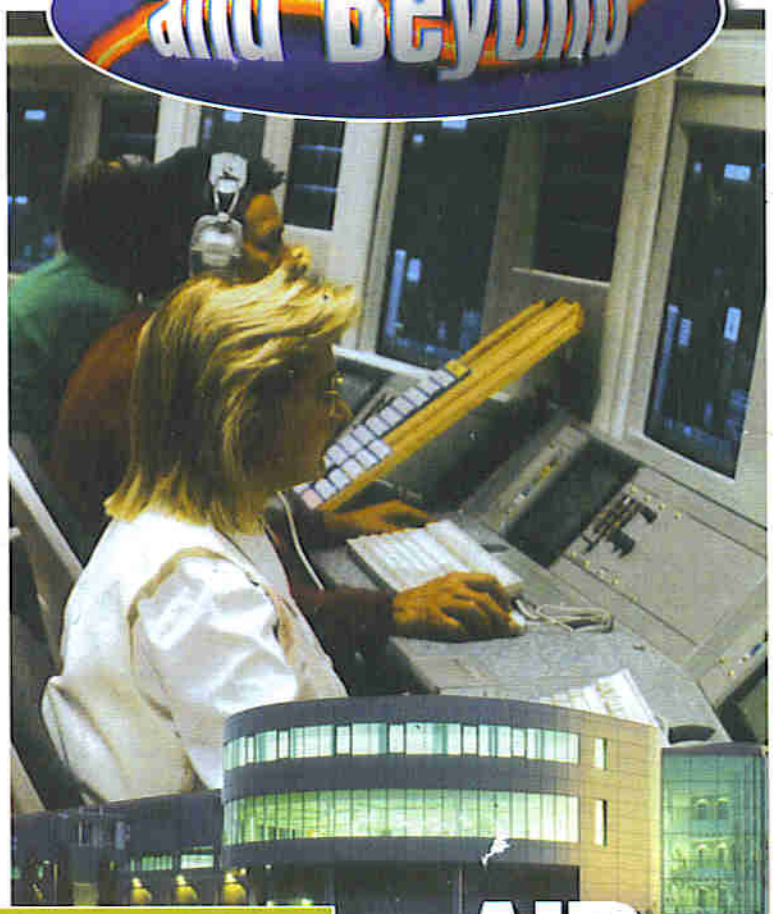
THE MAPLIN MAGAZINE

# ELECTRONICS

## and Beyond

# Tesla

**The life of a genius**



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# ELECTRONICS and Beyond

February 1997 Vol. 16 No. 110

## Projects



## Features



## Regulars









## Inside

**Educational Mini Circuits Supplement**

A variety of Stripboard Projects for your to make.

**See centre pages**

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# ELECTRONICS and Beyond

Amongst these pages we feature an article on Nikola Tesla. He is one of the few world-class scientific experimenters who has since been credited by the use of his name for one of the metric SI units, magnetic flux density. Without doubt this man was a genius. His unique foresight of mechanics and electro-magnetics produced hundreds of complex inventions that would take some beating by any man or woman today.

For here was a man who could not only have 'thought experiments' as Einstein was noted for, but also take those 'thoughts' through to a conclusion to see the outcome. In other words he could create and see the inner workings of a machine in his head and check for wear and tear sometime after.

Tesla might have been gifted with the use of his brain as a powerful simulator but it remains a great shame that the method by which he achieved this could not have been taught to others. The fact remains that each of us has the mental capacity to acheive greater things if only we could unlock the way to do it.

Who knows, by reading this fascinating article from Douglas Clarkson, you might be stirred into some creative thought experiments yourself.

***Paul Freeman-Sear, Publishing Manager***


## Britain's Best Magazine for the Electronics Enthusiast

# NEWS REPORT

## Intel Endorses Spread Spectrum Clocks

Intel has announced a new feature on its i960 processor families to enable end-users to pass the worldwide radio emissions tests.

The EMI (Electromagnetic Interference) specifications do not usually concern digital system designers, since they typically leave the emission reduction to the EMC Engineers, who use filters, shielded boxes and ferrite beads to contain the EMI within the box. These techniques add complexity, time delays and added cost at the end of the product development cycle.

IC Works has addressed the problem by developing a family of PLL Clock Oscillators (The W42C30 Series) that reduce the emissions at source, through a technology called Spread Spectrum Clock Generation (SSCG). This is a patented technique which modulates the clock oscillator frequency over a narrow frequency spectrum, thereby reducing the typically high emission amplitude at any one frequency.

By using an SSCG solution, system designers can reduce electromagnetic emissions by as much as 10 to 20dB, before the EMC engineers are set to work. Actual reductions vary with frequency, with the greatest reduction occurring at the higher frequencies. One unique advantage of SSCG is that the emissions of every harmonic of the clock and all signals are synchronised to the clock. This means signals such as the address, data and control buses, all experience reductions in EMI.

In the UK, for full details of the IC Works W42C30 series, contact distributor 2001-METL, Tel: (01844) 278781.


## LucasVarity Introduces Sensor

LucasVarity has made a new addition to its range of pressure sensors. The NPP series is a low cost, silicon piezo-resistive pressure sensor encased in industry standard SOIC-8 robust plastic packaging. The NPP series has been designed to provide a cost effective solution for OEM applications requiring small size and mild corrosive media isolation capabilities. The sensors are available in pressure ranges of 0 to 15, 0 to 30 and 0 to 100psi, and provide an unamplified full scale output ($V_{SO}$) of 60±20mV with 3V DC output. Detailed specification sheets are available from LucasVarity.

Contact: LucasVarity, Tel: (+1) 510 661 6105.

## MCI and BT Announce Largest Corporate Merger in History

The big news in the telecommunications sector this month, is that BT and MCI have signed a definitive merger agreement. MCI is the second largest US telecommunications company after AT&T.

The merger combines the substantial financial resources and global position of BT with the growth momentum and competitive market expertise of MCI. The combined company will be headquartered in London and Washington DC, and will operate under the BT and MCI brand names in the UK and the US, respectively.

Providing it goes ahead, this merger will create the world's first global communications company, with revenues of over $42 billion, cash flow of $12 billion and 183,000 employees who support 43 million business and residential customers in 72 countries. The new merged company will provide an integrated set of local, long distance, and international services including voice, data, wireless, Internet and Intranet, information technologies and outsourcing.

The decision to merge MCI and BT follows the investment by BT in 20% of MCI in 1993 and the creation of the Concert Communications Services joint venture between the two companies. The joint venture has been touted by industry analysts as having a one-year lead over its competitors in providing global services and solutions to the world's multinational companies. Concert Communications Services has sold more than $1.5 billion in contract revenue, and recently announced that it would break even one full year ahead of original forecasts.

Meanwhile, AT&T has acted swiftly to the news, demanding that the deal receive the scrutiny of the US Department of Justice, the Federal Communications Commission and the appropriate regulatory authorities in the United Kingdom and Europe.

"We would expect that our government would condition any such approval on the complete and unqualified opening of the telecom market in the United Kingdom. In spite of the progress made to establish competition, the UK market is not fully open. New entrants and carriers who want to serve customers still face significant barriers", said Robert Allen, chairman, AT&T.

"BT still controls more than 90% of all local telephone connections in the UK, and equal access to customers and telephone providers simply does not exist. The ability of a company with this kind of market power to negatively impact competition and reduce customer choice makes the evaluation of this proposed merger a global priority of the highest order", added Allen.

For further details, check: **http://www.concert.com.**

Contact: BT, Tel: (0171) 406 8314.

# Wide Screen Notebook

**WideNote is a portable wide-screen notebook computer from Sharp. The industry's first 1,024 × 600 wide-screen colour notebook weighs under 2kg and offers users the cinema-type widescreen capability previously only available from extra large desktop monitors.**

**The WideNote is an ideal tool for users requiring a larger viewing capacity. It allows the business user to view all twelve months of a spreadsheet in full size, on a single screen, without needing to scroll multiple screens for the same application. It is also designed for true multi-tasking, with two applications running on screen at the same time.**

**On the same principle, Internet users can browse two Web pages simultaneously, or combine Internet surfing with locally based applications like word-processing. This wide-screen feature makes comparative research on screen easier and more efficient.**

**The WideNote is available immediately, priced £3,200.**

**For further details, check: http://www.sharp-usa.com.**

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

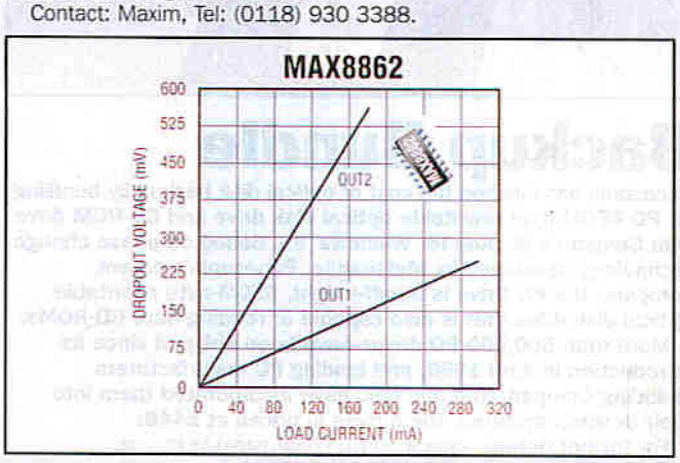

# Dual Linear Regulator Offer 200mV Dropout at 250mA

The MAX8862 dual linear voltage regulator launched by Maxim this month is targeted at portable, battery-powered applications. The device includes two separate circuits with independent supply voltage inputs with swings of 2·5 to 11·5V.

A pair of p-channel MOSFET pass transistors maintain low quiescent current in the IC, particularly during dropout – where a pnp bipolar transistor would typically saturate and draw excessive base current.

MAX8862 regulators make ideal power supplies for the radio and micro controller found in PCs and digital cordless phones. The main regulator delivers 250mA and is optimised for transient and dynamic response – the secondary regulator delivers 100mA and exhibits a low level of wideband output noise. At 250mA load currents, the dropout voltage is a low 200mV.

Contact: Maxim, Tel: (0118) 930 3388.




NEWS BYTES

## In-Car Cryptography

**Over 60% of car immobiliser systems are based on encryption technology from Philips Semiconductors. Now, Philips wants to clean up the entire market with a new generation of immobiliser key technology – SECT (SECurity Transponder) – which is the first to use a cryptographic transponder embedded in the key.**

**Any attempt to monitor the RF transmissions between the key and the car will only reveal a string of random numbers. A special code sequence, stored both in the key and used to cypher the initial random number, is never transmitted, making it impossible to deduce this code from the data flow between key and car.**

**Copying the key is impossible – the code cannot be determined. And it is impossible to use the car without a key that the system recognises. The car itself can be programmed to recognise the code sequences of a number of different keys, which means that it is possible for the car to recognise the driver and automatically adjust mirrors, seat position and driving performance accordingly.**

**For further details, check: http://www-eu.philips.com.**

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

## Radio Authority Publishes Guidelines On Public Interest Tests

The Radio Authority has published its procedural guidelines on the way in which it will conduct the new public interest tests under the Broadcasting Act 1996 introduced at the beginning of November.

The new rules for both radio specific and cross-media concentrations remove a number of previous restrictions on ownership whilst at the same time introducing safeguards to protect diversity.

The guidelines set out the criteria against which the Authority will apply the tests and the information which it requires from parties involved in order to reach a decision. The Authority will require a full description of the arrangements in question and the party's views on the implications of those arrangements.

A company will now be permitted to own two licences on the same waveband in the same area if the Authority determines that it is not against the public interest for it to do so. A concentration falling under this category cannot be effected without the Authority's approval.

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

# NEWS BYTES

## Retail Consultants Issue Data Warehousing Report

**The challenge facing many retailers today is not collecting information, but in using it to improve the sales and profitability of their business, according to a new report on the impact of data warehousing by retail consultants, Management Horizons Europe.**

**Management Horizons' report lists the top 10 challenges which retailers face as they move into the year 2000. Winning and maintaining a competitive edge by constantly improving customer satisfaction will remain as the primary focus for retailers.**

**According to the report, although retailers are responding to these challenges by implementing an array of customer-driven and cost reduction programmes, in many cases, they have not seen a return because of a lack of effective technology. The job of a data warehouse is to untangle the maze of operational, financial, customer and external marketplace data.**

**Contact: Management Horizons Europe, Tel: (0181) 560 9393.**

## Toshiba Cuts Notebook Prices

Toshiba has slashed prices right the way across its notebook range with reductions of up to 27%. It is now offering the entry level Satellite 200CDS with full multimedia capabilities for £1,800.

For further details, check: `http://www.toshiba.com`.

Contact: Toshiba, Tel: (01932) 828828.

## StrongARM Microprocessors Take NC Lead

**Digital claims its StrongARM SA-110 microprocessor has taken pole position as the CPU for Internet/intranet appliances and thin-client computer products.**

**To date, five companies – Wyse Technology, Boundless Technologies, LG Electronics, Acorn Computer Group and AlphaVision – have announced Internet/intranet appliances based on the StrongARM microprocessor. Wyse and Boundless currently account for approximately 80% of the industry's set-top box and thin-client terminals.**

**"These five companies exert a broad influence across both corporate and consumer markets, and will give StrongARM microprocessors a significant worldwide presence in the network client arena", said Ed Caldwell, vice president, Digital Semiconductor.**

**For further details, check: `http://www.digital.com`.**

**Contact: Digital, Tel: (01734) 868711.**

## PC Dictation

Home computer users can now dictate rather than type their messages, letters, essays or e-mail directly into their computers with IBM VoiceType Simply Speaking for Windows '95. This latest addition to the VoiceType family of speech recognition software is priced at approximately £100.

Jan Winston, Worldwide Speech Systems Manager at IBM told *Electronics and Beyond*, "We wanted to give many more people the opportunity to experience the benefits of being able to talk to their computer. VoiceType Simply Speaking offers the power of state-of-the-art voice recognition technology at an affordable price."

VoiceType Simply Speaking offers powerful capabilities, including eyes-free and hands-free dictation at speeds of 70 to 100 words per minute, as well as built-in correction. The product is ideal for students, families and all home computer users who type lots of letters and documents but would prefer a new method of writing and a more natural way of interacting with their computers.

One of the benefits of the system's technology is that users do not have to teach it to recognise their voice, enabling them to achieve accuracy of over 90% immediately. This accuracy builds to over 95% with use as Simply Speaking continually updates its language model, adapting to the words and terminology most commonly employed by the user.

For further details, check: `http://www.ibm.com`.

Contact: IBM, Tel: (0171) 202 3799.

## Powerlogic IC Eases Power Plugs Design

A high-voltage BCD Powerlogic IC from Philips Semiconductors allows constant-voltage/constant-current DC supplies to be housed in a universal slim-line power plugs that plug directly into 90 to 280V AC line supplies. Target applications for this new IC include fast-chargers for cellular and cordless telephones.

The TEAl401t Self-Oscillating Flyback Power Supply Controller derives feedback on output voltage and current from an auxiliary winding on the isolation transformer, eliminating the need for any current or voltage sensing circuitry on the secondary side of the transformer.

The device also includes an on-chip 630V/0·5A DMOS switching FET – as a result, the only other components required in an electronic power plug capable of charging 10 to 20W loads are an AC line supply filter and rectifier, a miniature transformer and a few passive components and diodes.

Previous solutions have required the use of a large number of active and passive discrete components in both the primary and secondary side of the transformer, leading to much bulkier power-plug designs.

For further details, check: `http://www-eu.philips.com`.

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



# Backup Bundle

**Panasonic has slashed the cost of optical disk backup by bundling its PD 650M-byte rewritable optical disk drive and CD-ROM drive with Seagate's Backup for Windows '95. Based on phase change technology developed by Matsushita, Panasonic's parent company, the PD Drive is a half-height, 650M-byte rewritable optical disk drive that is also capable of reading bare CD-ROMs.**

**More than 500,000 PD drives have been shipped since its introduction in April 1995, and leading PC manufacturers including Compaq, IBM and NEC have incorporated them into their desktop systems. The bundle is priced at £440.**

**For further details, check: `http://www.panasonic.com`.**

**Contact: Panasonic, Tel: (01344) 853550.**

# Short Wave Battery Saviour

Portable rechargeable light and power manufacturer, Nitech is promising short wave radio enthusiasts longer life from its power supplies.

The inadequate performance of battery life in scanners and transceivers is the greatest source of misery for users, who can typically expect only around four or five hours of life from standard rechargeable AA Ni-Cd cells.

Nitech's own nickel cadmium AA cells not only provide fast charging capabilities and extended cycle range, they also give an ultra-high capacity of 900mA, effectively doubling the duration of airtime attainable from a single recharge in many cases.

Nitech's managing director, Peter Barker, is a short-wave listener himself, and once shared with other operators the frustrations of airtime lost because of below par power cells.

Barker told *Electronics and Beyond*, "Amateur Radio is shared by many thousands of people around the world, but the loss of enjoyment caused by dead batteries was my greatest and most frequent disappointment. Now my own company's products have changed all that and these days, I can stop receiving when I have had enough, not when my batteries have."

Contact: Nitech, Tel: (01424) 852788.

# RESEARCH NEWS

## Advantages of the new 'Cool' Laser Therapy

This treatment shows several advantages over existing techniques, it permits treatment to take place within an outpatients department, and may be repeated. There is no thermal heating of the patient's tissue and hence, scarring is almost non-existent. Large areas can be treated where surgery is difficult, and it is especially suitable for medically compromised patients for whom surgery may not be appropriate and where radiotherapy could damage blood vessels, salivary glands and bone. With the use of directed fibre endoscopes, less damage to delicate close surrounding tissue structures will be caused. The treatment has been used for both cancerous and precancerous tissue and a flash lamp pumped dye layer has allowed this technique to be used on port wine lessions.

Mouth cancer is the largest clinical project currently undertaken at UCL, accounting for some 2,400 patient cancers annually in the UK, but the laser centre is an umbrella organisation covering a number of projects such as skin cancer, prostatic cancer, bile duct cancer, large bowel tumours, osteosarcoma and metastatic breast cancer.

## Cool Lasers

Dr Cohn Hopper, Senior Research Fellow at the National Medical Laser Centre at UCL, is developing a therapy for the treatment of mouth cancer using new photodynamic therapy (PDT) drugs combined with low power optical lasers rather than traditional techniques involving scalpel surgery.

The research team, headed by Dr Hopper, Consultant Maxillofacial Surgeon, is composed of a Research Fellow and a research nurse, who are involved in the treatment of patients using light sensitive drugs. The patients are then illuminated by low power laser light which causes toxic photochemical reactions in the host's tumour cells which are destroyed, allowing healthy tissue to fill the space left by the tumour. Cells unexposed to the light are unaffected.

Cohn's work uses both the more commonly known photosensitising agent 5-aminolaevuhnic acid (5 ALA) and the new drug meta tetra hydroxy phenyl chlorin (mTHPC). Upon exposure to laser light, the photosensitiser causes production of singlet oxygen that damages cancer cells. However, the usual power density is quite low – 200mW/cm², from either a copper vapour dye laser or a semi-conductor laser diode.

Drugs such as 5 ALA often possess more than one wavelength at which the cytoxic photochemical reaction may be generated. Colin says that no heating effects have been observed with their treatment. Multi-mode fibres are used for laser light delivery in order to direct as much of the laser illumination as possible to the site of interest. The penetration depth may be controlled by appropriate choice of the photosensitising chemical, up to 1cm for mTHPC, but only 1-2mm in the case of 5 ALA.

## Critial Timing

The length of a typical exposure treatment is quite short – 5 minutes in the case of the mTHPC and a little longer, in the case of 5 ALA. It is envisaged to take place as a one-off treatment – but those patients who have further tumours may be retreated. So far, over 100 patients have been treated in a year-long trial.

This technique may readily be applied to all surface tumours, including those in hollow organs such as the gut and bladder, in addition to any organ such as the liver or prostate, where fibres may be inserted under ultrasound control.

## Future Antibiotic Free Laser Treatment of Dental Decay

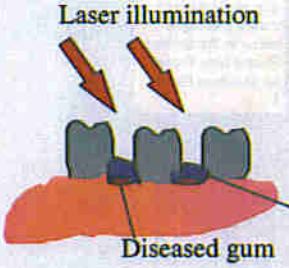
A revolutionary laser dental therapy to combat antibiotic resistant bacteria is being developed by Dr Michael Wilson and co-workers at the Eastman Dental Institute in London. Members of the Oral Surgery department are developing a technique to kill a broad range of antibiotic resistant bacteria. Dental surgery problems involving resistant bacteria are caries, and gum disease. Bacteria cells are coated with inactive light sensitive chemicals which are activated by a short burst of low power laser illumination. Chemicals used are phthalocyanine-based dyes already well-known for having different colours in variable oxidation states and porphyrins (which are water-soluble nitrogen containing pigments). Helium-neon laser light at 632·8nm and semiconductor laser diodes across the range of 630-680nm have been used, with peak powers of up to 7mW and 11mW, respectively, being delivered by optical fibre to the bacteria within a narrow beam diameter of 1-2mm².

Red laser light is chosen, as the blue compounds used absorb strongly in the red region of the visible spectrum. The absorption of red laser light causes singlet oxygen and toxic free radicals to be produced which cause damage to bacteria cell membranes, and has been effective at killing a dozen species of bacteria, including Staphylococcus aureus, an antibiotic resistant bacteria which has been found in hospitals.

Wilson reports a 100% lethality rate with bacteria cultured in petri dishes and is hoping to move to human trials, when the consequences of toxic free radicals affecting healthy mammalian tissues has been examined fully.

If future experiments are successful, Wilson believes such light sensitive compounds could easily be applied on teeth and to cover diseased gum by simply injecting the compounds into the site of a decayed tooth and focusing the laser light accurately on the region of interest.

The limiting factor is the unselective nature of the treatment which could be improved by the use of antibodies which attach to specific tissue, explains Professor Brian Henderson, also of the Eastman Dental Institute. This permits the compound to be applied systemically, allowing broad irradiation and yet only affecting specific body tissue.




**Laser illumination of light sensitive compound above diseased gum tissue.**

# Paperless Office

# POST-IT SOFTWARE NOTES UNDER TEST

**by Steven Waddington**

***Post-it Notes have gone virtual. Has the notion of the paperless office suddenly become a reality? Here, Stephen Waddington takes a first look at 3M's recently launched Electronic Post-it notes.***

It is so annoying when you come across an invention that is so simple and perfect that you wonder why you haven't come up with the idea yourself. And I am not talking here about the type of product advertised in the Sunday Colour Supplements. Classic inventions are simple ideas applied to consumer market gain. The zip, the tea bag, the sliced loaf and the tin can all have that elusive quality that combines sheer genius with elegant but simplistic design. I would now like to add Post-it notes to that list.

My Grandfather used to collect old envelopes to scribble ideas and notes on the back. He always had a stack held together by a huge bulldog clip lying on his desk. Post-its did not exist in those days, but my Grandfather had exactly the right idea.

3M (the creators of Post-it notes) turned over $13.46billion globally last year. Even if only 5% of this income is due to sales of Post-it notes at 75p to £1.00 per pack, that is a hell of a lot of notes. Nevertheless, it is hardly extreme. If you are anything like me, you will have six or seven Post-it notes stuck around your PC screen, containing anything from phone numbers to e-mail addresses and from to-do lists to shopping lists.

Recognising the way the world is moving, 3M has decided to take its Post-it note concept virtual. My screen is now free of yellow and pink stickies. Instead, I'm running 3M's Post-it Software Notes on my desktop. Electronic Post-it notes allow PC users working in any application to create electronic notes in the familiar Post-it Note format, as shown in Photo 1.

A click on the note pad dispenser creates a note that can then be left on the desktop as a reminder, stuck on a customised memoboard or sent to someone via e-mail. Other features include the capabilities to set alarms on individual notes and to find notes via a simple text search.

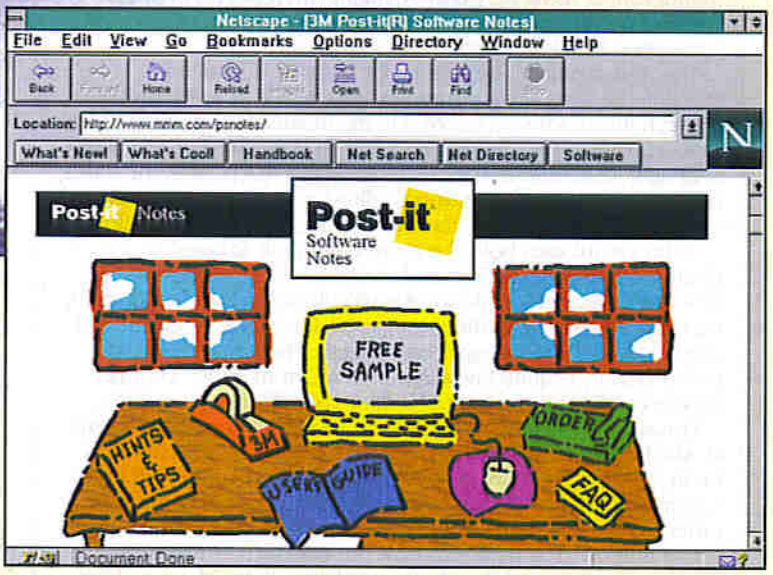



**Photo 2. Download 30-day trial version of Post-it Software Notes.**

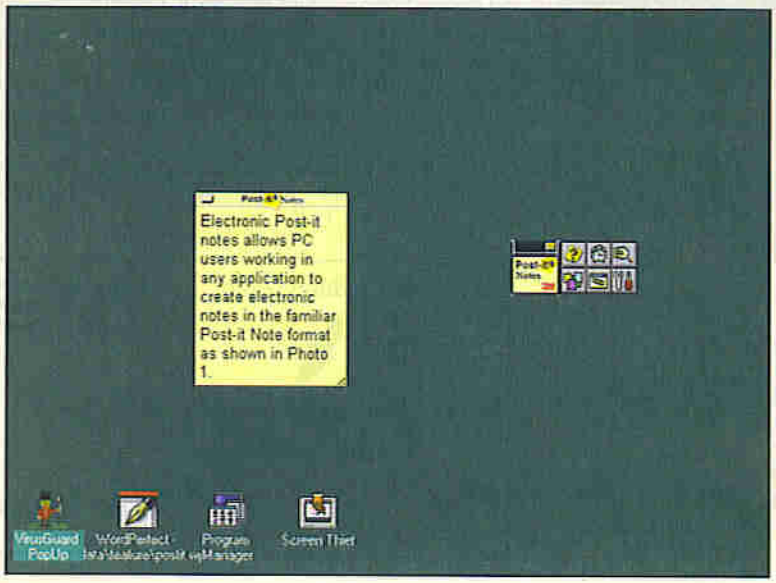



**Photo 1. Electronic Post-it note.**

## Trial

If you fancy trying electronic Post-it for yourself, you can download a free 30 day product sample from 3M's Web site at **`http://www.mmm.com/psnotes`**, as shown in Photo 2. Downloading the software takes 15 to 20 minutes, depending on the quality of the connection and the number of users logged on to the 3M Web server at the time you call. Once you have downloaded the software, installation is easy. Double-click the file named **`setup.exe`** and follow the installation instructions that appear on your screen.

The setup routine puts a Post-it Software Notes icon in the start-up group, which is annoying, but can be deleted from the Program Manager File Menu by selecting Delete. Because the Post-it alarm feature relies on your computer's clock, make sure the clock is set correctly. I made the mistake of using an alarmed Post-it to order my to-do list without realising my clock was wrong. Of course, I missed the last post.

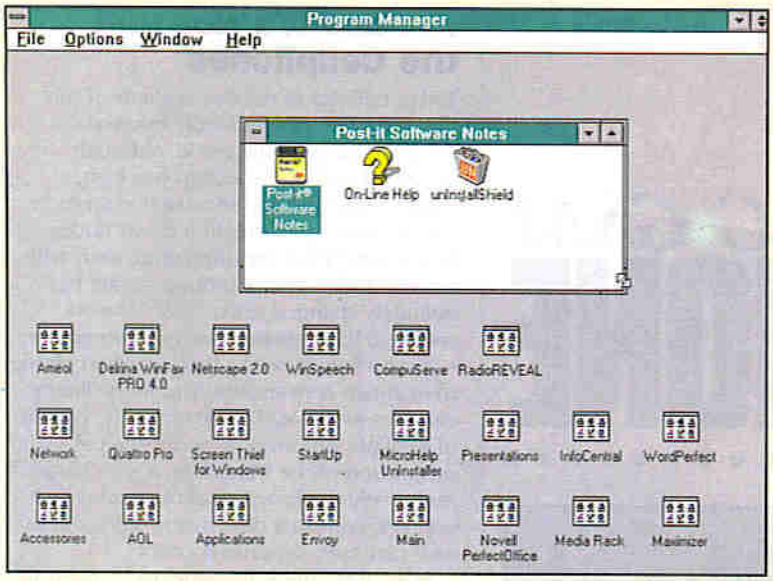



**Photo 3. Launch Post-it Software Notes from application window.**

Post-it notes have a couple of truly neat features. When you log out of Windows and switch your machine off, the contents of any notes that remain open are saved to disk and reopened automatically next time you switch on. This means that you never lose any of the notes. Post-its will even survive a crash, or at least they did the couple of times under test. Finally, the sound effects when you select a note and then trash is fun.

## Availability

3M's Post-it Software Notes is available in the UK from January 1997 for Windows 3.1 and Windows '95. In the Windows '95 version of the software, notes can be attached to documents and sent to others, even if the recipient does not have Post-it Software Notes. And for serious computer users, there is a facility to import and export notes so notes can be transferred from laptop to desktop or vice-versa.

## Features

Once you have launched Post-it notes – from its own application window, as shown in Photo 3 rather than automatically from start up – a small note pad icon appears on the top of your screen; this remains here until you exit the application. Clicking on the yellow pad releases a note. The Post-it notes are basically miniature text editors. You can type on the note and change its size using your mouse. Clicking on the left Post-it note button releases a menu. This gives you access to a load of features such as font, colour, cut, copy, paste, set alarm, send note, print note, and trash note.

Individual Post-its are handled by the PC as objects rather than applications. They can be either pasted on the desktop, on a memoboard, or dispatched to another user by e-mail. Memoboards, as shown in Photo 4, are the equivalent of a desk jotter. They enable Post-its to be grouped together under a certain topic. You can have more than one memoboard, and notes can be dragged from one memoboard to another or to the desktop, as shown in Photo 5.

Clicking the right button on the notepad icon opens a small toolbar. This provides help, alarm lists, a find function, colour preferences, memoboard options and configuration options.

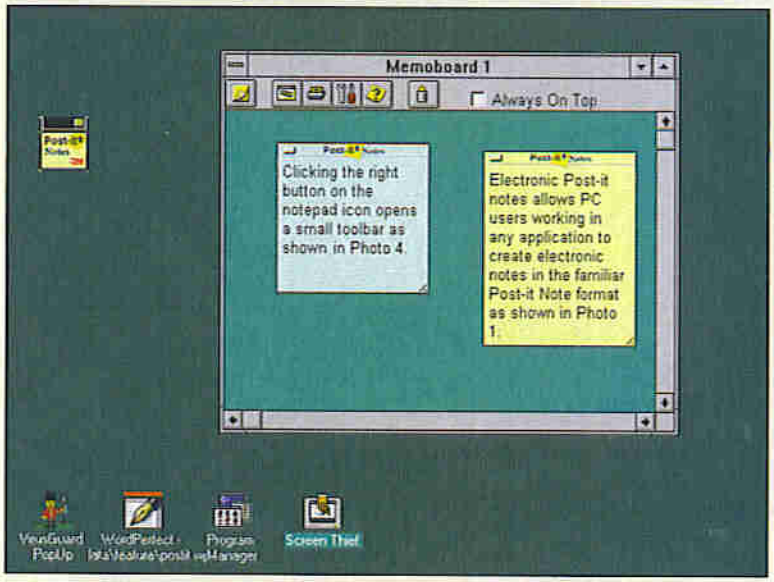



**Photo 4. Memoboards are the electronic version of a desktop jotter.**

## Back to Paper

Here is real irony. A special print button on the memoboard allows users to print their own customised Post-it Notes on an ink jet or laser printer. So, chuck out your Post-it note pad and use virtual notes that you can print out. Users can also print entire memoboards or alarm lists.

The trial software remains live for 30 days. After that, if you like the software, you will have to purchase a full version. At the time of going to press, the pricing for the UK version had not been announced, although it was expected to be slightly more expensive than the US retail price of $24.95 (£16.50). You could, of course, just delete your original version and reinstall the trial software, but with such a low purchase price, it is probably not worth the effort.

## A Love-hate Relationship

You will either hate electronic Post-its or you will be a complete fan. If you are the sort of person that is constantly searching for scribbled notes, this is definitely the software application to solve your problems. If, on the other hand, you are an organised, structured sort of person, then forget it. Electronic Post-it notes are the type of cool software application that everyone thinks they have to have – I just wonder how many people use them for more than the 30-day trial period.

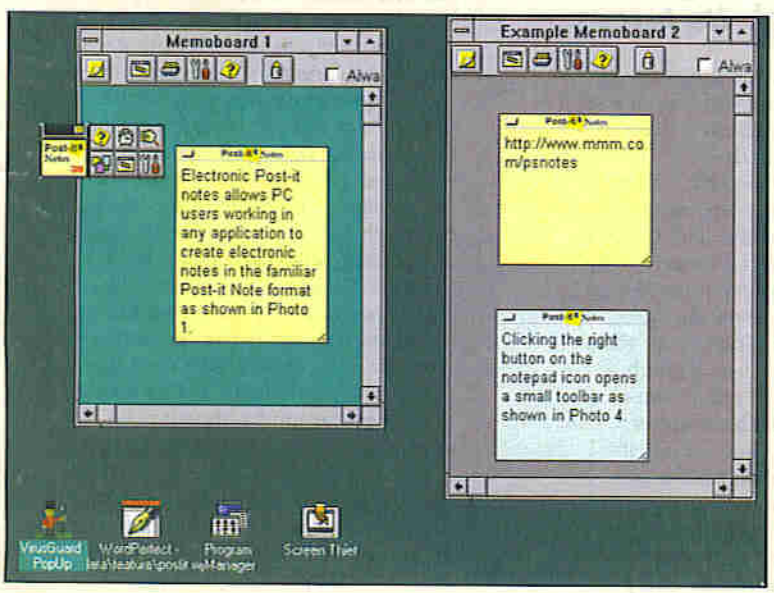



**Photo 5. Electronic Post-it notes can be transferred between memoboards and the desktop.**

## Specification

In both the Windows 3.1 and Windows '95 operating environments, Post-it Software Notes will run in minimum memory (RAM) configuration for the operating system (2M-byte for Windows 3.1 and 4M-byte for Windows '95) with no additional memory requirements. Installation of the software requires 2M-byte of available hard disk space.

REVIEW

# Motorola StarTAC GSM MOBILE PHONE

## PART 1

**by Martin Pipe BSc (Hons.) AMISTC**

***It's not only the world's smallest mobile phone, but also the world's most expensive. Harbinger of things to come, or expensive morale-boosting exercise on Motorola's part? Martin Pipe has dutifully put the new phone through its paces.***

## Oh, How Things Have Changed . . .

In 1989, the world's first truly portable cellphone – the Motorola MicroTac – was introduced. At the time, portable cellphones were basically car-phones. A typical example was Motorola's own 4500X. The electronics – a substantial heat-sinked block that would normally be located in the car boot – slid into a bulky carrying unit that accommodated a hefty battery, the aerial and the cradle for the handset that would be mounted within reach of the car's dashboard. The 'portable' 4500X was heavy, but it did mean that people could stay in touch with you. There were some more compact handsets, such as the Nokia Mobira, but they were essentially briefcase items, and too bulky to stow away comfortably in a jacket pocket.

When the MicroTac came along, it was a revelation; even now, it's seen as a design classic (there's even a childrens' toy that copies it). It was comparatively lightweight, offered a reasonable battery life and was comfortable to handle. The controls were hidden behind a hinge or 'flip', which helped to prevent accidental operation. Opening the flip also answered the call. The phone wasn't particularly easy to use, though – accessing menus required you to remember a particular number for each function. But overall, it encouraged a mobile phone as a 'lifestyle' accessory. MicroTac was expensive when launched, but in 1989, ownership of any mobile phone was hardly cheap.

## . . . and it's Not Just the Cellphones

Today, millions of the descendants of the 'MicroTac Flip', as it's fondly referred to, are in use around the world. Although the initial cost of ownership was high, mass production and the use of custom components has brought it down. Today, bottom-end Flips are often given away with airtime deals – the cellphone market has definitely changed since 1989. Network coverage has improved beyond recognition – you no longer need a high-powered phone to maintain conversation within the limited confines of the M25 circle – and the benefits of a cellphone can now be afforded by wider proportion of the UK public. It's no longer exclusively the province of obnoxious City yuppies, company directors or salespeople with extensive expense accounts.

Since 1989, there are rather more networks to choose from. Back then, there was Cellnet or Vodafone analogue. In late 1991, the first digital networks conforming to the GSM (Global System for Mobile Communications) standard was introduced by Vodafone – and Cellnet followed suit in mid-1994. GSM has many advantages, including greater freedom from interception by scanner enthusiasts, additional network features, faster data rates with computer equipment, and the ability to 'roam' with your phone on a foreign network that has an agreement with the one to which you subscribe. More recently, 1993 and 1994 respectively saw the introduction of two rather different networks – first, One2One and then Orange. These two networks use a newer system – PCN, or Personal Communications Network - and, with their attractive pricing schemes, are marketed heavily towards consumers and small business users. There are Motorola Flips for not only the original analogue networks, but also GSM and PCN.

## New Wave for the Rich and Brave

At the moment, Motorola's next 'wave' of cellphone design – known as StarTac – is available for analogue and GSM networks only. There's no doubt that PCN versions will follow – but it won't be for some time yet. The StarTac's major selling point is its lifestyle appeal. This phone is truly small and lightweight to the extent that you can almost forget it's there. It's almost the first phone that fits comfortably in a shirt pocket without breaking stitches. I say 'almost', because Sony offered a 'wearable' cellphone – the CM-R111 – as long ago as 1993. OK, it was analogue, extremely basic (it didn't have a display of any kind, unless you paid extra for a calculator-like peripheral device) and its performance wasn't up to much, but it certainly came first, and was certainly more affordable – even then! The idea behind StarTac is that taking a cellphone around with you need not be a burden – physical or otherwise. Indeed, it can be stylish; Motorola's PR glossy puffery shows StarTac-clad models in various states of semi-undress – it's a pity that the StarTac advertising seen to date is comparatively rather boring.

Don't start drooling yet – for most of us, the phones are about as out of reach as the models. StarTac is expensive – just as the original MicroTac was in its day. The analogue version retails for around £1,000, while the GSM will set you back £1,400-odd. Unfortunately, with perfectly good cellphones being 'given away' nowadays, who in their right mind will pay that sort of money for StarTac? It's not just cellphone technology that's radically changed since the late 1980s – so have user and public attitudes, methods of charging and the cost of ownership. At this stage, StarTac will only appeal to the poseur fraternity, the technofreaks who haven't been taken in by the Nokia Communicator (a bulky but innovative GSM phone that includes a powerful electronic organiser), rich foreigners who want to take the phones abroad with them and company directors with cash they want to get rid of before the tax year ends.

Sadly for Motorola, such people are in small numbers and StarTac won't be an overnight success. It's unlikely that the phones are being produced in volume quantities, a factor that won't do anything for the unit costs. Motorola has been losing significant market share to companies like Nokia and Ericsson recently, and so StarTac can at this stage perhaps be seen as a PR exercise. Producing the world's smallest and lightest phone certainly elevates the company's status as an innovator. Chances are that new and gradually less expensive models will be introduced with time. One can certainly look to the MicroTac example to see what Motorola is planning. Within five years, you will probably see a distant relative of StarTac being given away with an airtime contract.

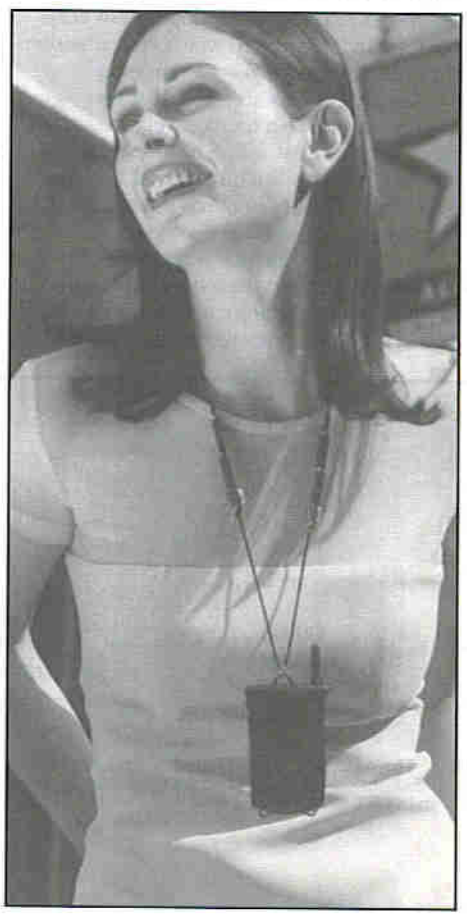
But back to the present. In the UK at least, the analogue version can effectively be discounted from serious consideration. The kind of jet-setter likely to consider a StarTac would prefer their significant investment to offer flexibility – such as the ability to work overseas; this, of course, means the GSM version. Those who adopted the analogue model – which arrived first – are probably kicking themselves for not waiting a few months for the GSM. On the other hand, the coverage offered by the UK GSM networks is still not yet at the levels of their analogue counterparts, and so the analogue may still appeal to a select view. That said, Vodafone and Cellnet claim that GSM coverage will match that of analogue very soon – but then again, they've been saying that for some time!

## What's StarTac Like as a Phone?

StarTac appears small – but only when it's folded up. To use the phone (or answer a call), it's opened up rather like a clam shell. It then looks rather more like a cellphone. It is possible to use the phone's construction to 'clamp' it onto a jacket pocket – but this is hardly advisable, since it makes your £1,400 kit obvious to undesirable types. The top lid harbours the earpiece, while the bottom half contains the keypad, a large and readable liquid-crystal display and the microphone. When opened, the two halves are angled with respect to each other in such a way that the phone fits comfortably around your face. There are also buttons on the side of the phone for changing earpiece volume level or accessing previously stored phone numbers. StarTac handles exceptionally well – it's comfortable to hold and use.

The aerial whip sticks out at the top by about an inch, even when retracted – it's really the only clue that the folded StarTac is a cellphone. On the base of the phone is a tiny (and fragile-looking) multi-way 'docking' connector. This mates with the charger unit supplied, or is used to connect to the PCMCIA data card needed to send faxes or e-mails from your notebook PC. Also on the base of the phone is a slot for the network-supplied GSM identity smart-card (also known as a SIM, or Subscriber Identity Module). Surprisingly for a phone of the StarTac's meagre proportions, a full-sized ('credit card') SIM is required – other phones take smaller SIMs that aren't much bigger than the smart-card's chip and its contact pads.

The battery system employed by StarTac is unique, and warrants further discussion. The StarTac's main battery pack fits into a recess in the lid. There are two main battery packs, both of which are supplied with the phone. The lower-capacity pack mounts flush against the rest of the lid, and designed for regular everyday use. The higher-capacity pack is heavier and protrudes from the case, but will operate the phone for longer – it's particularly handy for prolonged calls and the transfer of data. And now for the clever bit – the concept of a 'hot-swappable' battery system. The flush-mounting battery has a capacity of 350mAh, which translates to between 60 and 90 minutes of talk time, or between 20 and 25 hours in standby. The extra capacity variant also included roughly doubles these figures.



A third battery type – which has the highest capacity of all – 900mAh, enough to power the phone for between 170 and 260 minutes of talk time, or between 55 and 70 hours in standby – is also supplied with the phone. This auxiliary battery clips onto the other side of the phone. As long as at least one battery type is present, the phone will continue to operate. When a 'low battery' warning is given, the battery in question can be replaced by a fully charged one – as long as there is a battery on the other side with some charge remaining – and the communication can therefore continue uninterrupted. Theoretically, a call could go on for infinity.

The cell technology employed within both battery pack types is lithium ion. Although expensive, these 3·6V cells offer a high capacity coupled with freedom from the memory effect that plagues conventional Ni-Cd cell types. StarTac has been engineered to run on energy-efficient 3·3V semiconductor technology, which is now used on nearly all portable computers and an increasing number of cellphones. Lithium ion battery technology is comparatively new, and early products to use it – such as one of Apple's PowerBooks – had problems with overheating. What's more, it was reported some time ago that one of the Sony factories producing the things burnt down. Since then, it would appear that these issues have been resolved.

## A Phone with Personality

As far as the user interface is concerned, Motorola has opted for its 'Personality' menu system – the company's phones have come a long way since menus were accessed via numbers (although the StarTac does support these, as 'short cuts', for the benefit of long-term Motorola users). Just as well, because the phone is well equipped with features (including support for those available from the GSM network) and is highly customisable. Personality guides the user through the menus by offering options and then prompting you via the display (which supports graphics as well as alphanumeric characters) in plain English (although it supports several other European languages). It is driven largely through the 'menu', 'OK', 'C(ancel)' and arrow keys.

The other benefit of Personality is that you can personalise the way in which the phone is used to suit yourself. For example, the menus used most often can be made easier and quicker to get to – thus circumventing 'information overload'. Personality is a good attempt to make phones easier to configure, although the (often simpler) user interfaces conceived by some other GSM manufacturers, such as (Amstrad-owned) Dancall, Nokia and Mitsubishi, are rather more intuitive.

Features-wise, the StarTac excels – although the feature count is pretty much the same as the Motorola's regular-sized International 8700 GSM, a phone that sells for less than half the price. For example,

you don't have to rely on boring old beeps and ringing tones as an incoming call alert. StarTac has another Motorola innovation, originally developed for paging receivers, by the name of Vibracall. This is essentially a tiny motor with an eccentric weight on the end; when current is applied to the motor, vibrations are caused. These vibrations are sufficient to be felt through clothing, and Vibracall is thus an excellent way of alerting you to a call when ambient noise levels are high (although finding a place to conduct the conversation might be difficult). Vibracall is also useful on trains, or in other instances where discretion is important. As soon as you feel those vibrations, you can make your excuses and find somewhere more private to hold your conversation. As an alternative, there are all kinds of audible call alerts – European ringing tones, various other bleeps, and even the now obligatory irritating tune guaranteed to bug everybody else in the room (cellphone-haters can thank Nokia for making these popular. . . .)

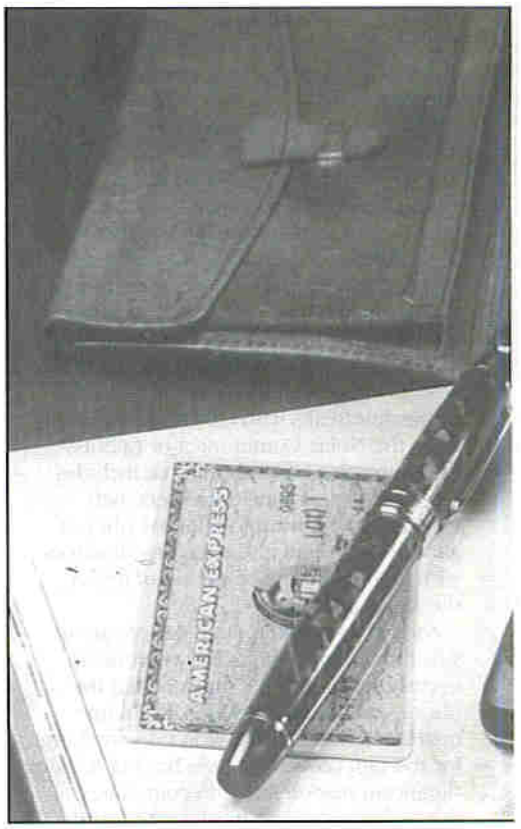
Another useful feature of the StarTAC is its ability to support CLI (caller line identification) systems, which are used by BT, cable companies, Orange, One2One and Cellnet GSM (Vodafone GSM will follow, I'm sure). The number of the person – should they be on a CLI exchange – calling you is displayed before the call is taken. An excellent screening device, and one for which landline phone networks, such as BT, charge you a monthly subscription. If the calling number is one that's been stored, along with a name, in the phone book database, then the name is displayed. A nice touch. Unfortunately, Motorola hasn't taken the next CLI step. The caller's number only appears for as long as they are calling. If, for some reason, you're not quick enough to answer or the calling party hangs up prematurely, then the number disappears – and it isn't stored in the phone's memory so you can't call back. (It wouldn't take much additional software to add this simple but useful feature, would it now? Most of the programming required is already there!). Compare this to cheaper GSM phones, such as Dancall's models, that do! On the positive side, you can block CLI on outgoing calls.

The internal phone book will store 100 numbers, each of which can be up to 32 digits long, and identified by a 16-character name tag. The SIM card itself can also store phone book entries – these are numbered 101 onwards. The exact number available on the card is dependent on its capacity, which is itself network-dependent (different companies use different smart card types). It is worth storing phone books on the SIM card; that way, you don't have to re-enter the lot on a loan phone when your own unit is being repaired (and the repairman can't read your numbers – particularly important if you're rich and famous enough to own a StarTac). It's also valuable if you have a GSM car-phone and use the same SIM in both car and handset alike. Searching of the phonebook database can be done alphabetically or by remembering the location number.

StarTAC is also compatible with SMS (short message service) systems. With this, you can send pager-type text messages to another GSM user. SMS is handy for instances where complex names and numbers have to be communicated and is also being used, via the medium of cell broadcast to distribute other (normally subscription-based) information such as stock prices to a group of users. Unfortunately, entering SMS messages is long-winded – you have to rely on the keypad (each key handles three or so letters of the alphabet, the one selected depending on the number of keypresses). Kits are available for some phones so that a computer can edit SMS messages and phonebook entries – unfortunately, StarTac isn't one of them.

SMS isn't the only network feature supported by the phone. Call holding, waiting, barring and diverting, together with voicemail, are all supported. So is a useful feature for users of PCMCIA fax/modems – talk and fax. With this, users can speak and send/receive a fax during the same call. A selection of resettable call-metering functions are provided, so that you can keep tabs on phone usage and the bill you can expect. Whether you can use some, such as those relating to call charges, is dependent very much on the network to which you subscribe. In all cases, though, you can monitor accumulated call totals – handy if you lend the phone to a teenage relative – and the time of the last call. A non-resettable 'lifetime' meter is built in, so that you can gasp in horror at how much your phone has been used over time.

