fifteenth Lincoln Hamfest, Lincolnshire Showground. Entry is £1.50. Morse tests available, plus all usual attractions. Caravans welcome (Saturday night only). Details from Sue Middleton, (XYL) (G8VGF) (QTHR), Tel: (01522) 525760.

18 to 19 September. EMC UK, Olympia, London. Tel: (01981) 590481.

21 September. Radio Rally, Scottish Convention, Glasgow. Tel: (01707) 659015.

24 to 29 September. Live '96, Earls Court, London. Tel: (0181) 742 2828.

25 to 26 September. Digital Signal Processing, Sheraton Skyline Hotel, London. Tel: (0181) 614 8042.

4 to 6 October. RSGB International HF Convention, Windsor. Tel: (01707) 659015.

7 October to 16 December. Science Museum Superhighway UK Tour, Kelvingrove Museum, Glasgow. Tel: (0171) 938 8192.

8 to 10 October. Voice Europe, Olympia, London. Tel: (01244) 378888.

18 to 19 October. Leicester Amateur Radio Show, Leicester. Tel: (01707) 659015.

28 to 30 October. International Conference on Sizewell B – The First Cycle, IEE, London. Tel: (0171) 344 8432.

29 to 31 October. Electronics Commerce, Barbican Exhibition Centre, London. Tel: (0181) 332 0044.

1 to 3 November. Acorn World, Olympia, London. Tel: (01295) 788386.

Please send details of events for inclusion in 'Diary Dates' to: News Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex SS6 8LR or e-mail to swaddington@cix.compulink co.uk

GENIUS OR MAGICIAN?

Above: Three satellites in orbit, girdling the Earth.

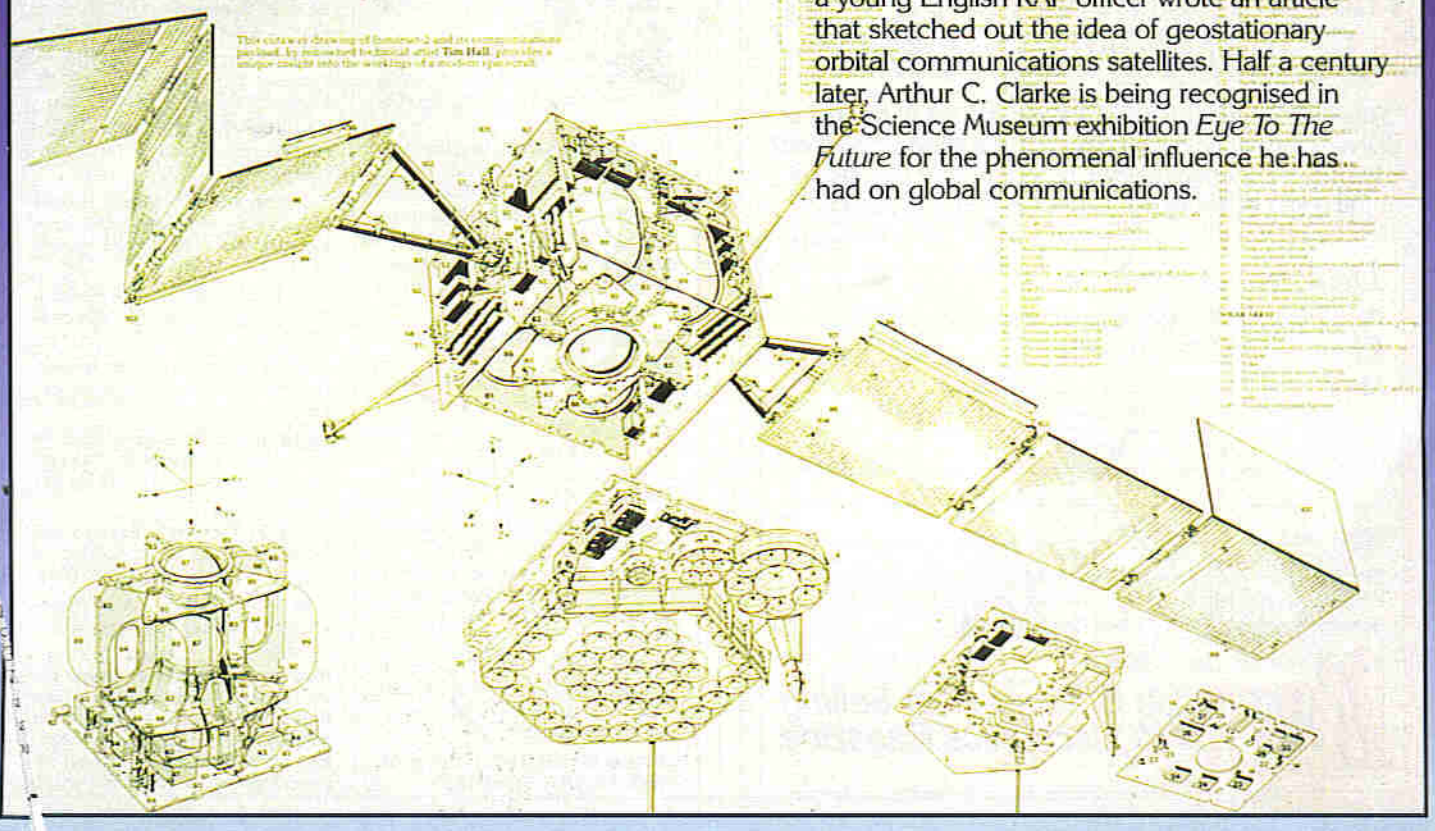
Below: Drawing and details of an Inmarsat-2 satellite.