Other features include a scratchpad (you can enter a number during a conversation for subsequent dialling), a 10-number redial memory, DTMF tone-signalling for access to




voice-messaging systems, telephone banking services and the like, auto-answer (only useful for hands-free car kits – and even then, beware of potentially embarrassing situations!), a PIN-based security lock (this accesses a feature provided on the SIM card), microphone mute, and a DTX battery saver (this system reduces transmitter power when you aren't talking). Motorola have also included an audible call pacer that beeps at you at predetermined intervals. This is quite pointless; it's distracting and in any case, the StarTac's display has a perfectly good clock.

Performance-wise, the StarTac is excellent and ranks amongst the best phones that Cellnet has produced. RF performance is awesome, and the phone is capable of conducting conversations in weak spots. It is also useful when you're on the move, and essential for data transmission! Audio performance is also good, and many people I spoke to with StarTac weren't aware that I was on a cellphone, let alone a GSM model. In the past, GSM phones have suffered from

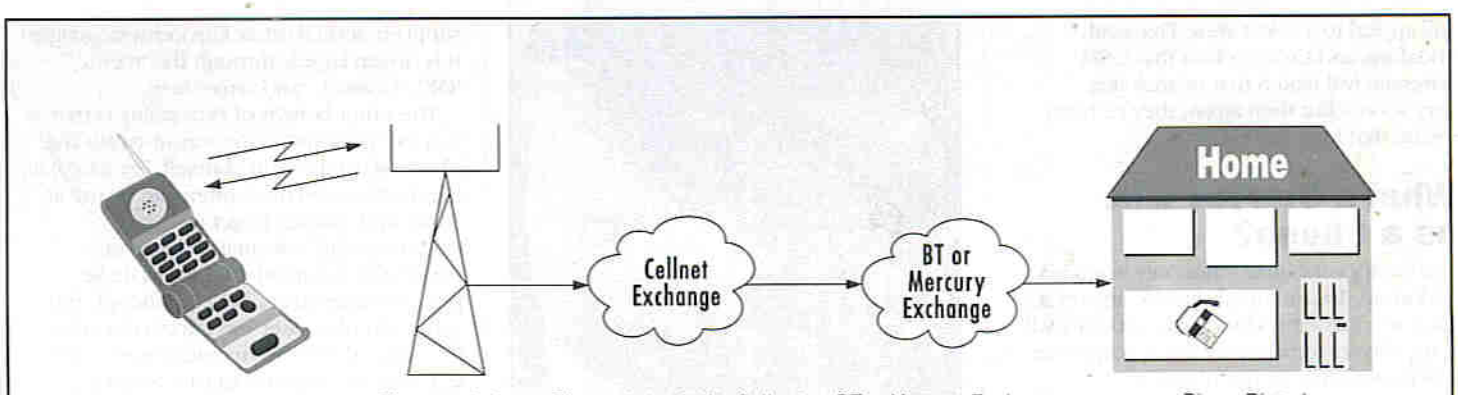
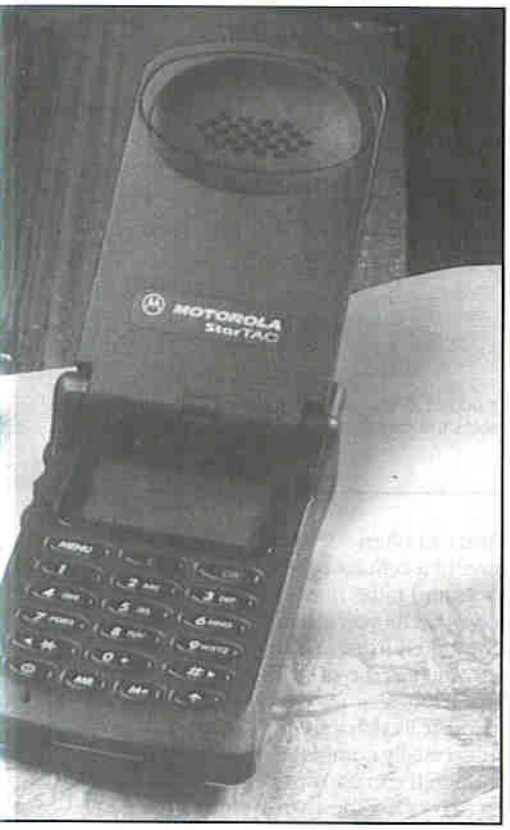



**Figure 1. Mobile calling land-line.**




poor sound quality – metallic twangs and Dalek voices introduced by digital artifacts and dropouts – but the StarTac is a different kettle of chips. It's also an indication of how GSM coverage in the UK has improved of late, although it's still not yet up to the standard of some other European countries. Our only real criticism of StarTac is the earpiece, which will distort severely when the volume is turned up high. Overall, though, the StarTac is an excellent phone despite its prohibitive pricing. I predict that this will change with time, though.

## GSM – What is It?

In December 1991, the UK saw GSM (Global System for Mobile communications) for the first time courtesy of Vodafone. Initially, it covered a small proportion of the UK and one can only assume that it was set up primarily for test purposes. Since then, coverage has improved to around 96% of the UK's population. In June 1994, Cellnet's GSM network began operating with greater coverage than that initially offered by Vodafone. Cellnet now claims 95% UK population coverage. Both networks will be improving coverage still further – the aim being the 98% coverage offered by the analogue networks – by introducing new cellular repeaters around the country. Although GSM was originally expensive to subscribe to, prices have been brought down significantly through competition from the PCN services.In analogue cellular telephony, the mike's audio signal is amplified, heavily filtered and used to modulate the transmitter directly (bandwidth is extremely limited to increase the number of channels offered in the amount of spectrum allocated). The same is true of the transmitters located at each cellsite. GSM differs in that the microphone audio is digitised, compressed in real time and encrypted (to preserve integrity, although it does have security spin-offs) using a DSP chip. The resultant datastream is then modulated, using narrowband TDMA (rather than analogue's narrowband FM) onto the carrier frequencies. The same DSP chip is also responsible for converting the receive bitstream, from the cellular repeater, into audio. The advantage of this approach is that the channel bandwidth is lower than that for analogue – hence more channels in the same frequency spectrum. No wonder the networks are so keen to promote it! In GSM, the two frequency bands used are 905-915MHz (transmit) and 950-960MHz (receive), both of which are just above the analogue band.

The other major technology difference between analogue and GSM relates to phone identity. Within analogue phones, which were first introduced in 1985, this information is held in EEPROM as an electronic serial number, or ESN, which is transmitted whenever the phone handshakes with the cellsite. In GSM phones, subscriber details are held within a smart-card that slots into the phone. The authentication system utilised by GSM is rather more complex than employed by analogue – there was a technological epoch between the development of the two systems – and hence, GSM offers greater security measures.

There has not yet been, to my knowledge, a cloning hack perpetrated on a GSM user – although the problem is well known to analogue users. The GSM smart card, known as a SIM, also has extra non-volatile memory space for the storage of subscriber-specific information, such as a phone book. The adoption of a SIM has unique benefits – since no information of this type is held on the phone, it is possible to transfer a SIM from one phone to another simply by swapping the cards around. Ideal for those with more than one type of phone (e.g., car and handset). It also simplifies the honouring of in-guarantee repairs and ensures that the subscriber potentially has continuity of service with a loan phone.

As the 'global' tag suggests, a GSM phone can be used in other GSM-compliant countries – there are over 40 of these currently, from Andorra to Turkey (the US, however, doesn't use GSM!). Prior to GSM, there wasn't any common cellular standard which was a drawback to the frequent business traveller. Take your phone overseas, however, and you can simply replace your old SIM with one for the local network. In many cases, Cellnet and Vodafone have signed 'roaming' agreements with overseas GSM operators. The advantage of this is that you can be reached on the same number – a powerful concept. I have been rung on a GSM phone at various countries within Europe, and the callers were only aware of my location after I had told them! You can also make outgoing calls, although the local dialling codes for international access are needed to call back home. With roaming agreements, the local networks charges are forwarded to the network whose service you subscribe to, and these charges will be billed to you.

## GSM Network Features

1. Full data compatibility. Up to 9,600bps data. A v.42bis type compression system can increase throughput to 36k-bps, but this will depend on the compactness of the transmitted file. Internet access is painfully slow, but the system is ideal for collecting/ sending e-mail for later off-line reading. For Web access, images should be turned off on your browser – although some crap web sites don't support text-only browsing! Faxes can be sent or received at the full (9,600bps) Group 3 rate. To handle faxes and data, you need a data-compatible phone (look out for the MC2 logo, normally hidden behind the battery pack), a PCMCIA GSM data card (300 to 500), the appropriate

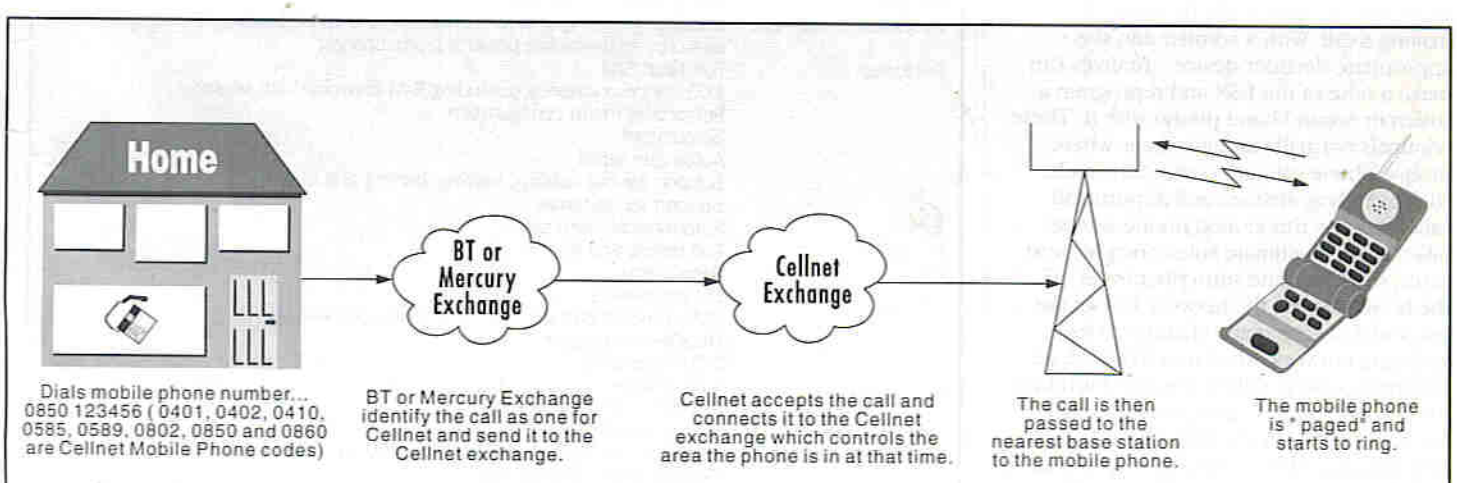



**Figure 2. Land-line calling mobile.**

| | | | |
|---|---|---|---|
| Andorra (STA) | Australia (Optus) | Australia (Telstra) | Australia (Vodafone) |
| Austria (MobilKom) | Belgium (Belgacom) | Bulgaria (MobiTel) | Cyprus (Cyprus Telecom) |
| Denmark (Sonofon) | Denmark (Telecom) | Eire (Eirecell) | Estonia (EMT) |
| Finland (OY Radiolinja) | Finland (Telecom Finland) | France (France Telecom) | France (SFR) |
| Germany (DeTe Mobil Gmbh) | Germany (Mannesmann) | Gibraltar (Gibtel) | Greece (Panafon) |
| Greece (Stet Hellas) | Guernsey (PTO) | Hong Kong (PTO) | Hong Kong (Hutchinson) |
| Hong Kong (SmarTone) | Hungary (Panon) | Hungary (Westell 900) | Iceland (P&T) |
| Indonesia (Satelindo) | Isle of Man (MT) | Italy (Omnitel) | Italy (PTO) |
| Jersey (PTO) | Latvia (LMT) | Lithuania (Mobilios) | Luxembourg (P&T) |
| Macau (CTM) | Mauritius (Cellplus) | Morocco (ONPT) | Netherlands (Libertel) |
| Netherlands (PTT Telecom) | Norway (Netcom) | Norway (Telenor Mobil) | Philippines (Globe) |
| Portugal (Telecel) | Portugal (TMN) | Qatar (Q-Tel) | Russia (MTS) |
| Singapore (PTO) | South Africa (MTN) | South Africa (Vodacom) | Spain (Airtel) |
| Spain (Telfonica) | Sweden (Comviq) | Sweden (Europolitan) | Sweden (Telia Mobitel) |
| Switzerland (PTO) | Taiwan (LDTA) | Thailand (AIS) | Turkey (PTT Turkcell) |
| Turkey (Turk Telecom) | | | |

At August 1996, Cellnet had Roaming Agreements with 61 networks in 42 countries. More networks are being added all the time, so please refer to your Roaming List for the very latest details. Note: These may change due to technical or commercial difficulties. PTO denotes the countries Public Telephone Operator.

**Table 1. Roaming arrangements: August 1996. (Courtesy Cellnet).**

interconnecting lead, and a PCMCIA-compliant PDA or notebook computer with the appropriate software. Nokia's Communicator GSM phone (900) has a Psion-type PDA built in. In a future issue, we'll be examining a PCMCIA data card.

2. International roaming.

3. The ability to send and receive pager-type SMS messages.

4. Freedom from call interception and cloning.

5. Support for CLI (Caller-Line Identification). If an intended recipient is in the bath (or whatever) and misses your call, (s)he can get your number by dialling 1471. GSM users can, with more modern phones, see the number of a caller before answering. All this assumes that the other phone is on a CLI-compliant network.

6. Call waiting. Subscriber is alerted to the presence of another incoming call, and can take this call without dropping the present one. Ideal for busy users. Both network and phone-dependent.

7. More flexible implementations of the features offered to analogue users, such as call diverting and voicemail.

## Cellphone Security

Analogue phones send out their electronic identities (ESN, or electronic serial number) when handshaking with the network or making a call. With a scanner and the appropriate decoder device, criminals can make a note of the ESN and reprogram a stolen or second-hand phone with it. These criminals normally monitor areas where mobile phone calls are commonly made, such as railway stations and airports. All calls made on this cloned phone will be billed to the legitimate subscriber. In most cases, the legitimate subscriber is 'let off the hook', leaving the network to foot the bill. Vodafone has made changes to its analogue network, known as ETACS-2, to eliminate cloning. Cellnet will also introduce the subscriber-transparent system, which involves combining the ESN with a 16-digit PIN authentication code to give a possible 10,000 million possible permutations for each outgoing call. Unfortunately, the system is incompatible with older phones.

Analogue cellphone conversations can be picked up on a scanner, provided that the scanner is within range of a cellular repeater. This scandal hit the news a few years ago, when Princess Diana's intimate phone calls were intercepted. It's illegal to do this, although it has done no harm to sales of scanners. You might not even need to buy a scanner, though – the Internet contains details of how you can convert an old mobile phone into a purpose-designed PC-controlled cellphone scanner. The upshot of all this? Be careful what you say on analogue cellular, and be careful where you make calls!

## How Cellphones Work

When you turn the cellphone on, the phone handshakes with the network's nearest base station. These base stations are arranged in areas known as 'cells' – hence the term 'cellular'. Each cell covers a small area of the country (exactly how much depends on terrain), and overlaps with adjacent cells around it to ensure continuity of service. PCN cellsites are greater in number and closer together than analogue and GSM cellsites, because they use higher frequencies (around 1,800MHz). The advantage of the cellular approach is that it offers maximum coverage.

You can often see the characteristic aerial arrays of a cellular repeater, on top of tower blocks and radio masts on the side of the motorway. As you move around, you may be switched from one cell to another – it's very much a case of which one receives the signal from your phone. The switching process (called 'hand-off') is totally automatic and is usually completely undetectable, although it can corrupt data and faxes (it's best to conduct these while you're stationary).

As soon as the number (complete with STD code, even for a local call) is dialled and the 'send' button pressed, a chain of events is set in motion. The nearest cellsite – which has already been determined – acknowledges that you wish to make a call. Each cellsite is connected, via a microwave link or a leased-line, to the network exchange. It is to the network exchange to which you connect first. This network exchange is itself hooked up to the wired telephone exchanges used by BT, Mercury, cable companies or other mobile networks. Mobile-to-mobile calls (on the same network) use the networks own communications infrastructure – tariffs, for some reason, don't seem to take the network's lower costs into account. . . .

Links to cellular-related Web sites can be found at **http://www.webshop.co.uk/mnews**.

## SPECIFICATION

| | |
|---|---|
| System: | GSM |
| RF power output: | Class 4 (2W) |
| Dimensions (WHD): | 52 × 93 × 21mm |
| Weight: | 98·5g (with slim battery) |
| Accessories supplied: | desktop charger (holds phone/battery and spare battery), 3 batteries, belt-clip, multi-voltage power adaptor/charger |
| Features: | Full-sized SIM |
| | 100 phone memories (excluding SIM capacity) with search |
| | Personality menu configuration |
| | Scratchpad |
| | Automatic redial |
| | Support for call holding, waiting, barring and diverting |
| | Support for voicemail |
| | Auto/manual roam select |
| | Call timers and meters |
| | Pace alarm |
| | CLI compatible |
| | SMS send/receive with cell-broadcast compatibility |
| | Data/fax compatible |
| | DTMF signalling |
| | Auto-answer |
| | PIN lock, microphone mute |
| | Battery saver (DTX) |
| | Choice of Vibracall and/or 11 ringing tones |
| | Flexible battery arrangement |
| | Wide range of accessories available (spare batteries, hands-free car kit, holsters, cigarette lighter power adaptors, etc.) |

PROJECT

# Remote Control EXTENDER

**Design and Text by Paul Stenning**

***Like many people, I have a second television set in the bedroom, which is connected to the video and satellite equipment downstairs. However, the pleasure of watching TV while lying in bed is lost by having to go downstairs to stop the video or change channel on the satellite receiver. This project allows you to take the video recorder and satellite receiver remote controls upstairs, and operate the equipment from there. There is no additional cabling to install, the signal being carried along the existing coaxial aerial cable linking the two rooms.***

The unit is in two sections, the infra-red receiver which lives upstairs by the TV, and the infra-red transmitter and power supply which lives downstairs and points at the equipment to be controlled.

The prototype has been tested and found to work reliably with about 50m of cable. Most domestic cable runs are much shorter than this, typically, 10 to 20m. Indeed, with 50m of cable, the picture quality at the far end would probably be fairly poor!

This project is an updated version of an article that was originally published in the January 1994 edition of *Electronics in Action* magazine. The main difference is that this version uses a proprietary infra-red receiver IC instead of a discrete receiver circuit. This change gives an increased reception range and makes the unit much less susceptible to noise and interference.

## Circuit Description

For now, assume that the two sections of the circuit are connected directly (SK1 joined to SK3).

## Infra-red Receiver

The infra-red receiver circuit is shown in Figure 1a. D1 is the IR photo-diode and IC1 (TBA2800) is the infra-red amplifier. This IC contains three stages of amplification, the first of which has an automatic gain adjustment system to cope with varying signal and ambient light levels. The second amplifying stage simply provides further amplification, and the third separates the wanted signal from the general background noise. An inverting stage is also provided to give both positive and negative outputs.

The overall gain of the IC is quoted as 70dB, and the typical current consumption is 1mA at 5V.

C3 and C4 are the coupling components between the amplifying stages. The values of these have been chosen to give good coupling at the IR transmission frequency, while rejecting lower frequency noise and interference. C2 is the filter component for the automatic gain control of the first amplifier in U101. The power supply to IC1 is decoupled by R1, C1 and C5.

The inverted output of IC1 is connected TR1 (BC558), which in turn drives TR2 (BC548).

TR2 connects the LED D3 across the power input to the circuit. The purpose of this is to cause

## SPECIFICATION

| | |
|---|---|
| **Receiver Unit** | |
| Range: | 5m typical |
| Power Supply: | Powered by transmitter |
| PCB Size: | 97 × 30mm |
| Overall Size: | 100 × 82 × 40mm |
| Weight: | 100g |
| **Transmitter Unit** | |
| Range: | 4m typical |
| Power Supply: | 230V AC, 3VA |
| PCB Size: | 115 × 34mm |
| Overall Size: | 119 × 114 × 45mm |
| Weight: | 250g |
| **General** | |
| Communication Method: | Via existing UHF aerial link cable |
| Communication Range: | At least 50m |

pulses of increased current consumption in time with the received infra-red, which are in detected by the other section of the circuit. The LED flashes in time with the received infra-red.

The circuit is powered from the other section of the circuit via SK1. D2 and R15 provide a regulated 5V supply to IC1, while D4 and C1 ensure that this supply does not vary significantly when the LED is pulsing.

## Infra-red Transmitter and PSU

The infra-red transmitter and power supply circuits are shown in Figure 1b.

The variations in supply current to the receiver section cause a varying voltage drop across R14. This is converted to logic pulses by TR5 (BC558). C12, R10 and D9 cause short (40µs) pulses to be applied to the base of TR4. TR4 (BC548) and TR5 (ZTX650) are in a Darlington arrangement, and drive the infra-red LED.

The infra-red LED (D7) has a maximum continuous current rating of 100mA, which would give a range of only a few centimetres. However, the device has a pulse rating of over 2A, providing the duty cycle is short and the mean current does not exceed 100mA.

This gives a much improved range and is the technique used in commercial remote controls, as well as this unit. C11 acts as a reservoir for the LED current, and is charged when the LED is not lit via R13. The current to D8 is limited to about 2·5A by R9; a red LED (D7) and series resistor (R8) are connected across R9 to give a visual indication that the unit is operating.

The circuit is powered by a small transformer, giving an unregulated supply of about 18V across C10. The supply reaching the infrared receiver section will be about 12V. A 100mA transformer is adequate since the current consumption is only a couple of milliamps when the unit is idle.

## RF Connections

The DC voltage is isolated from the TV/video equipment by C7 and C13. 100pF ceramic disc capacitors are used, which give good coupling at UHF frequencies. The high frequencies are blocked by L1 and L2, which prevent the circuit from loading the signal.

There will inevitably be slight attenuation to the UHF signal; this has not been measured due to the author not having suitable equipment! No picture degradation occurred with the prototype, although some problems may be experienced in very poor reception areas. This would only occur on off-air signals, as the signal strength from the UHF output of a video recorder or satellite receiver is generally fairly high.

## PCB Construction

The PCB overlays are shown in Figure 2. There is nothing out of the ordinary about the PCB assembly – simply fit the components in the usual size order. D7 and D8 must be fitted on the solder side of the PCB, with their tops about 12mm above the PCB surface. D3 is mounted at the same height on the component side of the other PCB. D1 should be mounted at the full length of its leads, and then folded over so that the flat side lays against IC1.

Terminal pins should be used for the off-board connections. Those for SK1 and SK2 are inserted from the component side so that wires may be attached to the solder side.

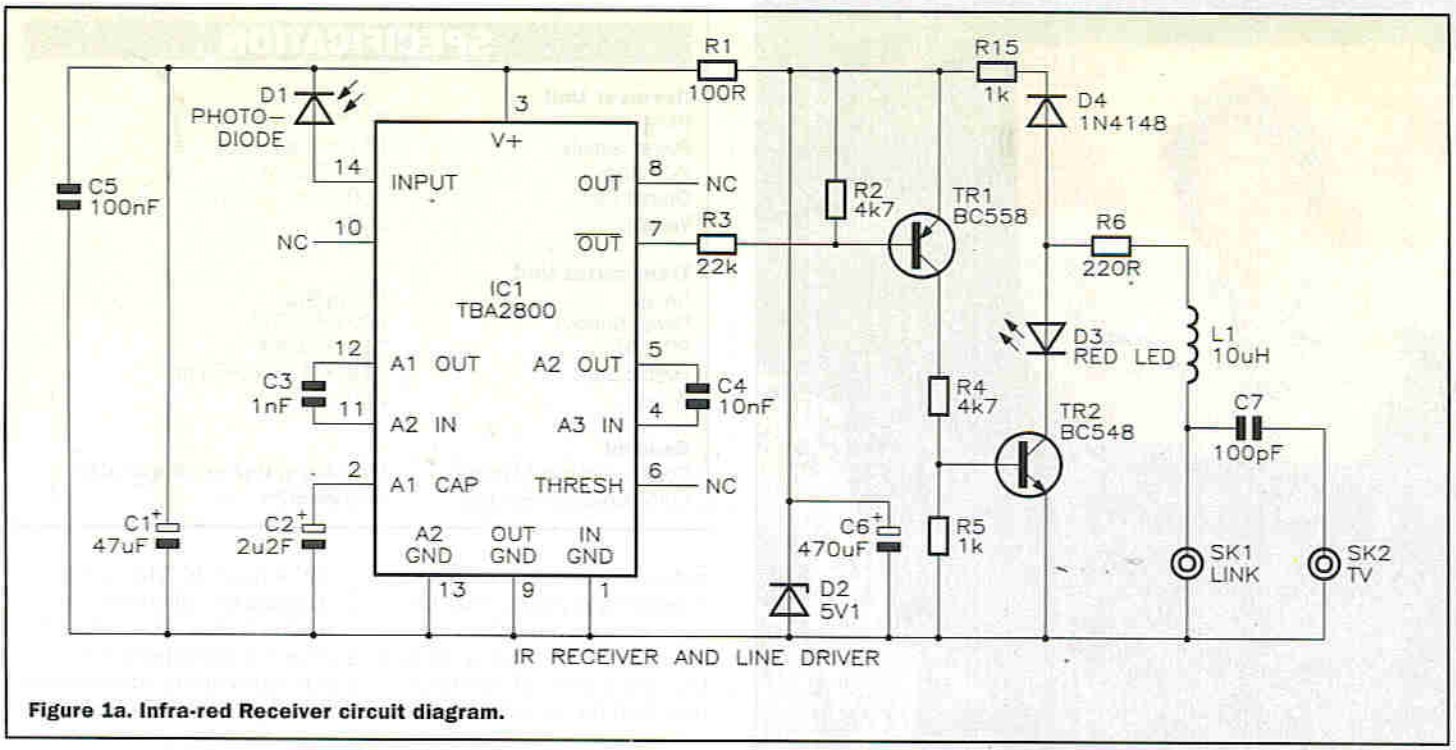



**Figure 1a. Infra-red Receiver circuit diagram.**

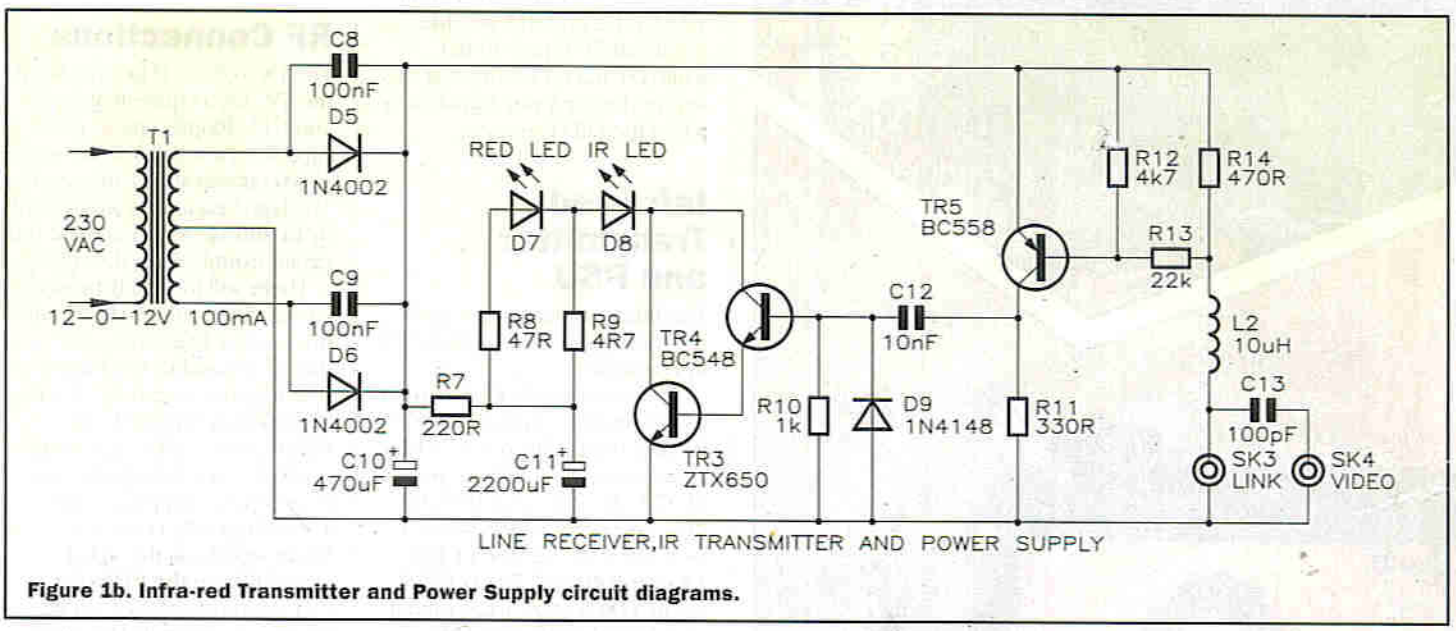



**Figure 1b. Infra-red Transmitter and Power Supply circuit diagrams.**

There are four holes for terminal pins around IC1 and related components. These may be used to secure a screening can (made from tin plate) if the receiver is prone to interference. This was not necessary on the prototype.

## Case Assembly

The general layout of the two cases can be seen in the photographs.

The infra-red receiver is housed in type MB2 plastic box, 101 × 76 × 39mm. A rectangular window should be cut in one side, approximately 55 × 24mm, positioned 12mm from the left end. Remove any PCB mounting guides from this area. A piece of red filter material is then fitted behind the cutout, and held in place with superglue. If the filter has a non-reflective surface, this should face outwards. The PCB is positioned in the PCB mounting guides in the case, immediately behind the window. The two coax sockets are fitted on the opposite side of the case to the window, and require a 12·7mm (½in.) mounting hole.

The infra-red transmitter is housed in a type MB3 plastic box, 118 × 98 × 45mm. A similar rectangular 40 × 26mm window is made in one side. The red filter material is again held in place with superglue. The PCB is fitted in the guides behind the window. The other side of the case is drilled to accommodate the two coax sockets and the mains cable entry. The latter must be fitted with a suitable cable clamp.

The transformer is mounted in the base of the case with M3 countersunk screws and nuts. An additional hole is necessary to mount a piece of choc-block connector, which is used to connect the mains cable to the flying leads from the transformer.

Cutting tidy rectangular holes in plastic cases is not easy! I drilled a hole in each corner and then cut out the remainder with a fretsaw. The hole was then filed to the correct size. Do not rush this section if you want to achieve a tidy job.

If the windows are cut to the sizes suggested, you will be able to use one piece of Maplin red filter material for both cases. Contrary to the information in the Maplin/MPS catalogue, this material cannot be cut with scissors as it will crack. Use a junior hacksaw.

## Interwiring

The interwiring is very straightforward. The transformer secondary wires are connected to the veropins in the T1 position on the PCB, with the black wire to the centre pin and the two red wires (either way round) to the other two. The brown and blue primary wires are connected to the incoming mains cable with a 2-way piece of choc-block connector mounted in the case. Brown to brown, and blue to blue.

The coax sockets are connected to the relevant pins on the PCB using suitable coaxial cable. Cheap audio cable was used in the prototype and worked successfully, but the type specified in the parts list would be more suitable. The outer of each socket is connected via the screen of

the cable to the relevant pin closest to the end of the PCB, while the core of the cable is used to connect the centre pin of the socket to the other pin on the PCB. Be sure to mark the sockets 'LINK', 'TV' and 'VIDEO', in accordance with the circuit diagram.

## Testing

No setting up is required; testing merely involves connecting the two sections and seeing if they work! When testing, ensure that the light from the transmitter does not shine directly on the receiver, or feedback may cause odd results.

Connect the two sections with a good length coaxial aerial cable between the 'LINK' sockets (SK1 and SK3). Alternatively, a length of two-core cable may be used; this may be soldered directly to the pins on the PCB's for convenience.

Connect the transmitter section to the mains and position it such that it is pointing at a video recorder, from about 2m away. Take the receiver and the video's remote control into another room, and try using the remote control about 2m from the receiver.

When the remote control is operated, the red LEDs on the receiver and transmitter should flash. If the channel change buttons are operated, the corresponding changes should be heard from the TV in the other room.

## Fault Finding

If the unit does not work, there are a few points to check before embarking on a full faultfinding procedure.

First, check the power supply voltages. There should be about 18V across C6 and C7, and around 12V at SK2. The power supply rail in the receiver (across D2) should be 5V.

Check that the LEDs are the right way round. The details in catalogues and data sheets can be confusing when it comes to identifying the polarity of LEDs, and different manufacturers use different arrangements. The PCB overlay is correct for the devices supplied by Maplin.

Check the aerial fly-leads for continuity, and short circuits. One of the two purchased (not from Maplin) by the author for these units was found to be open-circuit on the centre core!

If all this checks out, it's down to good old fashioned fault finding procedures. The circuit is not complicated so this should not take too long.

## Installation and Use

In the interests of safety, all equipment should be disconnected from the mains before making any connections. However, this is not essential if your video recorder is one of the older types that forgets the time if it is disconnected even momentarily from the mains!

The receiver should be positioned near the television, in clear sight of the normal viewing positions. Unplug the aerial cable from the TV, and connect it to the 'LINK' socket of this unit. Using a standard aerial fly-lead, connect the 'TV' socket on this unit to the aerial socket on the TV.

The transmitter positioning is more involved, and is left to the ingenuity of the individual constructor. The unit needs to be located so that the infra-red output reaches the front of the equipment to be controlled. In addition, the cables need to reach (or be extended), and the installation should look tidy if peace is to be maintained! The prototype was placed on a cabinet on an adjacent wall, and although the infra-red reached the equipment from an angle of about 45°, no problems were experienced.

It may be easier in some cases to mount the infra-red LED remotely, and link it to the electronics with a length of thin two-core cable. Two or three LEDs could be wired in series, and placed near the receivers on the equipment to be controlled.

Some constructors may wish to try bouncing the infra-red off a wall mirror at the opposite side of the room, although the distances involved may be too great.

There will, presumably, already be a Y-splitter connected to the output of the video recorder, with its outputs connected to the local and remote TV sets. Unplug the lead to the remote TV, and connect it to the 'LINK' socket on the infra-red transmitter unit. Connect the 'VIDEO' socket on the infra-red transmitter to the splitter.

Note that the infra-red transmitter and infra-red receiver must be at opposite ends of the link cable. There must be no splitters, attenuators, amplifiers, filters or other equipment between the two units, since these will block or load the DC path.

Finally, connect the system to the mains (via a 3A fuse) and test it.

If the LED on the receiver remains lit, it is picking up interference from something, try moving it further away from the TV set or other electronic equipment. This can be confirmed by switching off the TV or the suspected equipment.

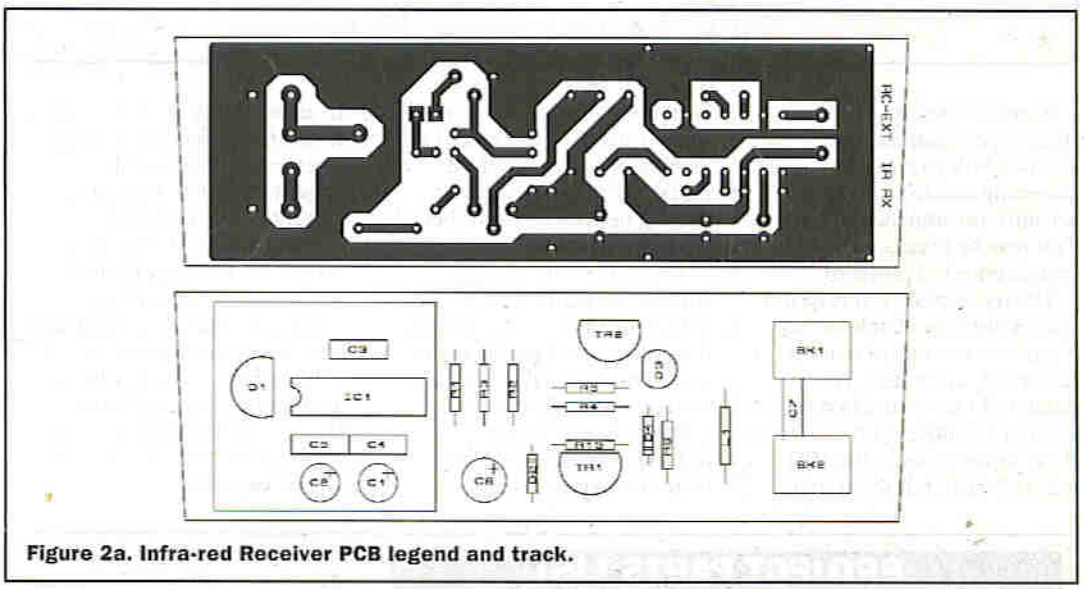



**Figure 2a. Infra-red Receiver PCB legend and track.**

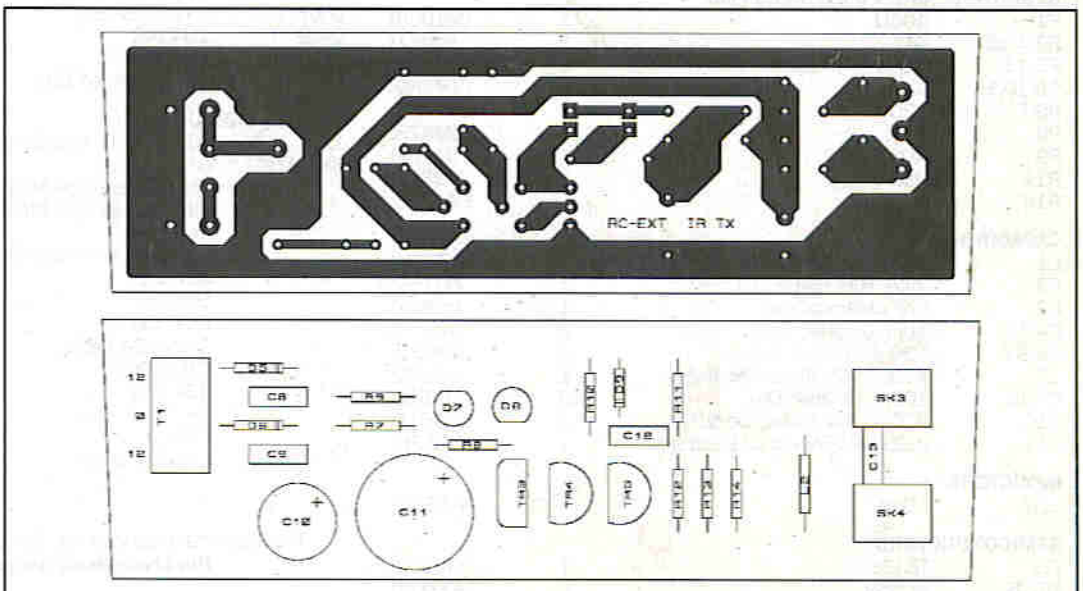
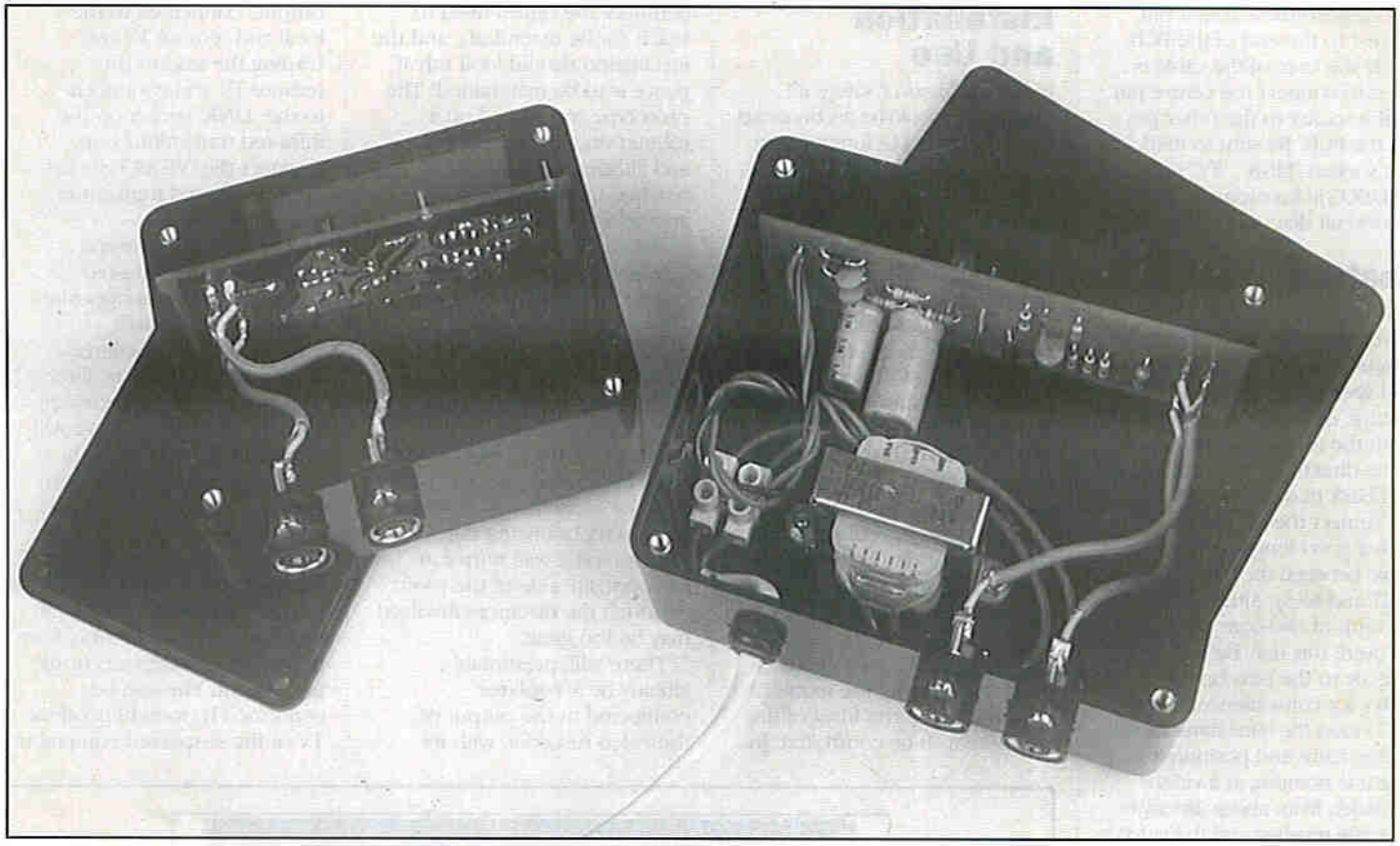



**Figure 2b. Infra-red Transmitter PCB legend and track.**



As mentioned earlier, there is provision on the receiver PCB to mount a screening can around the sensitive preamplifier circuit. This may be necessary if interference is a problem.

The receiver should respond from a distance of at least 5m, if the remote control is aimed reasonably accurately. The range will vary with different makes of remote control. If the signal is weak, the LED may still flash, but the remote equipment will fail to respond; this is caused by the receiver picking up only part of the signal. Try moving closer or putting new batteries in the remote control.

The transmitter should control the equipment from a distance of 3 to 4m, although this will drop off as the angle increases. Again, this will vary with different equipment.

There should be no reduction in picture quality with this system installed.

In areas of very poor reception, it may be preferable to install a separate cable for this system, thin two-core cable (used for doorbells and speakers) is ideal. The 'LINK' coaxial sockets may then be replaced with something suitable for the cable used, and the other coax sockets omitted.

Hopefully, this unit will allow you to be even more lazy, just don't forget to take the remote controls with you! Happy viewing.

## Printed Circuit Boards

The pair of PCBs for this project are available (subject to sufficient interest) from the author. For price and ordering details please write, enclosing an SAE or IRC, to:

Paul Stenning,
1 Chisel Close,
Hereford HR4 9XF,
England.

## PROJECT PARTS LIST

**RESISTORS: All 1% 0·6W Metal Film**

| | | | |
|---|---|---|---|
| R1 | 100Ω | 1 | (M100R) |
| R2,4,12 | 4k7 | 3 | (M4K7) |
| R3,13 | 22k | 2 | (M22K) |
| R5,10,15 | 1k0 | 3 | (M1K0) |
| R6,7 | 220Ω | 2 | (M220R) |
| R8 | 47Ω | 1 | (M47R) |
| R9 | 4Ω7 | 1 | (M4R7) |
| R11 | 330Ω | 1 | (M330R) |
| R14 | 470Ω | 1 | (M470R) |

**CAPACITORS**

| | | | |
|---|---|---|---|
| C1 | 47µF 16V Radial Electrolytic | 1 | (AT39N) |
| C2 | 2µ2F 63V Radial Electrolytic | 1 | (AT75S) |
| C3 | 1nF Ceramic Disc | 1 | (WX68Y) |
| C4,12 | 10nF Ceramic Disc | 2 | (WX77J) |
| C5,8,9 | 100nF Ceramic Disc | 3 | (BX03D) |
| C6 | 470µF 10V Radial Electrolytic | 1 | (AT33L) |
| C7,13 | 100pF Ceramic Disc | 2 | (WX56L) |
| C10 | 470µF 25V Radial Electrolytic | 1 | (AT51F) |
| C11 | 2,200µF 25V Radial Electrolytic | 1 | (AT53H) |

**INDUCTORS**

| | | | |
|---|---|---|---|
| L1,2 | 10µH | 2 | (WH35Q) |

**SEMICONDUCTORS**

| | | | |
|---|---|---|---|
| IC1 | TBA2800 | 1 | (JU36P) |
| TR1,5 | BC558 | 2 | (QQ17T) |
| TR2,4 | BC548 | 2 | (QB73Q) |
| TR3 | ZTX650 | 1 | (UH46A) |
| D1 | Infra-red Photodiode | 1 | (YH71N) |
| D2 | 5V1 500mW Zener | 1 | (QH07H) |
| D3,7 | 5mm Red LED | 2 | (WL27E) |
| D4,9 | 1N4148 | 2 | (QL80B) |
| D5,6 | 1N4002 | 2 | (QL74R) |
| D8 | 5mm Infra-red LED | 1 | (CY85G) |

**MISCELLANEOUS**

| | | | |
|---|---|---|---|
| T1 | 12V 100mA Transformer | 1 | (WB02C) |
| SK1-4 | Coax Socket | 4 | (HH09K) |
| | Plastic Case Type MB2 | 1 | (LH21X) |
| | Plastic Case Type MB3 | 1 | (LH22Y) |
| | Red Filter | 1 | (FR34M) |
| | M3 10mm Panhead Screw | 1 Pkt | (JY22Y) |
| | M3 Nuts | 1 Pkt | (JD61R) |
| | Veropins | 1 Pkt | (FL24B) |
| | Coax Cable | 1m | (XR88V) |
| | 2-core 3A Cable | 2m | (XR47B) |
| | Cable Clip | 1 | (LR47B) |
| | 13A Plug | 1 | (RW67X) |
| | 2A 25mm Fuse | 1 | (HQ31J) |
| | PCBs | 1 pair | |
| | Coax Fly Leads | As Req. | (RW36P) |

The Maplin 'Get-You-Working' Service is not available for this project.
***The above items are not available as a kit.***

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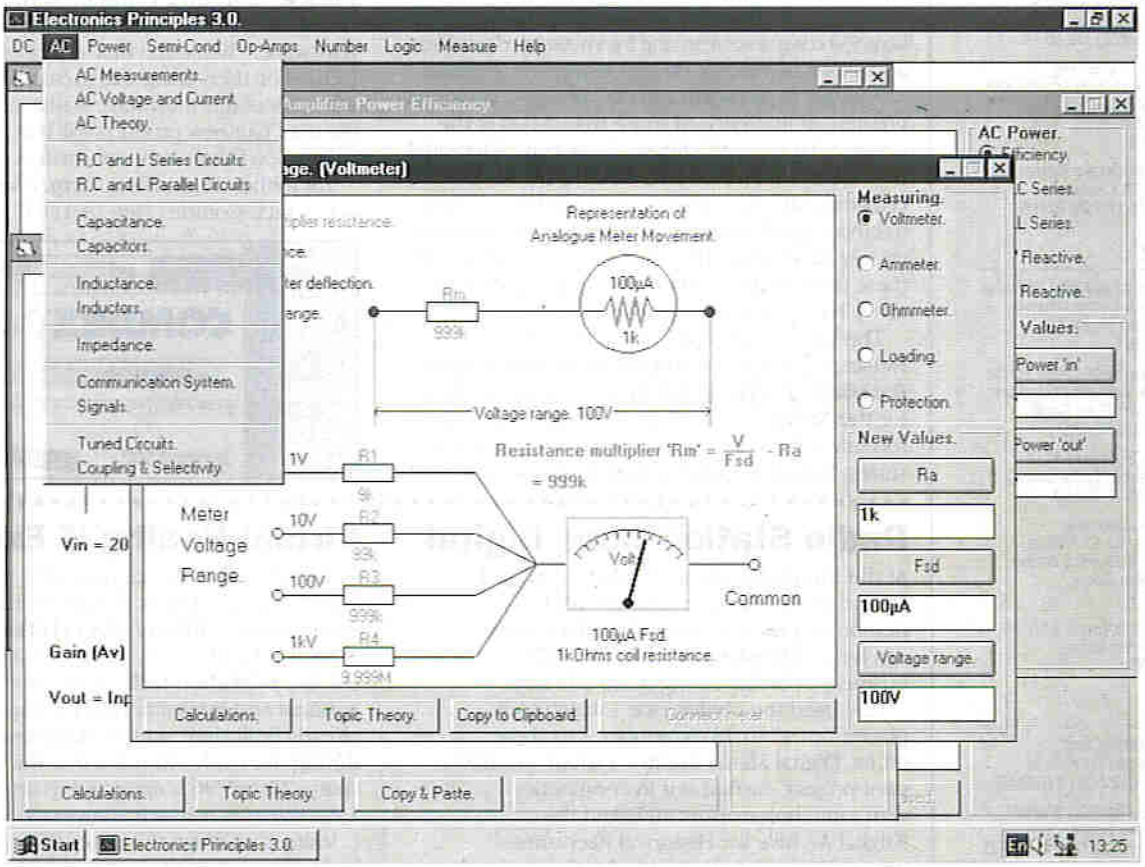


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# Diary Dates

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

### January 1997

**13 January.** Annual Dinner/Social, Stratford-upon-Avon & District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

**19 January.** Oldham ARC Mobile Rally, Queen Elizabeth Hall, Civic Centre, West Street, Oldham, Lancashire. Tel: (01706) 846143.

**22 to 23 January.** Electrical Network Protection and Supply Quality, Ramada Hotel, Heathrow. Tel: (01372) 367000.

**22 to 23 January.** Sensors and Measurement Instrumentation, NEC, Birmingham. Tel: (01822) 614671.

**27 January.** Members Evening/ Demonstration of home-built equipment, Stratford-upon-Avon & District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

**29 to 30 January.** Business Computer Systems Show, G-MEX Centre, Manchester. Tel: (0161) 725 8016.

### February 1997

**10 February.** Kitchen Table Metal Bashing, Stratford-upon-Avon & District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

**16 February.** 5th Northern Cross Radio Rally at Thornes Park Athletics Stadium, Wakefield. Details from Pete Smith G0BQB, Tel: (01924) 379680.

**19 to 20 February.** Software in Accounting and Finance, Earls Court, London. Tel: (0181) 541 5040.

**24 February.** Test Equipment, Bring Your Equipment for Checking, Stratford-upon-Avon & District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

**25 to 28 February.** Windows Show – Computing, Olympia, London. Tel: (01256) 381456.

### March 1997

**6 to 9 March.** Innovation and Inventions Fair, Barbican Exhibition Centre, London. Tel: (01202) 762252.

**10 March.** Antennas, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

**12 to 14 March.** The Television Show – The Film and Video Production, Business Design Centre, London. Tel: (0171) 344 3888.

**23 to 25 March.** Electrical Retailing Show, NEC, Birmingham. Tel: (01737) 768611.

**24 March.** Surplus Equipment Sale, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

**25 to 27 March.** Institute of Physics' Annual Congress, University of Leeds. Tel: (0171) 470 4500.

### April 1997

**8 to 10 April.** Environmental Technology, NEC, Birmingham. Tel: (0181) 910 7910.

**14 April.** Annual General Meeting, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

**14 to 17 April.** Tenth International Conference on Antennas and Propagation, Heriot-Watt University, Edinburgh. Tel (0171) 240 1871.

**22 to 25 April.** COMDEX – Information Technology Trade Show, Earls Court, London. Tel: (0181) 741 8899.

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

# What's On?

## Show Report: Comdex Fall

Thousands of professionals from the IT industry streamed into Las Vegas for the week beginning November 18, to visit COMDEX/Fall '96, one of the world's largest technology trade shows. Exhibitors stepped up the competition among desktop hardware architectures, as more than 2,100 exhibitors launched their introductions of a record number of new products. The Internet was the show's main star, with 550 companies featuring Internet-related products and services – nearly double last year's number.

Andy Grove, president and CEO of Intel Corporation, greeted an audience of more than 6,000 at the opening day keynote address. Grove commemorated the microprocessor's 25th anniversary, now being celebrated at COMDEX/Fall, and urged the audience to broaden its thinking about what future consumers should expect from PCS. "We are in competition for these consumers, for their dollars and their leisure time. That competition is the TV", Grove said.

The second day's keynote was given by Netscape's president and chief executive officer, Jim Barksdale. He spoke about Netscape's vision for the Net in 1997 and demonstrated Netscape's recently announced integrated client/server software suites, Netscape Communicator and Netscape SuiteSpot 3.0. In addition, Barksdale previewed a future Netscape Communicator component, code named Constellation, which lets users merge and customise desktop and network information, tune into content broadcast over the Internet and automatically receive customised information from various locations across a network.

"We are entering the third wave of the Internet, where e-mail and groupware with all the richness of the Web are key elements of computing", said Barksdale. "While the first waves of the Internet focused on users being able to easily find information, the mark of this third wave is that information finds the user. Our new products will have the intelligence to help you focus on the information you care about."

For further details, check: **http://www.comdex.com**

Contact: Comdex, Tel: (+1) 617 433 1755.


## Radio Station Goes Digital

At the International Convention on Sound Design in Germany last month, IBM demonstrated how a digital media archive can help radio stations make the daily business of broadcasting more efficient.

IBM used the conference – which took place from 15 to 18 November – to show off its 'Digital Media Archive System' (DMAS) pilot project, carried out in conjunction with radio broadcaster SWF, and the 'Digital Archive for Historical Recordings' project, in conjunction with the German Radio Archive in Frankfurt.

DMAS is an implementation of IBM's ADMIRA solution combined with Musis, SWF's descriptive music database. ADMIRA, which stands for Archiving of Digital Media for Interactive Retrieval and Access, is founded on the concept behind the IBM Digital Library. The system allows media content to be digitally stored, queried and distributed. ADMIRA gives radio broadcasters the technology to link their descriptive databases with digital music recordings, allowing access to titles from all networked workstations. The flexible system can not only be adapted to a broadcasting station's individual requirements, but also changed or expanded at will.

SWF relies on the technology for digital archiving, research and online access to digital audio recordings, among other applications. As time goes by, SWF aims to add capabilities for direct access to multimedia elements, such as image, text and video.

For further details, check: **http://www.ibm.com**.

Contact: IBM Deutschland Informationssysteme, Tel: (+49) 69 6645 2177.

## Virtual Reality IT Exhibition

The world's first virtual reality information technology exhibition, Virtex '96, has gone live on the Internet at **http://www.virtex.co.uk**. Every aspect of IT and computing is being covered by the five exhibition halls, where over sixty major national and international IT companies have already built their stands. Many more will appear during the twelve months that the exhibition will span – Virtex '96 is expected to attract a further 150 exhibitors before it is superseded by Virtex '97.

Visitors who visit the Virtex Web site are greeted by Dr Who's famous Tardis, this time brought to Virtex '96 and the Internet by another famous doctor – Dr Solomon of virus detection software fame. By simply clicking on Dr. Solomon's Tardis, they will be whisked in true Tardis fashion directly to Solomon's stand in the Security Hall.

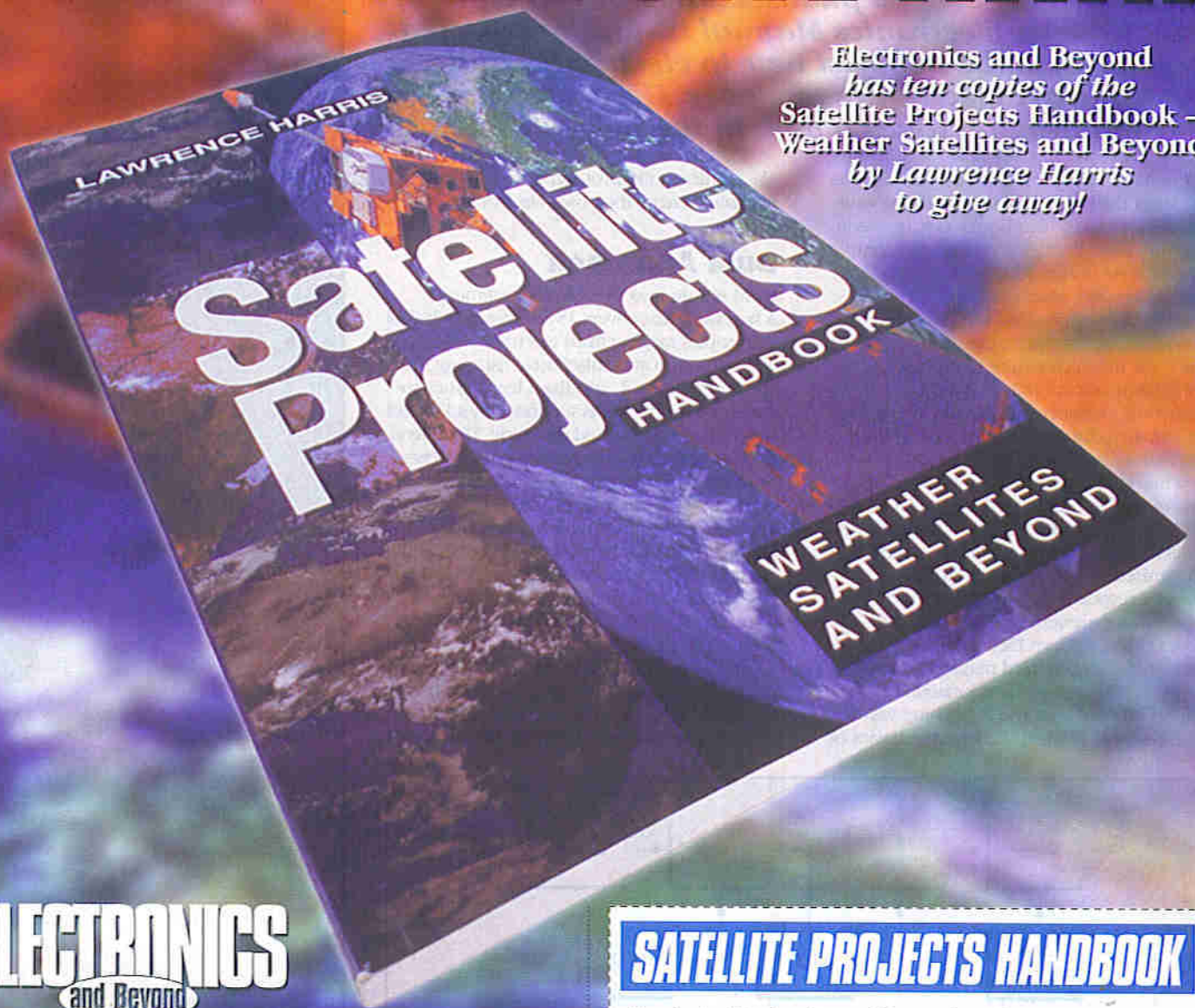
All five theme halls in this revolutionary exhibition are modelled entirely in virtual reality, using Superscape's virtual reality authoring software. The 'Novell Networking and Intranet Hall' holds stands showing the latest products and services in the networking arena, while the Kasten Chase Security Hall covers numerous key security issues important to both new and experienced Internet users.

Stands in the Superscape Internet Services and Desktop 2000 Hall cover a wide range of the latest software and services while the other two halls feature Document Management, Groupware, Data Warehousing and Electronic Commerce.

The halls abound with well known IT companies such as ICL, Computer Associates, Siemens-Nixdorf, Rank Xerox, Sareen Associates, SQL, Platinum Technology, and Sterling Software, but there are also many exciting niche players. Part of the attraction is that stand prices are far cheaper than in a conventional exhibition, starting at under £1,000 and averaging only a tenth of a normal exhibition's cost.

Contact: Virtex, Tel: (01691) 670543.

# FREE BOOK GIVE-AWAY




**Electronics and Beyond *has ten copies of the* Satellite Projects Handbook – Weather Satellites and Beyond *by Lawrence Harris to give away!***

## ELECTRONICS and Beyond

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All aspects of setting up a home satellite station are covered, including the practicalities of working within a budget, the selection of a computer for picture decoding, where to purchase kits and ready-built systems, in addition to other useful advice.

The author first became involved in the world of satellites while working within the support team at the Appleton Laboratory in the mid-1970s, and continues to write for *Short Wave Magazine* in addition to tutoring.

*Satellite Projects Handbook* by Lawrence Harris is published by Butterworth Heinemann, and priced at £14.99, softback with 56 illustrations and 174 pages.

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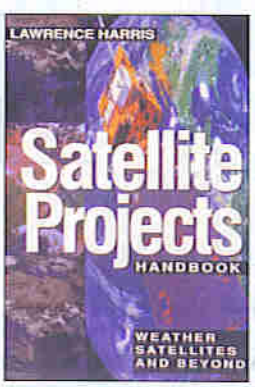


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ELECTRONICS and Beyond

# REVIEW

***Recently revised and published in its third edition, the Modern Electronics Manual is a well-respected text for both the hobbyist new to electronics and the stalwart electronics engineer. Here, Stephen Waddington takes a look at the new edition.***

If you're new to electronics, how do you learn the basics and start building your own projects? Text books vary between the very basic hobbyist manual and complex degree level design texts. There is no middle ground. Magazines such as *Electronics and Beyond* are good, but you're reliant on the magazine covering the topic in which you're interested.

I was fortunate enough to have an electronic engineer for a Grandparent that had an encyclopaedic knowledge of both technology and the electronics industry.

While learning from a professional is one of the best introductions to electronics, not everyone has this luxury. Matthew Pulzer, a research and instrumentation engineer recognised exactly this back in 1985. Pulzer's response was to gather together a group of experienced engineers and develop the Modern Electronics Manual (MEM). Now in its third major revision, the MEM is a 1,000-page encyclopaedia published by Wimborne Publishing which aims to guide readers through the basics of electronics, build prototype circuits and ultimately, create their own electronic designs.

## Dual Approach

MEM is split into two discrete segments. A basework text covers 15 sections which deal with topics ranging from electrical safety to amateur radio and short wave listening, as shown in Figure 1, and from legal issues to communications. This is supported by additional supplements published quarterly. These tend to either expand on topics covered in the basework or review a fast moving or emerging aspect of electronics, such as microprocessor control or computer based instrumentation. During the last ten years, Wimborne Publishing has added over 30 additions, and redeveloped.

There are nine main categories, for which a wealth of data is provided in the basework. A further six categories are also allocated to subjects which are covered and revised periodically by supplements, but for which no basework is provided. A summary of the individual sections is shown in Table 1.

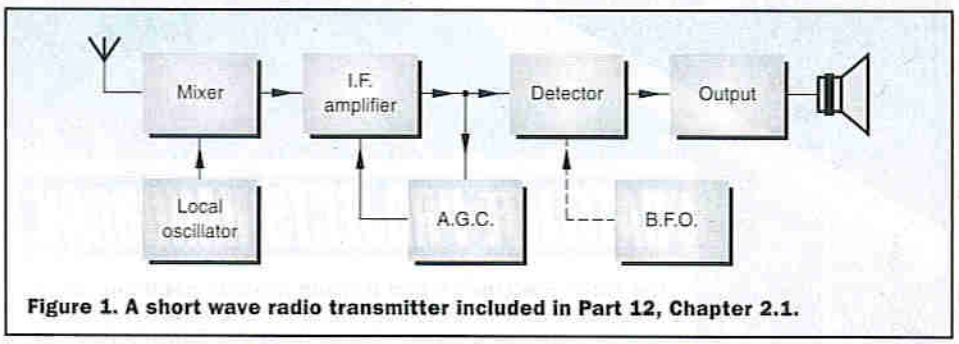



**Figure 1. A short wave radio transmitter included in Part 12, Chapter 2.1.**

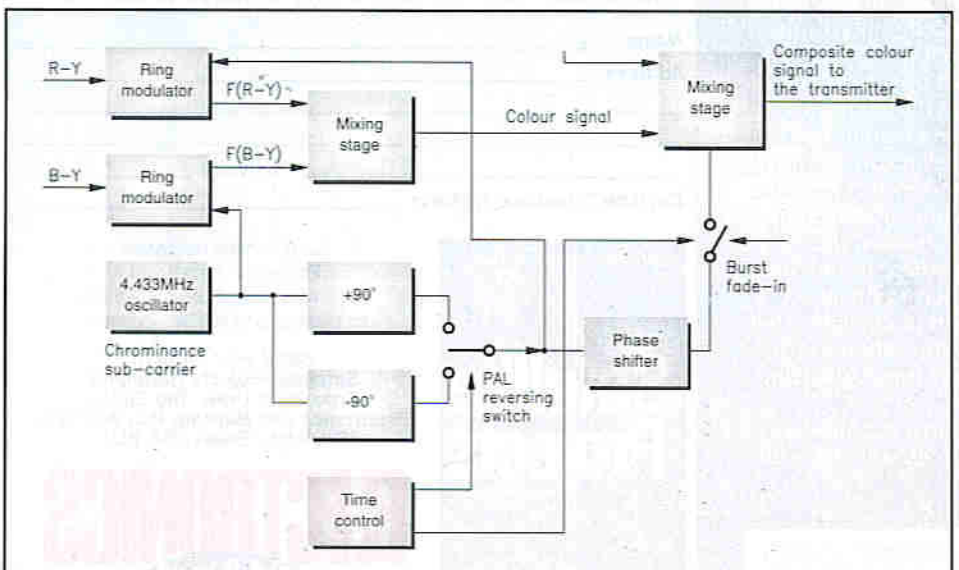
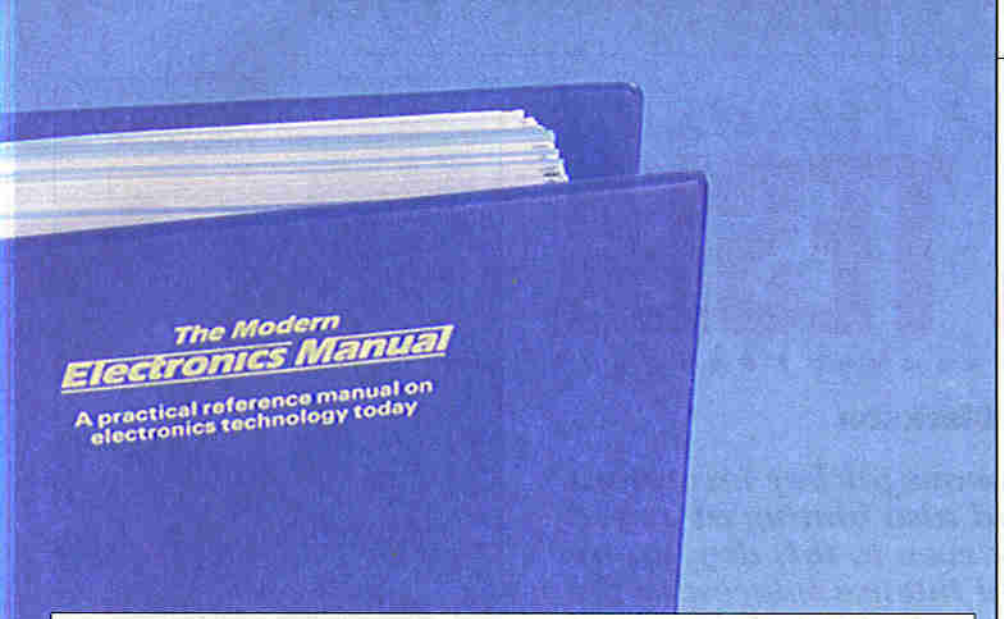



**Figure 2. MEM deals with complex topics, such as the composite colour signal circuit.**




| Section | Title | Description |
|---|---|---|
| 1 | Contents | Contents index of MEM presented in quick-read access to various subject sections. |
| 2 | Electrical Safety | Discusses potential dangers of electricity. Highlights the fact that while circuits may not be powered by mains electrical currents, other components can sometimes be a source of danger. |
| 3 | Basic Principles | Outlines the basic principles of electronics. In this section, there are descriptions of the main electronic components encountered in everyday use and an explanation of relevant associated theory. |
| 4 | Selected Circuits to Build | Introducing this section is a chapter which describes how to design and construct your own Printed Circuit Boards (PCBs). The remainder of the section outlines a variety of functional examples of useful electronic equipment to build. |
| 5 | Repairs and Maintenance | Want to fix a broken radio, television, Hi-Fi, video, telephone or even a computer? This section outlines some of the most basic electrical and electronic tests required to troubleshoot a consumer electronic product. Probably the most useful element of the book. |
| 6 | Table of Data | No data tables can ever be complete, due to the speed that the industry is moving and the reluctance on the part of some manufactures to issue component specifications. That said, this section gives a very useful overview to some of the key semiconductor devices. |
| 7 | Legal Questions | Reserved for supplement. |
| 8 | Specialist Vocabulary and Abbreviations | A glossary of specialist vocabulary is rare even in degree level electronic text books. This section outlines over 300 formal definitions. |
| 9 | Miscellaneous | Reserved for supplement. |
| 10 | Communications | Reserved for supplement. |
| 11 | Computers | Reserved for supplement. |
| 12 | Amateur Radio | This is a topic that occupies the minds of many electronics enthusiasts. Indeed, many amateur radio enthusiasts become interested in electronics after an introduction in radio communications. If you're not an amateur radio fan, read this section and before too long, you'll be scanning the shortwave band. |
| 13 | Leisure Systems | Reserved for supplement. |
| 14 | Suppliers | No electronic enthusiasts workbench would be complete without a selection of suppliers' catalogues. This sections outlines the names and addresses of companies to write to for catalogues and component information. A compact table summarises which suppliers deal with which components. |
| 15 | Future Developments | Reserved for supplement. |

**Table 1. Outline of sections within MEM.**

# Modern ONICS MANUAL

**by Steven Waddington**

Each section of MEM is written by a specialist author. Pulzer, who created the original concept, is the managing editor. A graduate of the University of Sussex, Pulzer has spent the majority of his career as a research and design engineer. And like the section authors, he maintains an enthusiastic interest in all aspects of electronics, but in particular, control systems, instrumentation, audio amplifiers and computer-aided design. This combination of professional expertise and raw enthusiasm for electronics is apparent in all of the sections, with a balanced mix of theory and practice.

## Thorough Basic Grounding

If I have a criticism of MEM it is that elements of the original basework have not been sufficiently revised since the first edition in 1985. Many of the practical examples use analogue test equipment and 4·5V batteries – items which I certainly haven't used in my workshop at home for at least five years. Also, some of the diagrams remain amateurish. This can be forgiven, but with modern desktop publishing and photography techniques, is unnecessary.

This apart, MEM provides an superb introduction to electronics. If you are new to electronics, the basework text is well worth its £39.95. The practical approach which is common throughout MEM, underpinned by a deep foundation of theory, is incredibly refreshing. The breadth of writers gives a rich variety and the text has been carefully knitted together by its editor Matthew Pulzer. Similar books which try and take a universal approach to the topic of electronics, such as Mastering Electronics and Electronics Engineer's Reference Book come nowhere close to MEM. They are either too theoretical and lack practical examples, or assume a fundamental knowledge of the subject.

If you are a professional working in the electronics industry, particularly in the area of research and development, MEM is an excellent reference text. It not only covers the basics from Ohm's Law to RC time constants, but also extends to advanced topics such as boolean algebra, error functions and RGB colour tube composition, as shown in Figure 2.

## Survey

Following a recent survey of MEM's readership, Pulzer claims that over 70% of those that use the Manual are professionally involved in electronics. The remaining readers consider themselves to be hardened enthusiasts. "A fair cross-section of abilities is prevalent in the other 30%, ranging from those who first considered themselves to be pure novices, to those who have been indulging in electronics as a leisure activity for many years", said Pulzer.

At £23.50, the additional supplements are expensive, but readers that sign-up to the basework are sent a supplement quarterly on approval. This provides an opportunity to review the text and return if it is not relevant or simply not required.

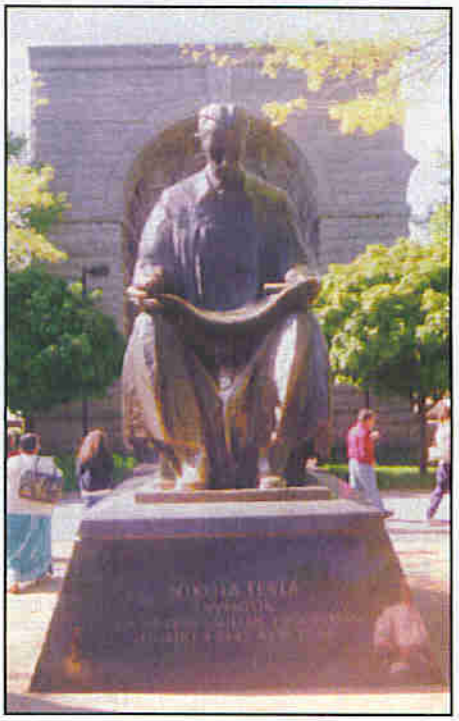
### Availability

The Manual Electronics Manual costs £39.95, available from Maplin Electronics, Order Code AN46A. Additional supplements and Back issues are available from Wimborne Publishing, priced £23.50 + £2.50 p&p per manual. Tel: (01202) 881749.

# The Life and Times of NIKOLA TESLA

**by Douglas Clarkson**

***It is the duality of being famous for key inventions in the industrial world and also hinting at as yet unappreciated effects, that even to this day, many people have maintained an intense interest in the life and times of Nikola Tesla. Indeed, the aura of mystery that Tesla in some ways encouraged is now attracting a more broad following from a new generation of investigators, who wonder what in the way of undiscovered truth is 'out there'.***



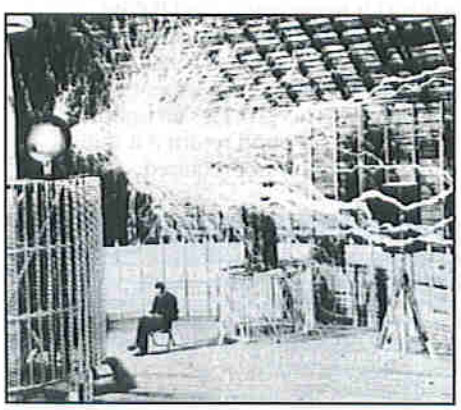
Tesla had a remarkably different mental makeup from his scientific contemporaries. While it was the practice of Thomas Edison, for example, to arrive at a successful product after rejecting along the way numerous prototypes, it was the hallmark of Tesla, especially in his more youthful days, to meticulously solve all problems of size, material and construction of his projects first in his mind without constructing a trail of prototypes. Tesla could apparently visualise, in the finest detail, working models of his inventions and even inspect them for wear and tear to determine if such an implementation would prove satisfactory in use.

The challenge of present day observers is, on the one hand, to patiently replicate various phenomena that he was uniquely able to demonstrate and also obtain an understanding of other principles which he alluded to but was not able to directly demonstrate. As an experimenter, Tesla possessed superb and meticulous skills and was subtly aware of how to produce electromagnetic phenomena that have so far eluded modern day experimenters – apparently including that of ball lightning.

Over the years since his death in 1943, there has been a gradual process of sifting through historical records from diverse sources – to clarify associations and in general, provide improved documentation with which to review his life and works. The lack of appreciation of Tesla's contribution to science is evident that following his death, Tesla's vast store of documents and notes was allowed to be dispatched to Belgrade – then in Yugoslavia and behind the Iron Curtain. There is, however, still a lack of level headed assessment of his work in the light of today's more expansive scientific understanding.

One of the reasons for the significant gaps in his life's study is the lack of an effective autobiography. Tesla had always planned to write one – perhaps in his 90s, when the greatest of his inventions would be firmly established and he would have peace of mind at last to set down his innermost thoughts on paper. Indeed Tesla may have perceived some aspects of technology which he thought the world would be best without and considered it better to make no record of such possible developments.

It is quite a challenge, therefore, to go in pursuit of the real Tesla. Another factor is that he never really had any close scientific associates in which he felt he could confide his most deep thoughts. He was able to keep relatively aloof from most people, even when pressed greatly to provide an explanation of his actions or opinions. He particularly avoided the company of all women – as if they would somehow reduce the brightness of the flame of his intellect.



## Early Years

Nikola Tesla was born of Serbian parents in 1856 in the village of Smiljan in Croatia. From an early age, he showed an inventive flair. One of the most dramatic incidents to shape his life was the death of his elder brother when Tesla was around seven years old. This seems to have propelled Tesla from being in the shadow of his talented elder brother to moving to become the leading light of the family.

Passing successfully through schooling, his father eventually relented and allowed Tesla to enter into a career in engineering rather than the ministry. Tesla was eventually enrolled in the Polytechnic in Gratz in 1875 and immersed himself in relentless, intense studies – so much so, that the college authorities feared for his well being. Unfortunately, a change in circumstances regarding fee remission prevented Tesla from continuing with his formal education.

He eventually found employment in the new telephone exchange in Budapest in Hungary and subsequently, in Paris. Within this period, Tesla's health would often be precarious after having suffered from Malaria and also Cholera as well as having periods which could be described as extreme mental exhaustion.

Tesla had by this time set himself the task of inventing the AC motor after having encountered previously at school the DC motor with sparking commutators. Suddenly, in a flash of inspiration, he mentally perceived the correct principle and before long, the design he had built worked perfectly – first time. Tesla had, however, laboured hard and long at a mental level in the resolving of this problem. He could not, however, attract any interest in his revolutionary AC motor design in Europe.

On American soil, Tesla would find acceptance for his polyphase electric motor would find acceptance. With a letter of introduction to Thomas Edison, Tesla succeeded in securing employment in developing and refining aspects of direct current supply systems. Edison was soon to realise what a valuable addition Tesla was to his staff, even though he did not want to hear a word about Tesla's brilliant AC motor invention.

It was, both the best and the worst of times in the embryonic power supply industry in the USA. As more and more DC systems were installed in buildings and homes of the wealthy, it was a severe challenge to maintain even existing systems in safe working order. Also, while Edison had seen off the gas companies in their efforts to supply light to many cities, this had been undertaken by largely subversive means, including bribing of officials and mass propaganda. Also, the rapidly expanding American economy was

inherently unstable. A large amount of infrastructure, such as the railways had been built speculatively based on the anticipated increase in share value of companies.

Tesla had indicated to Edison that he could significantly improve the efficiency of his direct current dynamos – with Edison apparently remarking casually that if this could be done, then he would give Tesla $50,000 for his effort. When, after almost a year of successful intense effort, Tesla duly returned to claim his fee, Edison was duly minded to remark "Tesla, you don't understand our American humour". His refusal to pay marked the end of their brief period of co-operation.

Tesla's next enterprise was as part of the Tesla Electric Light Company, which became engaged principally in the development of arc lamps for street lighting. In the spring of 1886, amid the gloom of a gathering depression, Tesla found that he had been manoeuvred out of the company and the value of shares he held was almost worthless. Tesla found himself living from hand to mouth obtaining any work he could find, including digging ditches and general labouring. It seemed that in these times, the only individuals to prosper were shrewd financiers, accountants and lawyers.

## The Westinghouse Era

As chance would have it, this casual form of work eventually brought Tesla into contact with AK Brown of the Western Union Telegraph company. Brown had correctly determined that the future of current supply was AC and not DC. The limit of transmission of DC current was about a mile, due to the inherent resistive loss in copper conductors. Diverse systems for power generation and transmission were already in place at this time in the USA. These included patented systems for AC as well as DC. AC distribution had the advantage that it could be transmitted much more efficiently over long distances than DC, while DC had the advantage that the DC motor already existed – though with sparking commutators. The AC motor was not – except in the mind of Tesla – in existence. Brown saw, therefore, that an effective AC motor would see off DC power systems for ever.

Moving into premises of the Tesla Electric Company at 33-35 South Fifth street in April 1987, Tesla commenced constructing AC motors and filing associated patents. His progress was remarkably rapid and Wall Street buzzed with anticipation of the new implications for power distribution systems and industrial development in general. It was George Westinghouse, however, who succeeded in securing Tesla's agreement in the use of his patents for AC motor technology.

In the 'war of the currents' between Edison (DC) and Westinghouse (AC), the clear advantage was now with Westinghouse. While Edison had lost the edge in technology, he now sought to make up for in propaganda. As ever, keen to manipulate public opinion to his own ends, stories of the inherent danger of AC current were put into wide circulation. It was Edison, for example, who clandestinely used Westinghouse patents to build the USA's first electric chair in order to discredit the Westinghouse AC system. These were countered squarely by Westinghouse, who gradually turned the tide of public opinion in his favour.

Telsa's contribution in the war of the currents was to have decisively moved events in favour of alternating current and speeded the rate of industrial development generally. The selection of 60Hz had specifically been determined by Tesla as the optimum frequency, based on the cost and efficiency of constructing AC motors. Initially, Westinghouse engineers had opted for 133Hz in power distribution systems and Tesla spent a frustrating time convincing engineers to change to 60Hz.

In order to secure the survival of Westinghouse in the intense rivalry of the war of the currents, however, Tesla apparently revoked an understanding to secure royalties based on the installed capacity of AC systems. This may have ensured the survival of Westinghouse, but it severely restricted in later years the work of Tesla in his researches. In the mould of financial takeover and mergers, Edison's own company became combined with others to form the General Electric Company.

Tesla's contribution to the infrastructure of North America was immeasurable. His development of the AC electric motor provided the impetus for AC power distribution to dominate and with it, the blueprint for power generation and distribution for the 20th century. Industrial production came more and more to be dominated by the supply of grid AC power rather than from local factory power houses. This was to be Tesla at the height of his fame.

All manner of requests for engagements, lecture tours, etc., followed. Eventually, he travelled to Europe in 1892. The lecture trip to London, Paris, and then a hurried trip to see his ill mother before she died saw Tesla on the edge of complete exhaustion when he returned to America in 1892. Fortunately, the notes for his various major lectures in the 1890s came to be written up in formal manner. They still provide stimulating reading today, and must have had a most dynamic effect when they were first presented.

## The 1892 IEE Lecture London

In presenting this lecture in London, Tesla acknowledged the major contribution of British scientists to the field of electricity and magnetism – singling out Crookes for especial praise. In his labours in the USA, he did not appear to work closely with what could be described as academic contacts. In Britain, he could perhaps have found more resonance among luminaries such as Lord Kelvin and Sir James Dewar.

It was almost as if, during this lecture, he was especially forthcoming in describing exactly how he managed to produce coil secondary voltages of such magnitude. High performance coils were apparently wound in oil that had been previously boiled. Also, coils could be wound then placed in an evacuated chamber, into which boiled out oil was slowly introduced. In this way, bubbles of air were prevented from becoming established to cause the oil to break down across neighbouring windings. The windings for the secondary were wound in gutta percha – a latex material derived from various tropical trees. Layers of windings were in turn separated by layers of cotton cloth which had also been boiled out in oil.

While the transforming principle to high voltage for alternating power transmission was widely appreciated, Tesla at this time indicated that a key problem in achieving transmission at voltages as high as 100,000V was the quality of insulation available.

Tesla was quite at home in the academia of London to testify to the prospect of 'free energy' in the Universe available for tapping. As an example, he quoted the radiometer of Crookes with the vane in the evacuated sphere that rotates when lit by sunlight. At this stage, Tesla is anticipating in some way the free energy of solar cells. His idea of converting lower energy quanta of heat radiation has not been realised due to the reduced efficiency of conversion and also the generally low energy of black body radiation at room temperatures.

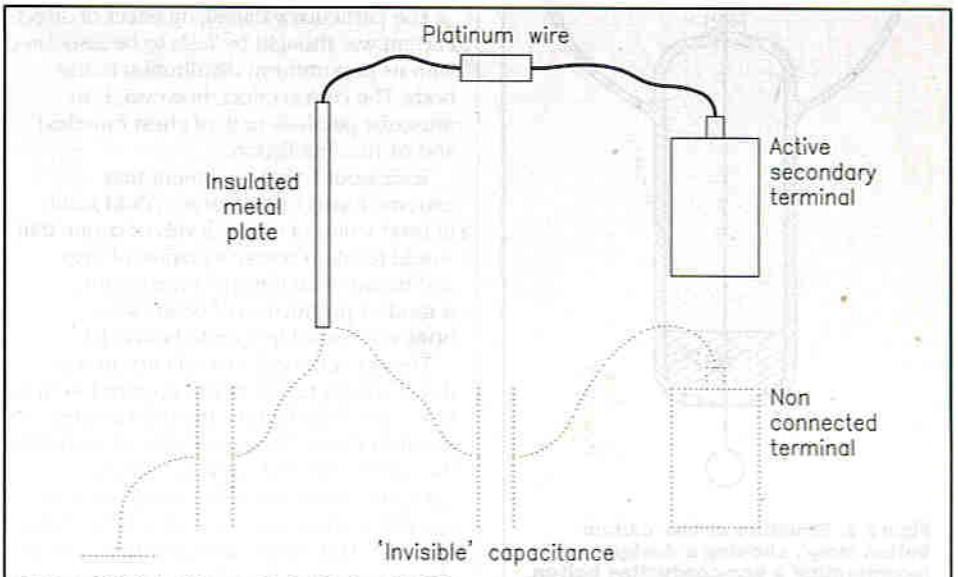



**Figure 1. Probable equivalent circuit of demonstration of passage of high frequency currents through a single wire with a platinum element. In the circuit, 'invisible' capacitance would be present to ground and to the non-connected terminal.**

It was during this lecture that Tesla introduced his London audience to the new product, 'carborundum', which was beginning to find wide application as a grinding material to replace diamond dust. It was introduced as an ideal material for constructing his button globes – details of which are provided in the next section.

In fact, the published text of the London lecture runs to almost 100 pages as published in Thomas Commerford Martin's book, which also contains the text of most of Tesla's formal lectures presented up to 1893. It is very striking in reading the account of this and similar lectures, of the great productivity of Tesla in designing and having constructed a considerable array of items of equipment.

## On Light and Other High Frequency Phenomena

A transcription of Tesla's lecture with the above title delivered to the Franklin Institute, Philadelphia, in 1893 provides a most useful insight into the experimental skill and observation of Tesla. As the title suggests, this discourse is all about light.

In the lectures that Tesla gave involving high voltage discharges, he would appear even more tall and imposing – courtesy of thick soles of cork built into his shoes. The remarks he made as to the inherent dangers of DC current were in a way aimed at flying the flag for the Westinghouse AC system, although to be fair, he did also stress the dangers of low frequency AC current.

While Tesla proceeded to provide details of his experiments to produce light in novel ways, he also referenced an experiment of

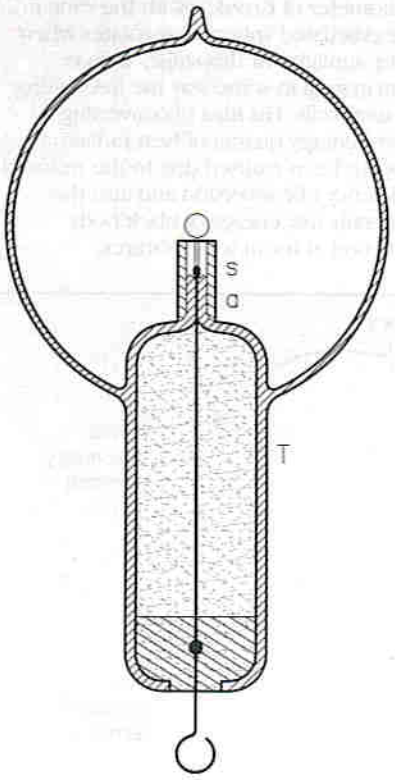



**Figure 2. Structure of the 'carbon button lamp', showing a design incorporating a non-conducting button. The small sphere of material is the 'button' of material being raised to high temperatures.**

Helmholtz, in which it is claimed that this investigator was able to see in total darkness by means of light emitted from the fundi of his eyes. Modern science has so far failed to validate such a phenomena.

Tesla, however, projected his deep awareness of the importance of light and vision in general in the development of civilisation as if to justify his own efforts in developing more effective sources of artificial light using electricity.

One of the first items of demonstration was for Tesla to excite a secondary coil to a voltage of around 200,000V at a frequency of around 1MHz. The secondary coil was itself immersed in a bath of oil so as to prevent breakdown in air across the coil surface, and the terminals of the secondary coil were insulated in hard rubber. With a metal rod in one hand, he approached one free terminal of the secondary coil. Sparks broke out but ceased when the terminal was touched.

Tesla's whole body was then at the oscillating potential of the coil terminal and faint streamers broke out from parts of his body. He then proceeded to demonstrate more vigorous streams of light breaking out from his hand as he approached the second coil terminal, to which was attached a large brass sphere. Tesla's body was acting as a conductor for the current flowing across the terminals of the coil with most of the resistance to the current accounted for in the spark gap between his hand and the sphere. He was reluctant to move his hand closer, as this could give rise to 'injurious' and powerful sparks.

The keynote of this demonstration, however, was the evidence of the faint streamers of light produced in air by high voltage/high frequency electricity. Tesla at this point conveys his derived wisdom that the most dangerous current is a continuous or direct one but 'the most painful is an alternating current of very low frequency'. Tesla had also an awareness of the importance of current density as an effect in the body for inducing fatal effects. It was customary for Tesla and his assistants when working with high voltage circuits to keep one hand permanently in a pocket, so that there was not afforded a current path across the body.

The particularly damaging effect of direct current was thought by Tesla to be associated with its non-uniform distribution in the body. The critical effect, however, is in muscular paralysis (e.g. of chest muscles) and cardiac fibrillation.

Tesla would often comment that extreme forms of discharges could result in production of excess levels of ozone that would result in severe irritation of eyes and throat of an intrepid investigator. A modest production of ozone was, however, considered quite beneficial.

The conventional view of current was that a complete circuit was required for it to flow – as in the battery, the bulb and two lengths of wire. Tesla could ably demonstrate the simple fact that with high frequency currents, return paths involving 'invisible' capacitive and inductive components were possible. This effect, demonstrated without clearly indicating the effective circuit of such configurations, was an excellent party piece.

Tesla would demonstrate this by means of Figure 1 where one terminal of a secondary coil would be connected via a fine platinum wire to an insulated metal plate. There would, presumably, be 'invisible' capacitive coupling between the other terminal of the coil to the metal plate. When the coil was activated, Tesla could demonstrate that the platinum wire glowed hot and sometimes fused – indicating the passage of current in the circuit. Assuming a coil frequency of 1MHz, a capacitive coupling to the other coil terminal of 100pF would only present an impedance of 1,500$\mu$. When such coils were excited at voltages around 10,000V, relatively large currents could flow.

A consistent feature of later work was the anticipation that power could be sent 'without wires'. In fact, as an evidential proof of this, extensive portions of his laboratory were lit by power derived from the electric field produced by wires from high voltage generators so that evacuated tubes had no visible wire connection. The same effect can be replicated today by placing fluorescent power tubes under present day high tension supply lines.

While the observations of Tesla gave detailed account of extensive experiments in this field, he displayed a far-sighted appreciation of the possible mechanisms of the production of light from molecular and atomic collisions within evacuated spheres and bulbs. At the conceptual level, he was aware that light is a form of high frequency radiation and that it would be impossible to directly drive electrical circuits to the frequency of visible light.

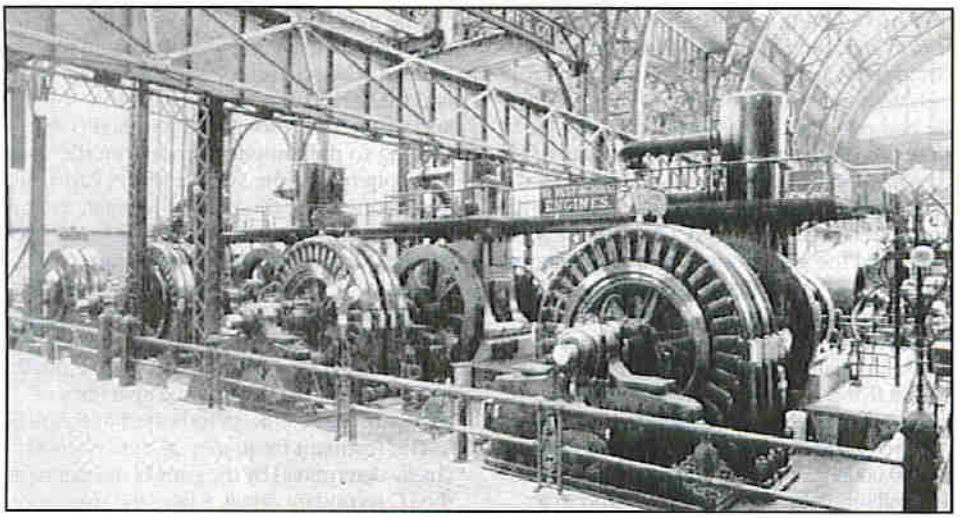
Tesla demonstrated what took place when an element of material was energised, as in Figure 2, where a terminal from a high voltage secondary was connected via a platinum wire to a 'button' of material at the centre of an evacuated spherical globe. Materials such as carborundum, diamond, sapphire, etc., would rapidly become incandescent and subsequently vaporise when energised. Patterns of phosphorescence would be noted on the surface of the globe during this procedure. It was later appreciated that as electrons streamed out from the small point source of the incandescent material, the incandescence was associated with the atomic 'landscape' of the irradiating surface, as in the emission field microscope.

Tesla was well aware of the need for luminous efficiency in light generation and how the higher the temperature of a radiant source, the greater the amount of light output produced. To him, it seemed sensible that just as gas had a limit for raising the temperature of the gas mantle or flame, his solid incandescent button was of more use than the 'frail filament'.

In fact, Tesla was often to draw the analogy between the particles he was sure were streaming out from his 'carbon button' lamp and particles that were streaming out from the sun. It was to be many more years later, however, before the Solar Wind was discovered.

## And So, to Radio

The expert experimental skills of Tesla served him well to demonstrate aspects of wireless technology. At a demonstration at St. Louis in 1893, Tesla demonstrated



induced electromagnetic resonances in one receiver circuit from a transmitting circuit at a distance of 30 feet. In the dispute of patents on wireless in 1943 between Marconi and Tesla, the US Supreme court was to rule in favour of Tesla as having pre-eminence in the invention of wireless.

After his successful London lecture of 1892, Lord Raleigh had recommended Tesla to specialise in a single area of research. Tesla appeared to be covering such a wide field of work that he did not have the inclination to focus on a single part of this creative work and bring that through to completion. Just as he began devoting his energies successfully to wireless, he became involved in assisting Westinghouse put on a display at the Chicago Fair of 1893 from January to October of that year.

At a time when Tesla was deeply preoccupied with a range of work, on March 13th 1895, his laboratory caught fire. Equipment on the fourth floor crashed through to the second as a pile of molten smoking metal. Years of valuable work and associated records were all destroyed. The loss was uninsured. This was a dreadful reversal of fortune.

## The 1897 Lecture before the New York Academy of Sciences

With the discovery of x-rays in 1895, and radioactivity by Becquerel in 1896, the pace of science accelerated significantly. The electron was discovered by J. J. Thompson in 1897, Planck proposed the quantum theory in 1900 and Einstein, the photoelectric effect in 1905. Science and technology were now leaping forward in great strides.

One of the cornerstone lectures given by Tesla during this epic time was one given before the New York Academy of Sciences on April 6th, 1897. At this time, the scientific wonder of the age was no doubt x-rays as first discovered by Roentgen in December of 1985. While Tesla gave all credit to Roentgen, he implied that during his researches with photographic plates and Crookes tubes, he had encountered 'unaccountable marks and defects' on photographic plates.

With true hindsight, the photographer, Edward R. Hewitt, had been engaged in photographing Mark Twain under a Crookes tube in Tesla's laboratory at 25 South Fifth Avenue prior to the disastrous fire of March 13th 1895. What appeared on the camera plate, however, was a camera lens adjusting screw. It was only after Roentgen's discovery that it was understood what had caused the image on the plate. With true humility, Tesla was happy to quote the words of Goethe – 'what Nature does not want to reveal to one's mind, one cannot force it from her with screws and levers'.

There is no doubt that Tesla and various of this laboratory staff were exposed to high levels of ionising radiation – especially to the hands, which were used as a form of crude exposure meter.

## Of Mysterious Resonance

At the core of Tesla's appreciation of the physical world was the phenomenon of resonance. There was, for example, the resonance of electrical LCR electrical circuits. There were to be resonance experiments where Tesla claimed that he was able to effect natural resonance of the Earth's electricity. There was also the case of mechanical resonance that is apparently reported as taking place in his laboratory on a day during 1898. Following reports of excessive vibration in the neighbourhood, police allegedly burst into his laboratory just as he smashed a compact mechanical resonator that he had placed on the floor. How such a effect over a wide neighbourhood could have been effected from a resonator of low power has never been determined.

## Other Developments

Tesla was also to reference the heating effect of high frequency currents passing through the body. There was initial general acceptance of the essential beneficial effects of 'electrotherapy' – so much so, that a hundred years later, there is no serious questioning of, for example, the short wave diathermy used in physiotherapy.

Tesla had apparently also been working on systems to produce cryogenic liquids, such as liquid oxygen. This would have had considerable commercial interest, but there is also the thought that their use to cool his large coils would have allowed them to pass higher currents and hence, achieve even higher voltages.

## Radio Wave Transmission

Prior to discussing Tesla's Colorado Springs experiments, some brief comments are made regarding modes of radio transmission. In radio transmission, waves are identified by the sky wave and the ground wave. At frequencies below 40MHz, radio waves may be reflected off the ionosphere so that they can be bounced around the world. The ionosphere is generally strongly absorbing below 10MHz. The ground wave can be propagated up to 1,600km, though this is dependent on frequency.

ELF (extremely low frequency) waves are used currently for communication with submarines and employ the prominent resonances in the natural cavity formed by the Earth and the ionosphere between 5Hz and 100Hz. Such waves are relatively weakly absorbed by seawater. The ionosphere, however, is subject to daily, seasonal and solar cycle variations.

The theory of low frequency resonances in the Earth-ionosphere waveguide is very complex and is probably not entirely in the public domain. Treating, however, the Earth-ionosphere as a simple waveguide indicated A B C D in Figure 3, where the condition that the circumference path through the ionosphere is a whole number of resonant wavelengths:

$$C = n \times w$$

$$C = \frac{n \times c}{f}$$

Where f is the frequency of the resonant wave, w is the resonant wavelength, C is the circumference path, n is the number of whole wavelengths and c is the effective velocity of the waves.

$$C = \frac{n \times c}{C}$$

Assuming an Earth radius of 6,356km and with a mean height above the surface of the ionosphere of 250km, Table 1 gives a simplistic set of values for the observed resonances. Resonances in the Earth-ionosphere waveguide are more complex due to consideration of wave propagation in an ionised gas medium and the presence of the Earth's magnetic field.

| Wave Number | Resonant Frequency |
|---|---|
| 16 | 236·8kHz |
| 15 | 118·4kHz |
| 14 | 59·2kHz |
| 13 | 29·6kHz |
| 12 | 14·8kHz |
| 11 | 7·4kHz |
| 10 | 3·7kHz |
| 9 | 1·85kHz |
| 8 | 925Hz |
| 7 | 462Hz |
| 6 | 231Hz |
| 5 | 115Hz |
| 4 | 57Hz |
| 3 | 28Hz |
| 2 | 14·45Hz |
| 1 | 7·22Hz |

**Table 1. Simple set of predicted ionosphere resonances.**

ELF resonances are apparently observed in the Earth at 8, 14 and 20Hz. Tesla was intuitively aware of the possibility of establishing resonances within the Earth-ionosphere waveguide, although the exact nature of the resonances he established are still unclear.

## Colorado Springs: The Magnifying Transmitter

Tesla was mindful of the inherent risks in his New York laboratory of his coils, which were now attaining voltages of around 4 million volts. Lewis Curtis, a Westinghouse patent attorney, arranged for Tesla to set up a laboratory in Colorado Springs, where with a range of investors, greater scope would be afforded to carry out his experiments. This interlude of a year in Colorado was to find Tesla perhaps in his best element – designing and conducting experiments, where he sought to tap into and resonate with the electrical activity of the Earth. The laboratory appeared to be a large wooden shed with tall mast and with a ball on the top.