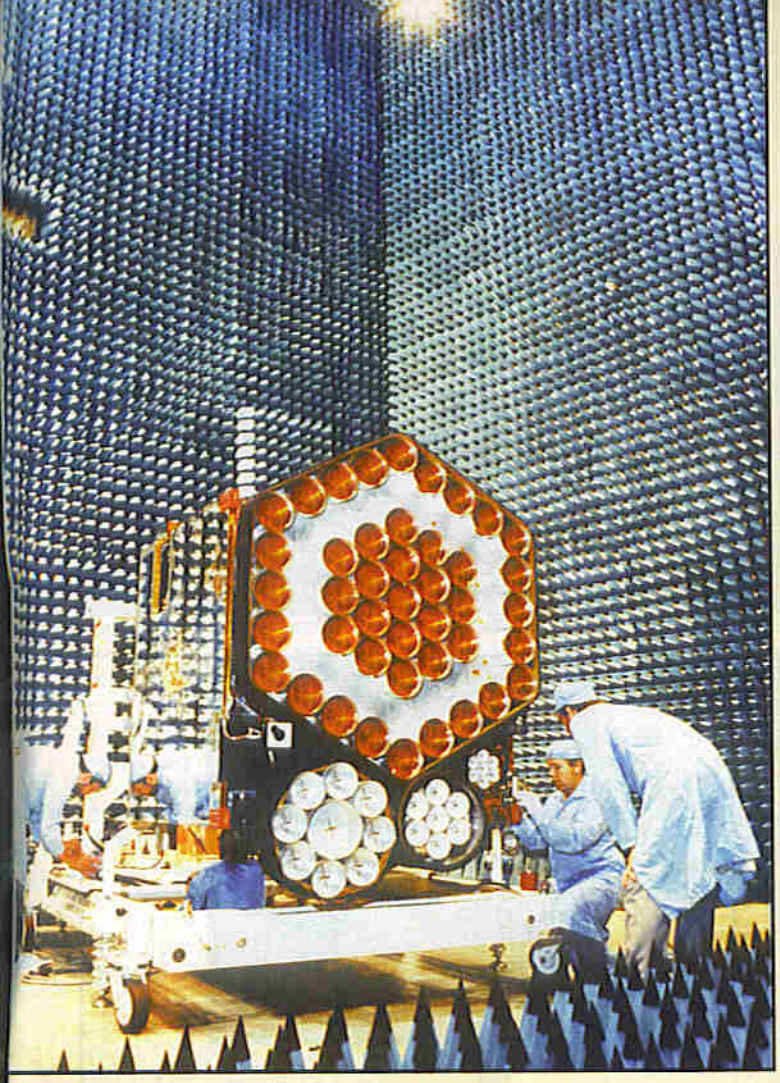
by Ruth Ling

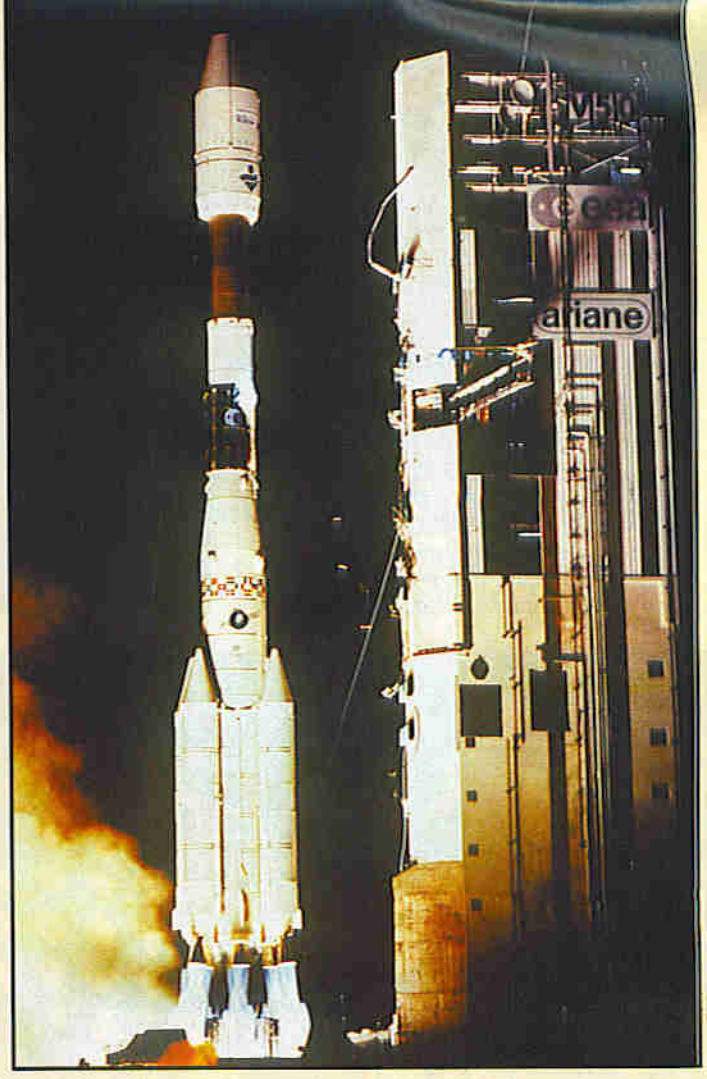
The Vision of ARTHUR C. CLARKE

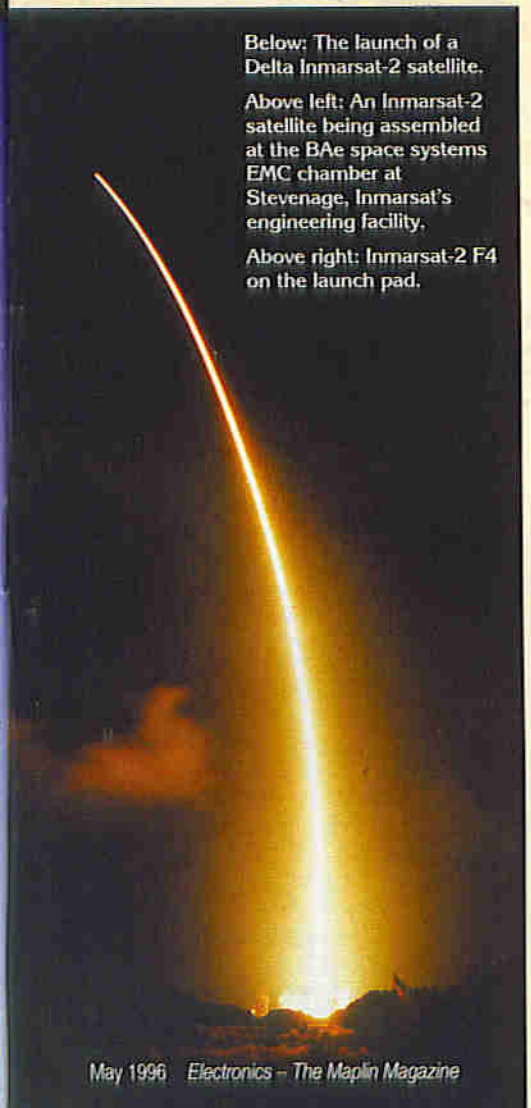
Inside Inmarsat–2

In the dying days of the Second World War, a young English RAF officer wrote an article that sketched out the idea of geostationary orbital communications satellites. Half a century later, Arthur C. Clarke is being recognised in the Science Museum exhibition *Eye To The Future* for the phenomenal influence he has had on global communications.









Below: The launch of a Delta Inmarsat-2 satellite.

Above left: An Inmarsat-2 satellite being assembled at the BAe space systems EMC chamber at Stevenage, Inmarsat's engineering facility.

Above right: Inmarsat-2 F4 on the launch pad.

FIFTY years ago, the journal *Wireless World* published an article called *Extra-Terrestrial Relays* by a 28-year-old Englishman, Arthur C. Clarke, who was later to make his name as one of the world's greatest science fiction writers.

However, this was no work of fiction. It may have been tapped out on the same old sit-up-and-beg typewriter on which Clarke went on to write his popular sci-fi novels. It may have come from the same mind that created *2001: A Space Odyssey*, the book that spawned the hit film of 1968. But, although readers at the time could have been excused for thinking it was just a flight of fancy, Clarke's article was to change the nature of communications around the world – and, in fact, the world itself. It took 19 years for his vision to be realised, but even that was far sooner than he had thought was possible.

As he wrote in 1961, in an essay entitled 'A Short Pre-History of Comsats; or How I Lost a Billion Dollars in My Spare Time', "It is with somewhat mixed feelings that I can claim to have originated one of the most commercially valuable ideas of the 20th century, and to have sold it for just £12". (That was the fee he received from *Wireless World*.)

Indeed, he *had* come up with a winning idea. In the four-page article (sub-titled 'Can Rocket Stations Give World-Wide Radio Coverage?' and published in the October 1945 issue of the journal), Clarke had introduced the notion of using satellites to relay radio signals around the Earth. He had estimated the energy needed to put a satellite into orbit 35,000km above the Equator. At that distance from Earth, a satellite orbits the planet exactly once every 24 hours, at the same angular rate as the Earth, thus appearing from the ground to be in a fixed position. This is what we know now as a geostationary satellite.