Tesla indicated that a key feature of the high voltage circuits at Colorado Springs was the avoidance, where possible, of high electric field gradients so that high potentials could be established without the air breaking down. In terms of the resonant structure, he indicated that it can be resonant over a range of a few to many thousands of cycles per second. There is some debate, however, of the range of frequencies over which Tesla actually drove his magnifying transmitter system.

Some of Tesla's equipment was used to measure local electrical activity in the Earth associated with local and distant thunderstorms. The unit used to determine electrical activity of the Earth was described as the secondary of a transformer unit with one side connected to ground and the other connected to an elevated terminal of adjustable capacity, and with the measuring circuit in the secondary of the circuit. His basic finding was that the 'Earth to be alive with electrical vibrations'. Tesla noted that as one particular storm was blown further and further away, the electrical activity decreased and then increased – as if he was observing standing waves.

In the first lengthy run of the system, oscillations began to build up so that the bolts of lightning were latterly around 135 feet in length and the associated thunder could be heard some 15 miles away. Tesla indicated that during one of his experiments, he had established a resonance at 150kHz. In terms of the experiments he conducted, the maximum voltages he is claimed to have established were around 12 million volts with antennae currents of 1,100A. Observers noticed that when the system was activated, grounded objects at a distance of 300 feet from the apparatus could support arcs an inch long.

'Flames of electricity' leapt from taps in the immediate neighbourhood. Sparks were visible flying between grains of sand and horses with metal hooves fled their stalls.

For comparison, in a lightning storm, currents of 100,000A across a potential difference of 100 million volts may flow to ground in a few hundred microseconds, resulting in the discharge to Earth of around 10 coulombs. While Tesla focused on the ability of such resonances for the transmission of 'intelligence', he also was convinced of the ability of the use of such a method to transmit electrical power.

Thus, while Marconi would later seek to develop radio by bouncing waves off the ionosphere, Tesla was probably at this time seeking to establish specific resonances in the Earth-ionosphere waveguide. Tesla first 'reported' his work in the Century Magazine of 1900 and also in 'The Transmission of Electrical Energy Without Wires' in the Electrical World and Engineer, March 5, 1904. More full details of his work were subsequently published by the Tesla Museum in 1978. He remained convinced throughout his magnifying transmitter work that he was not setting up 'Hertzian' wave resonances. Almost a hundred years after his investigations at Colorado Springs, his work there still retains its aura of mystery.

In the Colorado Springs experiment, one very simplistic interpretation of the effective circuit is indicated in Figure 4. The higher the tower, then the greater the voltages that could be driven in the secondary windings without air breakdown. As far as impedances, there is a discharge path to ground from the upper dome and possibly a path for current injection to the ionosphere via a very small capacitance effect. Of key importance would have been the relative values of the capacitance to ground and the capacitance to the ionosphere from the elevated tower.

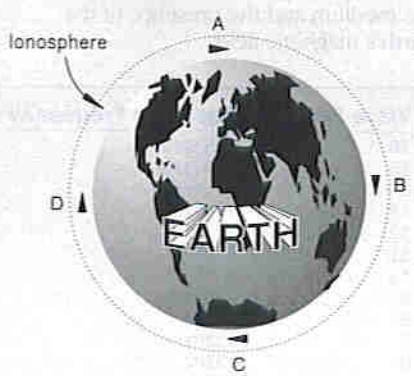



**Figure 3. Simple representation of the Earth-ionosphere waveguide, where a standing wave resonance is achieved by a wave propagating within this system. The path length ABCDA would be a whole number of wavelengths.**

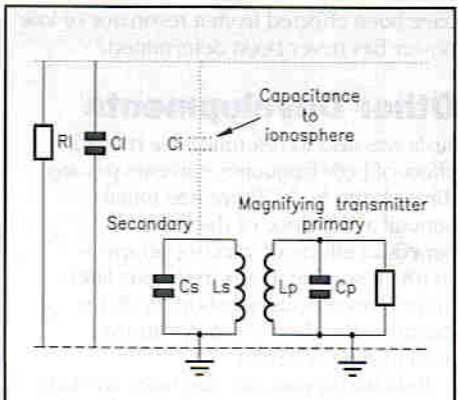



**Figure 4. One simplified interpretation of the equivalent circuit of the magnifying transmitter at Colorado Springs. The terms Rl and Cl relate to an equivalent resistance and capacitance of the entire ionosphere to the surface of the Earth.**

One interpretation of the equivalent circuit of Tesla's magnifying transmitter indicates the parallel LC circuit in the secondary windings and the series capacitance to the ionosphere, and where the resonance identified is that relating to the impedance between the ionosphere and the surface of the Earth. At low frequencies, the parallel resonant circuit of the secondary of the magnifying transmitter will be dominated by the inductance giving a positive reactance and at high frequencies by a negative reactance. The resonant frequency of the ionosphere/transmitter circuit would occur when the positive reactance of the parallel circuit is matched by the negative term of the ionosphere link, as indicated in Figure 5.

The resonant frequency of the system is chiefly determined by the parallel resonance of the LC secondary circuit, where the magnitude of the currents through L and C are the same but out of phase by 180°. Whatever secondary LC resonant frequency the transmitter had been driven at, the resonance with the ionosphere would have been undertaken at a slightly lower frequency. The larger the effective capacitance to the ionosphere, the lower the resonance that would have been achieved. It is known that Tesla observed closely the modes of resonance he observed as he changed the height of the sphere above his laboratory. Thus, Tesla could have tuned the apparatus over a range of frequencies by modifying the coil construction and elevation of the central mast. The lower resonant frequency was, however, apparently primarily determined by the maximum size of inductance that could be established.

Thus, there would have been a frequency at which energy was more effectively delivered from the high potential end of the transmitter. Was the key to Tesla's work the selection of this frequency to coincide with some global parameter of ionosphere resonance – so he was making two resonance effects overlap?

## The Wardenclyffe Era

Tesla was determined to press on with a much larger magnifying transmitter. Tesla was careful to indulge the interests of financiers in New York and was successful in obtaining finance from J. P. Morgan, among others. The tower at Wardenclyffe on the north shore of Long Island opposite Newhaven, was some 187 feet high and constructed entirely of wood on its outer structure. Tesla, however, was suffering from the fact that he had neglected to secure adequate financial security from commercialisation of whole ranges of devices which he had invented. Also, inflation was then rampant, so any new development was likely to be considerably more expensive.

During 1901, plans for the tower were nearing completion and equipment being designed and manufactured for it. Money, however, was getting more difficult to come by and Marconi was attracting the limelight with his developments of radio, and work at Wardenclyffe was sporadic. Gradually, all developments were to cease as there was not even enough money for the coal to fire the generating plant. The tower was eventually scrapped for salvage in 1917. There was certainly not the intense series of experiments as had been undertaken at Colorado Springs.

Some information, however, did usefully come to light in the script of legal proceedings

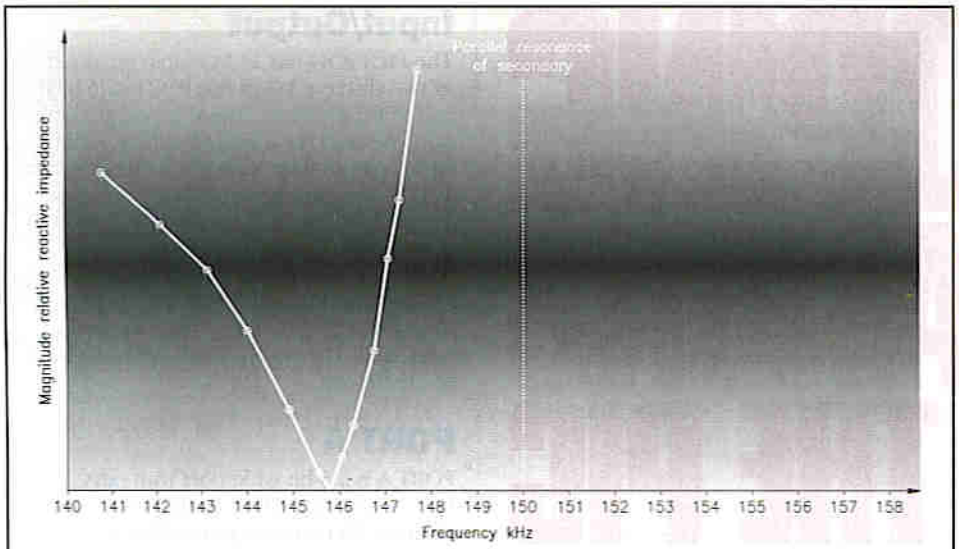



**Figure 5. Possible equivalent resonance of the Colorado Springs magnifying transmitter, showing the series reactive impedance between the ionosphere and Earth. Any resonance of the ionosphere-Earth connection would occur below the frequency of the parallel resonance of the secondary LC components of the magnifying transmitter.**

for the enforced sale of the Wardenclyffe facility. According to Tesla's transcript of the 1922 Supreme Court hearing, a key feature of the Wardenclyffe construction was the 120 feet shaft in the ground. This was encased in a rectangular wooden enclosure of sides 10 × 12 feet and on the inside by metal plates. Inside this enclosure, a winding metal staircase allowed access within this shaft to inspect a central iron conducting column. There is also the reference to an additional 300 feet of iron pipes driven into the ground below this.

The water table at Wardenclyffe was identified as being at 80 feet. The access to the upper iron column was apparently required to identify standing wave resonances in the resonant system. This description was by way of indicating how 'expensive' the site had been to construct.

Details are also listed of the extensive set of equipment at Wardenclyffe, including 60,000V Westinghouse transformers and a 300kW power plant – presumably the one to drive the magnifying transmitter. With this construction, Tesla intended to establish voice contact across the globe and also achieve power transmission with losses of no more than 5%. There was also anticipation of working with groups to tap into the power of the Canadian Niagara falls. He even anticipated superimposing an 'American' time signal on the entire world.

In defeat, however, Tesla was reflective and not bitter. In 1919, he reflected 'My project was retarded by laws of nature. The world was not prepared for it. It was too far ahead of time. But the same laws will prevail in the end and make it a triumphal success.'

## Far Frontier Technology

Tesla remained for many years after this time, a source of creative output, though through financial hardships, he was latterly not able to build and test many of his thought experiments. He succeeded, however, in developing and constructing bladeless turbines. Their chief drawback, however, was the lack of availability of materials to withstand the extreme forces experienced by the turbine components.

There has been a significant upsurge in interest in Tesla's motive power generation systems. The formation of TEBA (Tesla Engine Builders Association) in 1993 has provided a very practical forum for the exchange of information on design and construction of Tesla turbines. One of the early insights that Tesla provided into motive power was that instead of using the internal combustion engine as a direct mechanical drive to the wheels, greater efficiency could be achieved by using an engine to drive a generator which would in turn power motors to each of the wheels as an 'electro hybrid drive.'

It is quite clear, that he was simply ahead of his time in proposing new aspects of technology. Tesla gave a clear description of radar in 1917, although it was not to be developed till 1935. He did make references to a 'death ray' – primarily as a means of defence – echoing the concept of Star Wars technology.

## Postscript

The tide of inventions of the modern age would always be too great for a single man to pioneer and develop commercially. While contributing greatly to the fields in which he was directly involved – with around 700 patents to his name – he also provided encouragement to a generation of developers who, fired with his infective enthusiasm, went on apply their energies to their own particular domain of work. Often in the saga of investigation and development, the key factor is the belief that it is worthwhile in the first place to undertake such work.

The literature surrounding Tesla is very diverse, with the quality of such work being highly variable. Unfortunately, not every book with 'Tesla' in its title is a useful contribution to the field. As our modern technology becomes increasingly well ordered and new materials are developed, however, technologists are looking very seriously at some key products of his inventive mind which were probably far ahead of his time to implement.

Tesla's writings also convey an inherent sense of wonder about the Universe. Part of Tesla's legacy is the ability of his writings to appeal to a broad cross-section of society and to awaken that spark of curiosity in others, which in him, was a consuming passion.

It is one thing to report on the investigations he undertook – documenting the various milestones of his eventful life, but certainly another to reflect on all his work in adequate scientific depth of understanding. It is this sense of his understanding slipping from our grasp that marks most studies of his exploits. The best hope we have is that specialists in well-defined fields relate to that part of his output which maps to their own understanding and experimental skills.

In his adopted land of America, while there is an increasing awareness of his vast contribution to its industrial might, the academic community still fails to recognise many of his unique insights and contributions to modern science. After his death in 1943, his large collection of papers was impounded and eventually shipped to Belgrade, where the Nikola Tesla Museum was established. The centre acts as a unique reference source for Tesla archives and also organises International Tesla Symposia.

It is a curious paradox that if Tesla's success was in part associated with his ability to enter into the deeper layers of his creative unconscious, could this be a signpost to raising the potential of our general collective creative awareness? This could be the greatest secret that Tesla in fact possessed.

## Further Reading

*The Inventions, Researches and Writings of Nikola Tesla*, Thomas Commerford Martin, Angriff Press, originally published in 1894 by the Electrical Engineer.
*Lecture before the New York Academy of Sciences, April 6, 1897 by Nikola Tesla*, editor Leland I. Anderson, Twenty First Century Books, Colorado, 1994.
*Prodigal Genius: The Life of Nikola Tesla*, John O'Neil, Angriff Press, (original 1944).
*Nikola Tesla 1856-1943: Lectures, Patents, Articles (1956)*, Nikola Tesla Museum.
*Lightning in his hand: the life story of Nikola Tesla*, Inez Hunt and Wanetta W. Draper (1964).
*Colorado Spring Notes 1899-1900: Nikola Tesla Museum*, Belgrade, 1978.
*Tesla: Man out of time* by Margaret Cheney, Dell publishing, 1981.
*Tesla's Engine: New dimension for power*, J.A. Hayes, Tesla Book Company, 1994.

### Points of Contact

Nikola Tesla Museum,
51 Proleterskih Brigada Street,
Belgrade, Republic of Yugoslavia.

International Tesla Society, P.O. Box 5636
Colorado Springs, CO 80931, USA.
Tel: 001 719 475 0918.

Tesla Engine Builders Association,
5464 N. Port Washington Avenue,
Suite 293, Milwaukee WI 53217, USA.

Twenty First Century Books, P.O. Box 2001,
Breckenridge, CO 80424 -2001, USA.
Tel: 001 970 453 9293.

Tesla Book Company, BOX 12873,
Chula Vista, CA 91912, USA.

**Internet Sources**
Searches under Nikola Tesla will soon provide many points of contact.

# DEVELOPING APPLICATIONS AROUND THE PIC ARCHITECTURE

## PART 4

## *Talking to the Outside World*

**by Stephen Waddington**

***Last month, we looked at the hardware features of the PIC microprocessor. This month, we look at how the PIC family is interfaced to other electronic devices. Here, Stephen Waddington examines the input/output capability of the PIC16C84.***

You may recall from a previous article, that I have chosen to focus throughout this series on a single member of the PIC family – the PIC16C84 – rather than try and describe the differences between each PIC microprocessor in terms of individual hardware features.

The PIC16C84 is an excellent device to learn the basics of microprocessor and PIC development. It uses the standard PIC instruction set of 33 instructions, with only two additions to the address registers, that are unique to the device. This means that once you have got to grips with programming the PIC16C84, you will be able to work with any of the other devices in the PIC family. In later parts of this series, we will look in greater detail at other members of the PIC family.

Once you get down into the theoretical depths of what makes up a microprocessor, it is easy to forget the reason for using a microprocessor in an electronic application. This month's article looks at the input/output functionality of the PIC family.

### Input/Output

The PIC16C84 has 13 I/O pins organised as two discrete I/O ports, PORT A (5-bit) and PORT B (8-bit). There is one general purpose 8-bit wide timer/counter, TMR0 which has an 8-bit programmable prescaler. This is separate from the Watchdog timer. The PIC16C84 also has a 64 × 8 EEPROM data memory, accessible through an 8-bit data register and address register. Figure 1 shows a schematic pin-out diagram of the PIC16C84. In conjunction with Table 1, it highlights the I/O capability of the device.

### PORT A

PORT A is a 5-bit wide port with pins RA0-4. Port pins RA0-3 are bidirectional, whereas RA4 has an open-collector output. Port A is file register 05h. Its corresponding direction control register TRISA is mapped in page 1 of a register file at address 85h. TRISA is a 5-bit wide register with bits 0 to 4 physically implemented. Tables 2 and 3 show the functions and summary of PORT A registers.

### PORT B

PORT B is an 8-bit wide bidirectional port (file register address 06h). The corresponding data direction register is TRISB (address 86h). A '1' in TRISB sets the corresponding port pin as an input. Reading PORT B register reads the status of the pins, whereas writing to it will write to the port latch. Tables 4 and 5 show the functions and summary of PORT B registers.

Each of the PORT B pins has a weak internal pull-up – approximately 100μA. The weak pull-up is automatically turned off if the port pin is configured as an output. A single control bit (bit 7 of the OPTION register) can turn off (RBPU is set) all the pull-ups. The pull-ups are disabled on Power-On Reset.

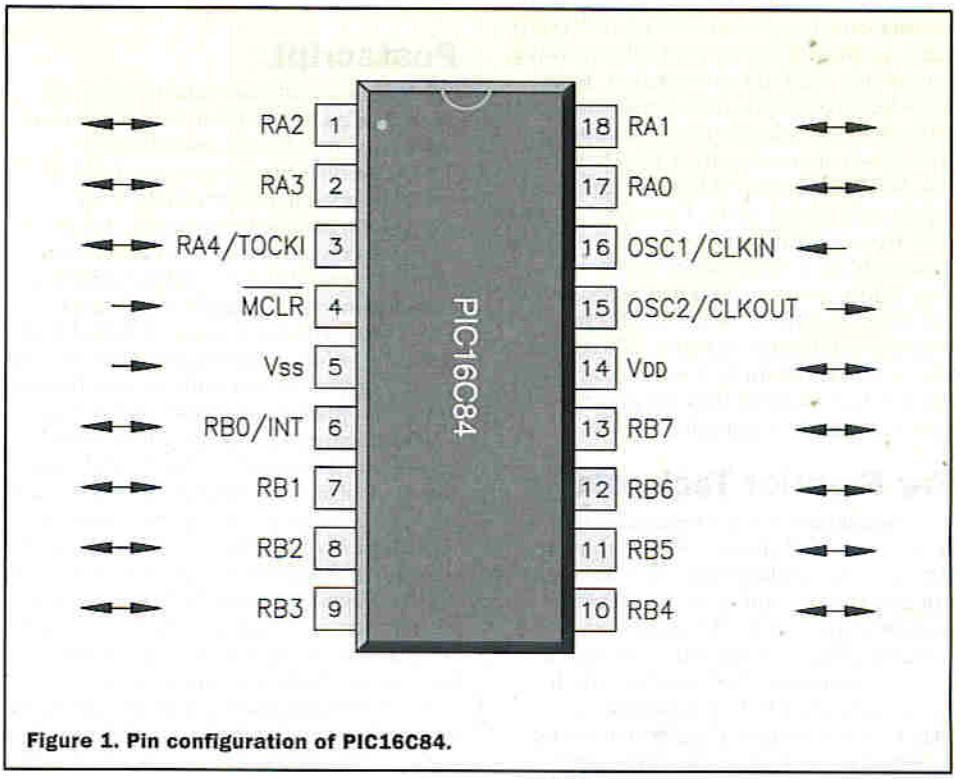



**Figure 1. Pin configuration of PIC16C84.**

| Pin Name | Pin | Pin Type | Pin Function |
|---|---|---|---|
| $V_{DD}$ | 14 | P | Power |
| $V_{SS}$ | 5 | P | Ground |
| OSC1/CLKIN | 16 | I/O | Clock input/oscillator connection |
| $\overline{MCLR}/V_{PP}$ | 4 | I/P | Oscillator connection/CLKOUT output. It is CLKOUT in RC oscillator mode and oscillator connection in all other modes. |
| RA4/T0CKI | 3 | I | Master clear (external reset) input. Active low. |
| RA0 | 17 | I/O | Open drain output/input pin. It is also the clock input to TMR0 timer/counter: Schmitt trigger input buffer |
| RA1 | 16 | I/O | Bidirectional I/O pin. TLL input levels. |
| RA2 | 1 | I/O | Bidirectional I/O pin. TLL input levels. |
| RA3 | 2 | I/O | Bidirectional I/O pin. TLL input levels. |
| RB0/INT | 6 | I/O | Bidirectional I/O pin/External interrupt pin. TLL input levels. |
| RB1 | 7 | I/O | Bidirectional I/O pin. TLL input levels. |
| RB2 | 8 | I/O | Bidirectional I/O pin. TLL input levels. |
| RB3 | 9 | I/O | Bidirectional I/O pin. TLL input levels. |
| RB4 | 10 | I/O | Bidirectional I/O pin. TLL input levels. |
| RB5 | 11 | I/O | Bidirectional I/O pin. TLL input levels. |
| RB6 | 12 | I/O | Bidirectional I/O pin. TLL input levels. |
| RB7 | 13 | I/O | Bidirectional I/O pin. TLL input levels. |

I Input.
O Output.
I/O Input/Output.
P Power.

**Table 1. PIC16C84 pin-out description.**

| Pin Name | Bit | Pin Function | Alternate Function |
|---|---|---|---|
| RA0 | 0 | Input/Output port. TTL input levels. | – |
| RA1 | 1 | Input/Output port. TTL input levels. | – |
| RA2 | 2 | Input/Output port. TTL input levels. | – |
| RA3 | 3 | Input/Output port. TTL input levels. | – |
| RA4/T0CKI | 4 | Input/Output port. Output is open-collector type. Input is Schmitt trigger type. | External clock input for TMR0 timer/counter |

**Table 2. PORT A functions.**

| Register Name | Function | Address | Power-on Reset Value |
|---|---|---|---|
| PORT A | PORT A pins when read<br>PORT A latch when written | 05h | ---X XXXX |
| TRISA | PORT A data direction register | 85h | ---1 1111 |

X Unknown.
– Un-implemented, reads as zero.

**Table 3. Summary of PORT A registers.**

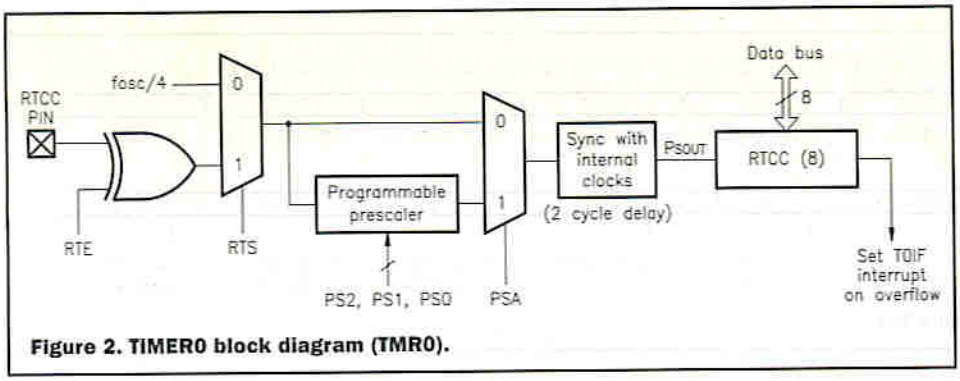



**Figure 2. TIMER0 block diagram (TMR0).**

PORT B has an interrupt on change feature on four of its pins – RB4-7. When configured as input, the inputs on these pins are sampled and latched on the Q1 cycle of a read. The new input is compared with the old latched value in every instruction cycle. An active high output is generated on a mismatch between the pin and the latch. The 'mismatch' outputs of RB4-7 are OR'ed together to generate the RBIF interrupt – latched in INTCON – bit 0. Any pin configured as output is excluded from the comparison. This interrupt can wake the device from SLEEP. The user, in interrupt service routine can clear the interrupt in one of two ways:

- Disable the Interrupt by clearing RBIE INTCON bit 3.
- Read PORT B. This will end mismatch condition, then clear RBIF but.

This interrupt on mismatch feature, together with software configurable pull-ups on these four pins, allow interface to a key pad and make it possible for wake-up on key depression.

Finally, pin RB0 is multiplexed with external interrupt input INT.

## Bidirectional I/O Ports

Some instructions operate internally, as read followed by write operations. The BCF and BSF instructions, for example, read the entire port into the CPU, execute the bit operation, and re-output the result.

Caution must be used when these instructions are applied to a port where one or more pins are used as input/outputs. For example, a BSF operation on bit 5 of PORT B will cause all eight bits of PORT B to be read into the CPU. Then, the BSF operation takes place on bit 5 and PORT B is re-output to the output latches. If another bit of PORT B is a bidirectional I/0 pin (say bit 0) and it is defined an input at this time, the input signal present on the pin itself would be read into the CPU and rewritten to the data latch of this pin, overwriting the previous content. Since the pin stays in the input mode, no problems will occur. However, if bit 0 is subsequently switched into output mode, the content of the data latch may now be unknown.

A pin actively outputting a '0' or '1' should not be driven from external devices in order to change the level on this pin (wired-OR wired-AND). The resulting high output currents may damage the chip.

Reading the PORT register reads the values of the PORT pins. Writing to the PORT register writes the value to the PORT latch. When using read/modify/write instructions on a PORT the value of the PORT pins is read, the desired operation is done to this value, and this value is then written to the PORT latch.

## Successive Operations on I/O Ports

The actual write to an I/O port occurs at the end of an instruction cycle, whereas for reading, the data must be valid at the beginning of the instruction cycle. Therefore, care must be exercised if a write followed by a read operation is carried out on the same I/O port. The sequence of instructions should be such to allow the pin voltage to stabilise (load dependant) before the next instruction which causes that file to be read into the CPU is executed. Otherwise, the previous state of that pin may be read into the CPU rather than the new state. When in doubt, it is better to separate these instructions with a NOP or another instruction not accessing this I/O port.

## TIMER0 (TMR0) Module

The TMR0 module timer/counter has the following features:

- 8-bit timer/counter
- Readable and writable (file address 01h)
- 8-bit software programmable prescaler
- Internal or an external clock select
- Interrupt on an overflow from FFh to 00h
- Edge select for an external clock

Figure 2 shows a simplified block diagram of the TMR0 module. Timer mode is selected by clearing the RTS bit (bit 5 of the OPTION register). In timer mode, the TMR0 module will increment every instruction cycle (without prescaler).

| Port Pin | Bit | Pin Function | Alternate Function |
|---|---|---|---|
| RB0 | 0 | Input/output port pin. TLL input levels and internal software programmable weak pull-up. | External interrupt input |
| RB1 | 1 | Input/output port pin. TLL input levels and internal software programmable weak pull-up. | – |
| RB2 | 2 | Input/output port pin. TLL input levels and internal software programmable weak pull-up. | – |
| RB3 | 3 | Input/output port pin. TLL input levels and internal software programmable weak pull-up. | – |
| RB4 | 4 | Input/output port pin. TLL input levels and internal software programmable weak pull-up. | Interrupt on port change |
| RB5 | 5 | Input/output port pin. TLL input levels and internal software programmable weak pull-up. | Interrupt on port change |
| RB6 | 6 | Input/output port pin. TLL input levels and internal software programmable weak pull-up. | Interrupt on port change |
| RB7 | 7 | Input/output port pin. TLL input levels and internal software programmable weak pull-up. | Interrupt on port change |

**Table 4. PORT B functions.**

| Register Name | Function | Address | Power-on Reset Value |
|---|---|---|---|
| PORT B | PORT B pins when read<br>PORT B latch when written | 06h | XXXX XXXX |
| TRISB | PORT B data direction register | 86h | 1111 1111 |
| OPTION | Weak pull-on/off control (RBPU bit) | 88h | 1111 1111 |

X Unknown.

**Table 5. Summary of PORT B registers.**

from FFh to 00h. This overflow sets the T0IF bit. The interrupt can be masked by clearing the T0IE bit (bit 5 of the INTCON register). The T0IF bit (bit 2 of the INTCON register) must be cleared in software by the TMR0 module interrupt service routine before re-enabling this interrupt. The TMR0 module interrupt cannot wake the processor from SLEEP, since the timer is shut off during SLEEP. See Figure 5 for details of TMR0 interrupt timing.

## Using TMR0 With External Clock

When external clock input is used for TMR0, it is synchronised with the internal phase clocks. Therefore, the external clock input must meet certain requirements.

Also, there is some delay from the occurrence of the external clock edge to the actual incrementing of TMR0. Referring to Figure 6, the synchronisation is achieved after the prescaler. The output of the prescaler is sampled twice in every instruction cycle to detect rising or falling edges. Therefore, it is necessary for PSOUT to be high for at least 2 $t_{osc}$ and low for at least 2 $t_{osc}$, where:

$t_{osc}$ = oscillator time period

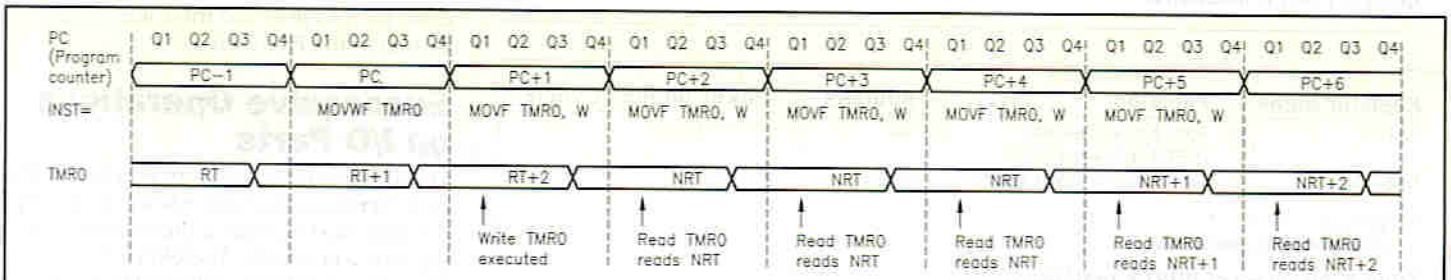



**Figure 3. TIMER0 timing: internal clock/no prescale.**

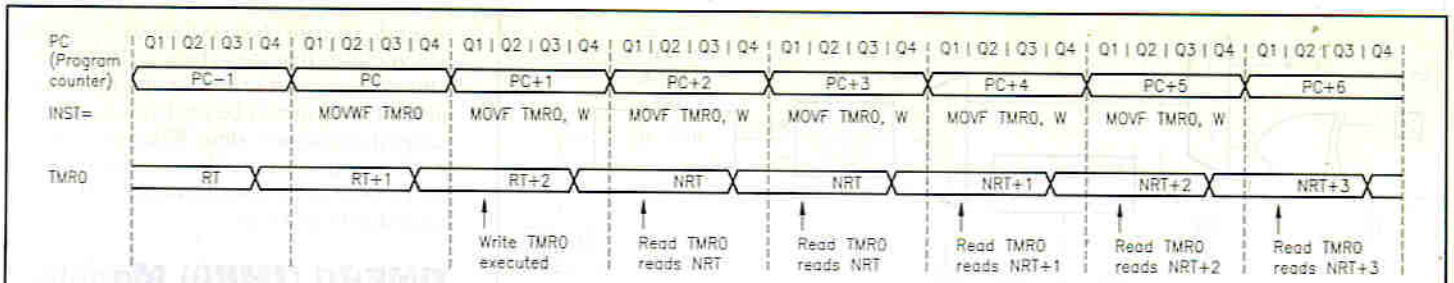



**Figure 4. TIMER0 timing: internal clock/prescale 1:2.**

If TMR0 is written, increments are inhibited for the following two cycles as shown in Figures 3 & 4. The user can work around this by writing an adjusted value to the TMR0 module.

Counter mode is selected by setting the RTS bit (bit 5 of the OPTION register). In this mode, TMR0 will increment either on every rising or falling edge of pin RA4/T0CKI. The incrementing edge is determined by control bit RTE (bit 4 for the OPTION register). Clearing the RTE bit selects the rising edge.

The prescaler is shared between the TMR0 module and the watchdog timer. The prescaler assignment is controlled in software by control bit, PSA (bit 3 of the OPTION register). Clearing the PSA bit will assign the prescaler to TMR0. The prescaler is not readable or writable. When the prescaler is assigned to the TMR0 module, prescale values of 1:2, 1:4, ..., 1:256 are selectable. Details of prescaler operation are discussed later within this feature.

## TIMER0 (TMR0) Interrupt

TMR0 interrupt is generated when the TMR0 module timer/counter overflows

When no prescaler is used, PSOUT is the same as TMR0 clock input and therefore, the requirements are:

$T_{RTH}$ = TMR0 high time $\geq 2t_{osc} + \Delta T$
$T_{RTL}$ = TMR0 low time $\geq 2t_{osc} + \Delta T$

When the TMR0 module input is divided by the asynchronous ripple counter-type prescaler, the prescaler output is symmetrical. Then:

$$P_{SOUT}\,hightime = P_{SOUT}\,lowtime = N.\frac{T_{RT}}{2}$$

Where:
$T_{RT}$ = TMR0 input period
N = prescaler value (2, 4, ..., 256)

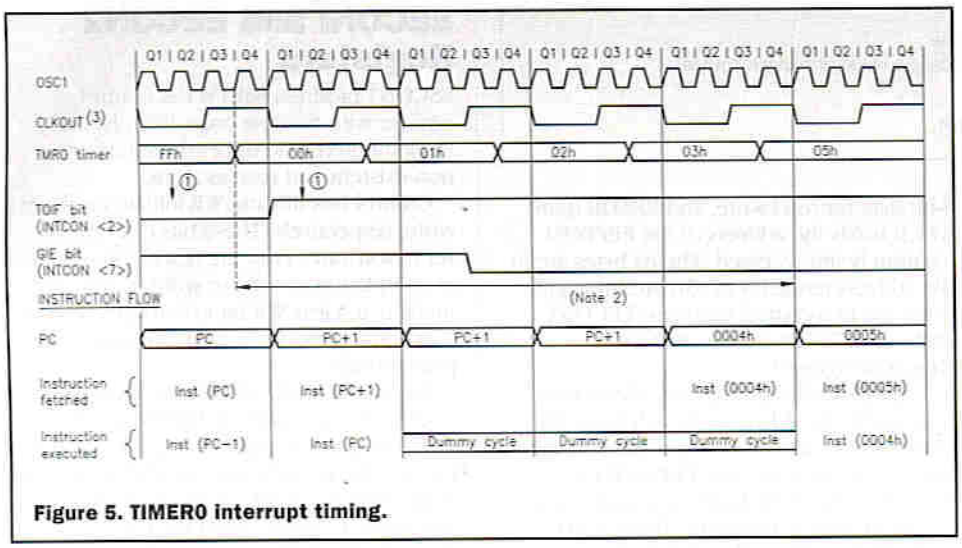



**Figure 5. TIMER0 interrupt timing.**

## Switching Prescaler Assignment

The prescaler assignment is fully under software control and so can be changed on the fly during program execution. To avoid an unintended device RESET, the instruction sequence shown in Example 1 must be executed when changing the prescaler assignment from TMR0 to WDT. The selected prescaler value (lines 1 and 2) determines if lines 7 and 8 are required.

Steps 1 and 2 are only required if an external TMR 0 source is used. Steps 7 and 8 are necessary only if the desired prescale value is '000' or '001'. Tables 6 and 7 show the functions and summary of register associated with TMR0.

To change prescaler from the WDT to the TMR0 module requires the code sequence shown in Example 2. This precaution must be taken even if the WDT is disabled.

The requirement is therefore:

$$\frac{N.T_{RT}}{2} \geq 2t_{OSC} + \Delta T$$

or:

$$T_{RT} \geq \frac{4tosc + 2\Delta T}{2}$$

Where:
$\Delta T$ = small RC delay

The user will notice that no requirements on TMR0 high time or low time is specified. However, if the high time or time on TMR0 is too small, then the pulse may not be detected, hence, a minimum high or low time of 10ns is required. In summary the TMR0 module input requirements are:

$T_{RT}$ = TMR0 period $\geq (4t_{OSC} + 2\Delta T)/N$

$T_{RTH}$ = TMR0 high time $\geq \Delta T$

$T_{RTH}$ = TMR0 low time $\geq \Delta T$

## Delay from External Clock Edge

Since the prescaler output is synchronised with the internal clocks, there is a small delay from the time the external clock edge occurs to the time the TMR0 module is actually incremented. As Figure 6 shows, this delay is between 3 and 7 $t_{OSC}$. Thus, for example, measuring the interval between two edges will be accurate within $\pm 4\ t_{OSC}$ ($\pm 200$ns @ 20MHz).

## Prescaler

An 8-bit counter is available as a prescaler for the TMR0 module, or as a post-scaler for the Watchdog Timer, respectively, as shown in Figure 7. For simplicity, this counter is being referred to as prescaler throughout this article. Note that there is only one prescaler available which is mutually exclusively shared between the TMR0 module and the Watchdog Timer. Thus, a prescaler assignment for the TMR0 module means that there is no prescaler for the Watchdog Timer, and vice-versa.

The PSA and PS2 to PS0 bits (bits 0 to 3 of the OPTION register) determine the prescaler assignment and pre-scale ratio.

When assigned to the TMR0 module, all instructions writing to the TMR0 module will clear the prescaler. When assigned to WDT, a CLRWDT instruction will clear the prescaler along with the Watchdog Timer. The prescaler is not readable or writable.

```
1. BCF     STATUS, RP0     ;Bank 0
2. CLRF    TMR0            ;Clear TMR0
3. BSF     STATUS, RP0     ;Bank 1
4. CLRWDT                  ;Clears WDT and prescaler
5. MOVLW   B'xxxx1xxx'     ;Selects news prescale value
6. MOVWF   OPTION          ;
7. BCF     STATUS, RP0     ;Bank 0
```

**Example 1. Changing Prescaler (TMR0 to WDT).**

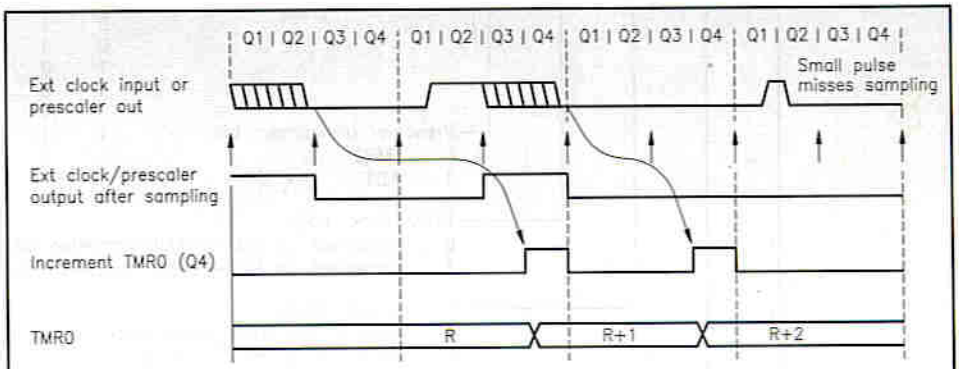



**Figure 6. TIMER0 timing with external clock.**

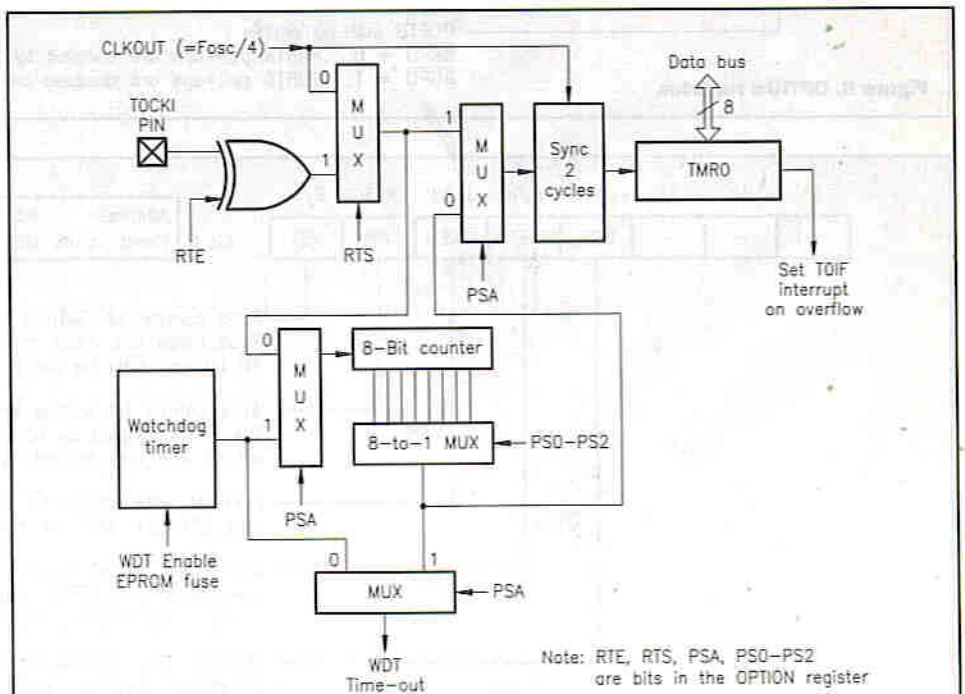



**Figure 7. Block diagram of the TMR0/WDT prescaler.**

```
1. CLRWDT              ;Clear WDT and prescaler
2. MOVLW B'xxxx1xxx'   ;Selects TMR0, new prescale value and clock source
3. MOVWF OPTION
```

**Example 2. Changing Prescaler (WDT to TMR0).**

## OPTION Register

The OPTION register (address 81h), as shown in Figure 8, is a readable and writable register which contains various control bits to configure the prescaler, the external INT interrupt edge select, the TMR0 and the weak pull-ups on PORT B.

## EEPROM Data Memory

The PIC16C84 has 64 × 8 EEPROM data memory which is readable and writable during normal operation. This memory is not directly mapped in the register file space. Instead, it is accessed through two registers: EEDATA (08h) which holds the 8-bit data for read/write, and EEADR (09h) which holds the address of the EEPROM location being accessed. The 64 bytes are in the address range 0h to 63h. Additionally, there are two control registers: EECON1 (88h) and EECON2 (89h). EECON1 is shown in Figure 9.

The EEPROM data memory allows byte read and write. A byte write automatically erases the location and writes the new data – erase before write. The EEPROM data memory is rated for high erase/write cycles. The write time is nominally 10ms, and is controlled by an on-chip timer. The actual write-time will vary with voltage and temperature as well as from chip to chip.

## EECONI and EECON2 Registers

ESCON1 (address 88h) is the control register with five low order bits physically implemented. The upper-three bits are non-existent and read as zeros.

Control bits RD and WR initiate read and write, respectively. These bits can only be set in software. They are reset in hardware at completion of read or write operation. Inability to clear WR bit in software prevents accidental termination of a write operation prematurely.

When set, the WREN bit will allow a write operation. On power-up WREN = 0. The WRERR bit is set when a write operation is interrupted by $\overline{MCLR}$ reset or a WDT time-out reset during normal operation. In these situations, following reset the user can check for WRERR bit and rewrite the location. The data and address will be unchanged in EEDATA and EEADR registers.

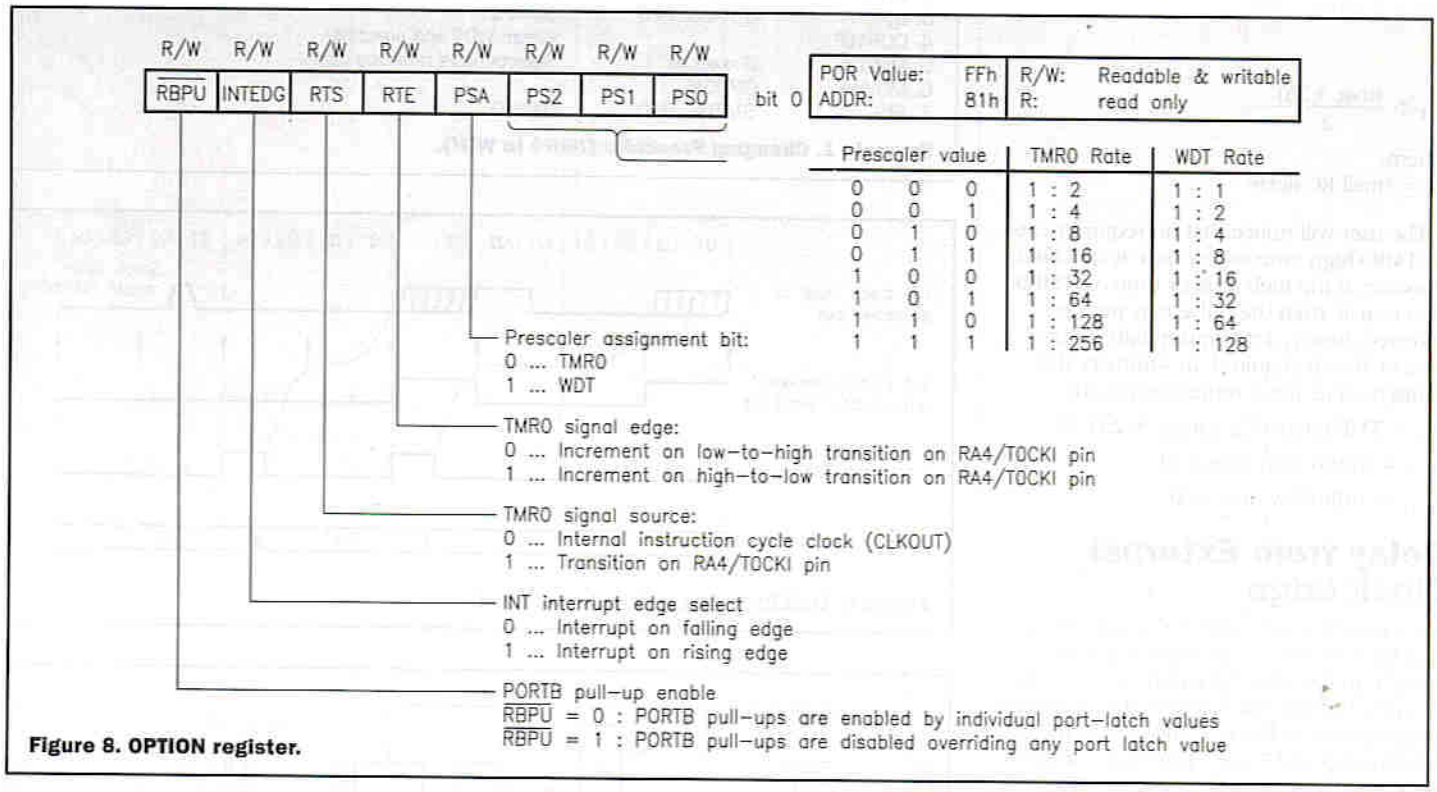



**Figure 8. OPTION register.**

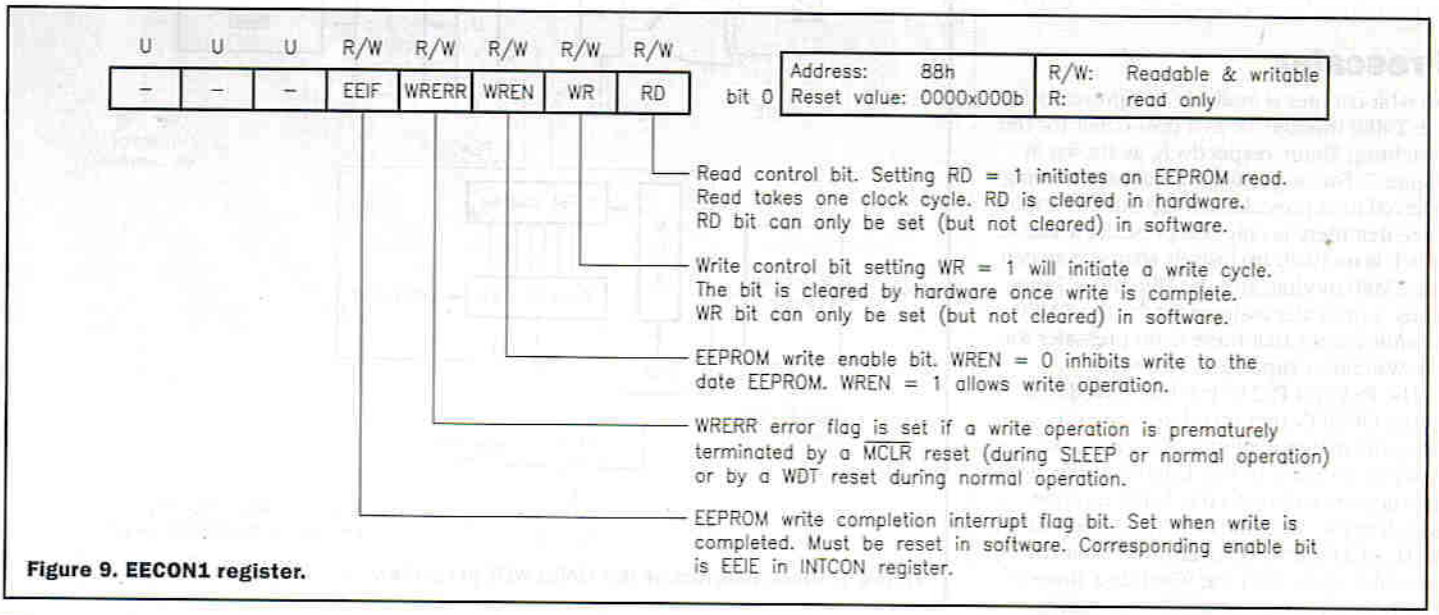



**Figure 9. EECON1 register.**

```
movlw   55h
movwf   EECON2
movlw   AAh
movwf   EECON2
bsf     EECON1, WR      ;set WR bits
                        ;begin write
```

**Example 3. Code sequence required to initiate a write.**

EEIF bit is the interrupt flag set when write is complete. It must be cleared in software.

EECON2 is not a physical register. Reading EECON2 will read zeros.

## Reading the EEPROM Data

To read a data memory location, the user must write the address to the EEADR register and then set control bit RD (bit 1 of the EECON register). The data is available in the very next cycle in the EEDATA register. Therefore, it can be read in the next instruction. EEDATA will hold this value until another read or until it is written to by the user – during a write operation.

## Writing to the EEPROM Data

To write an EEPROM data location, the user must first write the address to EEADR register and the data to the EEDATA register. Then, the user must follow the code shown in Example 3 to initiate a write sequence.

Write will not initiate if this sequence (write 55h to EECON2, write AAh to EECON2, then set WR bit) is not followed with exact timing. The user must disable interrupts during this code segment.

Additionally, WREN bit in EECON1 must be set to enable write. This mechanism is to prevent accidental writes to data EEPROM due too errant (unexpected) code execution, such as lost programs. The user is recommended to keep WREN off always, except when updating EEPROM. Furthermore, the code segments that enable WREN and initiates write should be kept at separate locations to prevent accidental execution of both of them in case of a software malfunction.