It was 12 years later, in 1957, that the very first satellite, the Russian Sputnik, was launched, but that was in a low earth orbit (around 150 to 500 miles above the Earth).

Anyone who remembers *Telstar*, the foot-tapping pop hit of 1962 by the Tornadoes, should also recall that Telstar was the talking point of that year. The first communications satellite capable of relaying messages immediately (in 'real time', as contemporary jargon has it), Telstar was launched in 1962. It circled the Earth at a height of between 950 and 5,600km, an orbit known as 'highly elliptical', but one which became redundant within a few years, as it permitted only an hour or two of transmission every day.

It was another two years before a geo-stationary satellite was put into orbit; the earliest was the American Syncom 3, the first truly synchronous or stationary TV satellite, which was successfully launched on 19 August 1964 – just in time for the Tokyo Olympics. The experience of watching a sports event as it happened on the other side of the world was indescribably exciting.

Clarke's Vision of the Future

Clarke wrote his article in May 1945, while serving as a flight lieutenant in the Royal Air Force near Stratford-upon-Avon, where he was training airmen to maintain the Ground Controlled Approach radar gear used to talk down aircraft during bad visibility.

The paper, which included four diagrams,

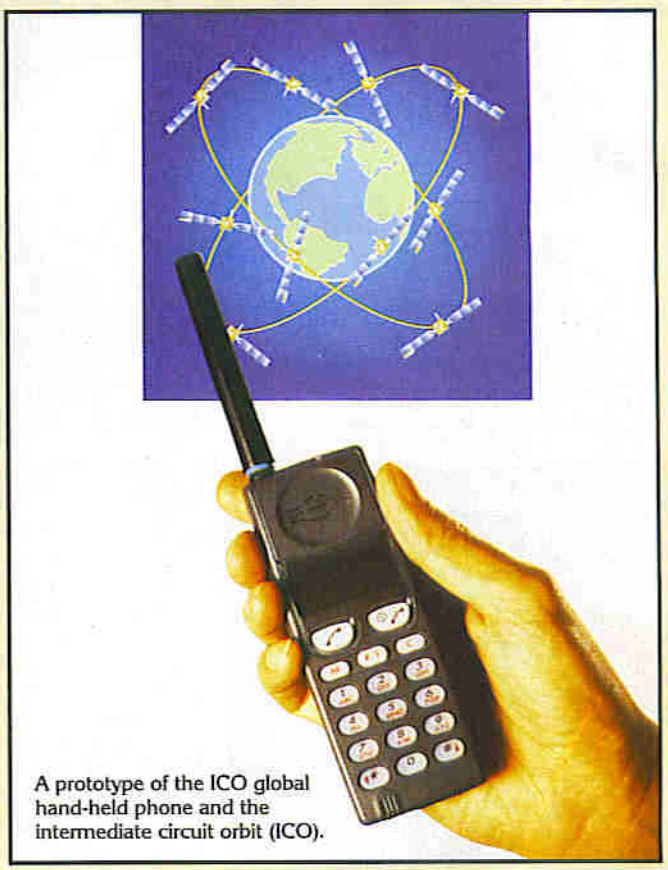
began with a brief discussion of the problem of long-range radio and TV. Although a choice of frequencies and routes could provide telephony circuits between any two points on the Earth for a large part of the time, Clarke said, "long-distance communication is greatly hampered by the peculiarities of the ionosphere, and there are even occasions when it may be impossible". A true broadcast service would be "indispensable in a world society", he wrote.

For television, Clarke said, coaxial microwave cables or relay links would be necessary, though even these could never provide transoceanic services – and they would be too expensive, costing 'millions' for a relay chain several thousand miles long. (Of course, in 1945, such cable links didn't exist even on land, but it was obvious that they soon would.)

Then Clarke set out his idea for artificial satellites, explaining that if a rocket could reach and maintain a speed of five miles

An Inmarsat-2 satellite in geostationary orbit.

An Inmarsat-3 satellite in the test chamber.



A prototype of the ICO global hand-held phone and the intermediate circuit orbit (ICO).

(8km) a second, it could continue to circle the Earth indefinitely without using up any power. In effect, it would become an artificial satellite.

Although a satellite could be established at any altitude, its "most interesting and valuable orbit" would be outside the atmosphere. At a height of 42,000km from the centre of the Earth, a satellite would take exactly one day to revolve around the Earth. Placed above the Equator, it would appear to be fixed in the sky.

He went on to predict that, in the following few years, it would be possible to build "radio-controlled rockets which could be steered into such orbits beyond the limits of the atmosphere and left to broadcast scientific information back to Earth. A little later, manned rockets will be able to make similar flights with sufficient excess power to break the orbit and return to Earth".

Clarke described how it would be possible to build a "space station" in such an orbit, using material ferried up by rockets. On board would be laboratories, receiving and transmitting equipment, living quarters and everything needed for the crew's comfort. The station could act as a repeater to delay transmission between any two points on the hemisphere. And, since a station would provide coverage to only half the globe, Clarke suggested three stations, at equidistant points around the Earth. These would be at 30° East to provide coverage for Africa and Europe, 150° East for China and Oceania and 90° West for the Americas.

He calculated that a worldwide FM system would need "no more power than the BBC's London TV transmitter". The relay stations would be solar-powered because, apart from brief spells around the equinoxes when they would enter the shadow of the Earth, they would be in continuous daylight and would intercept a flood of radiation, which could be used to operate a heat engine coupled to an electric generator. Clarke also suggested that "thermoelectric and photoelectric developments may make it possible to utilise the solar energy more directly". This came to happen only a few years later, when the solar cell was invented at the Bell Telephone Laboratories; it now powers almost all satellites and space probes.

Although modestly claiming that "everything envisaged here is a logical extension of developments in the last 10 years – in particular, the perfection of the long-range rocket of which V2 was the prototype", Clarke admitted that "many may consider the solution proposed in this discussion too far-fetched to be taken very seriously".

As we can see now, much of what Clarke proposed in his 1945 paper has become commonplace. One fact he missed, though, was that developments in electronics would make unmanned communications satellites possible long before there were any permanent manned space stations. He had pictured his 'extraterrestrial relays' as large structures with their own operational and maintenance

crews, but in fact miniaturisation and the invention of the transistor made human presence unnecessary.

Clarke, however, still believes that space communications would be much more reliable with personnel out in space, saying that "a troubleshooter who knows how to replace a component costing a few cents can put a multimillion dollar satellite back on the air". Quite a lot of the space debris languishing in orbit ("junk costing many times its weight in gold") could, he said, "be fixed by a screwdriver and a good mechanic".

During the '40s and '50s, Clarke propounded his theories about communications satellites extensively in books and articles. His first novel, *Prelude To Space* (1950), plugged communication satellites, and in 1952 his earlier work *The Exploration Of Space*, about the synchronous satellite network, was published as a Book Of The Month Club edition. In this way, by the end of the 1950s anyone seriously interested in space travel would have been aware of the potential of these satellites. Clarke himself has admitted, though, that "probably few knew where the idea originated". He has subsequently rued that he didn't patent his idea, while realising that it wouldn't have been possible even if he had made the effort – and that, in any case, a patent's lifespan is only 17 years, and his would have expired just as the Communications Satellite Corporation was set up in 1962.

Telstar, launched in the same year, was funded entirely by private investment and was a significant step toward the commercial realisation of Clarke's idea. However, the principal contributors towards the development of satellite communications in the 1960s were not private investors, but space agencies such as NASA in the USA, the European Space Research Organisation (now the European Space Agency), NASDA of Japan and Intelsat (the International Telecommunications Satellite Organisation, based in Washington, DC).

In 1979, Inmarsat was established to serve the maritime community by pioneering the use of satellite technology for mobile communications. It has since evolved to become the world's leading provider of global mobile satellite communications for commercial and distress and safety applications at sea, on land and in the air. An inter-governmental organisation with 79 member countries and headquarters in London, it offers various mobile satellite communications systems (Inmarsat-A, B, C, E, M and Aero), which can support all-digital and direct-dial telephone, telex, facsimile services, electronic mail and data communications. Applications of these services include data reporting and polling, position reporting, safety and emergency alerting, remote monitoring, control and data collection. There are nearly 60,000 Inmarsat terminals commissioned and in use worldwide.

The BT coast earth station at Goonhilly, Cornwall.

Is Arthur C. Clarke impressed by these giant strides that mankind has made in the past 50 years? Perhaps the highest accolade comes when he said: "Any sufficiently advanced technology is indistinguishable from magic."

The Renaissance Man

Clarke's invention of communication using satellites in geostationary orbit has brought him the nickname "Grandfather of Satellites" and such official honours as the 1982 Marconi International Fellowship, a gold medal of the Franklin Institute, the Vikram Sarabhai Professorship of the Physical Research Laboratory, Ahmedabad, the Lindbergh Award, and a Fellowship of King's College, London.

The Arthur C. Clarke Centre Award is given in his honour for distinguished services to satellite communications, and the International Astronomical Union has named the geostationary orbit the Clarke Orbit.

Probably the most celebrated science fiction writer of the 20th century, Clarke has written more than 60 books, with 50 million copies in print. Among the many prizes he has won are the Kalinga Prize for science writing, which is administered by UNESCO (1962), the AAAS-Westinghouse science writing prize (1969) and the title of Grand Master from the Science Fiction Writers of America (1986). In 1968, he shared an Academy Award nomination for an Oscar with director Stanley Kubrick for the film version of his book *2001: A Space Odyssey*. The Arthur C. Clarke Award is given annually to the best British science fiction novel.

Clarke is a member of the Academy of Astronautics, the Royal Astronomical Society and many other scientific organisations, and is a past Chairman of the British Interplanetary Society.

He co-broadcasted the Apollo 11, 12 and 15 missions with Walter Cronkite for CBS.

His recent non-fiction book, *How The World Was One*, is a history of global telecommunications, and spawned a Japanese TV series which he hosted. In the book, he proposes that telephone companies should abolish all long-distance call charges. Clarke believes that the Next Big Thing in global communications will be the personal telephone. He told *Wired* magazine: "That's it – when everybody has his or her own personal communications devices. It has started with the cellular telephones, and it'll go farther with the cellular satellite telephones."

At the age of 78, he can see just that happening. Inmarsat is following his prediction with the formation of ICO Global Communications. A private company with its origins in Inmarsat, ICO is developing what should be the world's first global hand-held mobile telephone. The ICO (intermediate circuit orbit) telephone should become commercially available in 1999 – just 54 years after Clarke made what must have seemed his astounding claims on the future of global communications.

SCIENCE MUSEUM

To celebrate the 'concept' of the Communications Satellite, *Electronics* has obtained free tickets (as prizes) to the Science Museum. There are three separate prizes of one Family Ticket (for up to two adults and four children), plus runners-up prizes of two pairs of tickets (each ticket admits two people). The tickets will be awarded to three readers whose names are drawn from the Editor's hat on 22nd April, who will receive their tickets by post. Closing date for entries is 19th April.

Science Museum Prize Draw

ELECTRONICS The Maplin Magazine

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VALUE ADDED INTERNET SERVICES

PART 1

Connecting to the Internet is easy (well, relatively, if your day job is catching wild tigers by hand) but where do you go from there? In a new series, Keith Brindley looks at the alternatives to the basic connection.

There are many, many Internet service providers around. It is a flourishing business, or seems to be. Hardly a week goes by without a fanfare of publicity for the latest provider, and each seems to offer better performance, cheaper pricing, and more features than the rest.

In among all this, however, it is the poor user who has to choose what is best. And if you have little or no experience of the Internet in the first place, how can you make a choice? It is not always easy to compare these different providers, simply because they can have (and do have) significantly different capabilities and services. What is meat for one Internet user can be poison for another.

So to get the best out of what is on offer, it pays to have knowledge. Then you can make an informed judgement, and get what is best for you. You may find that the cheapest provider is not always the best if you want some specialized features.

In this series I will be taking a close look at several of the Internet access providers and their services. While I am not going to make any hard-and-fast rules about which is best – in fact, that is impossible for me to say, because users' requirements are so varied – by the end of the series most readers should have more than just a passing idea of what is best for them. The series is intended to be useful to readers who want a dial-up connection – using their computer with a modem to access the Internet over an ordinary telephone line. Yes, there are other methods of getting on the Internet, but we are not considering them here.

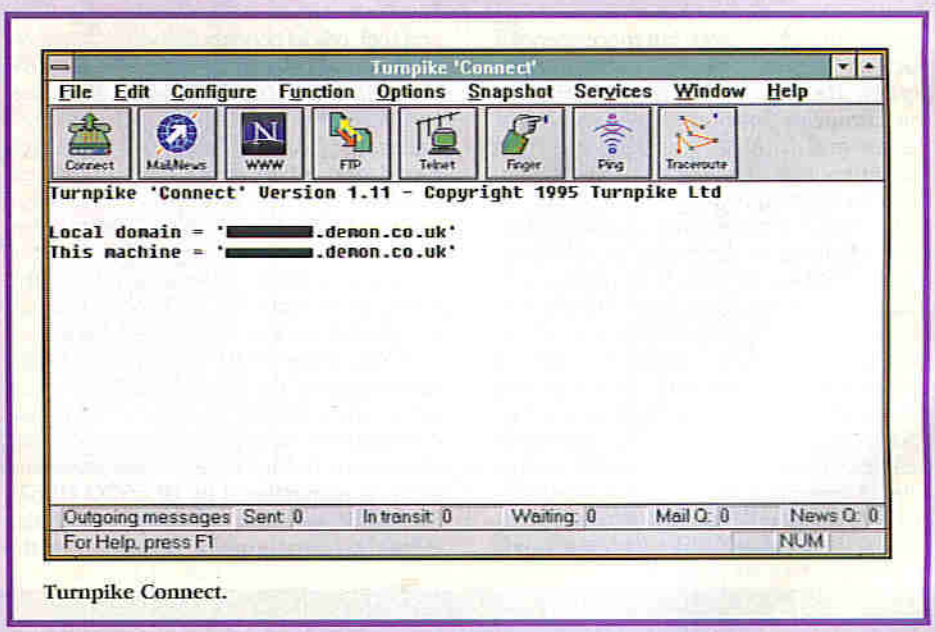
Technically Speaking

We will start with a brief look at areas where all Internet service providers have to share common ground. Given that you have a computer (and almost any computer will do the job here – accessing the Internet does not require a particularly fast computer), a modem and a telephone line, you have got what it takes. But what about the Internet service provider? There are three main things to consider.

First is where the Internet access is available from. In other words, is the access point located a local phone call away, or is it beyond that? This might not be of crucial importance if all you intend to use the Internet for is e-mail (that is, sending messages electronically to other computer users who have Internet access), but it is of vital importance if you want to use it for anything else. After all, if you spend an hour logged onto an access point which is a local 'phone call away your 'phone bill will be big enough. But if you do the same on a long distance connection it will be even bigger.