At the end of the write, the WR bit is cleared in hardware and the EE write complete interrupt flag is set (bit EEIF). The user can either enable this interrupt or poll this bit. EEIF must be cleared in software. A summary of EEPROM registers is shown in Table 8.

| Register Name | Function | Address | Power-on Reset Value |
|---|---|---|---|
| TMR0 | Timer/counter register | 01h | XXXX XXXX |
| OPTION | Configuration and prescaler assignment for TMR0 | 81h | 1111 1111 |
| INTCON | TMR0 overview interrupt flag and and mask bits | 0Bh | 0000 000X |

X Unknown.
– Un-implemented, reads as zero.

**Table 6. Summary of TMR0 registers.**

| Address | Name | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---|---|---|---|---|---|---|---|---|---|
| 01h | TMR0 | | | T | I | M | E | R | O |
| 0Bh/8Bh | INTCON | GIE | PEIE* | TOIE | INTE* | RBIE* | TOIF | INTF* | RBIF* |
| 81h | OPTION | $\overline{RBPU}$* | PEIE* | TOIE | INTE* | PSA | PS2 | PS1 | PS0 |
| 85h | TRISA | – | – | TRIS* A5 | TRIS A4 | TRIS* A3 | TRIS* A2 | TRIS* A1 | TRIS* A0 |

– Un-implemented locations, read as zero.
* Not used by TMR0 module.

**Table 7. Registers associated with TMR0.**

| Register Name | Function | Address | Power-on Reset Value |
|---|---|---|---|
| EEPROM | EEPROM data register | 08h | XXXX XXXX |
| EEADR | EEPROM address register | 09h | XXXX XXXX |
| EECON1 | EEPROM control register 1 | 88h | 0000 X000 |
| EECON2 | EEPROM control register 2 | 89h | – |

**Table 8. Summary of EEPROM Registers.**

## Protection Against Spurious Write

Various mechanisms are built in to the PIC family of devices to prevent spurious EEPROM writes. On power-up, WREN is cleared. Also, the power-up timer (72ms duration) prevents EEPROM write.

The write initiate sequence and the WREN bit together help prevent an accidental write during brownout or power glitch or software malfunction.

## Next Month

Next month, we will look at the instruction set for the PIC16C84 and start to look at the development of microcontroller-based applications. Later parts of the series will take a detailed look at a number of development and simulation systems for the PIC microprocessor family, including the low cost Maplin PIC16C84 programmer – see Issue 105 of *Electronics* for construction details.

# COMMENT

by Keith Brindley

However complacent the gadget-buying public intends to be about the Network Computer (NC), the manufacturers themselves are banking on the concept being a huge success.

Based on an idea from Oracle (we've looked at the concept several times over the last few months in this very column – and will no doubt look at it further over the coming months) that has grown to seemingly massive proportions, the Network Computer is seen by many as being the next big step in computing.

Instead of an all-singing, all-dancing desktop machine which can run any kind of computer application, the Network Computer is designed to be quite limited in comparison. It will have the basic features of being able to surf the Internet and a few other small applications, but above that, not much else. Although impossible to predict at such an early stage of its development, it will probably find uses primarily in the home as a games machine cum Web browser, and in business as a basic computer for the vast majority of office workers who don't need the high power which modern computers are accustomed to providing.

Cost is the primary factor, of course, and will make or break the Network Computer. With base computers at not much more than £500 these days, it'll be a tough job for manufacturers to be able to market the Network Computer at a significant saving and, perhaps more pertinent, remain profitable.

Many observers (Microsoft and, until recently, Intel, for example) have given the Network Computer the Cold Shoulder, but things seem to be taking a turnaround. For a start, Intel is now indeed rubbing shoulders with Oracle, providing 133MHz Pentium chips for one of Oracle's forthcoming Network Computer models.

Fortunately, the Network Computer also looks as though it could bring some success home to the UK. One of our best-known chip manufacturers, Acorn RISC Machines (developer of the much-loved ARM processors in the hearts of Acorn's RiscOS computers popular in UK schools) also provides chips for Oracle, and is manufacturing the chips for use in Acorn's very own Network Computer products. As you should guess, Acorn RISC Machines is a division of Acorn Computers, as is Acorn RISC Technologies.

In fact, it was Acorn RISC Technologies which worked closely with Oracle in the first place to develop and prototype the Network Computer reference design. Such a close connection to the Network Computer is important to Acorn. It intends to market its own Network Computer, and already has prototyped several variants. These include a base Network Computer, an Office Network Computer, a set-top box Network Computer, the ExecPhone Network Computer, and the Network Computer TV. When a company so close to the original concept of the Network Computer isolates the markets in which it feels it can take a market share so definitely, then I think we can all see where the Network Computer will take us over the coming years. In truth, there's not going to be just one or two areas where the Network Computer will exist, there are going to be several.

## Not So Smartcards

It's fairly apparent which way the tide is turning on the use of smartcards. There's more than a likely chance that documents such as driving licences, passports, even identity details, will eventually be maintained on a smartcard for each and every one of us in the country. To date, all the signs are that politicians have assumed that these smartcards – or more precisely, the microprocessors at their hearts – are technologically secure. But that's a false assumption. Hacking a smartcard is merely a question of enthusiasm. If someone really wants to crack an electronic code, they will.

Indeed, a Cambridge University lecturer recently demonstrated a simple computer-based solution to crack what is accepted as one of the world's most secure (and most common, I might add) chips – used in over a million point-of-sale terminals worldwide. Rather than using the feat for his own purposes, which is, I suppose, what the average hacker might do, the lecturer merely published the results as a warning to smartcard and chip manufacturers. And, as a warning, it should be heeded by politicians, too.

In effect, what the lecturer proves is that, whatever can be electronically constructed, can be electronically destructed as well. Whatever system is used in any future smartcard system (Governmentally approved, or otherwise) will be capable of being hacked. Whereas passports and driving licences can be currently forged by printing the details carefully enough on paper to fool the policeman or customs officer who checks it, future smartcards will equally be forgeable by hacking the data on the card in a way which will fool the computer terminal the policeman or customs officer feeds the smartcard into. The electronic hacker will merely become the forger of the future.

## Life on Mars?

Despite Russia's failed Mars probe space launch recently, we're set to have another crack at reaching out to Mars. NASA remains on target to launch a probe every other year for the foreseeable future. By the middle of the next decade, one of the Mars probes will even feature a return stage, allowing it to takeoff from the Mars surface and return to Earth with samples for scientists to study.

Two NASA probes – both actually bound for Mars this year – Mars Global Surveyor and Mars Pathfinder, will reach Mars shortly. Mars Pathfinder is expected to reach Mars early in July, for a soft landing in the Ares Vallis. A six-wheeled small mobile robot – Sojourner – will then conduct experiments on soil and rock samples. Sojourner is remote-controlled but with the command response of some 40 minutes due to the distance, it has quite a lot of intelligence built-in to allow it to make its own decisions about dangerous circumstances.

The failure of Russia's Mars 96 probe was quite a setback to our pushing back of the final frontier – space, that is – as it was carrying more than 30 instruments from 20 countries. Mars Global Surveyor and Mars Pathfinder only go part way to making up for the lost time. Data from all three probes was to be used together to provide valuable information about the planet's mineral contents, weather, atmosphere, and surface conditions.

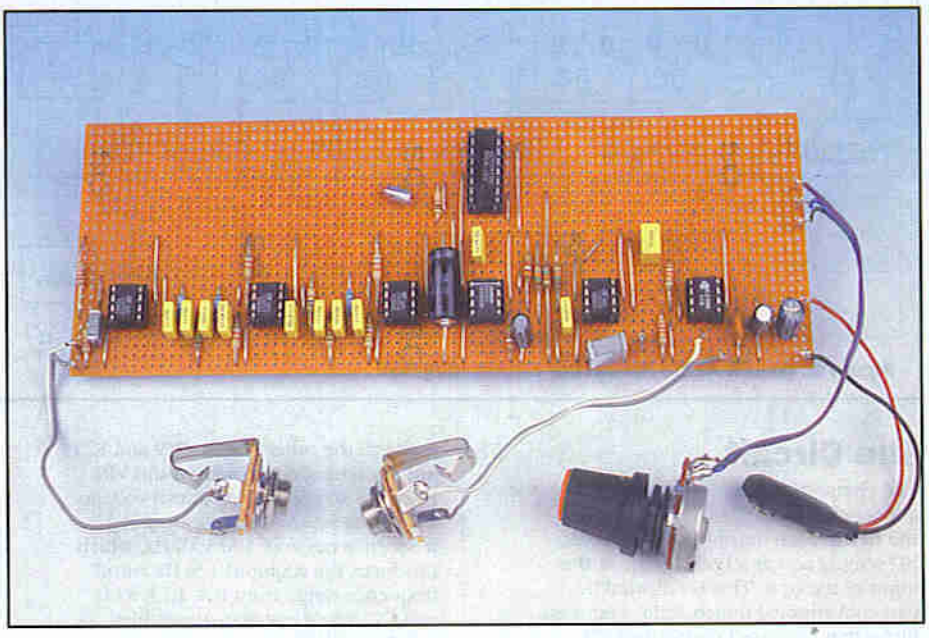
# Educational Mini Circuits

4 PAGE SUPPLEMENT

## DXer's AUDIO PROCESSOR

by Robert Penfold

PROJECT RATING 2



Modern upmarket communications receivers mostly have top quality built-in filtering, giving almost total suppression of any adjacent channel interference. Unfortunately, many 'budget' receivers, and those that were designed some years ago, often leave something to be desired in this respect. Unless you are prepared to make internal modifications, the only way of improving this aspect of performance is to use an external audio processor. These can be very effective provided they have suitably sharp filtering. Digital signal processors (DSPs) offer the ultimate in performance, but as yet, are extremely expensive. Analogue filters do not provide the same level of performance, but can still do an excellent job at a fraction of the price.

### Variable Cutoff

This audio processor provides high- and low-pass filtering. The high-pass filter has a fixed cutoff frequency giving a -6dB point at approximately 300Hz, and a nominal attenuation rate of 48dB per octave below the cutoff frequency. Low frequency interference tends to be less noticeable than the high frequency variety, but high-pass filtering can still give a very worthwhile improvement in signal quality. The high-pass filter uses a switched capacitor filter that provides a variable cutoff frequency which can be varied from around 1kHz to approximately 5kHz.

Having an adjustable cutoff frequency enables the unit to be set for optimum results under the prevailing conditions. With a fixed cutoff frequency, it is necessary to select a compromise that gives wide enough bandwidth for good intelligibility with any voice, but a narrow enough bandwidth to avoid excessive adjacent channel interference. With an adjustable bandwidth, a wider passband can be used when conditions are good, and a narrow bandwidth can be selected when there are problems with severe adjacent channel interference. Although using a narrow bandwidth will probably impair the intelligibility of the signal somewhat, it may give an overall improvement in the signal's readability if the adjacent channel interference is otherwise very severe.

The low-pass filter is an 8-pole circuit, but it is an elliptic filter which gives a much faster roll-off than a conventional filter having the same number of stages. An elliptic filter is a variation on a notch filter, and it is designed to have a non-symmetrical response with much higher attenuation on one side of the notch than the other. In this case, low-pass filtering is required, and higher attenuation is produced above the notch frequency. This gives a very rapid transition from relatively little signal loss to a peak attenuation that is usually more than 80dB. The problem with a basic elliptic filter is that having reached this high degree of attenuation, the response tends to fall back to a much lesser amount well above the cutoff frequency. This problem can be overcome by using more complex elliptic filters, or a basic type plus some conventional low-pass filtering.

Figure 1 shows the frequency response for the unit with the low-pass filter set for a -6dB point at 3kHz. The high-pass filter is quite effective, but it is overshadowed by the 'brick wall' response of the low-pass filter. This goes from 6dB of attenuation at 3kHz to 60dB at 4kHz, which is equivalent to a roll-off rate of well over 100dB per octave. In fact, it is in the region of 150dB per octave! At higher frequencies, the output signal soon drops into the background noise level. The degree of attenuation reduces slightly at the highest audio frequencies, but this is probably due to stray coupling through the stripboard layout rather than any inadequacy in the filter circuit. Either way, it is of no practical consequence.

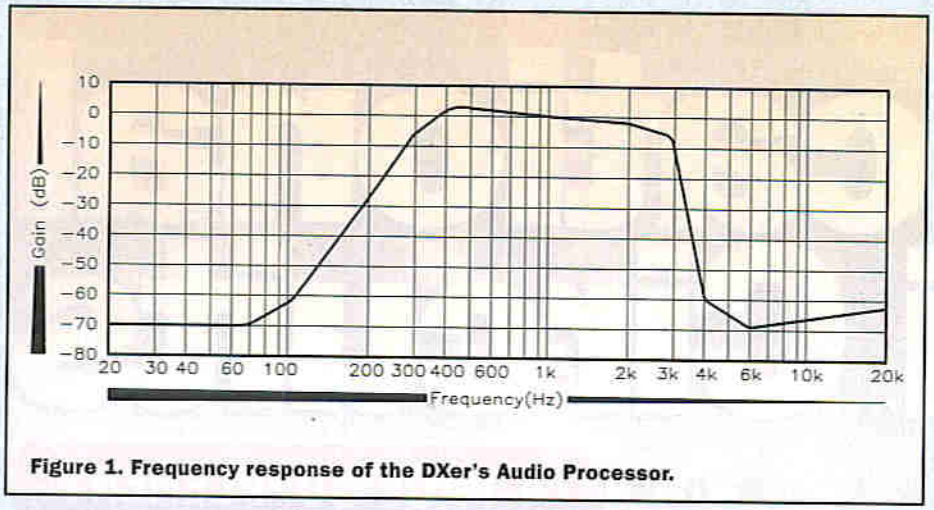



**Figure 1. Frequency response of the DXer's Audio Processor.**

## Construction

Construction of this project offers little out of the ordinary, but the MAX293 and 4046BE integrated circuits are MOS types that require the normal anti-static handling precautions. The batteries are fitted into a plastic holder, and the connections to the holder are made via a standard PP3 style battery clip The receiver's headphone socket is connected to JK1 via a screened jack lead. VR1 is given the setting that provides the best subjective results under the prevailing conditions. With VR1 set for a very low cutoff frequency, the unit will only have a bandwidth of a few hundred hertz, and it is likely that all speech signals will be rendered totally unintelligible. Although unsuitable for speech signals, this very narrow bandwidth will give good results with CW, RTTY, etc.

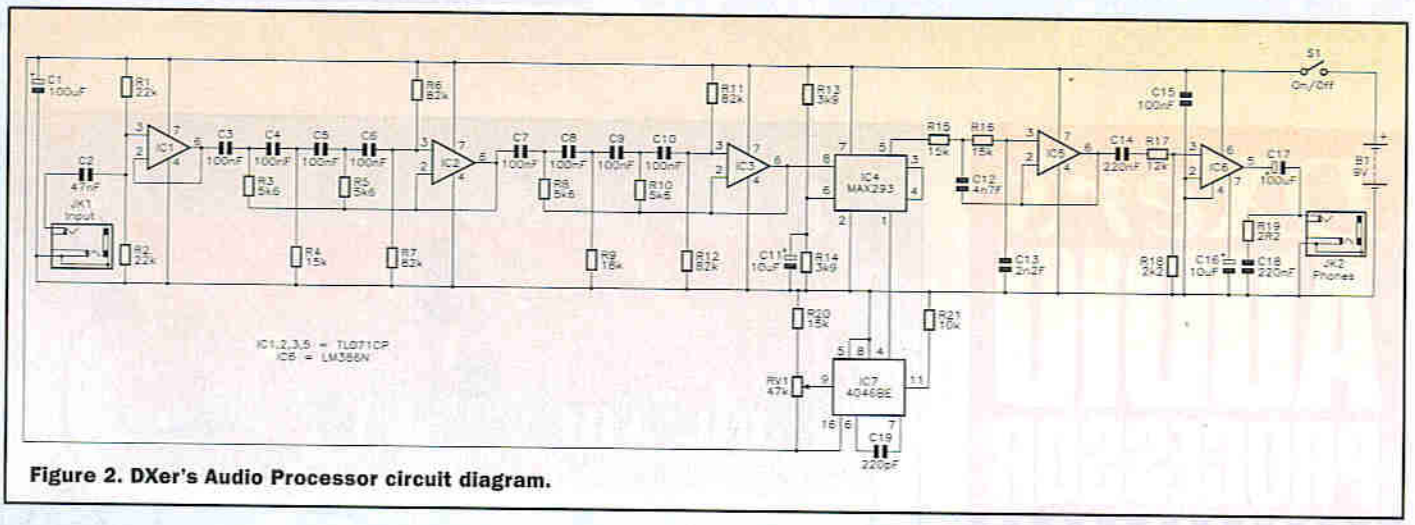



**Figure 2. DXer's Audio Processor circuit diagram.**

## The Circuit

The circuit diagram for the audio processor appears in Figure 2. JK1 is fed from the headphone output of the receiver. IC1 simply acts as a buffer stage at the input of the unit. This is followed by two conventional fourth order high-pass filters that are based on IC2 and IC3. The two filters are virtually identical, and combine to give the required 8-pole filtering.

IC4 is a MAX293 switched capacitor low-pass filter. A conventional filter uses resistors and capacitors. A switched capacitor filter is essentially the same, but uses capacitors and electronic switches controlled by a clock oscillator in place of the resistors. Like a resistor, each switch and capacitor can couple a current from the input to the filter capacitor at the output. The faster the switching rate, the more current that can be coupled to the filter capacitor, and the lower the effective resistance provided by the switch and capacitor. This enables the filter's cutoff frequency to be varied by altering the clock frequency. Practical switched capacitor filters normally have the cutoff frequency at 1/50th or 1/100th of the clock frequency. In the case of the MAX293, the cutoff frequency is 1/100th of the clock frequency.

The clock signal is provided by IC7, which is a CMOS 4046BE phase locked loop. In this circuit, only the Voltage Controlled Oscillator (VCO) section is utilised, and no connections are made to the other stages. C19 and R21 are the timing components, and VR1 provides an adjustable control voltage. This gives an approximate output frequency range of 100-500kHz, which produces the required 1-5kHz cutoff frequency range from IC4. R13, R14, and C11 provide a mid-supply bias voltage to IC4.

One slight drawback of a switched capacitor filter is that the output signal is a stepped waveform. With the clock frequency at around one hundred times the maximum output frequency, there is no difficulty in filtering out the steps to produce a normal waveform. In this circuit, the filtering is provided by IC5, which is used in a simple second order low-pass filter. This provides a −3dB point at about 3kHz. The output from IC5 is coupled via an attenuator to the input of IC6, which is a small audio power amplifier. This can drive an 8Ω impedance loudspeaker at up to about 300mW rms, and it can also drive virtually any type of earphone or headphones. The output is excessive for many types of headphones, but a resistor of about 100Ω in series with C17 is all that is needed to suitably attenuate the output signal.

The current consumption of the circuit is about 25mA under quiescent conditions, but can rise to around three times this figure at high output levels. The unit must, therefore, be powered from a reasonably high capacity 9V battery, such as six AA-size cells in a holder.

### DXer's AUDIO PROCESSOR

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

| | | | |
|---|---|---|---|
| R1,2 | 22k | 2 | (M22K) |
| R3,5,8,10 | 5k6 | 4 | (M5K6) |
| R4,15, 16,20 | 15k | 4 | (M15K) |
| R6,7,11,12 | 82k | 4 | (M82K) |
| R9 | 18k | 1 | (M18K) |
| R13,14 | 3k9 | 2 | (M3K9) |
| R17 | 12k | 1 | (M12K) |
| R18 | 2k2 | 1 | (M2K2) |
| R19 | 2R2 | 1 | (M2R2) |
| R21 | 10k | 1 | (M10K) |
| RV1 | 47k Linear Rotary Potentiometer | 1 | (FW04E) |

**CAPACITORS**

| | | | |
|---|---|---|---|
| C1 | 100µF 16V Axial Electrolytic | 1 | (FB48C) |
| C2 | 47nF Polyester Layer | 1 | (WW37S) |
| C3-10 | 100nF Polyester Layer | 8 | (WW41U) |
| C11,16 | 10µF 50V Radial Electrolytic | 2 | (FF04E) |
| C12 | 4n7F Polyester Layer | 1 | (WW26D) |
| C13 | 2n2F Polyester Layer | 1 | (WW24B) |
| C14,18 | 220nF Polyester Layer | 2 | (WW45Y) |
| C15 | 100nF Ceramic | 1 | (YR75S) |
| C17 | 100µF 10V Radial Electrolytic | 1 | (FF10L) |
| C19 | 220pF Polystyrene | 1 | (BX30H) |

**SEMICONDUCTORS**

| | | | |
|---|---|---|---|
| IC1-3,5 | TL071CP | 5 | (AV59P) |
| IC4 | MAX293 | 1 | (AY41U) |
| IC6 | LM386N | 1 | (UJ37S) |
| IC7 | 4046BE | 1 | (QW32K) |

**MISCELLANEOUS**

| | | | |
|---|---|---|---|
| B1 | AA Battery | 6 | (JY48C) |
| S1 | SPST Miniature Toggle Switch | 1 | (FH97F) |
| JK1,2 | Standard Jack Socket | 2 | (HF90X) |
| | PP3 Battery Clip | 1 | (HF28F) |
| | 8-pin DIL Socket | 6 | (BL17T) |
| | 16-pin DIL Socket | 1 | (BL19V) |
| | Battery Holder | 1 | (HQ01B) |
| | Stripboard, Case, Control Knob, Connecting Wire, Solder, etc. | | |

The Maplin 'Get-You-Working' Service is not available for this project.
***The above items are not available as a kit.***

# Waa-Waa PEDAL

by Robert Penfold

PROJECT RATING 2

The waa-waa effect is far from a new idea, but it seems to remain as popular as ever. The name is simply derived from the 'waa-waa' sound that is produced by this effect when it is used to process the output from an electric guitar, or any electronic instrument which provides an output signal that is rich in harmonics.

It is generated using a bandpass filter which has its centre frequency controlled via a foot-pedal. Pressing down on the pedal raises the filter frequency, and raising the pedal reduces the filter frequency. This effect does not require any complex electronics, but the need for a potentiometer control via a pedal mechanism complicates construction. One common way around the problem is to have the effect controlled by a low frequency oscillator, but this gives the user very limited control over the effect.

The simple but effective method used in this design is to have the filter frequency controlled via a pushbutton switch. The unit is a sort of pseudo-pedal unit, and user operates the pushbutton switch by foot. Pressing the switch causes the filter to sweep upwards in frequency, and releasing it results in the filter frequency being swept back down again. A potentiometer enables the rate at which the filter frequency rises and falls to be adjusted. This method does not give the precise control available from a proper pedal, but it still enables the user to regulate the effect with a reasonable degree of precision. It certainly provides much more expressive control than is possible using a low frequency oscillator to control the filter.

## The Circuit

Figure 1 shows the circuit diagram for the waa-waa pedal. IC1 is used as a buffer stage at the input of the circuit. This stage provides an input impedance of 50kΩ, which is suitable for any normal guitar pickup. The bandpass filter is based on IC3. If we ignore R4 and IC2 for the moment, this leaves IC3 in a conventional bandpass filter configuration. The filter components are R3, C4, C5, and R7, and these set the filter frequency well towards the bottom end of the audio range. The ratio of R3 to R7 sets the Q of the filter. Making R7 much higher in value than R3 gives a high Q value, which results in the filter having a very narrow response with high voltage gain at the centre frequency. Making R3 and R7 similar in value gives a broad response with only low voltage gain at the centre of the passband.

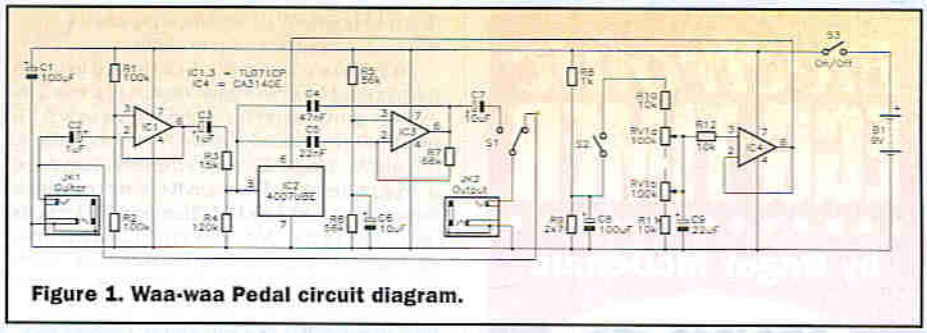



**Figure 1. Waa-waa Pedal circuit diagram.**

IC2 is a CMOS 4007UBE complementary pair plus inverter. In this circuit, only one N-channel MOSFET is utilised, and no connections are made to the other parts of IC2. The drain and source terminals (pins 8 and 7, respectively) are used as a voltage controlled resistance. The control voltage is applied to the gate terminal at pin 6. The drain-to-source resistance is hundreds of megohms when the gate voltage is low, reducing to a few hundred ohms with the gate biased a few volts positive of the source terminal. As far as the operating frequency of the filter is concerned, the resistance of IC2 is effectively in parallel with R3.

The resistance of IC2 is too low to have a significant effect on the filter with a low gate voltage, but the filter's centre frequency is swept upwards as the gate voltage is increased. It is swept towards the upper end of the audio range with the gate of IC2 taken a few volts positive.

The required waa-waa effect can, therefore, be obtained by supplying a suitable control voltage to pin 6 of IC2. One slight flaw in this arrangement is that the Q of the filter rises dramatically as the filter frequency is swept upwards. The increased voltage gain is to a large extent nullified by the increased losses caused by a potential divider action across R3 and the drain-to-source resistance of IC2. The reduced bandwidth at high frequencies does not seem to impair the effect, and probably provides some improvement.

R8 and R9 provide a potential that is about double the required maximum control voltage to IC2. If S2 is closed, C9 charges via R10 and VR1a, but R11 and VR1b act as a potential divider which limits the maximum charge voltage to half the output potential from R8 and R9. C9 discharges through VR1b and R11 when S2 is opened again. The voltage on C9 is coupled to the control input of IC2 via buffer amplifier IC4.

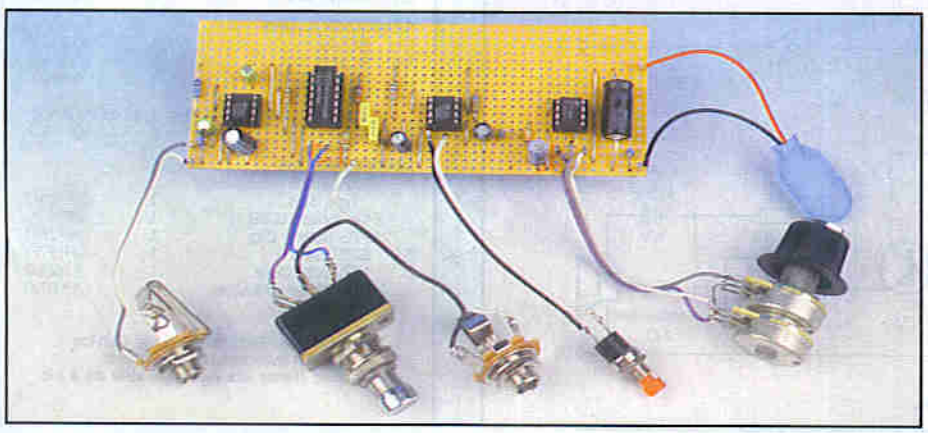
Therefore, closing S2 sweeps the filter frequency upwards, and releasing S2 sweeps the filter frequency back down again. The setting of VR1 controls the rate at which the frequency rises and falls.

S2 enables the effect to be switched in and out. The current consumption from the PP3 size battery is about 7mA.

## Construction

The layout of the circuit board is not critical, but bear in mind that the CA3140E and 4007UBE are MOS devices. Consequently, they both require the normal anti-static handling precautions. S2 must be foot operated, and it must, therefore, be mounted on the top panel of what must be a reasonably strong case.

A metal case is preferable to a plastic type in this application. A large pushbutton switch is likely to be harder wearing and easier to use, but an ordinary type is just about usable. Ideally, S1 should also be a pushbutton type fitted on the top of the case so that it can be operated by foot. A successive operation switch is required, so that operating the switch once activates the effect, operating it again switches out the effect, and so on. The specified switch is a DPDT type, and one section is, therefore, left unused. The unit is wired between the guitar and the amplifier using ordinary screened jack leads.



### WAA-WAA PEDAL

**RESISTORS: All 0-6W 1% Metal Film (Unless Stated)**

| | | | |
|---|---|---|---|
| R1,2 | 100k | 2 | (M100K) |
| R3 | 15k | 1 | (M15K) |
| R4 | 120k | 1 | (M120K) |
| R5,6 | 56k | 2 | (M56K) |
| R7 | 68k | 1 | (M68K) |
| R8 | 1k | 1 | (M1K) |
| R9 | 2k7 | 1 | (M2K7) |
| R10-12 | 10k | 3 | (M10K) |
| RV1 | 100k Linear Dual-gang Rotary Potentiometer | 1 | (FW88V) |

**CAPACITORS**

| | | | |
|---|---|---|---|
| C1 | 100µF 16V Axial Electrolytic | 1 | (FB48C) |
| C2,3 | 1µF 100V Radial Electrolytic | 2 | (FF01B) |
| C4 | 47nF Polyester Layer | 1 | (WW37S) |
| C5 | 22nF Polyester Layer | 1 | (WW33L) |
| C6,7 | 10µF 50V Radial Electrolytic | 2 | (FF04E) |
| C8 | 100µF 10V Radial Electrolytic | 1 | (FF10L) |
| C9 | 22µF 25V Radial Electrolytic | 1 | (FF06G) |

**SEMICONDUCTORS**

| | | | |
|---|---|---|---|
| IC1,3 | TL071CP | 2 | (AV59P) |
| IC2 | 4007UBE | 1 | (QX04E) |
| IC4 | CA3140E | 1 | (QH29G) |

**MISCELLANEOUS**

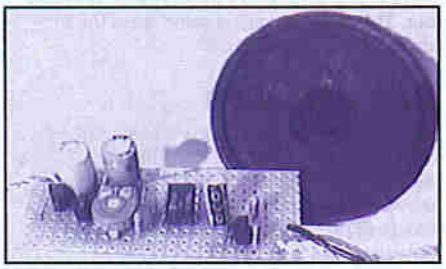
| | | | |
|---|---|---|---|
| B1 | 9V PP3 Battery | 1 | (JY60Q) |
| S1 | DPDT HD Push On - Push Off Switch | 1 | (FH93B) |
| S2 | Large Push to Make Switch | 1 | (FH91Y) |
| S3 | SPST Miniature Toggle Switch | 1 | (FH97F) |
| JK1,2 | Standard Jack Socket | 2 | (HF90X) |
| | PP3 Battery Clip | 1 | (HF28F) |
| | 8-pin DIL Socket | 3 | (BL17T) |
| | 14-pin DIL Socket | 1 | (BL18U) |
| | Stripboard, Case, Control Knob, Connecting Wire, Solder, etc. | | |

The Maplin 'Get-You-Working' Service is not available for this project.
***The above items are not available as a kit.***

# Electronic EGG TIMER

by Roger McDonald

PROJECT RATING 2



This low cost circuit is designed to provide an electronic alarm to indicate that a preset time delay has finished and is capable of driving a small loudspeaker. At the end of the time period, the circuit will play a tune continuously until the circuit is switched off. The elements that go to make the circuit are as follows;

1. A stabilized power supply (TR1, ZD1).
2. A Monostable (or 'One Shot') using a dedicated integrated circuit (IC1).
3. An R-C time constant (R3 & C2) to automatically trigger the monostable when the circuit is switched on.
4. A solid-state switch (TR2) to control the tune generator (IC2).

## Circuit Description

Figure 1 shows the circuit diagram of the circuit. Transistor TR1 is configured as an emitter follower. The base of the transistor is held at a constant 3·6V by the Zener diode and is forward biased, so will pass a current from the battery through the collector across the emitter and on to the circuit. Resistor R1 reduces the current to the Zener diode to approximately 11mA. The transistor drops 0·6V across the base-emitter, so the voltage at the emitter will be 3V which is exactly what is needed for the circuit. As the battery voltage drops with use, the voltage to the circuit will remain constant until, of course, the battery runs down to below 5V or so, when the circuit will in all probability stop working.

An R-C time constant (R3 & C2) is used to trigger the monostable; it has a time constant of about 2ms. As soon as the supply is switched on via switch S1, pin 2 will immediately fall to 0V and then rise to the supply voltage. This gives the very short pulse to trigger the chip. The main R-C time constant is formed by R2, VR2 and C1. Transistor TR2 inverts the output of the 7555, thus preventing IC2 from playing until the monostable has timed out. When the output of the 7555 returns to 0V, TR2 turns on and supplies power to IC2. Resistor R4 boosts the output of IC2 and capacitor C3 blocks the DC present on pin 1.

The power switch could be replaced with a mercury tilt switch so that when you want to start your egg timer, you just turn it upside down and then upright again when it has timed out, just like a conventional sand timer.

## The Resistor-capacitor (R-C) Time Constant

The minimum resistance of the R-C time constant is the value of R1 and the maximum is R1 plus VR1. To calculate the R-C time constant using the 7555, use the formula: $t = 1{\cdot}1 \times R \times C$. This gives us a resistance range of 910kΩ to 1·38MΩ, so the minimum and maximum time constants are $R = 9{\cdot}1 \times 10^{2}\Omega$, $C = 2{\cdot}2 \times 10^{-4}$ Farads $\times$ 1·1 $= 2{\cdot}2 \times 10^{2}$ seconds = 3 minutes, 40 seconds.

Adjusting VR1 to its maximum resistance: $R = 1{\cdot}38 \times 10^{3}\Omega \times 2{\cdot}2 \times 10^{-4}$ Farads $\times$ 1·1 $= 3{\cdot}34 \times 10^{2}$ seconds = 5 minutes, 34 seconds.

## Circuit Board Assembly

The veroboard for this project has 10 tracks and 24 holes per track. The copper tracks need to be thoroughly cleaned before inserting the links and components. Cleaning the tracks will help to avoid tracks being bridged by molten solder, this is because the solder will flow properly onto cleaned copper tracks, whereas if the copper is dirty, more solder will be needed to get through the dirt which thus increases the risk of the solder flowing onto the adjacent track.

The first items that are soldered are the six links. The links are single-strand wire, bent to the correct length. Next, insert the Zener diode and the resistors. The resistors stand up on the board, so ensure that when they are soldered, they stand upright; not only does this mean that you will not have any short circuits, but it gives your finished project a look of neatness. The two transistors and the tune generator are inserted next. Take careful note of the orientation of these components as per the diagram. Take care not to overheat these components – once you have soldered one pin, let it cool down for a few seconds before soldering the next. Solder the IC holder and VR1 into place. Finally, solder the capacitors, taking careful note of which way round they go.

We come now to the components that are not soldered directly onto the board. Prepare and tin four stranded wires for the loudspeaker and the switch. If you look at the speaker, you will note that the terminals are marked '+' and '–'. Convention states that the '–' is connected to 0V on the board and the '+' is connected to the capacitor. It makes no difference in this project which way the speaker is connected, but we shall follow the convention in this instance.

Having completed this, we now come to the 7555 chip. The chip is static sensitive, that is, you can destroy the chip by mishandling it. The chip comes in a special package which shorts out the pins until it is inserted into the circuit.

Carefully open the package and pick up the chip by the ends, avoiding the pins where you can. The pins of the chip need to be bent slightly inwards so it will fit the holder. So, place all the pins on one side of the chip onto a table top and gently bend the pins in. After this, the chip will fit tightly into the holder (again, taking careful note of which way round the chip goes in.)

## Testing and Use

So, now you have completed your construction of the circuit the first thing that you'll want to do is power it up – DON'T!! If you don't want egg on your face (sorry, no pun intended!), the very first thing that you must do is to check very carefully that you have placed all the components in the right place and that all the components are the right way round. Secondly, ensure that you have not bridged any of the tracks with solder. When you are satisfied that your circuit is correct, connect the battery to your circuit and switch on. If all is well, the tune will start to play after a few minutes.

There is, unfortunately, no quick way to get the time delay you want apart from sitting down with a watch and fine-tuning VR1 with a small screwdriver and timing several runs until you get the delay right. Remember, you will need to FULLY discharge capacitor C2 before you start each timing run, as it will hold some residual charge from the previous test run.

That completes the electronics of the project. It remains for you to enclose your project into some case or other. I have suggested a box that the project will fit into very snugly.

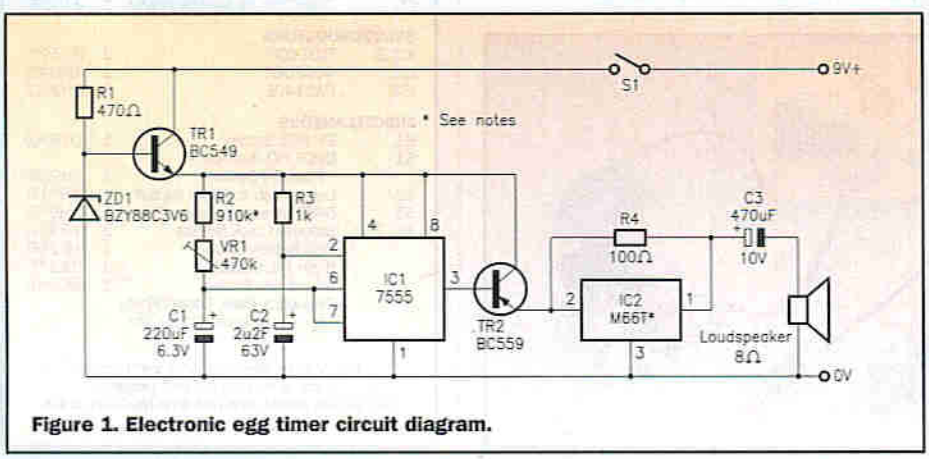



**Figure 1. Electronic egg timer circuit diagram.**

### GUITAR TUNER

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

| | | | |
|---|---|---|---|
| R1 | 470Ω | 1 | (M470R) |
| R2 | 910k | 1 | (M910K) |
| R3 | 1k | 1 | (M1K) |
| R4 | 100Ω | 1 | (M100R) |
| VR1 | 470k | 1 | (UH08J) |

**CAPACITORS**

| | | | |
|---|---|---|---|
| C1 | 220µF 6·3V | 1 | (JL06G) |
| C2 | 2µ2F 63V | 1 | (AT75S) |
| C3 | 470µF 10V | 1 | (AT33L) |

**SEMICONDUCTORS**

| | | | |
|---|---|---|---|
| TR1 | BC549 | 1 | (QQ15R) |
| TR2 | BC559 | 1 | (QQ18U) |
| IC1 | ICM7555IPA | 1 | (YH63T) |
| IC2 | M66T- . . . (Refer to MPS Catalogue) | 1 | (GX55K-GX60Q) |
| ZD1 | BZY88C3V6 | 1 | (QH03D) |

**MISCELLANEOUS**

| | | | |
|---|---|---|---|
| | 8Ω 38mm Loudspeaker Type 388 | 1 | (WB04E) |
| | Veroboard 1039 | 1 | (JP46A) |
| | PP3 Battery Clip | 1 | (HF28F) |
| S1 | SPST Switch | 1 | (FH97F) |
| | MB2 ABS Case | 1 | (LH21X) |
| | PP3 Battery (Alkaline) | 1 | (FK67X) |

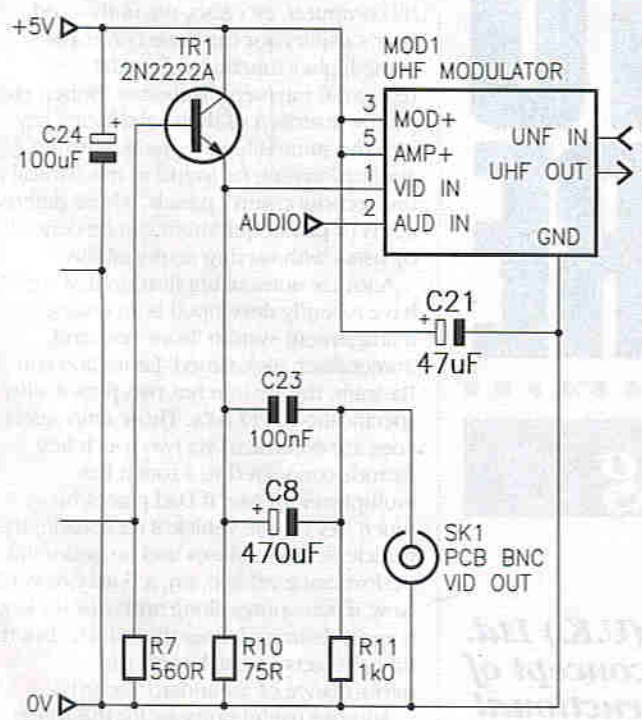
The Maplin 'Get-You-Working' Service is not available for this project.
***The above items are not available as a kit.***

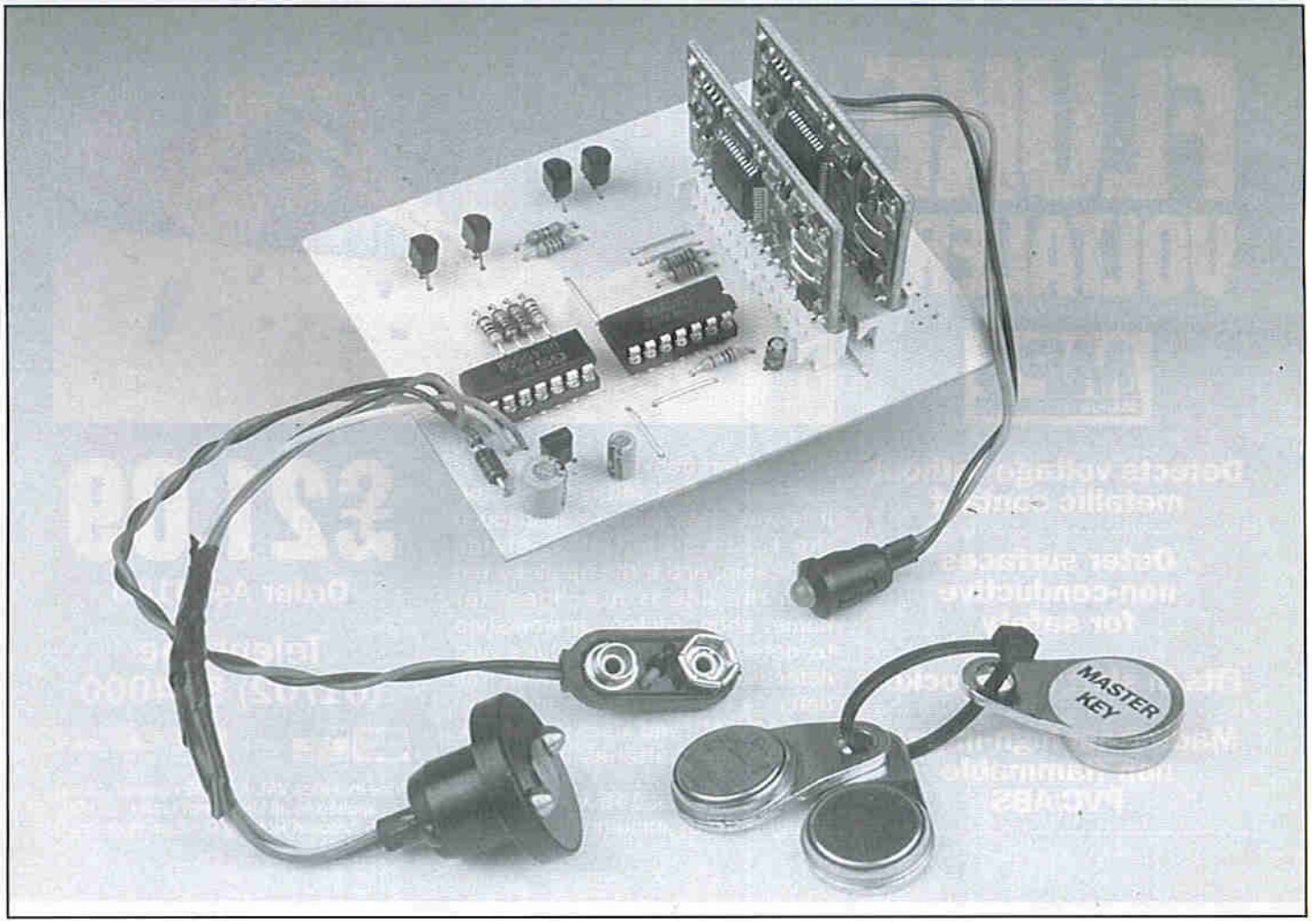
# ELECTRONICS CORRIGENDA

**January 1997/Issue 109**

**Test Pattern Generator** Page 10

Figure 1b. Note that C21 and C8 should have been shown as illustrated below.






# Touch Memory

# THE KEY TO THE FUTURE

## PART 4

## Touch Multiplexing

**by Tony Ellis**

***In the last of my current articles on E.R.D. (U.K.) Ltd. Touch Key Technology, I will introduce the concept of touch key multiplexing and give full constructional details of a dual channel touch key multiplexing system.***

Touch key multiplexing is basically a method of securely controlling more than one device via a single touch receptacle. Take, for example, our electronic point of sale (EPS) unit as shown in our Application Notes (see Part 1). This unit allows an authorised user to plug their touch key into the special receptacle to gain access to their designated till/computer, etc. Also, the authorised user's supervisor can have control of some higher functions of the till (e.g., void payment, withdraw money, etc.) via the insertion of their valid touch key into the same one receptacle. Further applications can be found in mechanical and fire/security control panels, where different items of plant/equipment can be controlled by users with varying responsibility.

Another unusual application that we have recently developed is an engine management system 'front end' and immobiliser, nicknamed 'father and son'. Basically, this system has two personality/specification EPROM's. Those chip select lines are controlled via two touch key hybrids connected to a touch key multiplexer. In use, if Dad places his touch key on the vehicle's receptacle, the vehicle de-immobilises and he gets a full performance vehicle, say, a Ford Cosworth. Now, if son comes along and uses his key, it again de-immobilises the vehicle, but this time, he gets a vehicle with the performance of a standard Escort!

Another useful purpose for the touch multiplexer is to double the maximum users

from 8 to 16. This is helpful for users who require more than 8 keys, but the learning procedure can be clumsy with 2 Master keys servicing 8 keys each, although a proper key management schedule/list generally alleviates any problems.

## Circuit Description

On the face of it, it's not as easy to use two separate hybrids with one receptacle as it might seem. The reason for this is the requirement of each hybrid to 'poll' the receptacle individually (for a full explanation of this, please again refer to the first article).

More than one touch hybrid receptacle input **must** never be 'paralleled' together. The multiplexer gets around this problem by continually switching between the two hybrids, thereby obviating any conflicts. The switching is done via 2 CMOS analogue switches, U2:B and U2:D, which are alternately switched on/off via the oscillator/inverter formed by U1:D and U1:C (see Figure 1a). With this set-up, the receptacle is connected first to Hybrid 1 for a small time period, disconnected, and then connected to Hybrid 2 and so on. But as can be seen, the hybrid inputs are never connected together.

The only problem to sort out now is the system's LED indication, which needs to be synchronised. This we have done by 'gating' the hybrid's LED lines with the hybrid's actual divide-by-two output lines. This is realised by the circuitry built round the Schmitt NAND gates U1:A & U1:B, together with the CMOS switches U2:A & U2:C, with Q1 & Q2 driving the bi-colour LED, which gives a highly attractive and useful display with the following characteristics:

Hybrid 1 active = Red (Flash)
Hybrid 2 active = Green (Flash)
Both Hybrids active = Yellow (Flash)

Referring to Figure 1b, U3, C2 & C3 form a simple 5V regulator circuit and Q3 & Q4 are final hybrid output drivers.