By the way, an Internet service provider's local access point is usually known as a point of presence (PoP). Do not confuse this with methods of e-mail transfer across the Internet called Post Office Protocol (POP).

Second, what speed of connection does the point of presence support? Data travelling from the Internet to your computer and vice versa is measured in terms of bits per second (the number of binary digits of data which travel over the line) or bytes per second (where a byte is an agreed number of bits, say, eight). If your Internet service provider's point of presence supports 28,800 bits per second then data flow is as fast as it can be over conventional telephone lines. If it is only 2,400 bits per second, on the other hand, then data transfer is quite slow and you could be on the line for long periods.



Turnpike Connect.

Coupled with this (although it is your problem not the Internet service provider's) is the speed of your modem. Modem speeds can be anything from 2,400 to 28,800, stopping at 4,800, 9,600, 14,400 in between. Generally, the rule is buy the fastest you can afford, you will save the extra you pay with lower 'phone bills over the long term.

Third, how comprehensive is the connecting software you use to interface your computer to the point of presence and on to the Internet? Some Internet service providers give you all the software you need, when you register with them. Some do not, leaving it up to you to locate any software you want to use. Even among the Internet service providers who do provide software there are significant differences in performance and ability.

Of these three considerations, the first two are physical ones. You have to weigh up what you want from the Internet and cut your cloth accordingly. Bear in mind, though, that you will probably want more than you first expect from the Internet. It is an expanding and fascinating medium. You might think you will never use it for anything other than e-mail occasionally, therefore an Internet service provider with a low data rate may not be a particular problem. But at some point in the future you might well find that surfing the World Wide Web and its graphical pages is the thing to do, in which case you need a fast

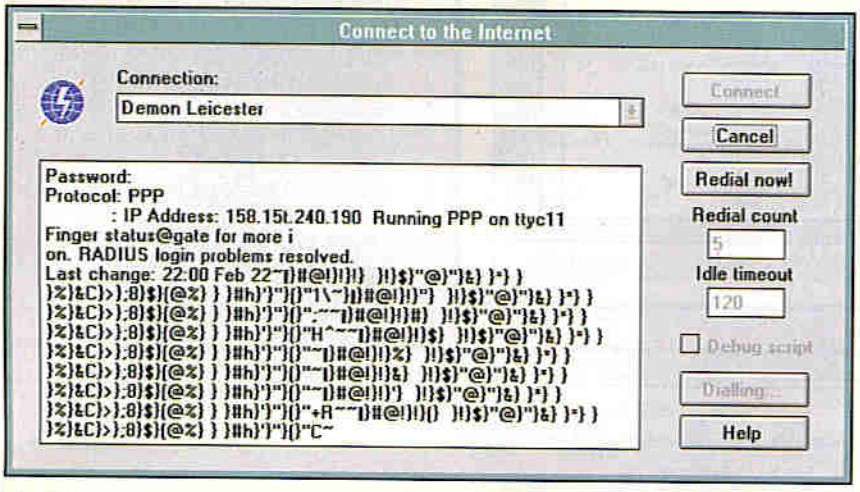
connection. The moral is, of course, do not get yourself trapped in an Internet service which is not expandable enough for your future needs.

The problem is, of course, that you do not know your future needs. To decide this you would be better off with a crystal ball. That is where this series steps in. To be honest, mind you, I have not got a crystal ball. So I can not tell you what you will need in the future. On the other hand, I can show you what is available then you can make up your own mind what you think you might need. I am going to look at quite a few different Internet services and, without highlighting any one service in particular, simply show what sort of things you can do.

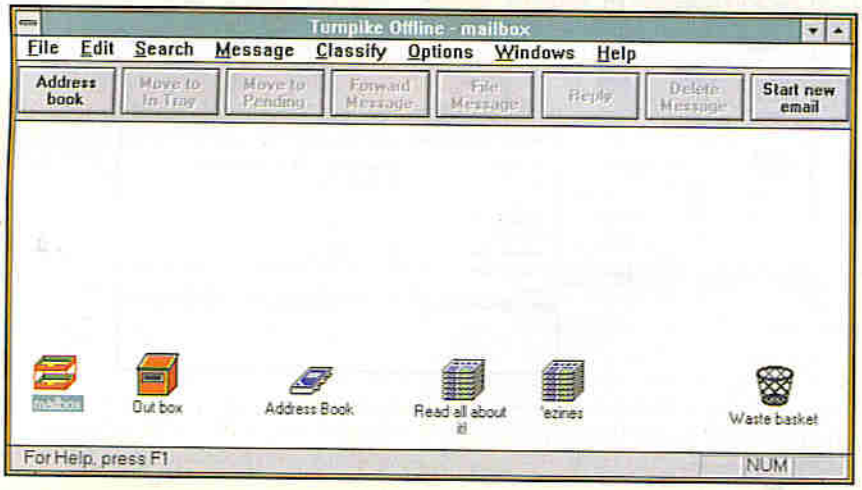
So, we are looking at Internet service providers which can provide features and abilities over and above the basic Internet connection. That is why the series is titled Value added Internet services. It is the value which you or your provider adds to the basic connection which differentiates one service from another, and that is the premise we start from.

This month, I consider what constitutes a basic Internet connection, and how it can be improved. Over the coming months I will look at some of the other Internet services around, focusing on online services. Some of these have been around for a while (for example, CompuServe) while some are a little newer – to the UK at least. AOL is a good example here, it has been around in the US for many years, but only recently has come this side of the pond. This month's cover disk provides the software to get PC users up-and-running on AOL – also see page 4 for our AOL feature.

Pipex front-end.



Turnpike Connect log-on process.



Turnpike e-mail mailbox.

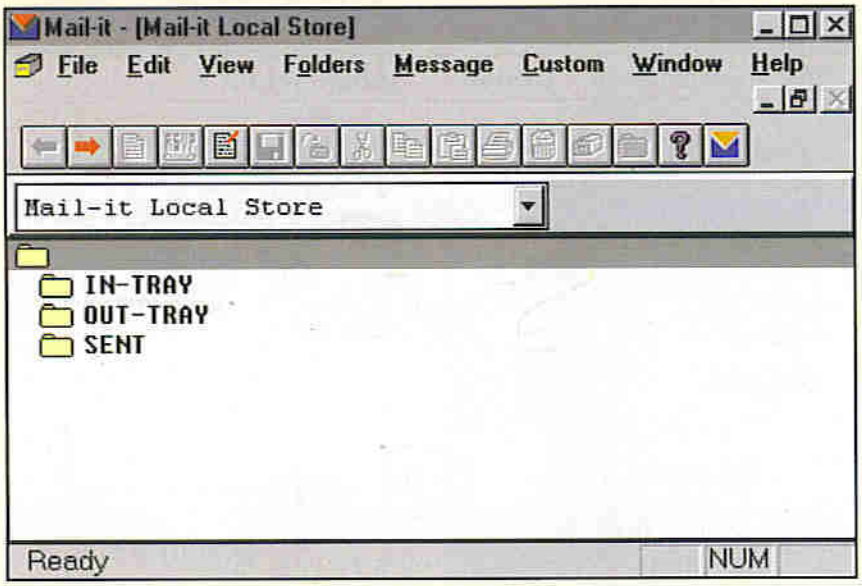
The Microsoft Network is an example of a relatively new online service. All these online services are new to the Internet. Until recently, they have had no Internet connection at all. True, they are linked globally by their own network, but it has been a separate network (both physically and conceptually) to the Internet. But things are changing now as they all get onto the Internet bandwagon, giving services which seem to offer the best of both worlds. I will also take a look at brand-spanking-new Internet technologies.

Internet Access

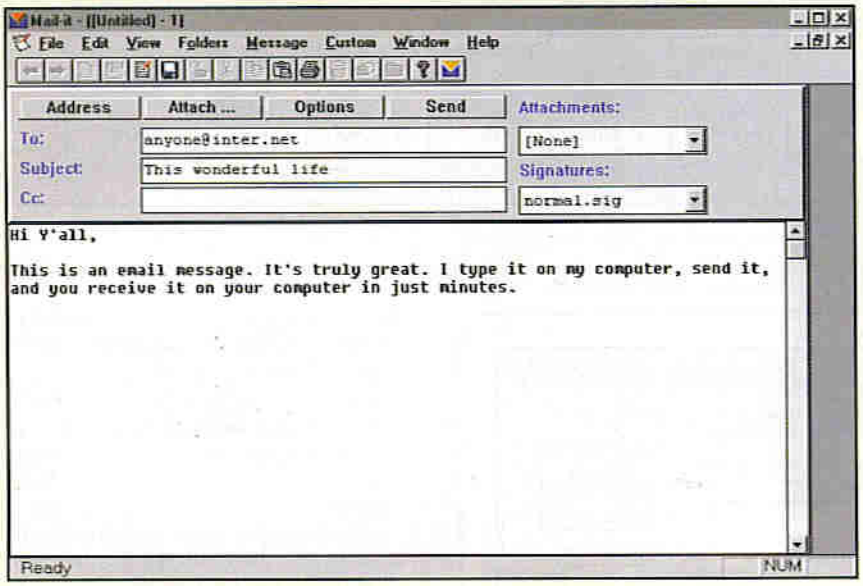
If you take a look in any of the magazines specializing in the Internet on the newsagents' shelves, you will see there is quite a selection of Internet service providers. One of the first, cheapest, and consequently largest is Demon Internet. Demon specializes in providing reliable, basic connection for computer users around the country. All the country is covered, at a local phone call rate – an important point as we have already seen. It is currently the main Internet service Maplin uses.

Demon has 'a tenner a month' policy for individuals, so for £10 + VAT you can have access to the Internet, together with your own e-mail address.

In the past, Demon has tended to stay away from supplying anything other than basic connection software to users, instead preferring users to obtain any commercial software themselves. After all, it is difficult to specify exactly what users want from the Internet. However, recently Demon has promoted Turnpike, a relatively new product which takes care of all the connection details, combining e-mail, World Wide Web browsing, file transfers and so on in a single package.



Pipex e-mail.



Pipex e-mail message.

box, address book and waste basket, together with news-stands for the newsgroups you follow. You can configure the news stands as you want, having different newsgroups in different news-stands or, indeed, having all of them in one.

One of the biggest things going for Turnpike is that it can be used with other Internet service providers, too. It is not exclusively intended for use with Demon, in fact it is intended otherwise, and comes supplied with connection details for many Internet service providers. This can be useful if you use an Internet service provider other than Demon, but want the features available in Turnpike. Useful, too, if you have Internet access through more than one provider. Having the same friendly interface whatever provider you log onto can be a real boon.

As we have seen, Turnpike is a very versatile program for Internet users. In fact, there is only one minor niggle, in that connection progress is always displayed. While this is perhaps useful the first couple of times you login to your Internet service provider, so you can see what is happening as you log on, it becomes an irritation after that.

Access All Areas

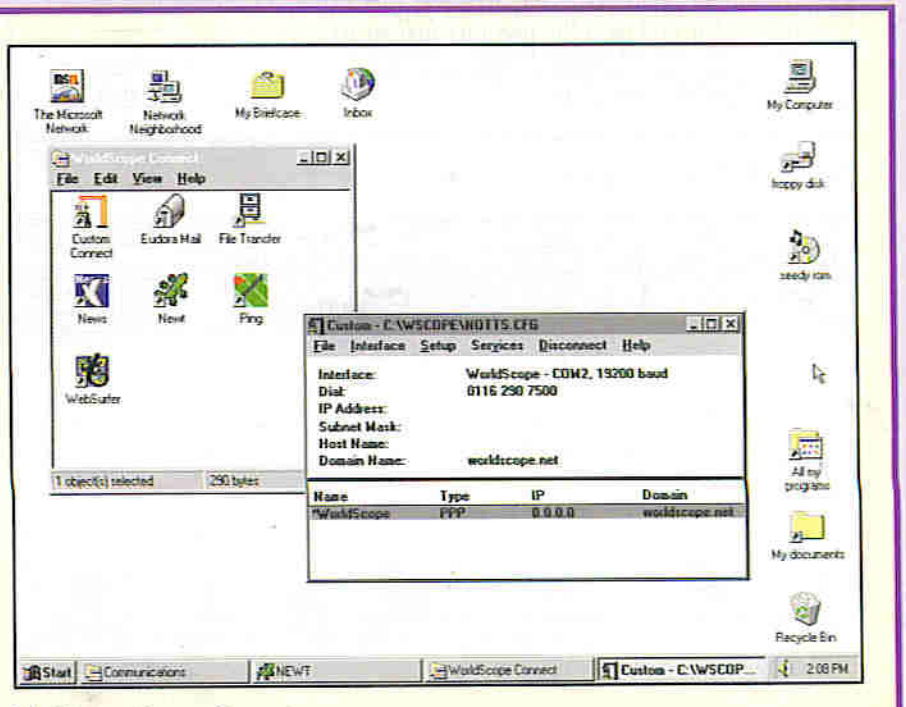
Demon is only one of the Internet service providers', there are many others of course. One of the best in terms of quality is Pipex, whose Pipex Dial access is very reliable albeit a little more expensive than Demon's. Its front-end application for supervision of connection and transfers is perhaps not as versatile as Turnpike, in that it is intended for connection to the Pipex Dial network alone, but it is an excellent program for doing just that. Like Turnpike it features one-click access via buttons to World Wide Web browsing, e-mail, news, Telnet, Ftp and Ping, if anything in a slightly simpler environment because connection progress is not viewed unless you request it. It has a particularly neat interface which is highly commendable.

Pipex Dial is another front-end program exclusively available for Windows operating system users. Note that does not mean you

Exclusively for use with the Windows operating system (that is, not yet available for DOS, Macintosh or any other computer platform), Turnpike gathers together all the Internet software you will probably ever need in a reasonably straightforward front end. Included, for example, is a licensed version of Netscape Navigator which lets you get to grips with World Wide Web page browsing right out of the box. Many Internet tasks are automated. Turnpike is by default setup to collect news messages, and delete ones you have had on your hard disk for a predetermined time.

You control everything from the reasonably friendly environment of the Turnpike Connect window. Buttons along the window top allow you one-click access to Turnpike's various modules: mail and news, World Wide Web browsing, FTP (file transfer protocol) file uploading and downloading, Telnet, Finger, Ping and route tracing. The concept is nice, and everything is easily available from here. Connect takes care of all technical details regarding logging onto the Internet and the services you want automated, and even allows you to customise the buttons along the top.

A feature of the mail and news environment is its desktop interface, with a mailbox, out



Worldscope Custom Connect.

can not access the Pipex network on another computer (in fact I logon to my Pipex Dial account with the built-in Internet access software on my Macintosh) but it does mean that you have to gather together all the other utility software you want (for e-mail, news gathering, Web browsing, Ftp and so on) yourself for anything other than Windows.