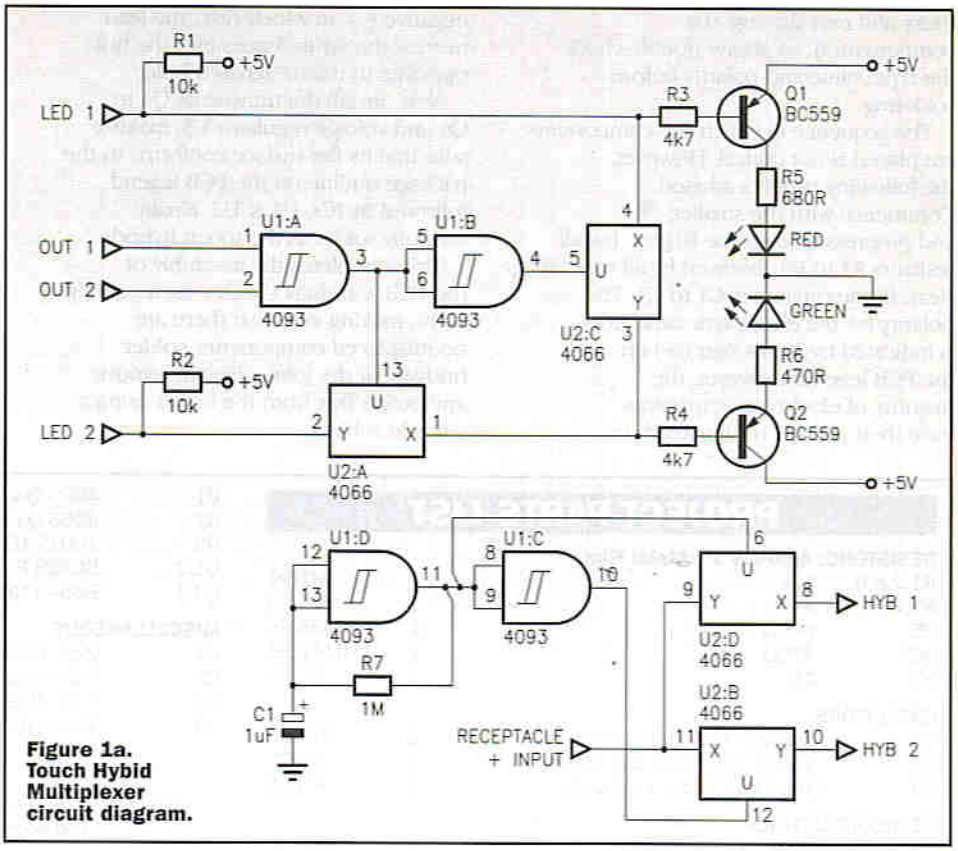



**Figure 1a. Touch Hybid Multiplexer circuit diagram.**

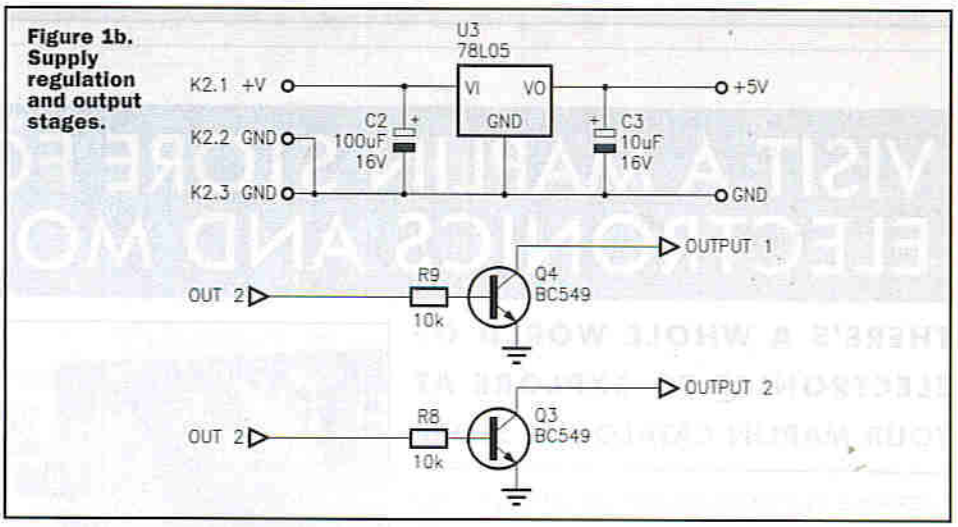



**Figure 1b. Supply regulation and output stages.**

## PCB Assembly

Refer to Figure 2, showing the PCB legend and track, whilst assembling the board. Removing a misplaced component can be

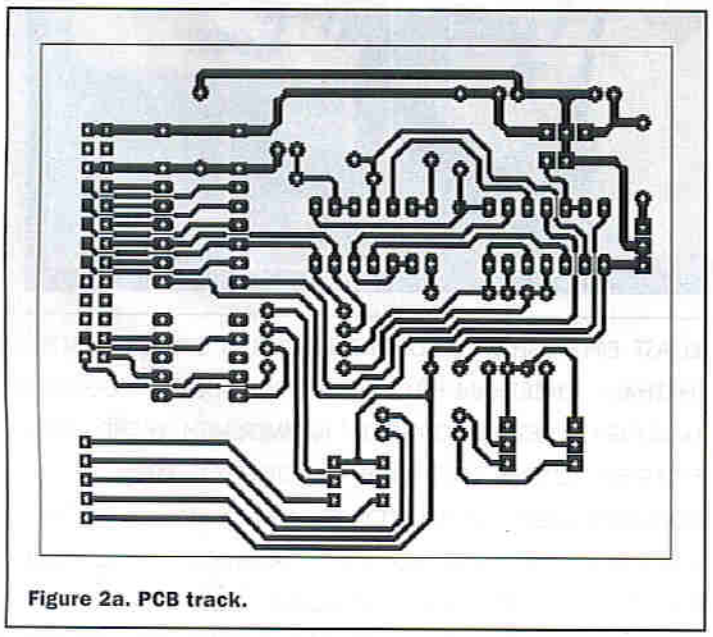


**Figure 2a. PCB track.**

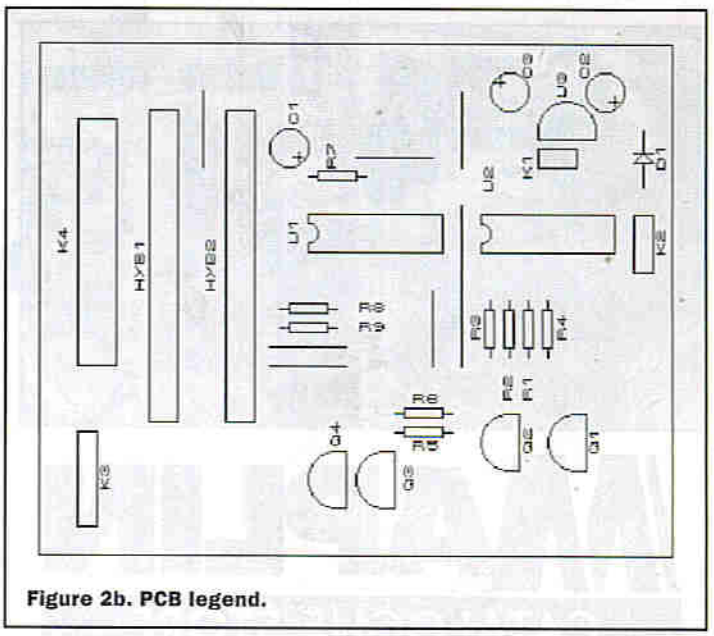


**Figure 2b. PCB legend.**

tricky and may damage the component(s), so always double-check the type, value and polarity before soldering.

The sequence in which the components are placed is not critical. However, the following order is advised. Commence with the smaller, and progress throughthe largest. Install resistors R1 to R9, followed by all wire links. Next, fit the capacitors C1 to C3. The polarity for the electrolytic capacitors is indicated by a plus sign (+) on the PCB legend. However, the majority of electrolytic capacitors have their polarity designated by a negative (–), in which case, the lead nearest the symbol goes into the hole opposite to the designated hole.

Next, install the transistors Q1 to Q4 and voltage regulator U3, making sure that its flat surface conforms to the package outline on the PCB legend, followed by ICs, U1 & U2. Finally, carefully solder in the touch hybrids.

This completes the assembly of the PCB. Carefully check your assembly work, making sure that there are no misplaced components, solder bridges, or dry joints. Finally, remove any excess flux from the board using a suitable solvent.

## Testing

Assuming that both hybrids each know a user key (to learn user keys, please refer to Part 2; the learn enable lines are accessible via the dual connector (pads) which are in parallel with HYB1. (These lines have to be taken to +5V for learn mode). Touch the key relating to HYB1 and the bi-colour LED should acknowledge by flashing red. Now touch the same key again to reset HYB1 and then touch the key relating to HYB2 to the receptacle. This should be acknowledged by the bi-colour LED flashing green. Finally, touch the first key on the receptacle and the bi-colour LED should now flash yellow, indicating both hybrids active.

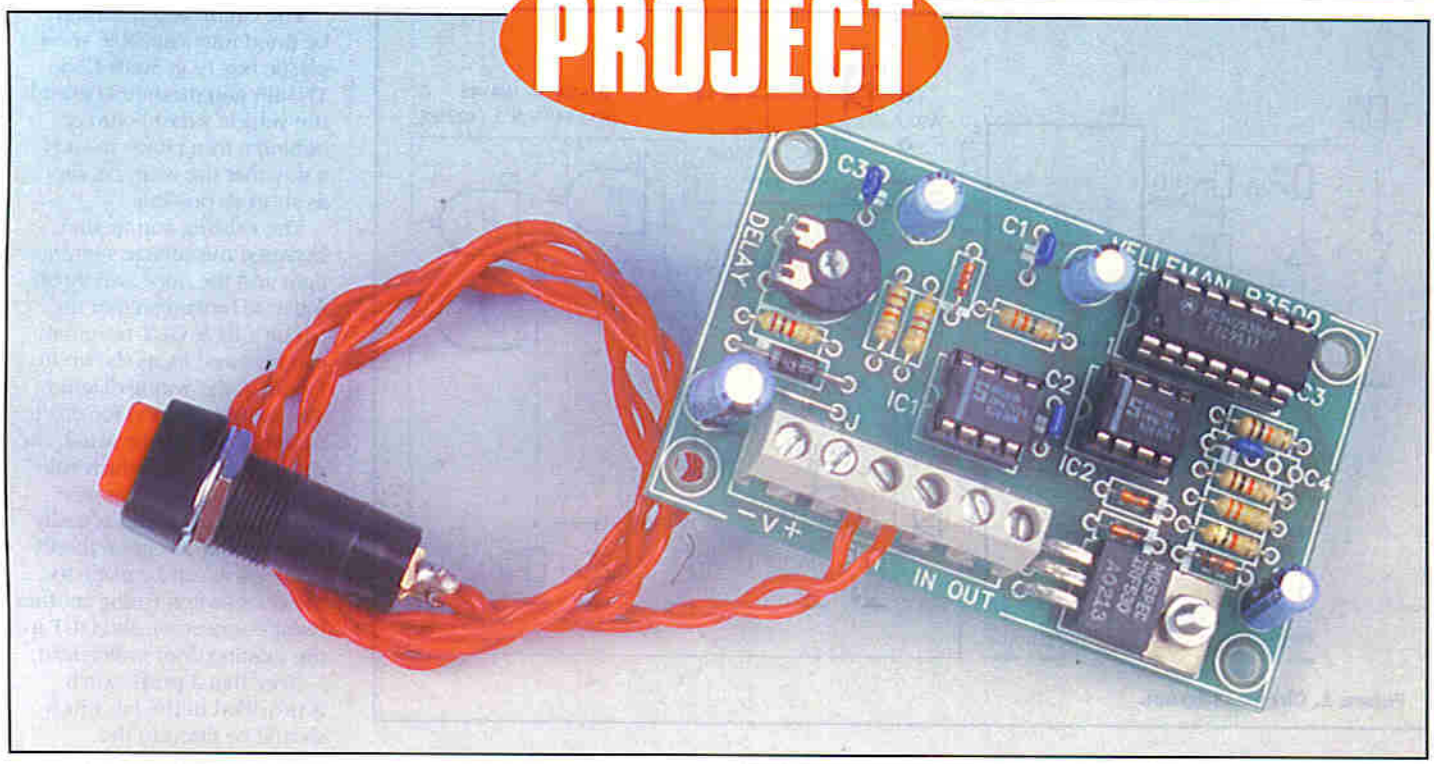
## PROJECT PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS: All 0·6W 1% Metal Film** | | | |
| R1,2,8,9 | 10k | 4 | (M10K) |
| R3,4 | 4k7 | 2 | (M4K7) |
| R5 | 680Ω | 1 | (M680R) |
| R6 | 470Ω | 1 | (M470R) |
| R7 | 1M | 1 | (M1M) |
| **CAPACITORS** | | | |
| C1 | 1µF 63V Radial Electrolytic | 1 | (AT74R) |
| C2 | 100µF 16V Radial Electrolytic | 1 | (AT40T) |
| C3 | 10µF 63V Radial Electrolytic | 1 | (AT77J) |
| **SEMICONDUCTORS** | | | |
| D1 | 1N4002 | 1 | (QL74R) |
| HYB1,2 | Touch Key Decoder Hybrid | 2 | (CK41U) |
| U1 | 4093 Quad Schmitt NAND | 1 | (QW53H) |
| U2 | 4066 Quad Bilateral Switch | 1 | (QX23A) |
| U3 | 78L05 100mA TO92 Voltage Regulator | 1 | (QL26D) |
| Q1,2 | BC559 PNP Signal Transistor | 2 | (QQ18U) |
| Q3,4 | BC549 NPN Signal Transistor | 2 | (QQ15R) |
| **MISCELLANEOUS** | | | |
| K1 | 2-pin Header | 1 | (RK65V) |
| K2 | 3-pin Header | 1 | (BX96E) |
| K3 | 5-pin Header | 1 | (FY93B) |
| K4 | 26-pin IDC Header | 1 | (CX69A) |

The Maplin 'Get-You-Working' Service is not available for this project.

***The above items are not available as a kit.***

PROJECT




**PROJECT RATING** 2

**Kit Available**
Order as VE06G
Price £11.21

**FEATURES**

Adjustable switch-off time

Automatic battery conserving switch-off

Easy to install

Manual switching control

**APPLICATIONS**

Any 12V negative-earthed vehicle with earth-switched interior light

# Multifunction CAR COURTESY LIGHT

**Text by Maurice Hunt**

***Night-time driving presents problems to many motorists, not least of which is trying to locate the ignition switch and successfully insert your key into it to start the engine. Often, there follows a similar infuriating battle to get the seatbelt to buckle up! Think how much easier these tasks would be if the interior light remained lit until you were ready to be plunged into darkness, yet without having to keep the door open. The solution is to install a circuit capable of providing control over the interior light – such as the project described here.***

The Multifunction Car Courtesy Light project enables you to easily upgrade your vehicle's interior lighting to luxury vehicle specification and standards of convenience. With this circuit installed, the courtesy light will remain on when the door is opened and shut, then switch off automatically after a preset delay (adjustable between 0 and 60 seconds). But that's not all! A dashboard-mounted push switch enables you to have manual control over the interior light, to switch it on and off at will, and to reset the delay time. This feature is a boon for map-reading at night, since it avoids you having to grope about to reach the roof-mounted interior light switch. There is also a further automatic switch-off timer that extinguishes the interior light after 5 minutes, to prevent battery drain.

The project is easy to build and install and adds a very worthwhile touch of convenience and luxury to your vehicle, particularly if you regularly need to use your vehicle during the hours of darkness.

## Circuit Description

Refer to Figure 1, showing the circuit diagram of the Multifunction Car Courtesy Light. The circuit is based around three integrated circuits, IC1 & IC2 being NE555 timers, while IC3 is a 4093BE CMOS quad 2-input Schmitt Trigger NAND gate chip.

Both IC1 and IC2 are configured as monostable multivibrators, with IC1 set to produce an adjustable (courtesy of preset potentiometer, RV1) delay period of between 0 and 60 seconds, while IC2 provides a delay period of approximately 300 seconds (around 5 minutes). These are necessary for the 'normal' and 'long duration' interior light delays, respectively; the former is triggered by the door switch (door being opened), while the latter is triggered by dashboard-mounted push-switch SW1 and automatically switches off the light after 5 minutes (if the door is shut) to conserve the vehicle's battery.

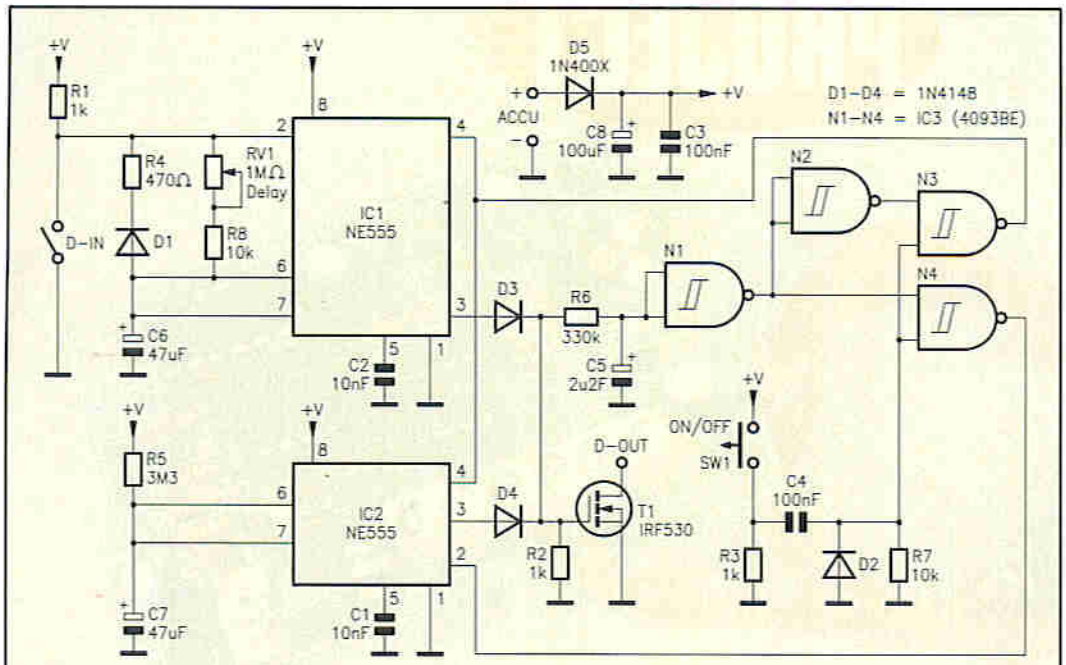



**Figure 1. Circuit diagram.**

## SPECIFICATION

| | |
|---|---|
| Operating voltage: | 12V DC nominal (negative-earthed vehicles) |
| Operating current: | 15·5mA (maximum) |
| Switch-off delay: | Adjustable between 0 and 60 seconds (approximately) |
| Battery-saver timer: | Automatic switch-off after 5 minutes (approximately) |
| PCB dimensions: | 70 × 44mm |

Push-switch SW1 provides a means of resetting the monostables, and manually switching the interior light on and off, with the door shut. A momentary positive-going pulse is generated if the push switch is activated, even if it is held down indefinitely – this is achieved by components R3, C4, D2 & R7

The logic formed by the four Schmitt trigger NAND gates contained within IC3 either causes both monostables (IC1 & IC2) to be reset, or IC2 to be triggered, depending on the output states of the monostables and whether SW1 has been pushed. For the monostables to be reset, the output of IC1 must be high and the push switch then pressed. Repeatedly pressing SW1 causes the interior light to be toggled on and off. For IC2 (the 5-minute delay timer) to be triggered, IC1's output must be initially low and SW1 then pressed.

The output of either monostable going high causes the power MOSFET transistor T1 to conduct, in turn switching on the interior light. Both monostables must be in their reset state (outputs low) for the transistor to deactivate, thus switching off the interior light.

Power is applied to the circuit via diode D5 which provides reverse polarity protection. Low frequency decoupling of the supply is provided by capacitor C8 while C3 provides high frequency decoupling.

## PCB Construction

Assembly of the components onto the single-sided glassfibre PCB should be carried out in the usual order of ascending part size/height. Note that there is one wire link to be fitted in the position marked 'J' (wire supplied). Take care to ensure correct orientation of the polarised components – diodes and electrolytic capacitors. Also ensure that the DIL holders' end notches align with the printed legends, but don't fit the ICs in them yet.

The leads of the power MOSFET transistor T1 must be pre-bent at a 90° angle using pliers prior to fitting it. Use the M2·5 nut and bolt supplied to secure the transistor to the board, heatsink side facing ownwards.

The 6-way terminal block is fitted with its cable access holes facing outwards. Having installed all the components, carefully check your work for misplaced parts, solder whiskers, bridges or dry joints, then clean excess flux off using a suitable solvent. Finally, fit the three ICs in their respective sockets (observe correct orientation), taking suitable anti-static precautions, particularly when handling IC3 as it is a CMOS device.

## Installation

Please read the safety warning printed in this article BEFORE starting to install the project into a vehicle.

The circuit board should be fitted into a suitable sized plastic box (e.g. Stock Code YN36P) and mounted beneath the vehicle's dashboard or behind a trim panel, in such a way that the wiring is kept as short as possible.

The existing connection between the vehicle's interior light and the door switch(es) must be broken so that the circuit's IN & OUT terminals can be wired in, as shown in Figure 2, the wiring diagram. The easiest method for this is to remove the door switch on the driver's door, which will probably have a Lucar-type connection to it; this is easily pulled off, whereupon the IN connection can be made to the door switch (using another Lucar connector), and OUT to the existing door switch lead.

Note that a push-switch is provided in the kit, which should be fitted to the vehicle's dashboard in a location that provides convenient access.

A suitably rated fuse (not supplied) should be wired in series with the live '+V' connection, as close as possible to the vehicle's battery. A suitable in-line fuseholder (Order Code DR79L) and 1¼in. 1A fuse (Order Code DA35Q) are available separately.

The earth connection can be made to any suitable point on the vehicle's (metal) body. Ensure that grommets are used where cables pass through holes in body panels, to prevent chafing and subsequent short-circuits.

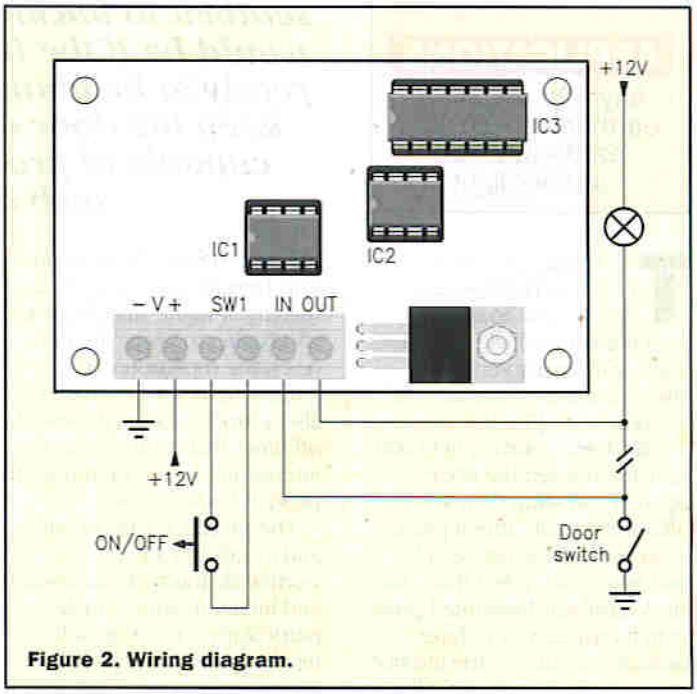



**Figure 2. Wiring diagram.**

## Testing

If a 12V DC power supply and 12V 5W (typical interior light power rating) lamp are available, the project can be bench-tested prior to installation in a vehicle, or alternatively, the project can be installed then tested. Either way, connect the project as shown in Figure 2, the wiring diagram.

Initially, rotate potentiometer RV1 fully anticlockwise (which gives minimum switch-on delay). Activate the door switch (door open) and ensure that the lamp lights and turns off a short time (or immediately) after the door switch is deactivated (door shut). Pressing SW1 should switch the light on and off.

Using SW1 to switch on the light (with the door shut), ensure that it then remains on for approximately 5 minutes.

Finally, adjust RV1 to give the required switch-on delay – turning clockwise increases duration.

## Important Safety Warning

Before starting installation work, consult owners manual regarding any special precautions that apply to your vehicle. Since a car battery is capable of delivering extremely high currents, it is imperative that every possible precaution is taken to prevent accidental short circuits occurring. Remove all items of metal jewellery, watches, etc. Before connecting the module to the vehicle's electrical system, the battery should be disconnected. Helpful hint – remove ground connection first, to prevent accidental shorting of the (+) terminal to the bodywork or engine, assuming negative earth vehicle. It is essential to use a suitably rated fuse in the supply to module. The wire used for the connections should also be rated to safely pass the required current. If in any doubt as to the correct way to proceed, consult a qualified automotive electrician.

## PROJECT PARTS LIST

**RESISTORS: All 0·5W 5% Metal Film (Unless Stated)**

| | | |
|---|---|---|
| R1-3 | 1k | 3 |
| R4 | 470Ω | 1 |
| R5 | 3M3Ω | 1 |
| R6 | 330k | 1 |
| R7,8 | 10k | 2 |
| RV1 | 1MΩ Horizontal Preset Potentiometer | 1 |

**CAPACITORS**

| | | |
|---|---|---|
| C1,2 | 10nF Resin-dipped Ceramic | 2 |
| C3,4 | 100nF Resin-dipped Ceramic | 2 |
| C5 | 2µ2F 50V Radial Electrolytic | 1 |
| C6,7 | 47µF 16V Radial Electrolytic | 2 |
| C8 | 100µF 16V Radial Electrolytic | 1 |

**SEMICONDUCTORS**

| | | |
|---|---|---|
| D1-4 | 1N4148 | 4 |
| D5 | 1N400X | 1 |
| T1 | IRF530 Power MOSFET | 1 |
| IC1,2 | NE555 | 2 |
| IC3 | 4093BE | 1 |

**MISCELLANEOUS**

| | | | |
|---|---|---|---|
| | 6-way 5mm PCB-mounted Terminal Block | 1 | |
| | 8-pin DIL Holder | 2 | |
| | 14-pin DIL Holder | 1 | |
| | M2_5 10mm Bolt | 1 | |
| | M2_5 Nut | 1 | |
| | Panel Mounting Push Switch | 1 | |
| J1 | Tinned Copper Wire | 1 length | |
| | PCB | 1 | |

**OPTIONAL (Not in Kit)**

| | | | |
|---|---|---|---|
| | In-line Fuseholder | 1 | (DR79L) |
| | 1A 31mm (1¼in.) Time-delay Glass Fuse | 1 | (DA35Q) |
| | Box and Base Type 2 | 1 | (YN36P) |

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

***The above items are available in kit form only.***

**Order As VE06G (Velleman Kit K3500) Price £11.21**

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

# Audio Delay-line SYSTEMS AND CIRCUITS PART 2

**by Ray Marston**

***Ray Marston looks at practical analogue delay line ICs and circuits in the second of this four-part series.***

Last month's opening episode of this new 4-part series explained audio delay line basic principles, described the operation of modern 'bucket brigade' delay line (BBD) ICs, and gave a brief introduction to the subject of psycho-acoustics. This month's episode looks at practical BBD ICs and application circuits.

## Practical BBD ICs

A major feature of the average BBD analogue delay line IC is that it inherently offers a very good 'medium-fi' performance; typically, it generates total signal distortion of less than 1%, has a signal-to-noise ratio (effective dynamic range) of about 80dB at maximum output, and suffers only a few dB of insertion loss (signal attenuation) between the IC's input and output terminals. This performance greatly exceeds that required in many modern 'low-fi' applications, such as in simple speech-signal processors and karaoke systems, etc.

Throughout the 1970s and 1980s, BBD ICs were the most widely used analogue delay line device, and were produced by several manufacturers. In the early 1990s, however, simple digital delay line systems became popular in the types of 'low-fi' application mentioned above, and BBDs sales began to decline. The current (late 1996) situation is that – in terms of cost-effectiveness – BBD analogue delay line systems still outperform digital systems in most medium-fi applications requiring delays of less than 300ms. However, digital systems are more cost-effective in most low-fi applications and in all medium-fi applications requiring delays far greater than 300ms.

Currently, only one major producer (Panasonic) still manufactures a significant range of BBD ICs, but many older devices are still stocked by some large retail suppliers. Table 1 lists basic details of the eight best-known BBD ICs that are still currently available, while Table 2 and Figures 1 & 2 show the major parameters and the IC outlines and pin notations of these devices. General details of the eight ICs are as follows:

The TDA1022 is a very popular general-purpose 512-stage delay line that can give a wide range of delays (from 0·85 to 51·2ms). It needs a 2-phase clock drive, and gives 12·8ms delay at 7kHz bandwidth when clocked at 20kHz.

The SAD512D is a 512-stage delay line that gives a performance similar to that of the TDA1022. It is a modified version of an earlier device known as the SAD512, but has a built-in clock divider and line drivers that enable it to be driven by a single-phase clock input. The SAD512D offers a wide range of delay times, and can give a signal bandwidth of up to 200kHz.

The MN3004 is a modern (current-production) high-performance 512-stage device that typically generates only 0·4% total harmonic distortion and has a typical signal-to-noise ratio of 85dB. Its delay periods are variable from 2·56 to 25·6ms, and its signal bandwidth is limited to 33kHz.

The SAD1024A is a dual version of the original SAD512, with each half needing a 2-phase clock drive. Its two halves can be used independently or can be wired in

| Service Number | Stages | Samples | Delay time (ms) - vs - clock frequency | Delay at 7kHz bandwidth (ms) | Notes |
|---|---|---|---|---|---|
| TDA1022 | 512 | 256 | 256/f | 12·8 | Popular low-cost device. |
| SAD512D | 512 | 256 | 256/2f | 12·8 | Has built-in clock divider; uses single-phase clock input. |
| MN3004 | 512 | 256 | 256/f | 12·8 | Modern high-performance device. |
| SAD1024A | 1,024 | 512 | 2 × 256/f | 25·6 | Dual SAD512 device. |
| MN3207 | 1,024 | 512 | 512/f | 25·6 | Modern low-voltage unit. |
| TDA1097 | 1,536 | 768 | 768/f | 38·4 | General purpose unit. |
| MN3011 | 3,328 | 1,664 | 1,664/f | 83·2 | Modern long-delay unit with six output taps (at stages 396, 662, 1,194, 1,726, 2,790 and 3,328. |
| SAD4096 | 4,096 | 2,048 | 8 × 256/f | 102·4 | 4,096-stage delay line. The clock terminal input capacitance = 1nF. |

**Table 1. Basic details of eight popular BBD delay line ICs.**

| | TDA1022 | SAD512D | MN3004 | SAD1024A | MN3027 | TDA1097 | MN3011 | SAD4096 |
|---|---|---|---|---|---|---|---|---|
| Stages | 512 512 | 512 | 2 _ 512 | 1,024 | 1,536 | 3,328 | 4,096 | |
| VSUPPLY range | –12 to +10 to –16V +17V | –14 to –16V | +10 to +17V | +4 to +10V | –12 to –16V | –14 to –16V | +8 to +18V | |
| Clock f range | 5 to 3,000kHz | 1 to 1,000kHz | 10 to 100kHz | 1 to 1,000kHz | 10 to 200kHz | 5 to 100kHz | 10 to 100kHz | 8 to 1,000kHz |
| Delay range | 0·85 to 51·2ms | 0·26 to 200ms | 2·56 to 25·6ms | 0·26 to 100ms | 2·56 to 51·2ms | 7·7 to 153·6ms | 16·6 to 166·4ms | 2·0 to 250ms |
| Signal f range | DC to DC to 45kHz 200kHz | DC to 33kHz | DC to 200kHz | DC to 50kHz | DC to 25kHz | DC to 20kHz | DC to 40kHz | |
| Maximum signal VIN | 2V rms | 2V Pk-Pk | 1·8V rms | 2V Pk-Pk | 0·36V rms | 1·5V rms | 1V rms | 2V Pk-Pk |
| Insertion loss | 3·5dB 2dB | 1·5dB | 0dB | 0dB | 4dB | 0dB | 2dB | |
| S/N ratio at maximum output | 74dB 70dB | 85dB | 70dB | 73dB | 77dB | 76dB | 70dB | |
| IC package | 16-pin DIL | 8-pin DIL | 14-pin DIL | 16-pin DIL | 8-pin DIL | 8-pin DIL | 12-pin DIL | 16-pin DIL |

**Table 2. Major parameters of eight popular delay line ICs.**

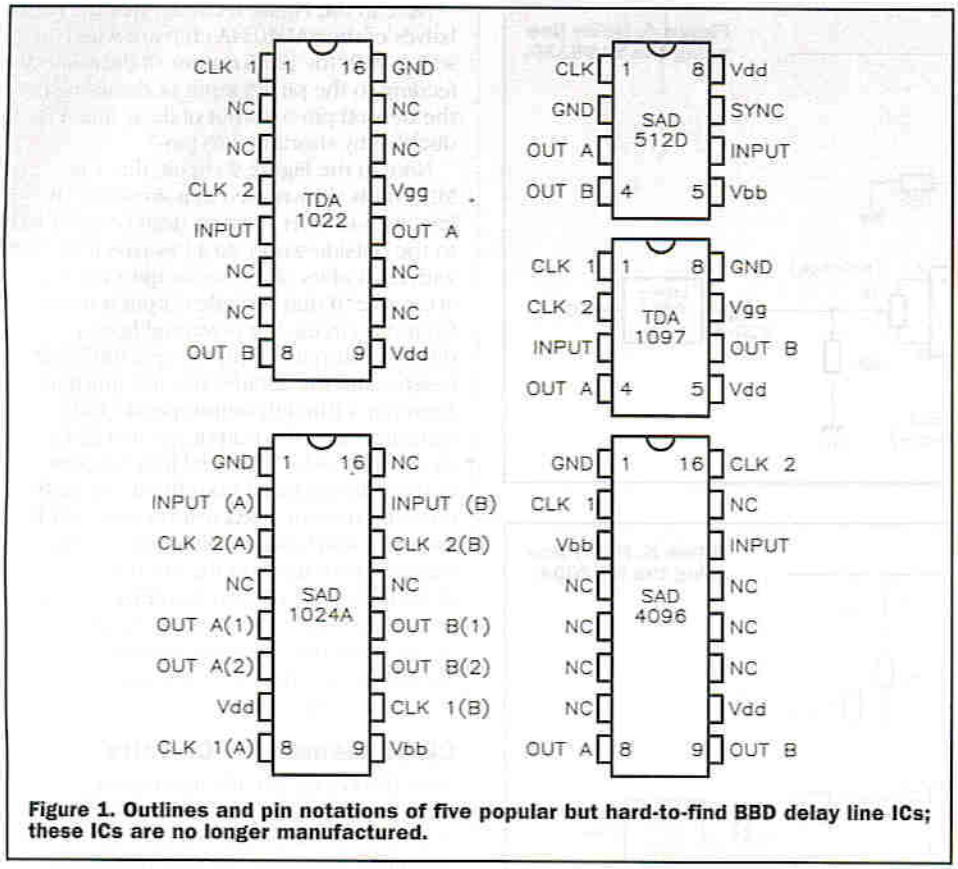



**Figure 1. Outlines and pin notations of five popular but hard-to-find BBD delay line ICs; these ICs are no longer manufactured.**

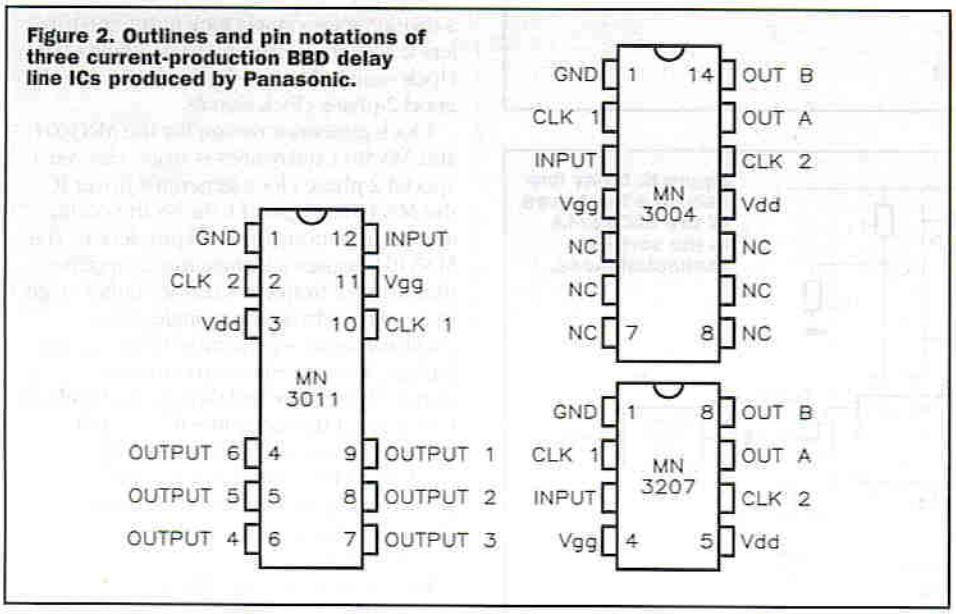



**Figure 2. Outlines and pin notations of three current-production BBD delay line ICs produced by Panasonic.**

series to give a delay of 25·6ms at 7kHz bandwidth.

The MN3207 is a modern (current-production) low-voltage 1,024-stage delay line that is housed in an 8-pin DIL package and is specifically designed for use in portable radios and karaoke units, etc. It can operate from supplies in the range 4 to 10V.

The TDA1097 is a general-purpose 1,536-stage delay line that is housed in an 8-pin DIL package. It needs a 2-phase clock drive, and can give a maximum delay of 153·6ms or a maximum signal bandwidth of 25kHz.

The MN3011 is a modern (current-production) 3,328-stage delay line with six output taps (at stages 396, 662, 1,194, 1,726, 2,790 and 3,328) which each offer a composite output from one particular point in the delay line chain. When these outputs are mixed together, they can be used to generate natural reverberation effects in ambience synthesizers, etc. The MN3011 is a high-performance device, with near-zero insertion loss and a typical distortion figure of only 0·4%. The IC needs a low-impedance clock drive, since its clock terminal input impedance is about 2,000pF.

The SAD4096 is a 4,096-stage delay line that gives a performance equal to eight SAD512s in series; it gives a delay of 102·4ms at 7kHz bandwidth, or 250ms at 3kHz bandwidth. The IC needs a low-impedance 2-phase clock drive, since its clock terminal input capacitance is about 1,000pF.

## Practical Circuits

### Delay Line Circuits

The eight delay line devices detailed in Tables 1 & 2 and Figures 1 & 2 are quite easy to use. All but the MN3207 are designed to operate from a supply with a nominal value of 15V, but some ICs are designed around n-channel IGFETs and use a positive supply on the $V_{DD}$ terminal, while others are designed around p-channel IGFETS and use a negative supply. In all cases, the $V_{BB}$ (or $V_{GG}$) terminal is operated at about 14/15 of the $V_{DD}$ voltage (at 14V with a 15V supply, 8·4V with a 9V supply), and the input terminal is biased at about half-supply volts (the precise value is adjusted to give minimum output signal distortion). All ICs except the SAD512D need a symmetrical 2-phase clock drive, which must switch fully between the ground and supply rail values; the SAD512D accepts a simple single-phase clock drive.

Figures 3 to 10 show how each of the above ICs can be wired as a simple delay line circuit that uses a +15V or +9V supply rail voltage and a grounded 'common' terminal. Note in the case of all ICs designed to operate with a negative VDD voltage (the TDA1022, MN3004, TDA1097 and MN3011), that this is achieved by grounding the VDD terminal and feeding the +15V line to the GND pin.

In each of these circuits, the input and output signals are applied and removed via low-pass filter stages; a pre-set is used to adjust the input DC bias so that symmetrical clipping occurs under overdrive conditions, and (except in the case of the MN3011) another pre-set is used to balance the IC's two outputs for minimum clock breakthrough.

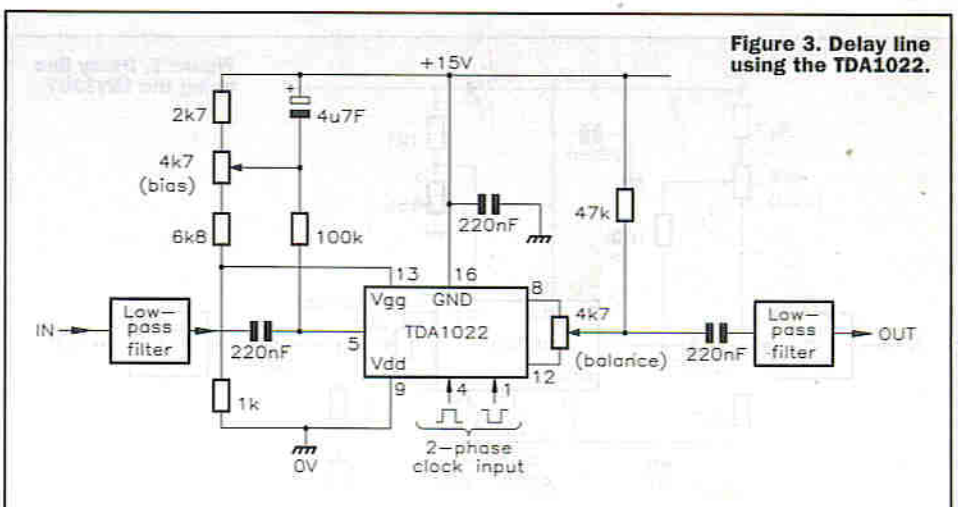



**Figure 3. Delay line using the TDA1022.**

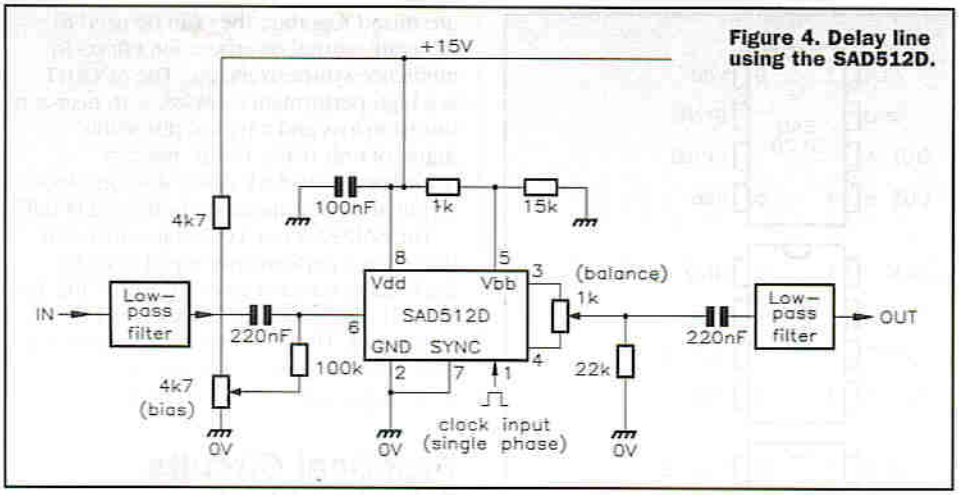



**Figure 4. Delay line using the SAD512D.**

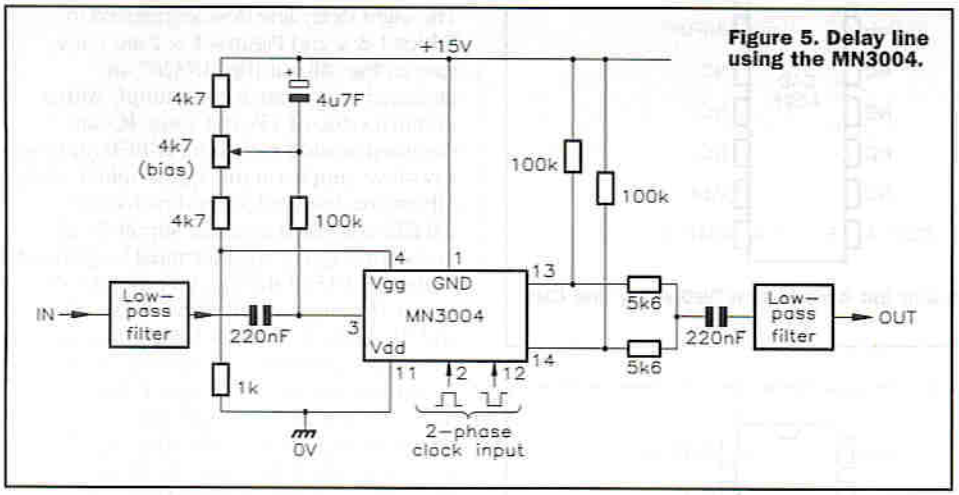



**Figure 5. Delay line using the MN3004.**

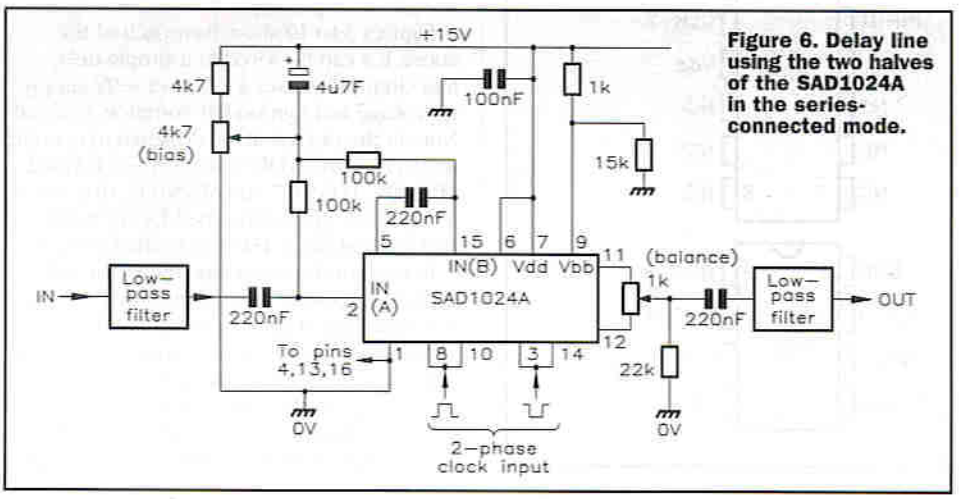



**Figure 6. Delay line using the two halves of the SAD1024A in the series-connected mode.**

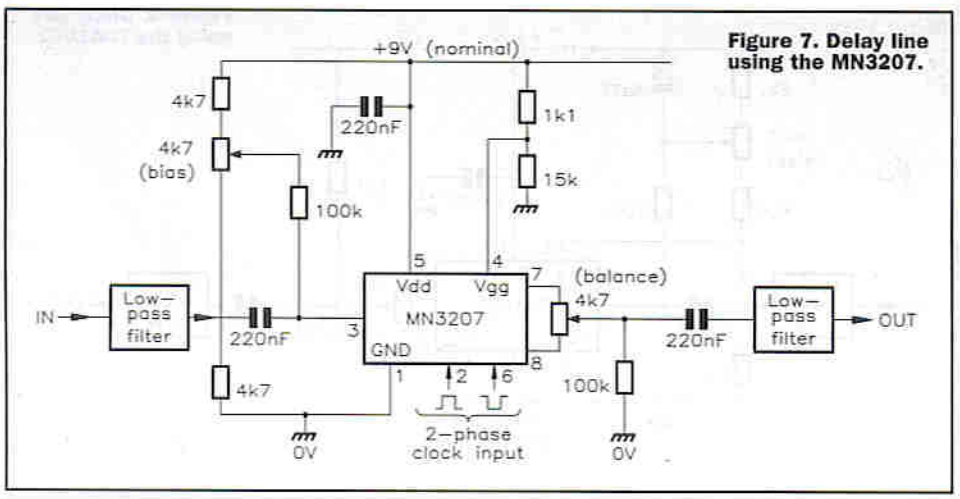



**Figure 7. Delay line using the MN3207.**

Note in the Figure 6 circuit, that the two halves of the SAD1024A chip are wired in series, with the pin-5 output of delay-line A feeding to the pin-15 input of delay-line B; the unused pin-6 output of delay-line A is disabled by shorting it to pin-7.

Note in the Figure 9 circuit, that the MN3011 is shown used as a simple delay line, with its 6TH (longest delay) output fed to the outside world via a low-pass filter but with each of its other five outputs externally accessible. If only a single output is required from this circuit, but is wanted from a different output, simply remove the 56kΩ resistor and the 220nF capacitor junction from pin 4 (the 6th output point) and reconnect it to the output pin that gives the desired delay. If several independent outputs are required from the IC, fit each one with its own 56kΩ resistor and 220nF capacitor and low-pass filter, in the same way as shown used on the 6th output. If the IC is to be used in its primary mode as an ambience synthesizer or acoustic 'room expander', in which several outputs are mixed together, refer to Figure 21 and its associated text.

## Clock Generator Circuits

Most BBD delay line ICs need clean squarewave clock signals that switch fully between the supply rail voltages. Clock generator design for the SAD512D delay line is very easy, since this IC incorporates a divider stage on its clock input line that lets it accept non-symmetrical single-phase clock signals, but most other BBDs require good 2-phase clock signals.

Clock generator design for the MN3004 and MN3011 delay lines is made easy via a special 2-phase clock generator/driver IC, the MN3101. Figure 11 shows the outline and pin notations of this 8-pin device. The MN3101 houses a 2-stage input amplifier that drives a frequency divider/buffer stage that – when driven by a single-phase oscillator input – generates a high-quality 2-phase low-impedance squarewave output that can be fed directly to the clock terminals of the delay line IC (up to 8,192 bucket brigade stages can be driven by a single MN3101). The MN3101 also provides a $V_{GG}$ output bias voltage that can be fed directly to the $V_{GG}$ terminal of the MN3004 or MN3011 IC.

Figure 12 shows two alternative ways of using the MN3101 as a 2-phase clock waveform generator. In Figure 12(a), the IC's input amplifier is used as a free-running oscillator, and the circuit acts as a self-contained clock generator in which the output clock frequency is inversely proportional to the R value and equals 125kHz at 5kΩ or 620Hz at 1MΩ. In Figure 12(b), the IC is used as a simple divider/buffer in which an external single-phase 'clock' signal is applied to input pin 7; in this case, the output clock frequency is half that of the input.

Note that the MN3101 can be used as a clock generator with any of the eight delay line ICs mentioned in the previous Delay Line Circuits section, with the single exception of the MN3207 low-voltage BBD IC, for which a special clock generator IC – the MN3102 – is available. Figure 13 shows the outline and pin notations of the

MN3102, which is internally similar to the MN3101, and Figure 14 shows the basic way of connecting the IC as a self-contained clock generator that can operate from any supply in the range +4V to +10V and can drive up to 4,096 bucket brigade stages. Resistor R can be given any value in the range 22kΩ to 1MΩ.

In most cases, BBD delay line ICs can be adequately clocked by generators designed around readily available low-cost CMOS digital ICs, and Figures 15 to 17 show some practical examples of such circuits. The simple 2-phase generator of Figure 15 is based on a 4001B IC, and can be used in most applications where a fixed or manually variable frequency is needed; the frequency can be swept over a 100:1 range via RV1, and the centre frequency can be altered by changing the C1 value.

The high-performance 2-phase generator of Figure 16 is based on the voltage controlled oscillator (VCO) section of a 4046BE phase-locked loop IC, and is useful in applications where the frequency needs to be swept over a very wide range, or needs to be voltage controlled. The frequency is controlled by the voltage on pin 9, being at maximum (minimum delay) when pin 9 is high, and minimum (maximum delay) when pin 9 is low. Maximum frequency is determined by the C2-R1 values, and minimum frequency by the value of C2 and the series values of R2-RV2. The frequency (delay) can be manually controlled via potentiometer RV1, or can be controlled by an external voltage by breaking the RV1 connection at the 'x-x' points and feeding the control voltage to pin 9, as shown.

The Figure 15 & 16 circuits can be used to directly clock all BBD delay lines except the MN3011 and SAD4096, which have clock terminal capacitances of 1,000pF or more and need a low-impedance clock drive that is best provided by the Figure 17 circuit. This uses both halves of a 4013BE divider wired in parallel to give the required low-impedance 2-phase output; the circuit is driven by a single-phase clock signal, which can be obtained from either of the Figure 15 or 16 circuits.

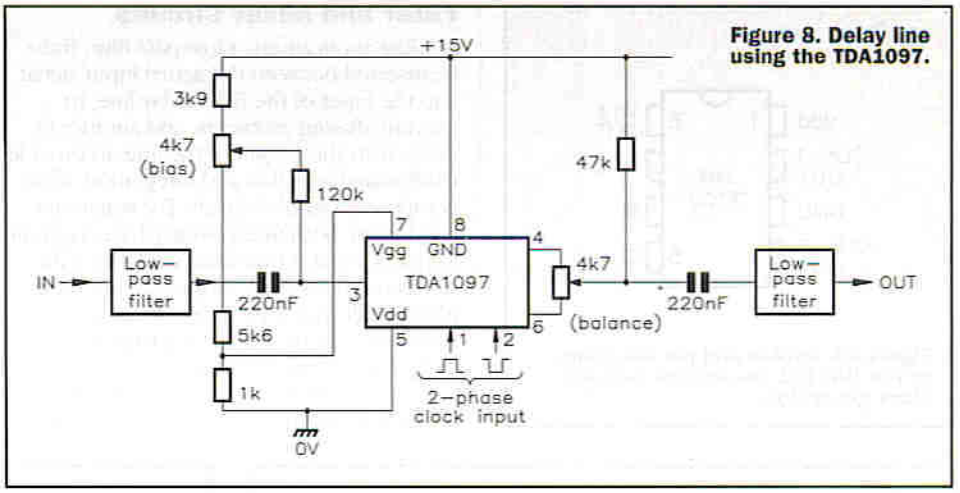



**Figure 8. Delay line using the TDA1097.**

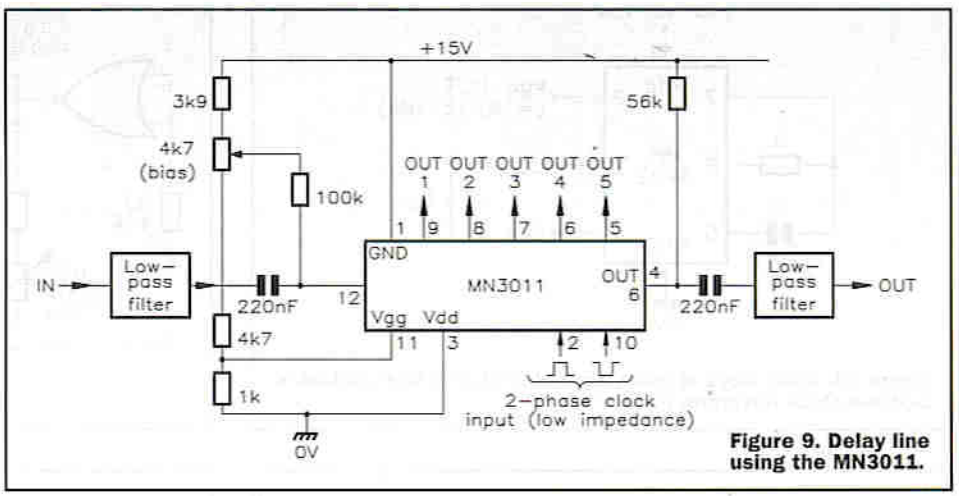



**Figure 9. Delay line using the MN3011.**

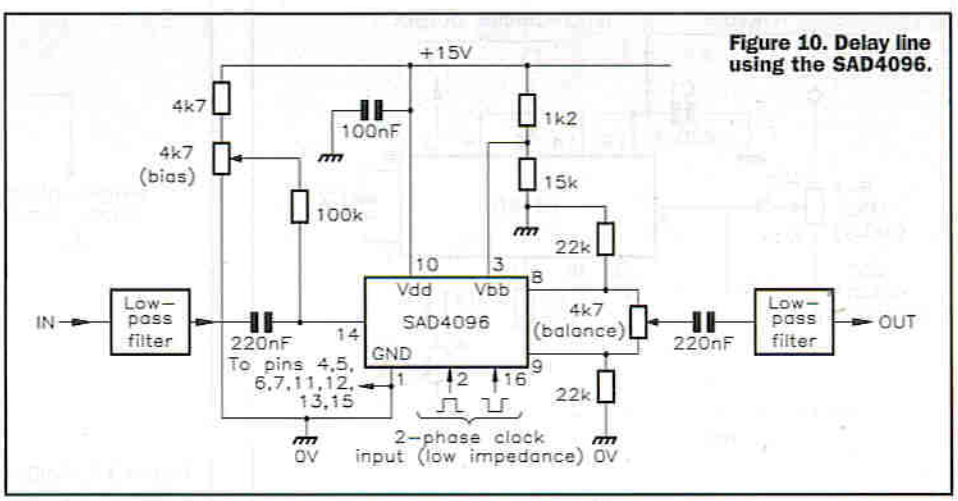



**Figure 10. Delay line using the SAD4096.**

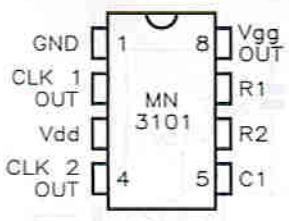



**Figure 11. Outline and pin notations of the MN3101 2-phase clock generator.**

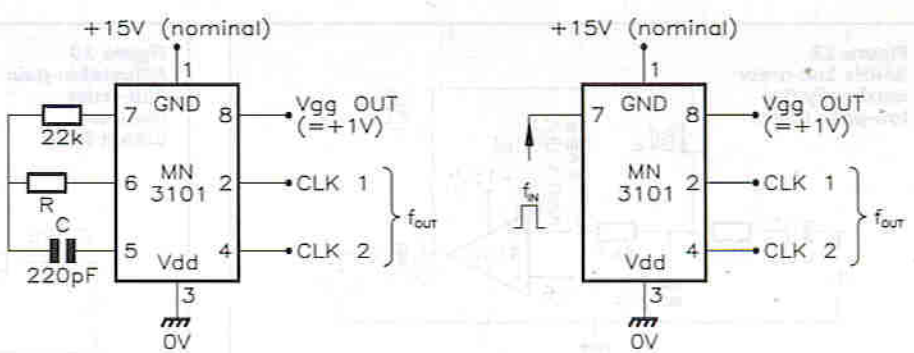



**Figure 12. Basic ways of using the MN3101 as (a) a self-contained or (b) externally driven 2-phase clock waveform generator.**

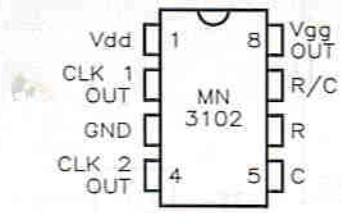



**Figure 13. Outline and pin notations of the MN3102 low-voltage 2-phase clock generator.**

## Filter and Mixer Circuits

In most applications, a low-pass filter must be inserted between the actual input signal and the input of the BBD delay line, to prevent aliasing problems, and another in series with the output of the line, to provide clock-signal rejection and integration of the composite 'sample' signals. For maximum bandwidth, both filters usually have a cut-off frequency that is one third (or less) of the maximum used clock frequency; the input filter usually has a 1st-order or better response, and the output filter has a 2nd-order or better response.

Figure 18 shows the practical circuit of a 25kHz 2nd-order low-pass filter with AC-coupled input and output. The non-inverting terminal of the op-amp is biased at half-supply volts, usually by a simple potential divider network. The cut-off frequency can be varied by giving C1 and C2 alternative values, but in the same ratio as shown in the diagram; e.g., cut-off can be reduced to 12·5kHz by giving C1 and C2 values of 1nF and 6nF, respectively.

Most delay lines suffer from a certain amount of insertion loss; typically, if 100mV is put in at the front of a delay line, only 70mV or so appears at the output. Often, the output low-pass filter is given a degree of compensatory gain, to give zero overall signal loss. Figure 19 shows such a circuit,

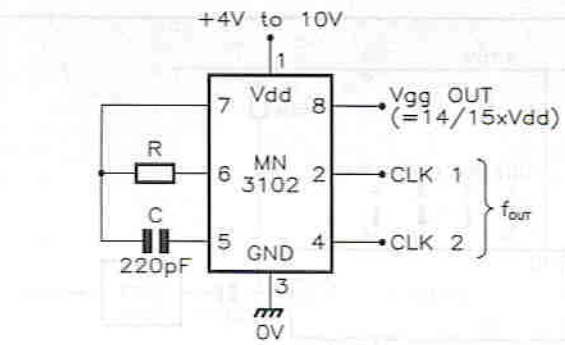



**Figure 14. Basic ways of using the MN3102 as a self-contained 2-phase clock waveform generator.**

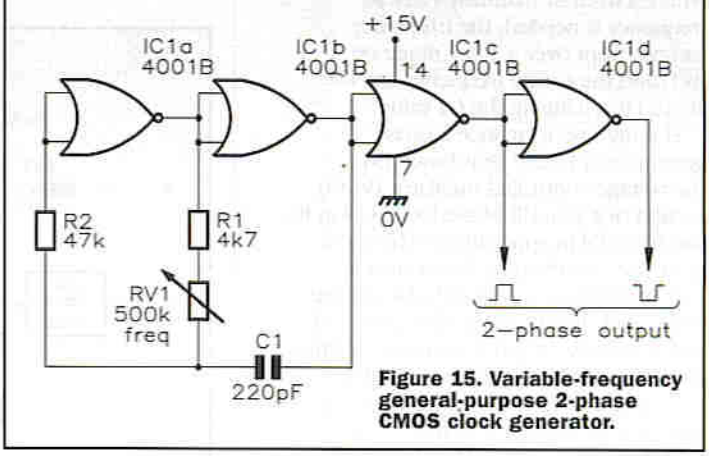



**Figure 15. Variable-frequency general-purpose 2-phase CMOS clock generator.**

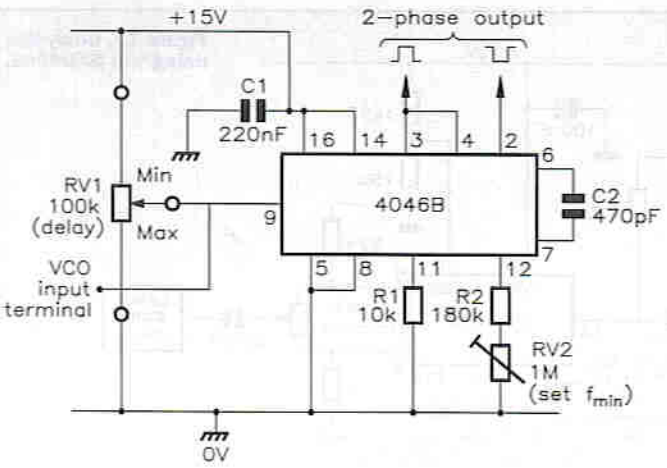



**Figure 16. High-performance voltage-controlled 2-phase CMOS clock generator.**

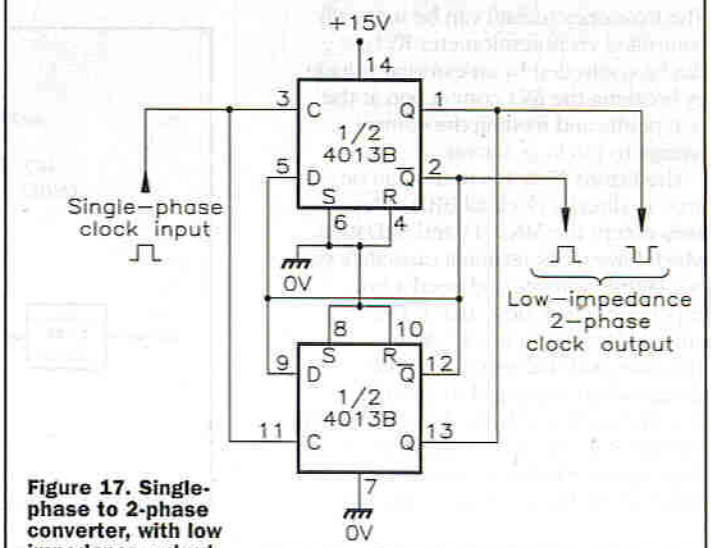



**Figure 17. Single-phase to 2-phase converter, with low impedance output.**

**Figure 18. 25kHz 2nd-order maximally-flat low-pass filter.**

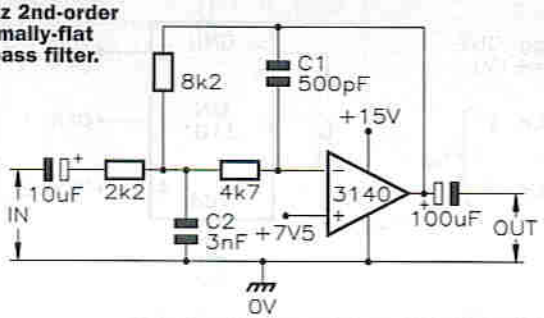
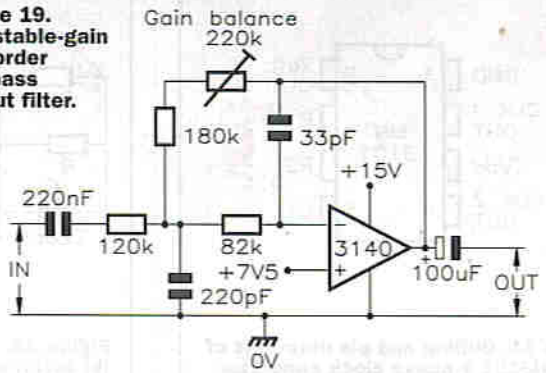



**Figure 19. Adjustable-gain 2nd-order low-pass output filter.**



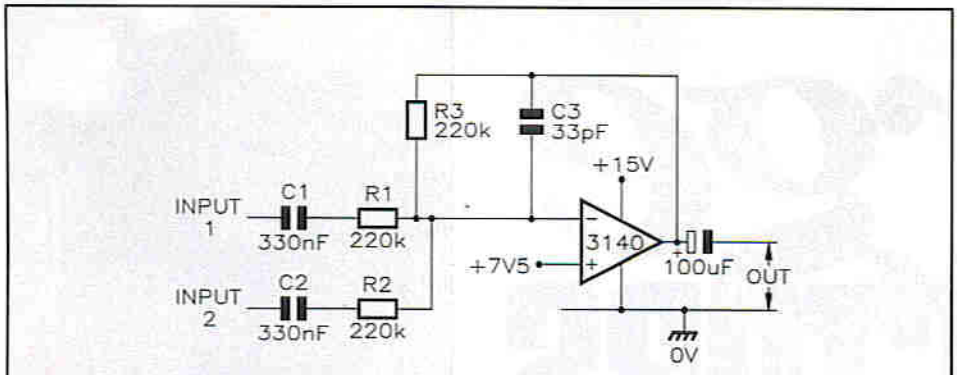



**Figure 20. Combined 2-input mixer/1st-order low-pass filter.**

ambience synthesizer circuit. Here, each of the six MN3011 delayed outputs has its own volume control in the form of a 47kΩ potentiometer wired between the output and the +15V supply rail, and the outputs of each of these – plus the original undelayed input signal – are added together in a simple 7-input unity-gain mixer of the basic Figure 20 type. The signals are then passed on to the outside world via a low-pass filter. This MN3011 circuit gives an excellent ambience synthesizer performance.

Part three of this series will look at digital delay line systems and explain their basic operating principles. ELECTRONICS

which has a nominal cut-off frequency of about 12kHz, depending on the setting of the gain balance control.

In most BBD applications, at least one multi-input analogue signal mixer (adder) is incorporated somewhere in the system. Figure 20 shows how a 2-input unity-gain mixer (adder) can also be made to act as a 1st-order low-pass filter by simply wiring a roll-off capacitor (C3) between the output and the inverting terminal of the op-amp. This type of circuit is often used at the front end of BBD flanger and reverberation designs.

Simple echo-reverb circuits of the basic type shown in Figure 4 {in Part 1 of this series} simulate the kind of reverberation that occurs when a sound bounces back and forth along a single fixed path between two hard surfaces (such as walls). Ambience synthesizers (acoustic 'room expanders'), on the other hand, try to simulate the kind of multi-path reverberation that occurs in real-life buildings such as churches and cathedrals, where sounds ricochet along a near-infinite numbers of paths between various walls and the hard floor and ceiling or inner-dome of the building. An adequately close approximation to this simulation can actually be achieved by wiring several of the basic Figure 4 {Part 1} circuits (with independently adjustable delay times) in parallel and adding their outputs together in an audio mixer. Such a setup is shown in the simple 'two paths' synthesizer circuit of Figure 19 {Part 1}), but such a system would obviously be very expensive. The 6-output multiple-delay MN3011 BBD IC (see Tables 1 & 2, and Figures 2 & 9) offers an easy and reasonably priced solution to this problem, as shown in the circuits of Figures 21 & 22.

Figure 21 shows the basic circuit of a practical MN3011 ambience synthesizer. Here, each of the IC's six delayed (echo) outputs has its own volume control, and the outputs of these controls are mixed together, along with the original input signal, and passed on to the outside world via a simple low-pass filter. The output with the longest delay (Output 6) is also coupled back to the delay line's input via a mixer (adder) and low-pass filter, to provide the system with a realistic reverberation effect.

Figure 22 shows practical details of the output mixer of the above MN3011

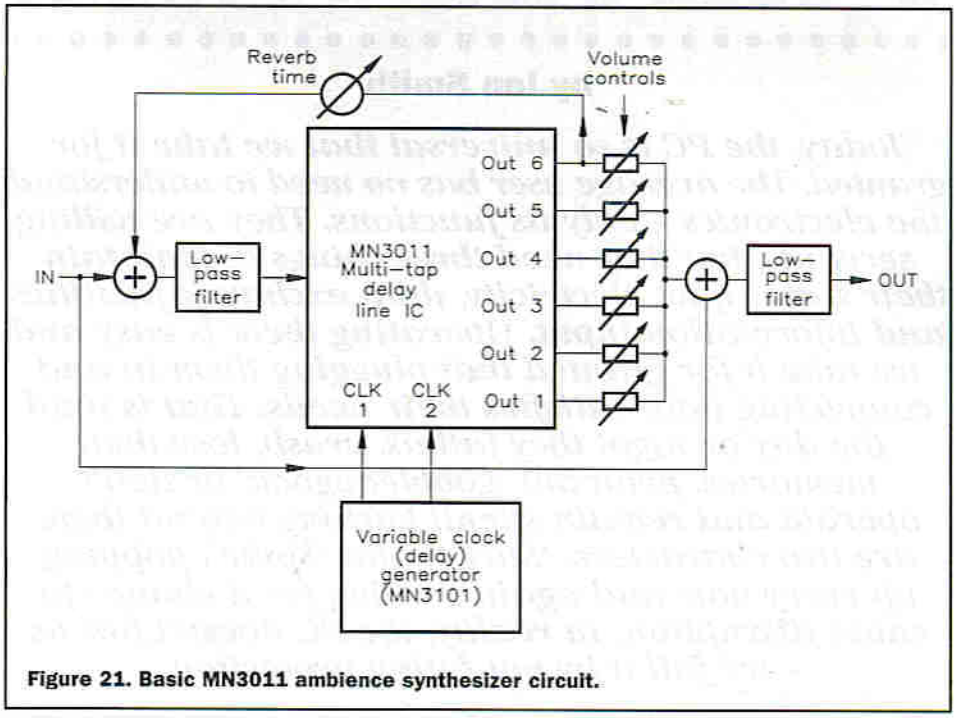
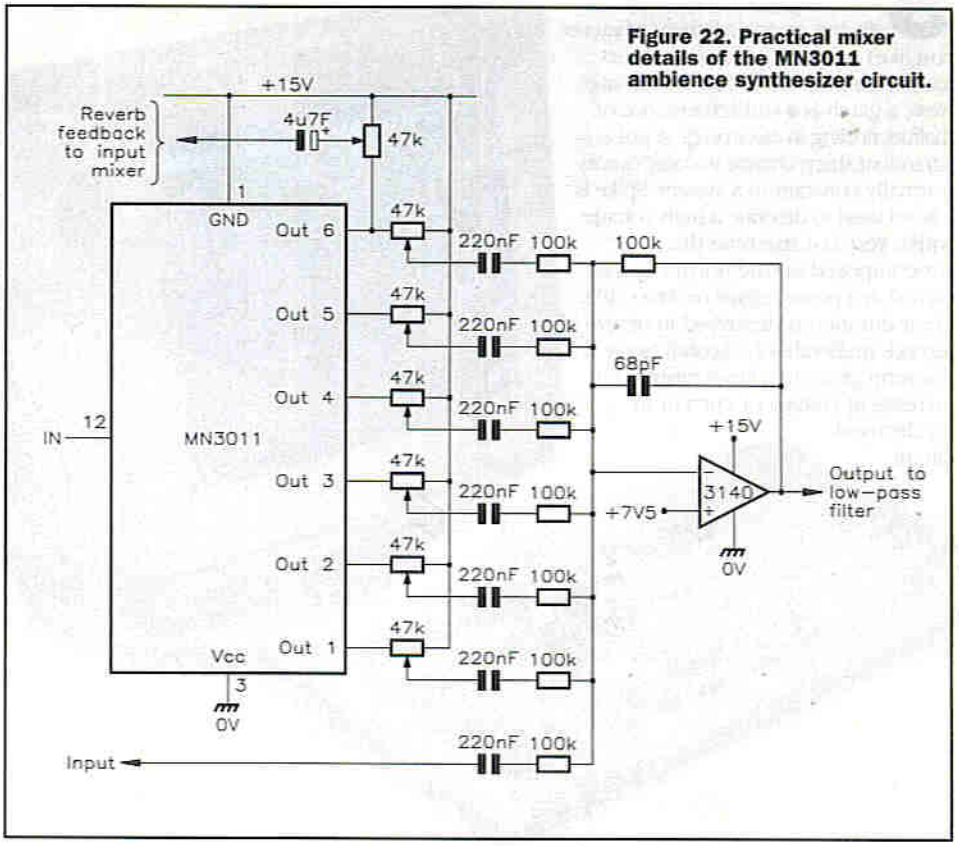



**Figure 21. Basic MN3011 ambience synthesizer circuit.**

**Figure 22. Practical mixer details of the MN3011 ambience synthesizer circuit.**



# Surge PROTECTORS

**by Ian Smith**

***Today, the PC is so universal that we take it for granted. The average user has no need to understand the electronics – only its functions. They are willing servants, but they need three things to maintain their status quo: electricity, data exchange facilities and information input. Operating them is easy and we take it for granted that plugging them in and connecting data satisfies their needs. That is until the day or night they fail us, crash, lose their memories, print out 'gobbledegook' or don't operate and remain silent! Lurking behind them are two characters, 'Surge' and 'Spike', popping up every now and again looking for a chance to cause disruption. In reality, the PC doesn't fail us – we fail it by not fitting protection.***

**Photo 1. A wall socket after a lightning strike.**

Spikes, electromagnetic pulses, switching transients, surges, glitches, bugs, (call them whatever you like) on power and data inputs are the culprits we have to eliminate. Now, a glitch is a sudden instance of malfunctioning in electronics. A pulse is a transient sharp change in some quality normally constant in a system. Spike is a word used to describe a high voltage with a very fast rise time that is superimposed on the normal voltage carried in a power, signal or data cable. Their duration is described in micro-seconds (millionths of a second). Surge is the term given to a large momentary increase in voltage or current in an electrical circuit.

Finally a transient is temporary, for a short time only, quickly passing away. They all cause havoc in an electronic environment! Remember one aspect of Murphy's Law – "The most inconvenient happens to the least prepared at the worst possible time"! Computers, communication and data transfer electronics faithfully obey this section of Murphy's Law!

Most people have experienced switching a light on at home to see a bright flash, perhaps hear a 'pop' and the bulb is dud. Whilst the bulb isn't designed to last forever, that last switching operation superimposed the spike that zips along the wire to the bulb: old or new, it is too much for the element to handle

Photo 2. TV/wall sockets following a lightning strike.

In considering the mechanisms of spike and surge propagation and other relevant points, remember that transients can pass between any two conductors regardless of whether they are positive, negative, neutral or earth: that the bigger the loop physically before any two conductors come together, the larger the resultant voltage can be, whether the transient source is induction, resistive or capacitive in origin. In the creation of spikes and surges, any one of the following could produce your system's eventual failure:

Direct, indirect, nearby, cloud-to-cloud lightning discharges with side flashing, associated magnetic field voltage gradients, induced currents on any type of conductor either above or below ground level, earth point-to-earth point voltage differences, effected by soil resistivity. Clashing of bare overhead conductors in strong cross winds, any short circuit striking, switching surges with arcing across contacts, both off and on, multiple contact bounce, switching off stepper or rotating motors and transformers, releasing stored magnetic and capacitive

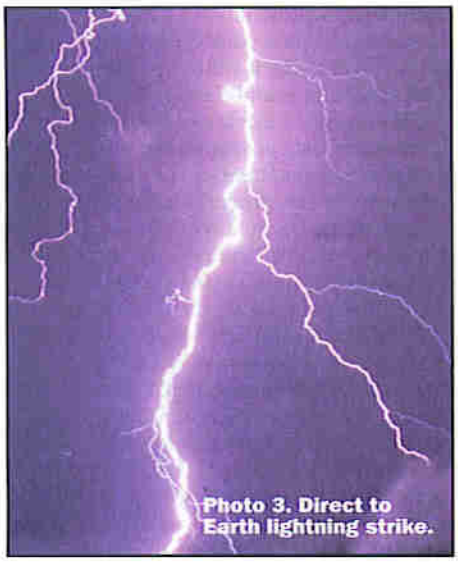


Photo 3. Direct to Earth lightning strike.

Photo 4. Cloud-to-cloud lightning strike.

and the bulb fails. The switching surge is ten times the operating current. We have all seen lightning, and experienced the house lights flicker as the supply company's auto-reclosers operate. It is these sorts of events that cause surges and spikes.

The Loss Prevention Council (LPC), funded by the Association of British Insurers and Lloyds of London, have shown that over 60% of computer failure and associated consequential loss claims could have been prevented. Other data suggests that over 80% of the hardware failures are due to power or signal source transients. Imagine 24 hours without electricity – it would be total chaos. We have evolved into a society where controlled electricity is taken for granted. Electricity Supply Companies protect their own equipment and distribution systems to deliver to our door, to the best of their ability, a standard product. Once it's gone through that meter, it's our responsibility. So, to ensure that our lives are not disrupted, we have to control the way electricity works for us: we also have to ensure we control the 'nasties' that pollute its quality. That is where the protection comes in, and we haven't been too clever about it until now.

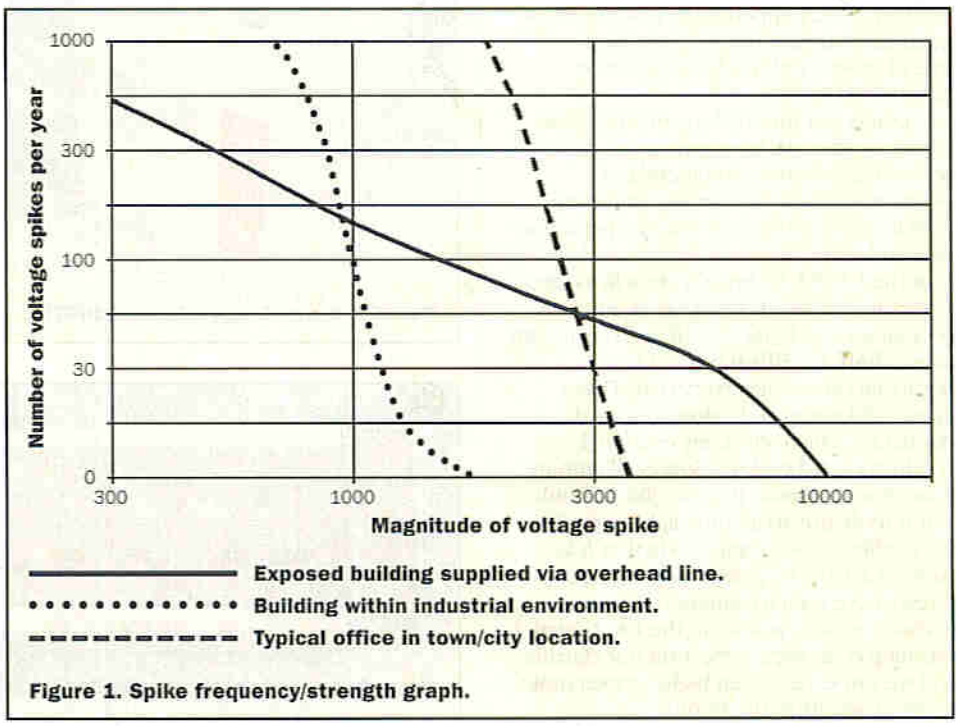



Figure 1. Spike frequency/strength graph.

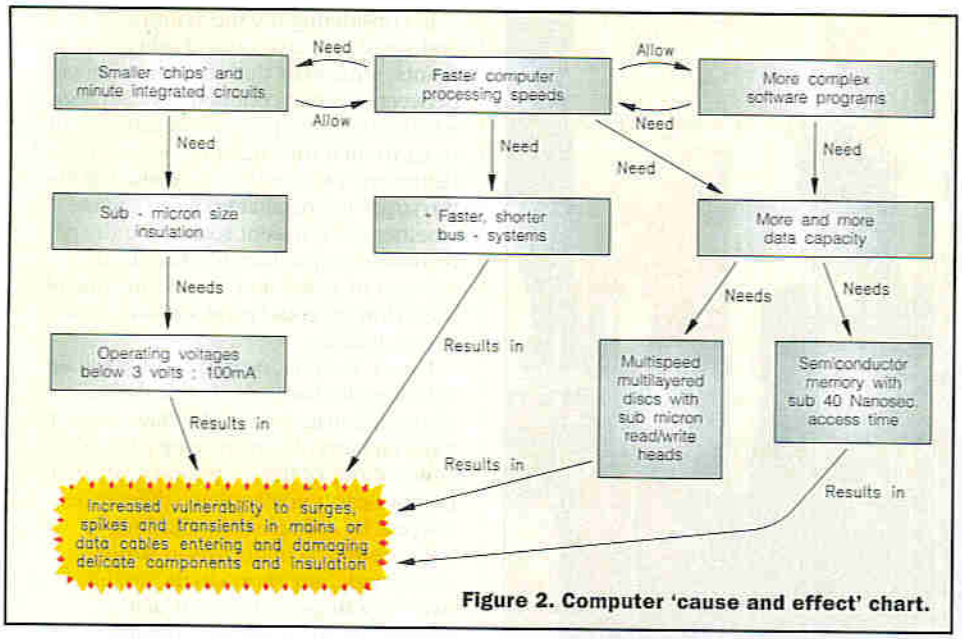



**Figure 2. Computer 'cause and effect' chart.**

currents, switching any reactive load, gas tube arcs extinguishing, fuses blowing, tripping and resetting of safety devices, boiler ignition mechanisms. Also, cellular and radar transmitters, reactive loads like fluorescent and neon lamps, induced voltages in any parallel or cable loop, operations of relay and solenoid coils, triacs, thyristors, generators, silicon controlled rectifiers, all types of switches in continuous everyday use; also strong harmonic-resonances from transformers and composite filters in switched mode power supplies, exhibiting crossover.

All types of cables can act like aerials and pick up trouble from other sources – and they dump this pollution into your system's equipment unless protection is present.

The mains supply and the phone lines are the 'networks' that bring the outside world right next to our PCs, faxs, modems and videos.

## Lightning and BS 6651, 1992, Appendix C

BS 6651 (1992) Appendix C: is an excellent guiding document but isn't supplied free of charge with each computer or networking system:

It points out the weak points that allow surges, spikes and transients to get at your sensitive electronic equipment and recommends ways and means of dealing with them. It particularly draws attention to data and signal cables being an Achilles heel.

In the UK, EA Technology monitors direct strikes to Earth with specialist equipment over an area of 1,400 × 900km. They record almost **half a million** ground strikes occurring on average every year. These figures did not include cloud-to-cloud discharges which affect any overhead conductors and cables below. So, lightning is far more common than we like to think.

It is foolhardy to assume lightning will never effect your location. Whether it is sunspot activity or global warming, the last 4 years have seen a tremendous increase in thunderstorm activity in the UK. Global warming *is* having an effect on our climate and we can expect even higher isokeraunic levels of activity in the future.

## What Happens when Lightning Strikes?

In milliseconds, enough electrical energy to supply a town for a year is dissipated to Earth!

Lightning always gets our attention, whether it's the flash, the loud crack or the distant rumble of thunder. Depending on where you live in this world, it is a rarity or a twice-daily phenomenon. The movement of air, water and ice particles inside a thundercloud builds up into an immense electrical charge which eventually discharges to Earth as a direct strike. Earth absorbs the energy into its vast mass.

The stroke of lightning is very hot (30,000°C), creates a very strong electromagnetic field, travels at about one fifth the speed of light (37,000 miles per second), on average, discharges about 30,000A and has been and gone in about 5ms (thousandths of a second).


**Photo 5. 3-way Surge Adaptor (CH67X).**

It is so powerful, it can afford to be wasteful. It will try any route along the way that looks promising.

If it strikes the ground directly, it imposes a voltage gradient all round that point. Its electromagnetic field imposes currents on overhead and underground conductors of all types, and the resultant charges rush off in all directions, creating an influence up to 1·5km away. Having ionised the air, normally a good insulator, to get to ground in the first place, it can easily vaporise small cables like house wiring and internal telephone lines should it get inside a building.

Spikes and surges from lightning sources with their high energy just zip in on the power or data cabling, burn their way across the boards and out to earth or on to the nearest connected equipment with similar devastating results.

How can we comprehend the speed at which these things occur? In a perfect conductor with no attenuation, a spike travels at the speed of light: 186,000 miles (300,000km) per second; attenuated in a cable, at about 93,000 miles (150,000km) per second.

It takes about 60,000V to create a spark across an air gap of 6in. (150mm). This is equivalent to 400V/mm. So, once a spike has passed leading edge components, you can see how easily it will saturate minuscule solid-state 'chips' and damage occurs.

Unfortunately, there are *many* more sources of transients than just lightning, so "We never get lightning round here" isn't a reason to relax!

All sorts of equipment is being switched on and off, and certain types of controls are going on and off all the time. We are surrounded by devices that pollute the mains power supply. By the early 1950s, manufacturers of switches were well aware of transients. If the spring was too strong, the contacts 'bounced' several times before closing; if they operated too slowly whilst opening, a large arc (spark) formed between the contacts. The arcs of ON/OFF operations create spikes or surges. It was found that switching motors OFF and switching electric lamps ON caused large transients.

Whilst more damage is caused by the indirect effects of lightning through inductive and resistive coupling than direct strikes, more spikes are caused by switching operations of installed equipment than those created by nature.

The transients created vary enormously in size and power, according to the type of equipment and the situation, but they are all very fast.

Electronic equipment designers are well aware of these problems. So computers, for example, are manufactured to have an immunity level or transient design level (TDL). This means they should withstand

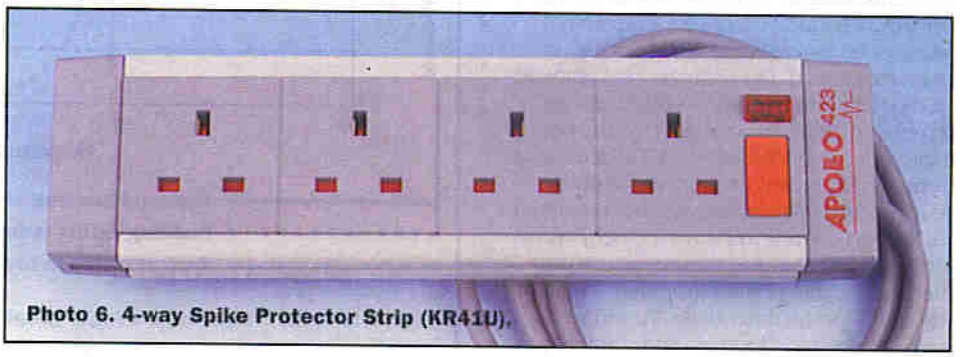



**Photo 6. 4-way Spike Protector Strip (KR41U).**

a small energy spike of about 1,200V. But, unless they are very responsible, the device they fit is minimal – they don't want to add to their costs providing for 'worst case' situations (anything above the TDL) which might make their product uncompetitive. They argue that the power supply is outside their control and the responsibility of the purchaser/user. (A quick read of your warranty document will confirm this!) Equally, your 'phone line provider (PTN) will not guarantee you transparent transmission: they do provide optical cabling between principal locations, but few buildings have this expensive link to the door.

Additionally, the designer will comply with the EMC regulations, but not over-specify; he doesn't want to encourage spikes to seek out his equipment, neither does he know whether a co-ordinated approach to protection will exist where it is to be located.

Bombarded by small transients, this minimal protection degrades with time. Computers have vastly improved operating speeds, memory capacities, etc., yet get smaller; more of their essential components are miniaturised and mass produced. This keeps prices and size down but exposes the weakest point – the insulation gaps are now measured in micro-dimensions.

Any combination of smaller induced or switching spikes over a period of time that get through to the circuit boards can cause a flashover on the minute insulation. This might cause a system malfunction on the first occasion, but unsuspected deterioration has been initiated. The next time a spike gets through, it makes it worse, until a tracking path is formed. Subsequent events cause permanent damage and processing failure.

Protectors sit waiting like sentries. Transients have fast 'rise times'. The protector's combination circuitry detects this and starts to divert the excesses safely away from your equipment, acting like an overflow in a bath or basin.

Protection units are set to work at different voltage levels; it varies with what they are designed to protect. So, there are different types for high voltage, low voltages, 3-phase and single phase, internal distribution positions, isolated power spurs, groups of office equipment, individual computers, telephone cables, signal cables, coax cables, data cables and networking cables. They all have different properties, outlined below.

Power supply protectors have eight main features:

1. They allow normal electrical signals and power to keep flowing.
2. They react very quickly to polluting abnormalities, whether they arrive on the live, neutral or earth wire (3-mode protection): less than 10ns is ideal.
3. They take that abnormality out by absorbing it or dumping it harmlessly to earth.
4. If the abnormality should be too big to handle (as made by a direct lightning strike), they commit hari-kari; they 'die' protecting the system rather than protecting themselves!
5. If they fail whilst doing their job, they fail-safe, have an indicator that tells you they need replacing and can be replaced easily.
6. They have a secure direct connection to the buildings main earth.

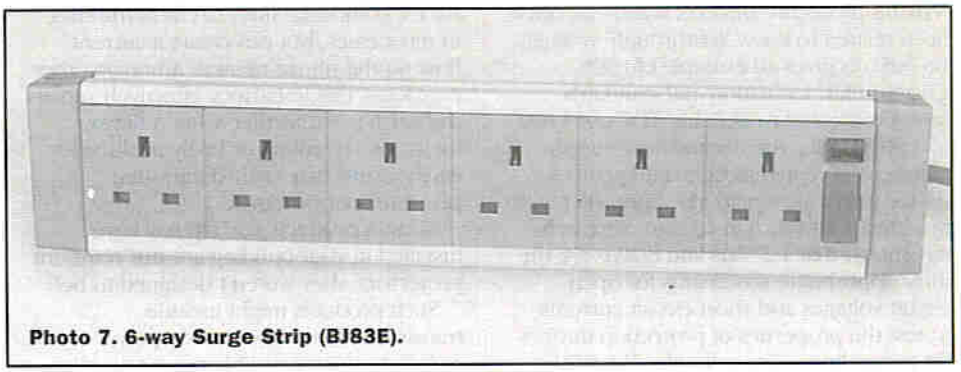


**Photo 7. 6-way Surge Strip (BJ83E).**

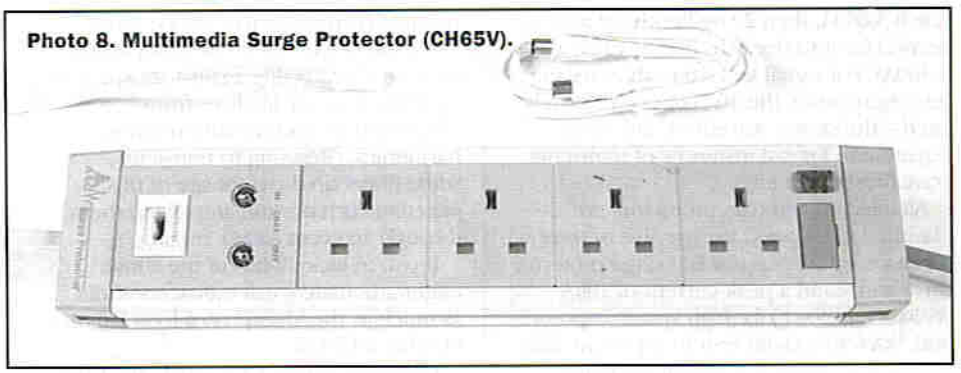


**Photo 8. Multimedia Surge Protector (CH65V).**

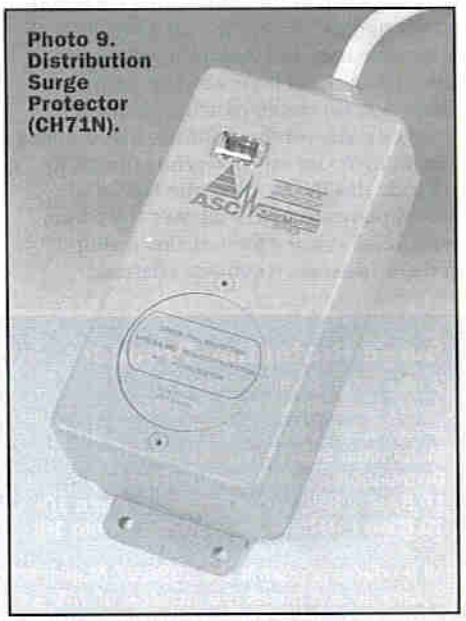


**Photo 9. Distribution Surge Protector (CH71N).**

BS 6651, Appendix C identifies different locations in a building:
Category C, Primary: the supply side of the incoming power distribution board.
Category A, Secondary: the load side of power socket outlets.

The magnitude of surge voltages and currents caused by lightning that appear at different locations on a power system are defined in the standard, as follows:

| Appendix C Location Category | C | A |
|---|---|---|
| Peak voltage (1·2/50μs waveform): | 20kV | 6kV |
| Peak current (8/20μs waveform): | 10kA | 500A |

7. The protector must be able to survive these values.
8. You put tough big ones at the entrance of your building (category C). They have two sets of protection circuitry, the status of which is also indicated.

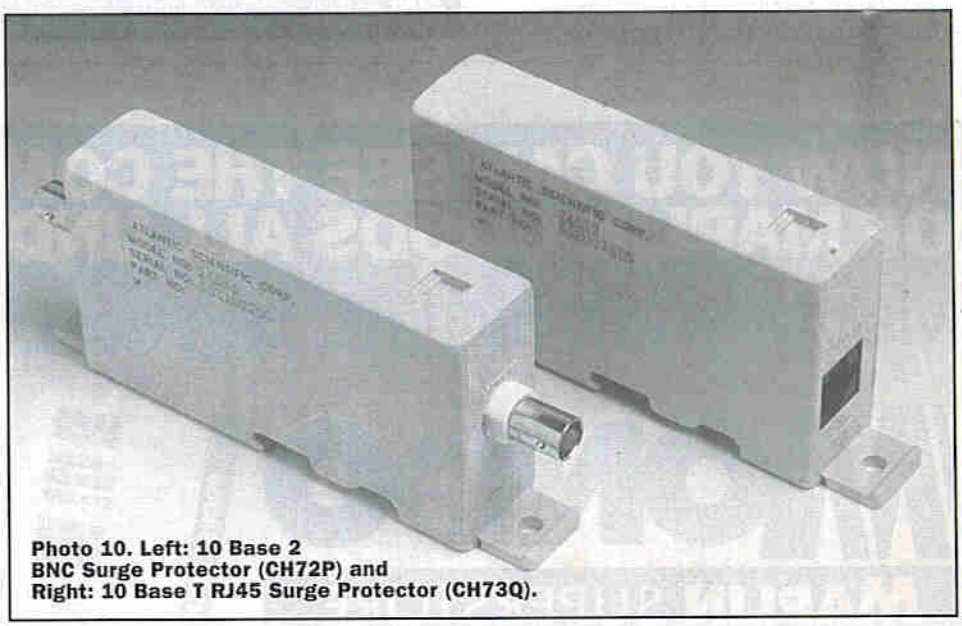


**Photo 10. Left: 10 Base 2 BNC Surge Protector (CH72P) and Right: 10 Base T RJ45 Surge Protector (CH73Q).**

A mains protective device's ability has often been related to a low 'let through' voltage; BS 6651(c) gives an example of 850V. Current EMC legislation and standards have progressed to defining TDL's of 1,000 to 1,500V: twice the normal peak supply voltage is accepted as quite adequate. A device with a slow response time will result in a higher let-through voltage. Research has shown that 1·2/50μs and 8/20μs are the most appropriate waveforms for open circuit voltages and short circuit currents to test the properties of protection devices for power lines. (For example, 3kA 8/20μs = 8 millionths of a second fast rise rime to reach 3,000A, then 20 millionths of a second for it to decay to half its value at 1,500A). For signal and data cables having less attenuation, the 10/700μs waveform is used – the slower wavefront and decay equating to known instances of transients travelling over 16km!

All telecom and data protectors are classified Category C irrespective of their locations, so every signal line surge protector must withstand a peak current of 10kA (8/20μs waveform) for high system exposure, and 5kA for medium system exposure areas. The reason is that a transient travelling along a signal line is not attenuated by the cabling in the same way as on a power line.

Telephone and networked data cables, telemetry and signal cables, coax lines, etc., operate on specific protocols. Additionally, they have different types of connectors and sockets. Surge protectors are available for all types to handle the most onerous transient conditions.

On data lines, a protector might chop out a small section of the message as well as the transient when it operates – your computer just asks for that bit of information to be transmitted again, something it does quite normally.

Signal and data cables, of course, operate at only a few volts, so protectors must not attenuate information, digital or analogue, yet must be critically aligned to signal voltages whilst blocking transients. The complex circuitry to do this results in quite expensive units – but not so when related to the equipment they preserve!

Earth is a reference point. Switched mode power supplies widely used in electronic equipment and computers have a composite filter to cut harmonics in most cases, but can create a current flow on the return neutral. Amongst other problems, this imbalance effectively moves the earth point further away. A flimsy, inefficient, overlong or badly positioned earth results in a vastly diminished protector performance.

Certain products you already have installed in your building are **not** transient protectors: they weren't designed to be!

Such products might include transformers, switched mode power supplies, uninterruptible power supplies (UPS), miniature circuit breakers (MCB), residual current devices (RCD), fuses, some filters, etc. Each one has a specific job to do: protecting against short-circuits, stopping fires, saving lives from electrocution, cutting out unwanted harmonics. (Reacting to transients, some filters do the opposite of this, injecting currents and amplifying them through an event called 'ringing'!)

If you're lucky, a few of the above might attenuate small transients about as much as the 'decay' on a long length of cable might do.

Lightning struck a TV aerial on a Lake District house in the middle of a sheltered position estate. The coax cable was laid across the roof and down the side to enter the ground floor window frame. There was no visible or actual damage to aerial or coax, yet the transient that entered the sitting room was powerful enough to implode the TV set, blow the Hi-Fi and record player to pieces all over the room, and almost cause a fire – mains wiring in the downstairs room was charred. The house was correctly connected to the incoming supply company's earth.

It's not so much technical knowledge but *common sense* that tells us to fit Surge Protection.

A Thames Valley modern fire station had good communication links by 'phone and radio, good structural lightning protection, but no surge protection on their systems. A direct strike to their rooftop resulted in all 'phones and the radio link being taken out – the police had to drive round and call them out to attend a fire caused nearby by another direct lightning strike!

## You Can't Stop Lightning, but You Can Tell it Where to Go!

Nick Anderson, Maplin Computer Products Group Manager, says "giving our customers information about surge protectors is essential. Because people don't realise the risk to their equipment, we have been displaying them as an integral part of a safe security system in our stores. The response has been tremendous."

Surge protectors are available as plugs, adaptors, built into power strips, or as specific units. Building big protection modules in a PC is not the solution: it's too close to the integrated circuits. Outside the casing, close to the mains earth is the ideal position. One combination strip (CH65V) has a common earth point for 4 power plugs, a BT 'phone line socket and a TV aerial socket – all surge protected. If your equipment is grouped together, it would seem to be the perfect solution.

| Surge Protection Product | Stock Code | Price |
|---|---|---|
| 3-way Surge Adaptor (Photo 5) | CH67X | £19.97 |
| 4-way Spike Protector Strip (Photo 6) | KR41U | £29.99 |
| 6-way Surge Strip (Photo 7) | BJ83E | £44.99 |
| Multimedia Surge Protector (Photo 8) | CH65V | £79.85 |
| Distribution Surge Protector (Photo 9) | CH71N | £105.70 |
| 10 Base 2 BNC Surge Protector (Photo 10) | CH72P | £79.85 |
| 10 Base T RJ45 Surge Protector (Photo 10) | CH73Q | £79.85 |

All products appear in the 1996/97 Maplin MPS Catalogue and prices are inclusive of VAT. A carriage charge of £2.95 is applied to all orders under £30.00 (MPS account holding customers exempt).

MAPLIN

**PROJECT RATING** 1

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- Detects ferrous and non-ferrous metal
- LED indicator
- Optional buzzer output
- Compact and easy to use

**APPLICATIONS**

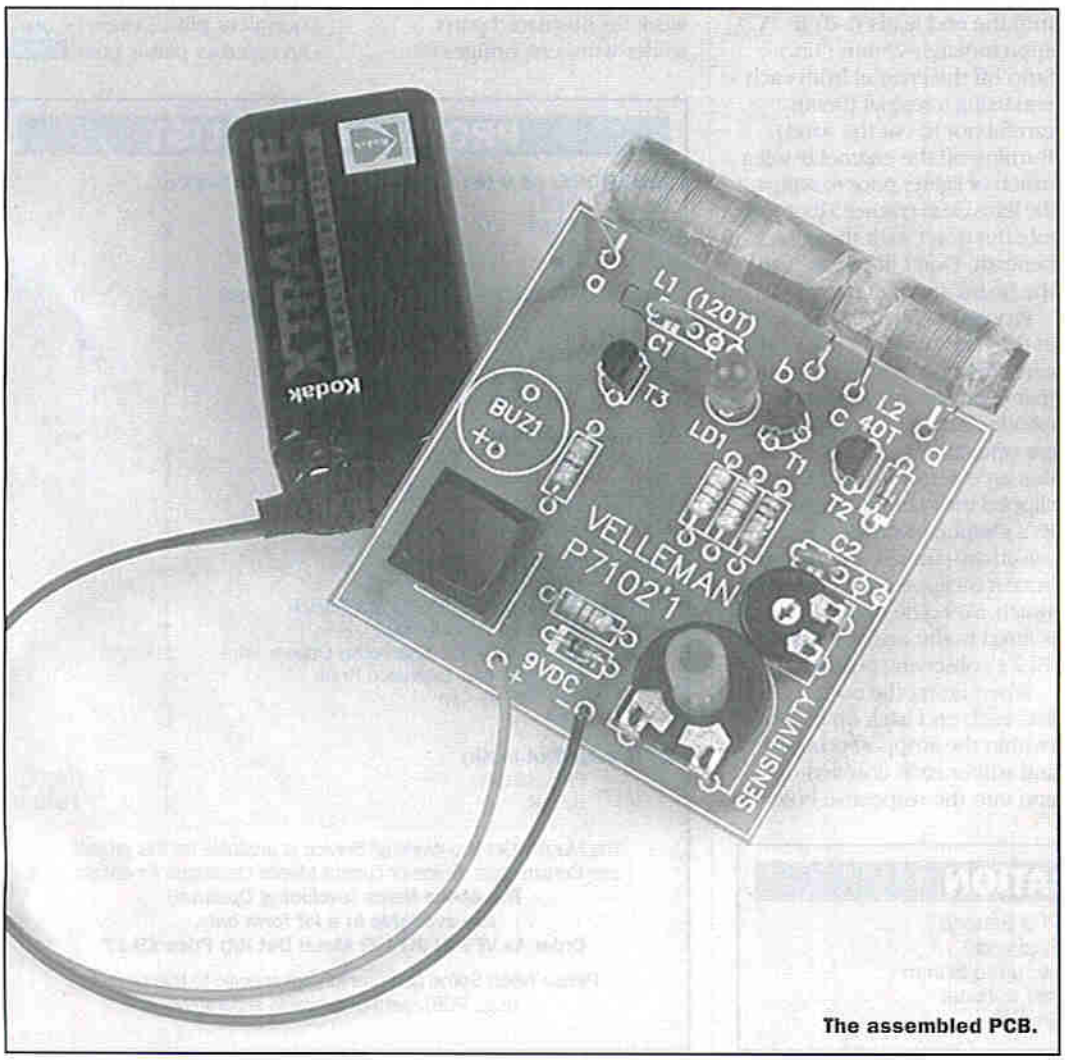
- Locating hidden pipes, cables, screws, nails, etc.
- Finding buried treasure!
- Revealing filler on car bodywork

PROJECT

# Metal DETECTOR

**Text by Maurice Hunt**

***To encounter a concealed electric cable when drilling a hole in a wall can have catastrophic, even fatal consequences. Likewise, to accidentally drill into water or central heating pipes can cause major problems, to say nothing of course, if one has the misfortune to drill into a gas pipe.***




**The assembled PCB.**

With this handy and compact metal detector, you can save yourself considerable potential hassle, grief and expense when drilling into walls, floors and ceilings, by locating concealed pipes and cables before venturing the drill bit beyond the point of no return! The detector will make short work of finding studding in partition walls and the like.