Other Internet service providers have their own connection programs too. Most of these are not as comprehensive as Turnpike or Pipex Dial, in that they do not feature a single front-end program, instead they usually provide a program which controls connection procedures, together with the other utility programs you may need.

One of the newest such Internet service providers is Worldscope, which provides connection software for Windows or Macintosh operating systems. Equalling Demon's service in price, it is a reliable network and the free software gives you everything you will need for general-purpose Internet use.

Utility programs with Worldscope are as comprehensive as Turnpike or Pipex Dial. E-mail facilities, for example, are included through Eudora, in my view one of the best and most straightforward e-mail programs ever to grace the screens of my various computers. While it is just the shareware version of Eudora (Eudora Lite), most facilities you could ever need for e-mail are built in.

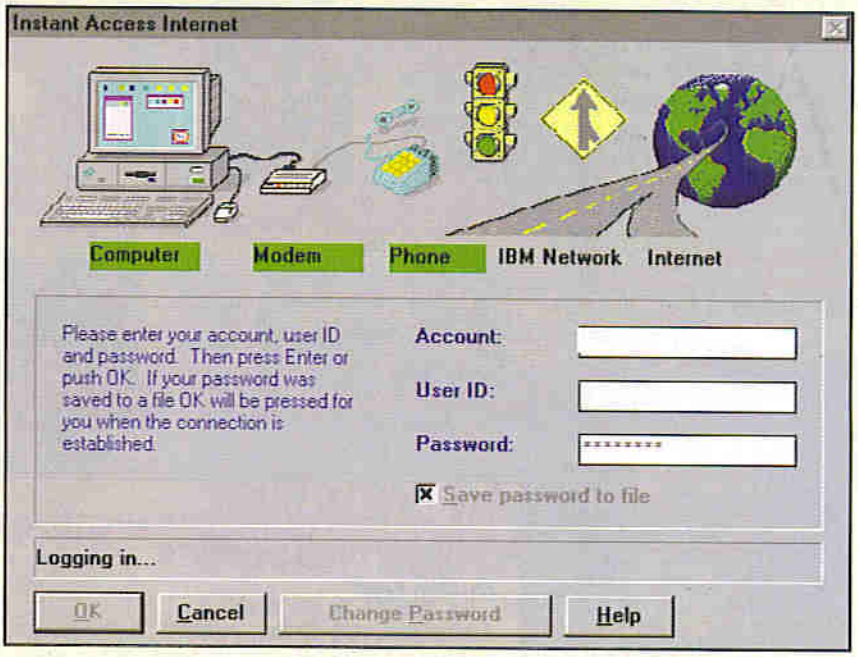
Another Internet service provider worth a mention is the IBM Global Network. If you travel abroad and need to keep in touch, the Internet is a tremendous way to do it. But you need to make sure the network you use is available wherever you travel. A network such as IBM's Global Network ensures that immediately. It features a slightly different pricing structure to others we have seen so far. You pay a basic £10 + VAT a month, and for this you get 3 hours' worth of online usage. Charges increase after this to £20 + VAT a month for up to 30 hours' usage. Ostensibly then, the network can be more expensive than some others, but if you want the global coverage, or only need e-mail facilities, it is a good option.

You can get access to the network in many ways, but probably the easiest is to pop out to a high-street shop such as W. H. SMITH, Boots, John Menzies, Dixons and so on, and buy a copy of Instant Access to the Internet.

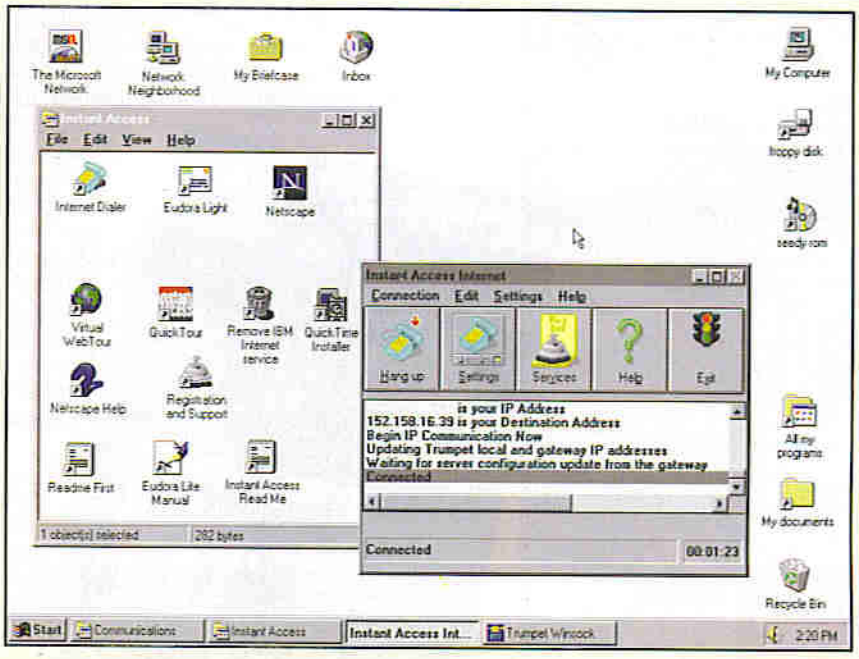
Instant Access to the Internet is a collection of utility programs together with a connection front-end which, like Worldscope's, uses Eudora for e-mail. At its price of under £25 you get a months' free network usage and all the necessary software. Currently available just for the Windows operating system, look out for a new uprated version available shortly, which will feature more powerful utilities (the very latest version of Netscape Navigator, for instance) and for both Windows and Macintosh computers. With a little luck, the uprated version will be available before I write the last part of this series, so I will look at it then.

Time to Jump?

We have had a close look at many ways to get onto the Internet using a basic Internet connection provided by an Internet service provider. The front-end connection programs we have considered in this part of the series all give you something more from your basic Internet connection, and save you the bother of locating utilities such as e-mail programs and Web browsers yourself.



Instant Access log-on process.



Instant Access dial-up.

It is important to remember that the four Internet service providers here, Demon, Pipex Dial, Worldscope and the IBM Global Network, are not the only ones. It is quite possible that one or more of the many others will be able to do everything you want (and maybe more). However, by seeing what is available from the four we have isolated, you are already in a better position to decide for yourself what to do.

Before you reach for your cheque book, though, you should ask yourself is that all you want from the Internet? What else is available which can give you all this? Is there anything else out there which can give you more? Alternatively, is this all too much for you – too complicated, and too many things to worry about?

Next month we will start to look at services which give you all the power of the Internet in a slightly friendlier way. Online services, as they are usually known, have been offering features which the Internet now brings for a long time. CompuServe, AOL, and, lately, The Microsoft Network have given Internet-style e-mail to users for many years, together with some other features which the Internet has not yet obtained to any great amount, all in a much more user-friendly way. More recently, online services have started to offer Internet access as well, all through the standard friendly interface, effectively giving users the best of both worlds.

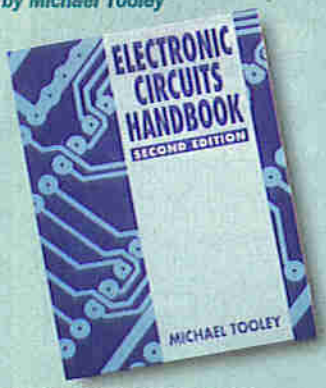
For now, why not try out the AOL software on this month's free cover disk? It is for Windows users only, but a Macintosh version is scheduled for the near future. If you are a Mac user and do not want to wait, look to @Internet elsewhere in this month's issue where you will find details of the AOL Web site from where you can download the Macintosh AOL program. It is not localised for UK use, so news and other things are US biased, but it gets a Mac user onto AOL nevertheless.

All of the books featured on this page are available from Maplin Regional Stores and by Maplin Mail Order. To find your nearest Maplin Regional Store Tel: (01702) 552911 or to order call the Credit Card Hotline on Tel: (01702) 554161

NEW BOOKS

Electronic Circuits Handbook – 2nd Edition

by Michael Tooley



Whether you are an electronics engineer, technician, student or enthusiast, this book could quickly become your basic reference source on electronic circuitry. It keeps coverage of the principles to a bare minimum, presenting instead a unique collection of practical working circuits, all thoroughly tested, and the information necessary to modify and extend them to meet specific needs. Related circuits are grouped together and cross-referenced and, as a bonus, ten test gear projects are included.

373

1993. 246 × 189mm. ***Order As 95088 (Elect Circuit H/Book) £24.95*** A2

Understanding Digital Technology

by F. A. Wilson

Initially, digital technology looks relatively simple, but there is more to it than at first might be imagined, and we have come to accept that it is here to stay, and to some extent taking us over! This probably happened with the arrival of the computer several years ago, but at the same time, digital technology was also creeping into the telecommunications world, to such an extent that 1000s of digital channels are accommodated on a single hair-width glass-fibre. This book first examines what this technology has to offer, and then considers its arithmetic and how it can be arranged for making decisions in so many processes. This is followed by a look at the part played in IT, especially in modern transmission systems and television. The mathematics at all times is kept to a minimum. An interesting delve into the digital world both for the beginner and those who need some revision or updating.

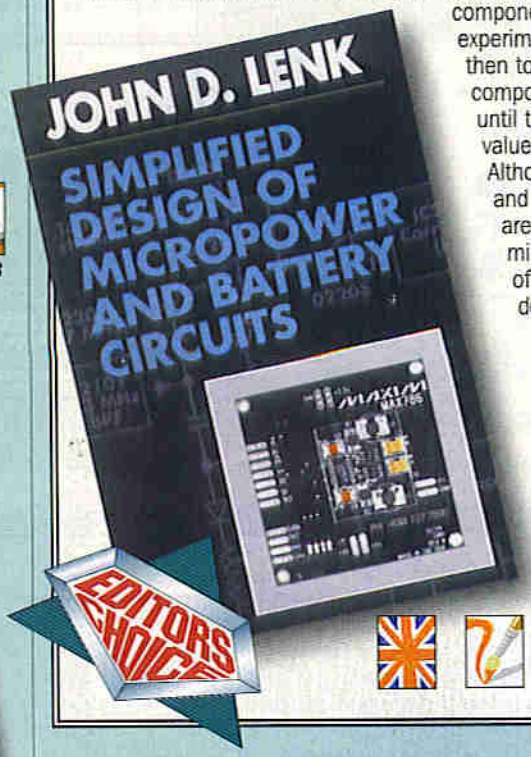
150

1996. 178 × 111mm. ***Order As 95090 (Understanding Dig Tech) £4.95 NV***

SIMPLIFIED DESIGN OF MICROPOWER AND BATTERY CIRCUITS

by John Lenk

A simplified, step-by-step approach to micropower and supply cell circuit design. No previous experience in design is required to use the techniques described thus making the book well suited for the beginner, student, or experimenter as well as the design professional. The book concentrates on the use of commercial micropower ICs by discussing selections of external components that modify the IC-package characteristics. The basic approach is to start design problems with approximations for trial-value components in experimental circuits, then to vary the component values until the desired values are produced. Although theory and mathematics are kept to a minimum, operation of all circuits is described in full.



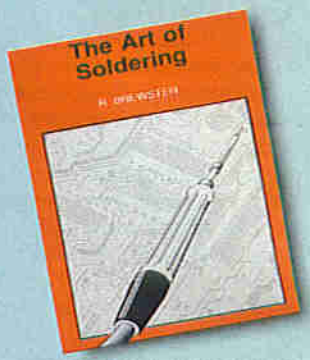
240

1995. 234 × 152mm, ***Order As 95091 (MicroPower & Batt Ccts) £22.99 NV***

The Art of Soldering

by R. Brewster

This is an attempt to dissolve the mysteries that surround a subject that is increasingly becoming a part of so many hobbies. Despite its reputation for being a difficult skill to acquire, soldering can be both easy and pleasurable once the basic principles and techniques are properly understood. The author explains how to choose the correct soldering iron, solder and materials and, with the aid of diagrams, the techniques needed to achieve the best results in a range of hobbies including electronics, model railways, and stained glass.

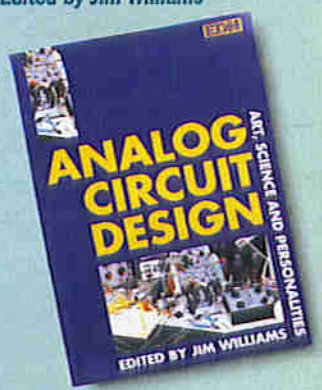


84

1992. 178 × 110mm. ***Order As 95089 (The Art of Soldering) £3.95 NV***

Analog Circuit Design, Art, Science and Personalities – 2nd Edition

Edited by Jim Williams



A collection of essays from 24 contributors (all experts in their field) in the USA, brought together to provide a tour through the world of analogue design, and combining theory and applications with the philosophies behind the design process. The topics covered include the definition of analogue design, the making of an analogue designer, design intuitions and insights, and a section for techniques, tips and applications. The book provides a wealth of practical working circuits together with anecdotes from each author's experience.

390

1993. 250 × 175mm. ***Order As 95087 (Analog Crct Design) £14.95 NV*** A1

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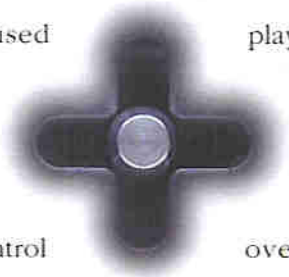
All singing All dancing

That's the CDJ2600 from Soundlab! It's the twin CD for DJ's that does just about everything you could possibly ever need.

It comes as two 2U rack-mount units, finished in black enamel with clear legends and large, user-friendly controls, which are easy to find and use, even in the lowest light conditions.

The green LCD displays both track number and elapsed time to frame accuracy. It even gives a visual reminder should you leave one of the CD trays open.

When you're looking for a cue point, you can choose between two methods offered by a single concentric wheel. The outer ring gives shuttle search, while the inner portion allows Jog Search. Once found, a cue point can be memorised then used instantly with a single 'cue' button.



An innovative joystick gives you total control over the comprehensive loop facilities: simply pushing the stick upwards memorises the loop start point and pulling it downwards marks the end point, giving a single repeat. Should you then pull the joystick down during the loop, it will repeat continuously.

Left/right movements of the joystick allow pitch bend.

And the CDJ2600 is as tough as it is talented.

The robust twin transport has been designed to survive life on the road, while damped mechanisms offer a very high degree of mechanical isolation, to maximise playability in any conditions.

High quality sound reproduction is ensured by 16 bit, 8x over-sampling DAC technology, and ease of set-up is guaranteed by the unit's intelligent design.

All these features for only

£499.99

Order Code 51252

For more information call

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