The metal detector indicates the proximity of ferrous (iron/steel) or non-ferrous (brass, copper, etc.) metal objects by means of the LED lighting, and an optional buzzer may be fitted to provide audible indication.

The metal detector could also be an extremely valuable aid when looking over a used car for sale; by sweeping it over vulnerable areas of a vehicle's bodywork, you can easily identify whether there is carefully disguised filler lurking beneath that gleaming paintwork and thus avoid being conned by an artful bodger!

## Circuit Description

Refer to Figure 1, showing the circuit diagram of the Metal Detector. Transistor T1, in conjunction with L1 and C1, create a tuned LC sinewave oscillator that operates at between 260 and 450kHz. The frequency of oscillation is dependent on the settings of potentiometers RV1 & RV2, and on the proximity of metal objects to the search coil, L1.

RV1 provides 'course' adjustment, while RV2, being of a much lower value, is used to provide 'fine' adjustment of the frequency and hence, sensitivity of the circuit.

Coil L2, wound on the same ferrite rod as L1, provides out-of-phase feedback to the signal detector formed by transistor T2, the DC bias of which is set by diode D1 and resistor R4.

The operation is such that in the absence of metal objects near the search coil, T1 oscillates and a strong amplitude sinewave signal is present on its collector. This causes a high amplitude signal (also sinewave) to appear on the base of T2. This results in the DC level at the collector of T2 remaining low, thus also keeping the transistor switch (T3) "off".

However, when the search coil is brought near a metal object, the amplitude of the sinewave signal progressively reduces the closer the object's proximity is (i.e., the oscillator

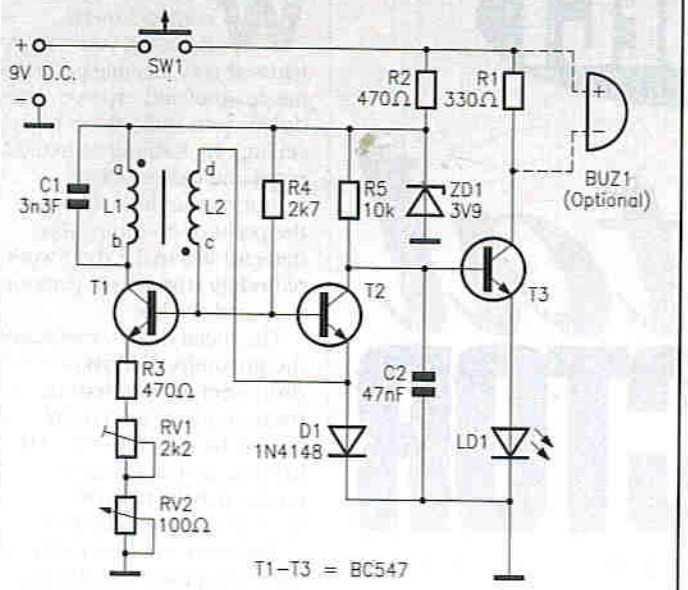



**Figure 1. Circuit diagram of the Metal Detector.**

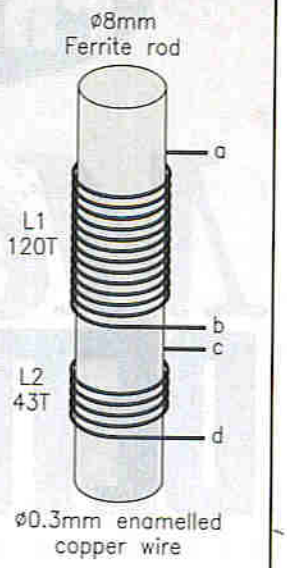



**Figure 2. Coil winding details.**

becomes detuned). Thus, the DC level at T2's collector rises, T3 conducts (switches 'on') and LED (LD1) lights. The optional buzzer (if fitted) will also sound.

Zener diode ZD1 and R2 provide a stable voltage reference (of 3·V) to the oscillator and signal detector stages.

## PCB Construction

It is advisable to wind the coils L1 & L2 onto the ferrite rod before commencing assembly of the PCB. A length of 31swg (0·3mm diameter) enamelled copper wire is supplied in the kit, which should be found to be of ample length for the winding of both coils. Figure 2 shows the required coil winding details.

Start by winding the larger coil (L1), which must be 120 turns, 60 turns wound on top of another 60 turns. The technique is to secure one end of the wire (a) onto the ferrite rod with a small piece of sticky tape, and wind on 60 turns. Use another piece of tape to secure the 60th turn, and pass the wire back along the coil to the starting point (a), before winding on the next 60 turns. Tape can be wrapped around the completed coil to hold it all in place. Alternatively, double-sided tape can be used which makes winding of the lower coil easier, though you'll still need normal tape to secure the top winding.

Use the same technique to wind L2, which is 43 turns (you can wind on 23 turns, then add 20 turns on top). Take care to wind the coils in accordance with the diagram; the coils must start and end in the positions shown.

Having wound the coils, trim the end leads (a-d) to approximately 25mm (1in.). Strip off the enamel from each end using a scalpel (being careful not to cut the wire!) Burning off the enamel using a match or lighter prior to scraping the leads clean ensures a thorough job, but don't melt the wire beneath. Don't fit the coils to the board at this stage.

Proceed to build up the board in the usual order of ascending component size/height. Ensure that polarised components (diodes, LED and transistors) are orientated correctly. Note that an extension spindle is clipped into potentiometer RV2's wiper, to provide the sensitivity control, and that a button is clipped onto the push switch, SW1. The optional buzzer is fitted in the position marked 'BUZ1', observing polarity.

When fitting the coils, fold each end back on itself (within the stripped portion) and solder each doubled-up end into the respective hole (marked 'a' to 'd') on the board. Further sticky tape can be used to provide a degree of support for the search coil against the board.

Ensure that the PP3 battery clip (supplied) is fitted with its red lead connected to the '+9V DC' terminal and black to '–'.

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

## Testing and Use

Simply snap a fresh 9V PP3 battery onto the clip and hold the push switch button down. Keeping the search coil away from any metal objects, turn potentiometer RV2 (via the extension spindle) to its midway position. Using a screwdriver, adjust potentiometer RV1 until the LED is on the verge of lighting. Now bring a metal object (such as the screwdriver blade) near the coil, and the LED should light, and turn off again when the metal object is removed. If the optional buzzer is fitted, it should buzz as the LED lights. Some fine adjustment of RV1 and RV2 may be needed to achieve optimum sensitivity.

The Metal Detector can be fitted into any suitably sized plastic box, and drilling details are given in the leaflet provided in the kit. However, a metal box is NOT suitable, for obvious reasons! Also ensure that the battery and box lid screws (if applicable) are distanced from the search coil (it is advisable to replace metal box screws for equivalent plastic ones, or use a clip-together plastic box).

## SPECIFICATION

| | |
|---|---|
| Operating voltage: | 9V DC (PP3 Battery) |
| Operating current: | 30mA (maximum) |
| Detection range: | Adjustable, up to 80mm |
| Output: | LED, buzzer optional |
| PCB dimensions: | 54 × 53mm |

## PROJECT PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS: All 0·5W 5% Metal Film (Unless Stated)** | | | |
| R1 | 330Ω | 1 | |
| R2,3 | 470Ω | 2 | |
| R4 | 2k7 | 1 | |
| R5 | 10k | 1 | |
| RV1 | 2k2/2k5 Horizontal Preset Potentiometer | 1 | |
| RV2 | 100Ω Horizontal Preset Potentiometer | 1 | |
| **CAPACITORS** | | | |
| C1 | 3n3F Ceramic Disc | 1 | |
| C2 | 47nF Ceramic Disc | 1 | |
| **SEMICONDUCTORS** | | | |
| D1 | 1N4148 | 1 | |
| ZD1 | 3V9 Zener | 1 | |
| T1-3 | BC547 | 3 | |
| LD1 | 5mm Red LED | 1 | |
| **MISCELLANEOUS** | | | |
| L1,2 | * See Text * | | |
| SW1 | PCB-mounted SPST Push Switch | 1 | |
| | 8 × 50mm Ferrite Rod | 1 | |
| | 31swg (0·3mm) Enamelled Copper Wire | 1 length | |
| | Potentiometer Extension Knob | 1 | |
| | PP3 Battery Clip | 1 | |
| | PCB | 1 | |
| **OPTIONAL (Not in Kit)** | | | |
| | PP3 Battery | 1 | (JY60Q) |
| | Buzzer | 1 | (FL39N) |

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 a kit form only.***

**Order As VF64U (K7102 Metal Det Kit) Price £9.17**

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

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Elaine Chapman, Human Resources Department,
Maplin House, 274-288 London Road,
Hadleigh, Benfleet, Essex SS7 2DE.

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**Applications should contain sufficient information about qualifications, experience, personal qualities, etc. to enable us to short list candidates for interview, to be held at Maplin House.**

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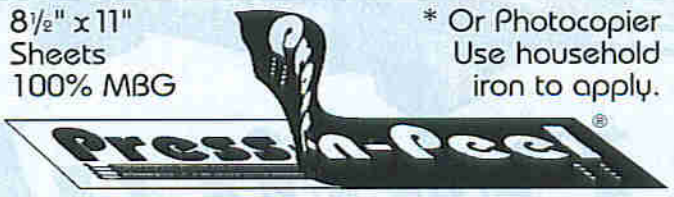


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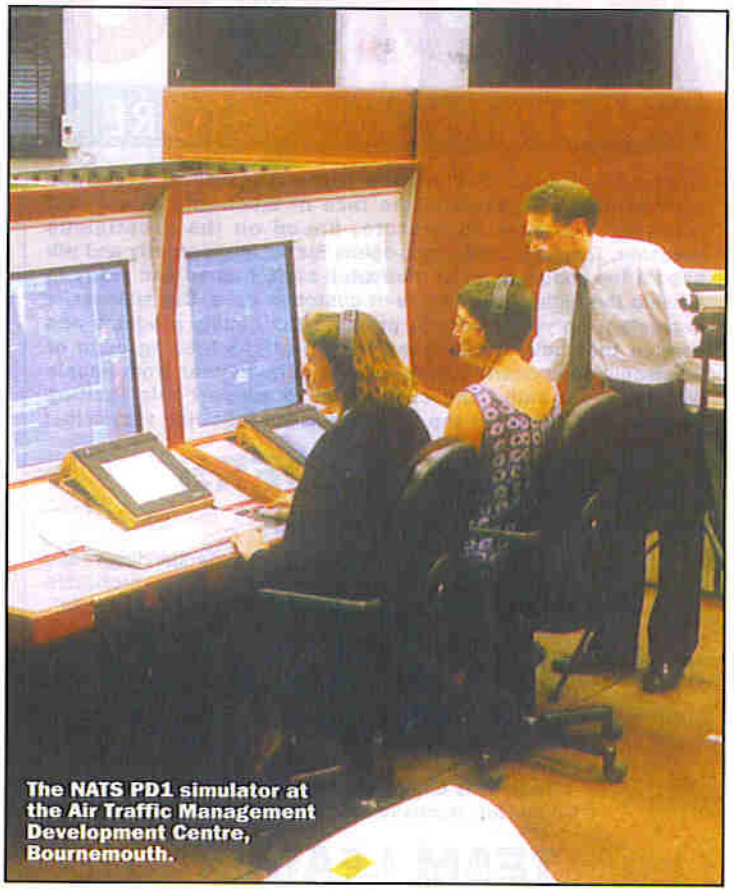
# Digital AIR TRAFFIC CONTROL SYSTEMS



The NATS PD1 simulator at the Air Traffic Management Development Centre, Bournemouth.

**by Alan Simpson**

***The days when Air Traffic Control involved handling plane identification cards on a desk as aircraft passed through structured sectors are strictly numbered. Electronics is about to replace the card shuffling. At the same time, satellite communications is increasingly supporting existing radar technologies.***

Air Traffic Control operations allow no scope for 'Mystic 'Meg' or 'Lottery Crossed Fingers'. It is a totally positive science, one where failure is simply out of the question.

In fact, the guiding principle of air traffic control is that safety is paramount. Controllers must, therefore, keep the aircraft they handle safely separated using internationally agreed standards.

In the next 24 hours, over 5,000 aircraft will fly through the airspace over the United Kingdom. Half of them will be commercial aircraft airliners making scheduled or charter flights to or from hundreds of different cities around the world. Whatever their destination, all these flights will be making an important contribution towards the UK's prosperity. Air transport itself pumps £4 billion a year into the nation's balance of payments and that is before taking into account its vital support for trade, tourism and employment.

But none of this would be possible without air traffic control. Here again, the UK is a world leader with a reputation for maintaining the speedy, efficient and above all, safe passage of aircraft through its airspace. This reputation is in the skilled hands of the air traffic controllers, engineers, scientists and support staff of National Air Traffic Services (NATS). They are working around the clock to maintain it.

**In the next 24 hours, over 5,000 aircraft will fly through the airspace over the United Kingdom.**

Until the early 1960s, air traffic control was divided between civil and military providers and users. But with major growth in air traffic, a more effective dovetailing of operations within UK airspace was needed. NATS was established in 1962 as an integrated civil-military organisation to ensure 'the safe, orderly and expeditious flow of air traffic in UK airspace' and to meet the UK's responsibility to provide services over the eastern part of the North Atlantic.

In 1972, NATS was separated from central government through the formation of the Civil Aviation Authority (CAA) and was made jointly responsible to both the new body and the Ministry of Defence.

Three decades after NATS' formation, its fundamental responsibilities remain unchanged, but traffic volumes have increased threefold. At the same time, the nationwide network of radars, navigational aids and communications systems used to provide services to operators of civil and military aircraft is far more extensive and complex.

Operating from centres at West Drayton near Heathrow, Manchester and Prestwick, Scotland, NATS controllers manage flights passing through UK airspace as well as out over the north Atlantic. They also provide services to traffic using key airports like Heathrow, Gatwick, Stansted, London City, Aberdeen, Belfast, Birmingham, Cardiff, Edinburgh, Farnborough, Glasgow and Manchester.

By the mid-1990s, NATS' airport air traffic controllers are handling over 1·5 million flights a year, nearly one third of them using Heathrow.

In fact, record traffic levels are being handled by National Air Traffic Services staff. The latest achievement occurred at 3.06pm on Sunday 25th August, when air traffic controllers at the London Area and Terminal Control Centre (LATCC) at West Drayton, handled the millionth flight of the year to pass through the London flight

information region. This milestone was reached eleven days earlier than in 1995 and 23 days earlier than 1994.

Other movement records broken by National Air Traffic Services this summer include:

- 5,000 movements handled in a day for the first time at the London Area and Terminal Control Centre on 19th July.
- 98 movements in an hour at Heathrow on 18th July. This record beat the previous best by three and included 50 departures and 48 arrivals. The succeeding two hours saw figures of 90 and 89 movements equalling 277 movements in a three hour period, which is also a record.
- 99 movements in an hour across the North Atlantic and 25,729 in a month in July, handled by the Scottish Oceanic and Area Control Centre.

With flights in the UK airspace expected to rise to two million by the turn of the century, forward planning is not a matter of wishful thinking but of necessity. Planning for the Millennium started way back in the 1980s.

By the end of the decade, NATS was embarking upon its biggest and most ambitious programme of investment in Britain's air traffic control infrastructure. The key objectives of the investment programme for the new En Route centre are to:

- Raise air traffic service capacity to match increased demand.
- Improve the flexibility and cost-effectiveness of the services to users.
- Take advantage of new technology, both in the air and on the ground and modernise existing systems to increase reliability and efficiency.

## Without Conflict

The term conflict is air traffic controller euphemism for close encounter of an aircraft kind. As the volume of air traffic grows, increasing emphasis is laid on ways of avoiding potential conflicts between aircraft. All incidents in which a loss of separation is suspected by pilots of air traffic controllers are fully investigated. Pilots who believe their aircraft were endangered by the proximity of another can file an AIRPROX (P) report based on their assessment of their circumstances. There is a similar procedure for reports by controllers, in which case, they are known as AIRPROX (C) filings.

All reports are fully investigated by NATS and also by independent groups drawn from a wide cross-section of the industry, involving both pilots and controllers. They assess each case, following internationally agreed guidelines, to establish a cause and may recommend follow-up action to prevent such incidents recurring. Reports are published to enable the aviation community to learn from the incidents. Despite major increases in air traffic, the number of risk-bearing incidents involving public-transport aircraft is declining.

Technology is already helping to maintain this trend. Airborne collision avoidance systems, which automatically warn pilots of the proximity of other aircraft, are already in use. They will be increasingly common on airlines as more and more countries mandate them.

**With flights in the UK airspace expected to rise to two million by the turn of the century, forward planning is not a matter of wishful thinking but a necessity.**

Since 1988, controllers at LATCC have been using a ground-based system called 'short term conflict alert'. This uses radar data to predict whether any two aircraft are likely to come into conflict within a given time on the basis of computer projections of their current tracks. The system, which NATS' scientists continue to enhance, has also been installed at the Manchester and Scottish centres.

## Sky-high Hi-tech

To ensure that flights pass safely and quickly through controlled airspace, controllers and pilots need to communicate with each other. Controllers must also know the exact position of all the aircraft they are handling.

## Radio

Normally, communication between pilots and controllers is maintained by very high frequency (VHF) and ultra high frequency (UHF) radio telephony (RT). A total of 26 RT transmitter/receiver stations is located around the country, giving controllers at West Drayton access to over 130 RT channels and those at the Scottish centre to over 40.

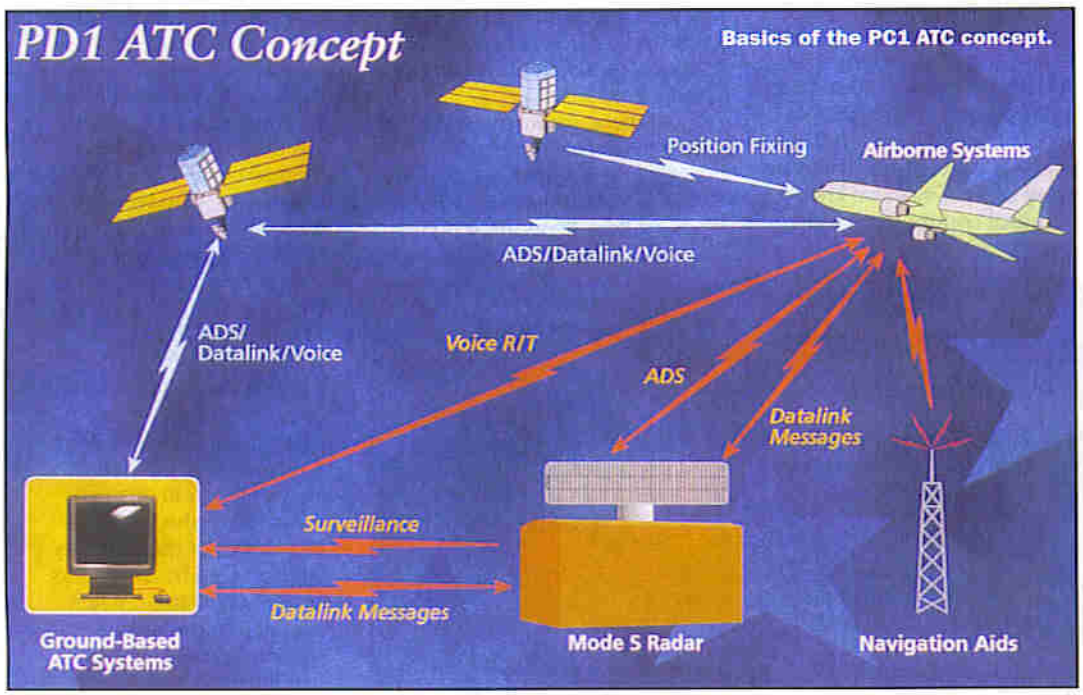
## Radar

Radar provides information which allows controllers to pinpoint the position of aircraft. This information is shown on controllers' displays, which also detail the airways and reporting points in the particular sector for which a controller is responsible. Aircraft flying in controlled airspace must be fitted with a transponder. This is a device which can be interrogated by a ground signal to find out information such as the aircraft's altitude, callsign and destination. This information appears as a label next to the aircraft's position indication on controllers' screens.

Radar displays are fitted in modern workstations which combine the technical features of television and computers. By linking with external data systems, information such as the prevailing weather at any given airport or the order in which flights will arrive and depart, can be selected for display by using a menu in a computer 'window'.

Incoming radar signals are put into digital form and passed to the control centres along a network of landline links with 14 radar stations. Like the radio installations, many are in remote locations and not permanently staffed. However, the technical performance of each one is constantly monitored from West Drayton and Prestwick to ensure continued availability.

Communications between air traffic control units is normally by telephone. West Drayton,



for example, has three separate exchanges. An integrated ground communications network, based on digital technology, has been developed to link NATS' operational and administrative units. All operational telephone messages, together with RT and radar information, are recorded and retained for 30 days as a matter of course for incident analysis.

## Data Processing

Computer-based systems automate those tasks which they can perform more accurately and more rapidly than human controllers can. Such systems are used for processing flight plans and radar-derived aircraft position information. They distribute and display data to controllers and also predict potential conflicts between aircraft, alerting controllers to situations as they develop.

Computers store and retrieve flight plan data, either electronically or on paper strip printouts. They also take data from the network of radar stations, choosing the best source for each part of the controlled airspace and match them to the flight plan information already stored to establish track status for each aircraft in the system and update the flight plan progress. Information to controllers is exchanged on-line between adjacent control systems in the UK and overseas.

**Computers store and retrieve flight plan data, either electronically or on paper strip printouts.**

## Navigation Aids

NATS is responsible for the landing aids at major UK airports and for the nationwide network of navigational aids which enable pilots to fly the UK airways system with precision. The basis of this system is a series of ground beacons emitting radio signals, from which pilots can work out their position.

For long over-water flights, pilots use airborne navigational equipment. Because even the most powerful radar equipment cannot 'see' far out over the ocean, traffic is controlled through regular position reports passed by radio (RT). But the effectiveness of VHF and UHF is also constrained by power losses and the Earth's curvature, so high frequency (HF) RT has to be used. A radio station near Shannon in the Irish Republic relays messages between controllers at Prestwick and the aircraft whose progress they monitor.

## In Safe Hands

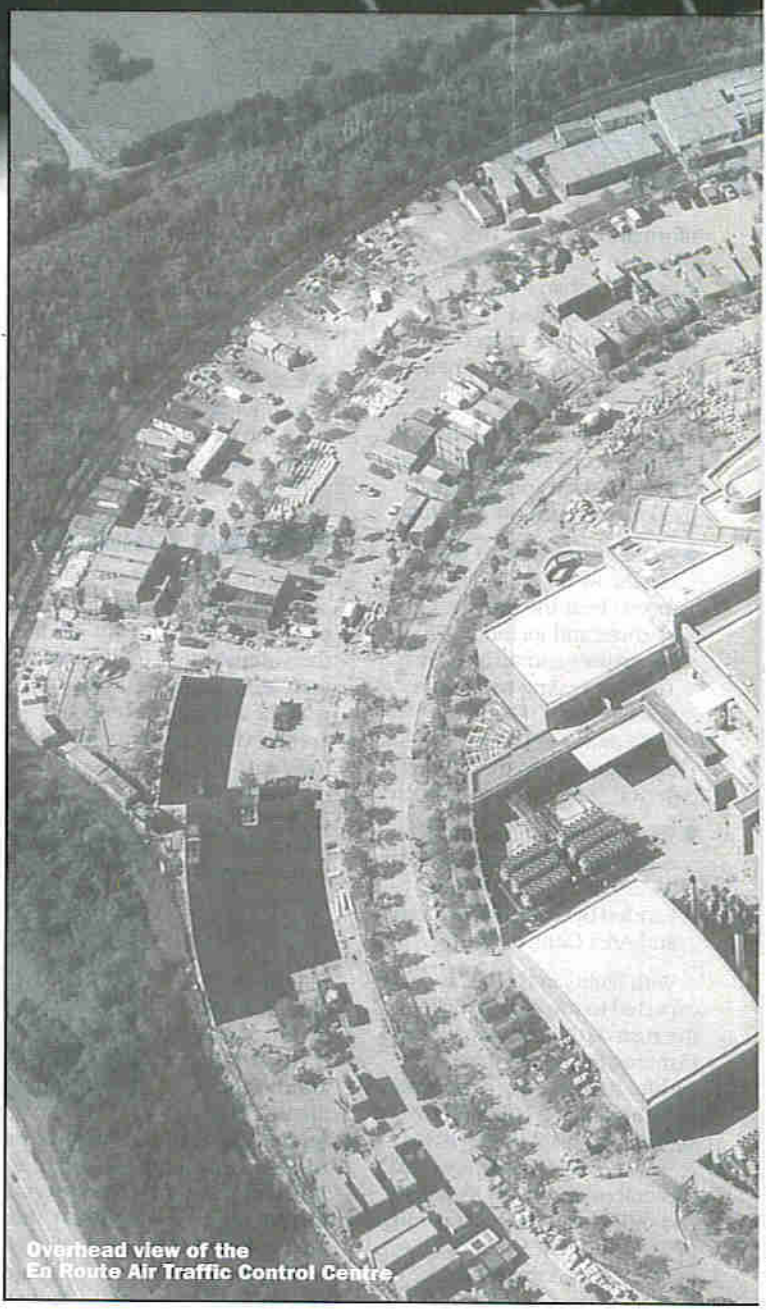
Controllers achieve full measures of safety by allocating different heights to aircraft or by arranging certain minimum horizontal distances between them. These distances vary according to circumstances, but aircraft flying along the airways under radar surveillance, for example, are kept five nautical miles apart horizontally or at least 1,000 feet vertically.

Within the airspace, a network of corridors has been established. These corridors or airways are usually ten miles wide and reach up to a height of 24,000 feet from a base of between 5,000 and 7,000 feet. They mainly link busy areas of airspace known as terminal control areas which are normally above major airports. At a lower level are the control zones which are established around each airport. The area above 24,500 feet is known as upper airspace.

All these areas are designated 'controlled air space' and aircraft fly in them under the supervision of air traffic controllers. Pilots are required to file a flight plan for each journey, containing details such as destination, route, timing and height.

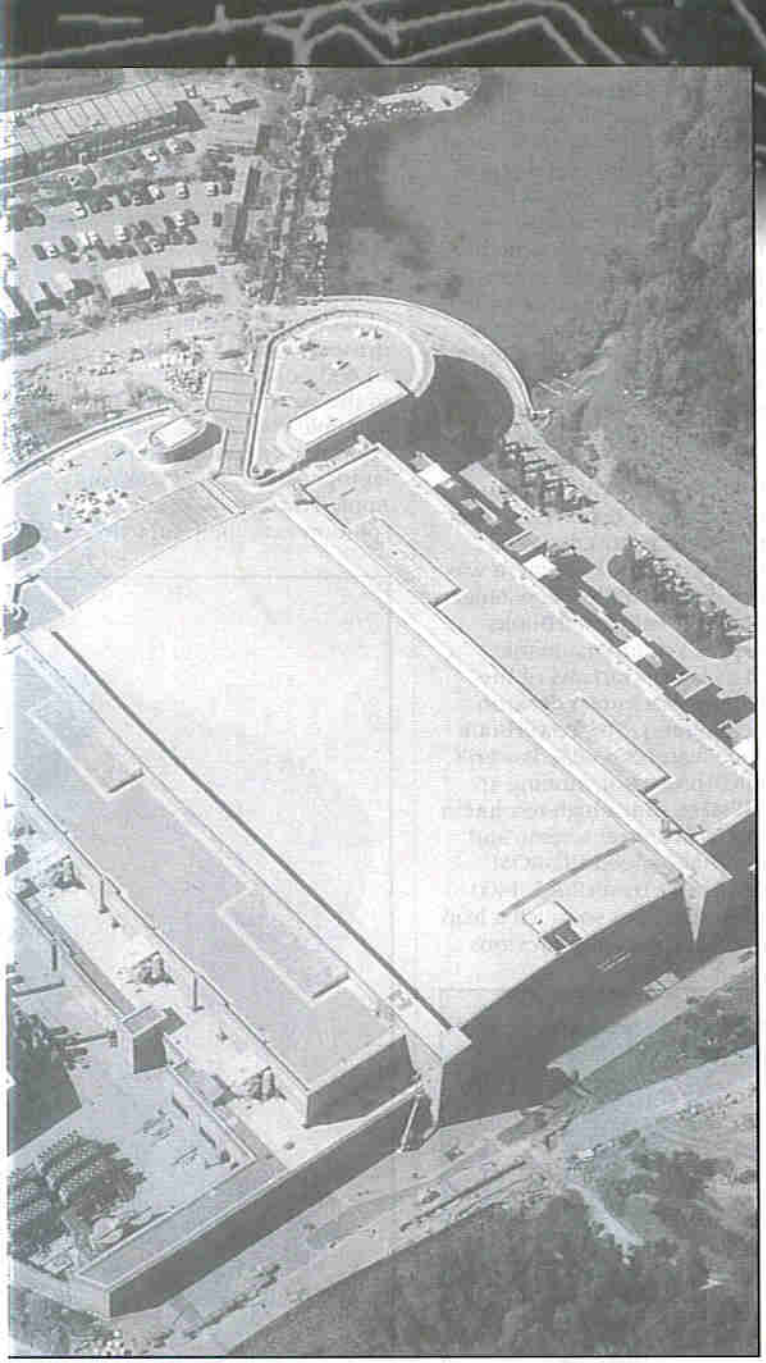
Within controlled airspace, pilots must follow controllers' instructions; outside controlled airspace, they take full responsibility for their own safety, although they can ask for assistance. In fact, military controllers, who work closely with their civilian colleagues to provide a fully integrated service to all users, offer an air traffic service to aircraft in uncontrolled airspace. Military personnel also provide services to aircraft crossing airways and for those flying above 24,500 feet. A priority task for them is aiding aircraft in distress.

Aircraft in the initial or final stages of their journey are managed by controllers at the airport itself. When aircraft join the airways system, responsibility for handling them passes to



Overhead view of the En Route Air Traffic Control Centre.

The new En Route Air Traffic Control Centre at Swanwick, near Fareham, Hampshire.



colleagues working at the appropriate area control centre. A flight through their airspace could pass through several 'sectors' of airspace, each managed by a different team of controllers.

Under international agreement, responsibility for north Atlantic traffic is delegated to five countries: UK, US, Canada, Iceland and Portugal. The UK is assigned the Swanwick Oceanic Control Area. In 1966, the two control centres serving the area, Shannon in the Irish Republic and Prestwick, Scotland, were consolidated at Prestwick. Ireland continues to provide high frequency radio cover for the area. NATS' area control operations in the 21st century will use new centres covering the United Kingdom. This strategy has been evolved to meet greatly increased forecast traffic levels.

## Satellite Reaches Global Parts not Covered by Radar

With 95% of global land mass out of bounds to radar systems and essentially over oceans, deserts and vast sparsely populated land masses, radar cover is not always available to air traffic control. However, a European project known as Automatic Dependent Surveillance (ADS) is providing a solution to the problem.

Radar works on a line of sight principle. This means that as the Earth curves away from a radar station, the signal from an aircraft is gradually diminished. This is not a problem when radar stations are just a few hundred miles apart, but there are parts of the world where such spacing is neither feasible nor economic.

One area of airspace that is of particular interest to NATS is formed by the Swanwick oceanic sectors of the north Atlantic. Because controllers can't 'see' the exact position of trans-Atlantic aircraft when they are out of radar range, aircraft must be kept many miles apart using vast areas of already congested airspace.

**Britain's new En Route Centre will be the biggest and most advanced air traffic control centre in Europe, if not the world.**

The aircraft are controlled using voice position reports on high frequency radio, which is relayed to air traffic control from a radio station in Ireland.

The ADS concept is that anywhere in the world – even where HF radio communications are poor and in airspace not covered by radar – an air traffic control centre can obtain the current position of aircraft, their intended flight paths and other relevant information held on the aircrafts' computer systems. These reports are transmitted automatically, by datalink, to an ATC centre.

Although not a radar replacement, ADS would enable controllers to provide an almost equivalent service. The positions of all the aircraft under the control of a centre can be regularly transmitted, on request from controllers, and displayed on their screens. Since aircraft positions are more accurately known, separations can be reduced and better use can be made of the available airspace, so increasing capacity. ADS will help to provide the increase in airspace capacity required to handle future air travel demands on long-haul routes around the world. NATs success with the ADS EUROPE trial paves the way for the system's implementation into active air traffic control service.

## The Horizon – New Air Traffic Control Centre

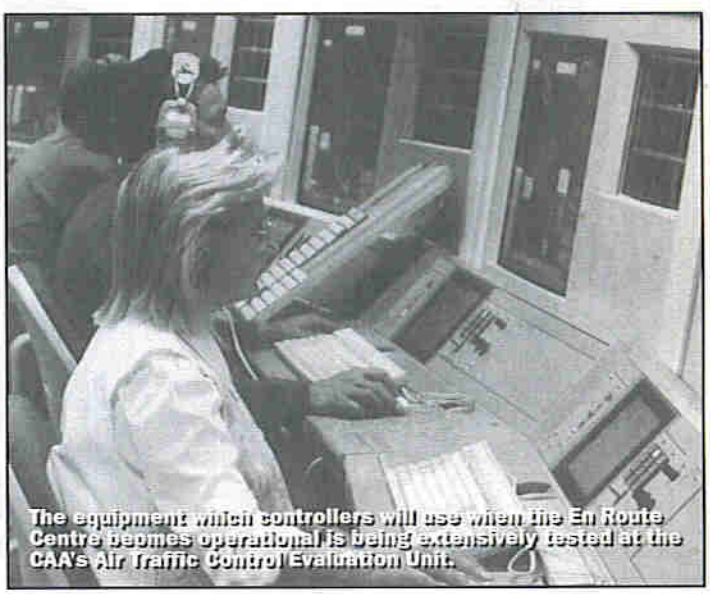
Due for completion in the near future, is the new £350 million plus, En Route Control Centre at Swanwick, Hants.

The operation room – equivalent in size to half a football pitch, is designed to be operational well into the next century.

## Key Facts

Britain's New En Route Centre represents one of the biggest construction and engineering projects in Europe. When complete, it will be the biggest and most advanced air traffic control centre in Europe, if not the world. As a result, its vital statistics are on a grand scale. When completed, the centre will accommodate some 800 air traffic controllers, engineers and other skilled staff, it will be the biggest and most advanced air traffic control centre in the world.

So, next time you are en route for South of France, relax and enjoy your in-flight drink. You are in safe hands.



The equipment which controllers will use when the En Route Centre beomes operational is being extensively tested at the CAA's Air Traffic Control Evaluation Unit.

# Apple EXPOSÉ

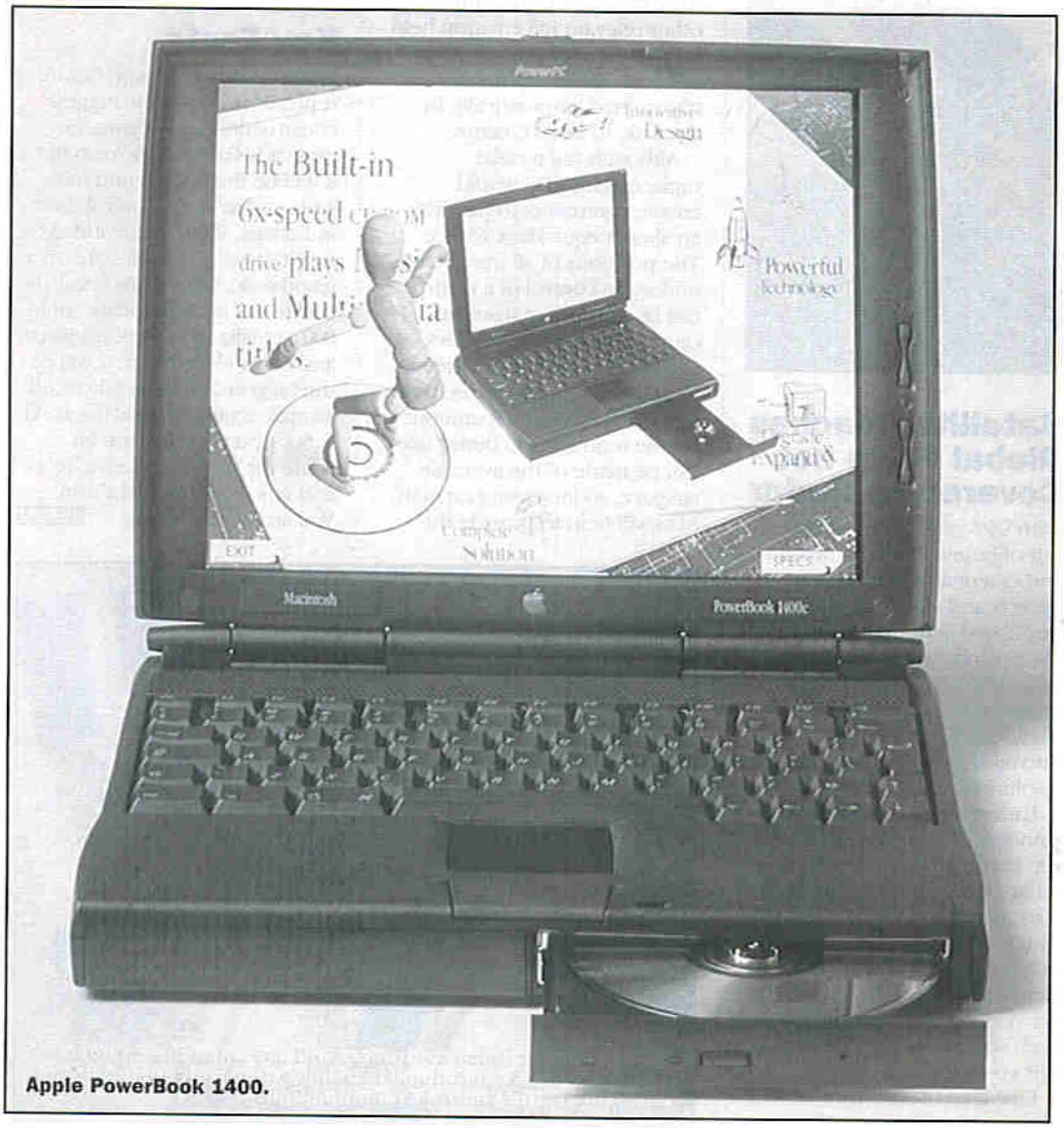
**by Keith Brindley**

***The Apple Expo took place from 6–9th November, at Olympia in London. As usual, it was the place for Apple computer users, and, in fact, is one of the biggest computer shows of the year in the UK. It's also the place to visit if you want to see into the crystal ball of computing's future.***

It's no exaggeration to say that what you see at an Apple Expo will influence computing for several years. Like no other computer or software manufacturer, Apple is busy developing the products and technologies which other computer and software manufacturers will incorporate or emulate for years to come. Without doubt, where Apple leads, the others – sooner or later – follow.

As a result, the Apple stand is always the central feature of any Apple Expo. This year, the stand featured several new products. Prominent was the first of Apple's new range of Macintosh PowerBooks (Apple's brand name for their laptop variants of the famous Macintosh desktop computers). The PowerBook 1400 features a 603e PowerPC microprocessor running at 117MHz, with a high-resolution 800 × 600 pixel screen, and internal 6-speed CD-ROM drive. The PowerBook 1400 represents not so much a leap in technology (the previous PowerBook range was that), but is more of an exercise in creating a cost-effective solution for all computer users – not just the typical Macintosh user – who need a portable solution.

A typical PowerBook 1400 configuration of, say, 12M-byte of RAM and 750M-byte hard drive sells now for around £1,600 or so, for the first time in the PowerBook series' life, an Apple PowerBook undercuts equivalently configured PC laptops. This should make an Apple PowerBook laptop solution extremely attractive to PC users, as well as Mac users (who would have paid a premium, anyway).

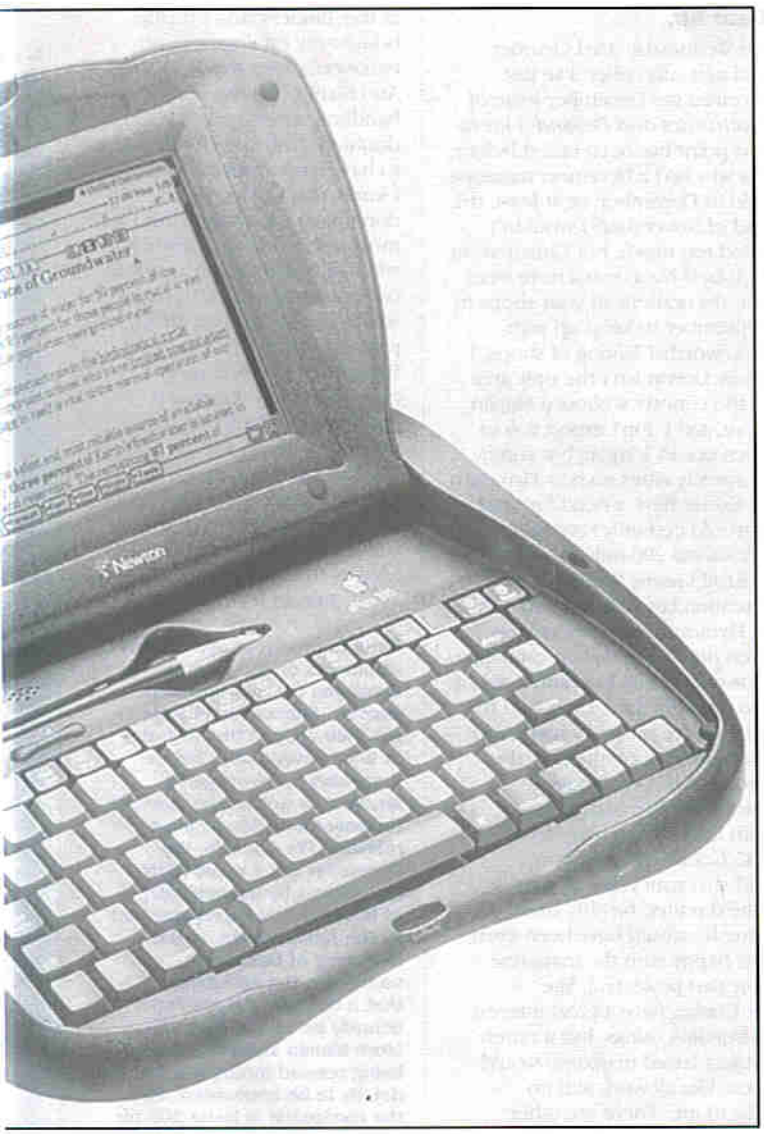


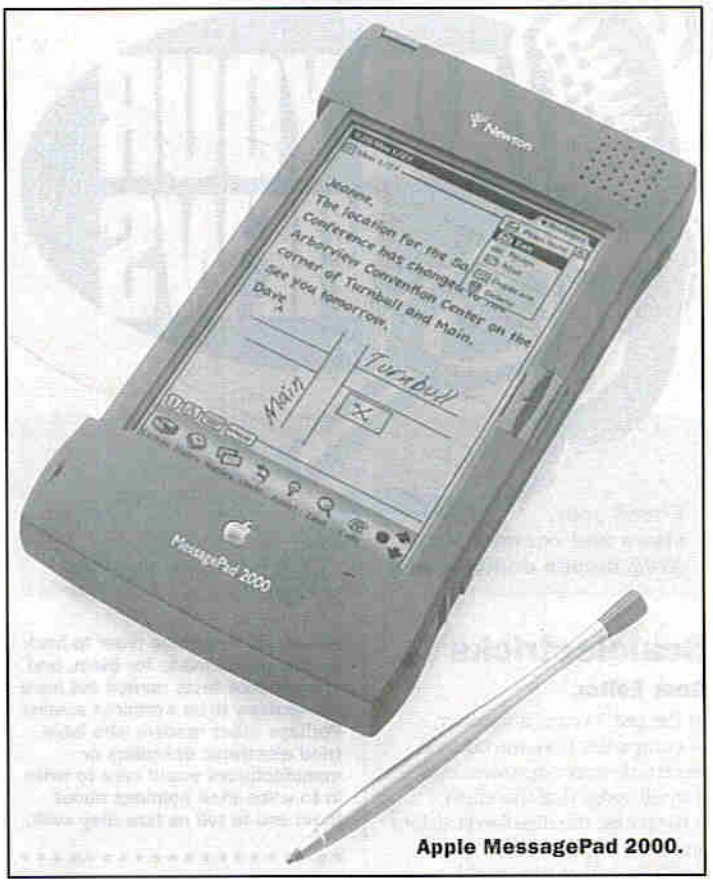
**Apple PowerBook 1400.**


**Apple eMate 300.**

Also on the Apple stand were two new MessagePad personal digital assistant solutions, due for release within a month or two. The top-of-the-range MessagePad 2000 is, quite simply, the fastest and most powerful handheld computer in the world. Sporting a 160MHz StrongARM microprocessor (developed by Acorn RISC

# Apple Expo 1996






**Apple MessagePad 2000.**

Machines in the UK), it's a pocketable device which understands handwriting like no other handheld computer. With a built-in microphone and all its internal power, it's not going to be long before speech recognition software (comparable to that built in to desktop Macintoshes) will be available, which will make this a valuable tool for many people.

The other MessagePad solution is the eMate 300. Unusual for an Apple personal digital assistant, this has an onboard keyboard, and is intended specifically for the education market. Looking something like a large black oyster shell, the eMate 300 has 25MHz ARM microprocessor and features Internet access. It can be connected to Macintosh or PC computers, so will be at home at home, and in any school. It'll be available through Xemplar, the new joint venture between Acorn and Apple, within months.

Elsewhere at Apple Expo, the expected Macintosh clone manufacturers were displaying their wares. It's only recently, of course, that Apple started to licence the MacOS operating system software, so these clone manufacturers were exhibiting for the first time. It's probably fair to say that if Apple had licensed its operating system ten years ago, that the MacOS would be the norm for most of the world's computers. As it turned out (and even Apple agrees this now, in hindsight), other software producers (OK, yes, I mean Microsoft) took advantage of the situation and produced a me-too product which allows PC users to have a vaguely Mac-like interface. Even Windows '95, however, the latest version of Microsoft's Mac-lookalike software, *still* doesn't have the same Mac ease of use, elegance, ability and reliability which Mac users have enjoyed from day one of the Macintosh computer, some thirteen years ago.

Now, though, Apple is intent on putting the matter straight and gaining market share. New licensees of the MacOS are signing up regularly, and more and more clones from manufacturers who have always been thought of as PC-only previously are appearing almost by the week. The MacOS marketplace is very bullish because of it, and it will be very interesting to watch computer trends over the coming years.

Several areas in the Apple Expo were focused on individual solutions. The Electronic Imaging Centre, for example, gave show visitors the chance to see and use the latest video, multimedia and desktop publishing products. Much fuss was made of the many digital cameras now starting to flood the shops. Similarly, the Internet Arena gave visitors the opportunity to try out the Internet, and test all the software and hardware available for themselves. As you might expect, this was a particularly busy area. For those interested in the inner workings of software, the Development Pavilion featured developer products, to aid you in your program writing.

All this, and more, much more, makes the Apple Expo a truly priceless exhibition. If you're a computer user (Macintosh, Amiga, Acorn *or* PC) and you missed this one, try to get to the next one. You'll not regret it.


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

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

## Scalelectricks

**Dear Editor,**

In the last 3 years, a number of companies have introduced electronic water descalers and they all agree that the effect is to change the dissolved calcium and magnesium molecules similarly so that they repel instead of adhering to each other or any other surface. There are various loose and possibly exaggerated statements about the nature of the signal generated. Some types employ a closed loop winding around the water pipe and some use two antiphase open circuit windings. They all claim effective performance on wrought iron, copper or plastic pipes. I am mystified as to:

1. How any pulsing signal can penetrate the effective screening of a copper pipe.
2. How it is possible to use alternatively a closed solenoid winding or two antiphase open circuit windings.

Perhaps you or one of your knowledgable readers could put me wise to this. I would suggest that a comprehensive article would be appropriate for the magazine, covering details of the signal waveform and the necessary circuit to provide this. As a further stage, perhaps Maplin could add a suitable kit to their excellent range of projects. I enclose superficial details of six brands currently being marketed from £100 to £250.

Wilfrid A. Sawyer BSc Eng. C.E. F.I.E.E., Beaconsfield, Bucks.

**One imagines these products to be about as effective as the numerous other 'miracle' gadgets offered to gullible buyers since time immemorial, such as fuel-saving devices for cars, magnetic bracelets and get-rich-quick schemes. Perhaps in a few instances, such products do provide some beneficial effect, but there is usually no conclusive proof to back up the claims made for them, and independent tests carried out have shown many to be worthless scams! Perhaps other readers who have tried electronic descalers or manufacturers would care to write in to voice their opinions about them and to tell us how they work.**

## Danger Money and Them Thar AC/DC Types!

**Dear Sir,**

Recently going through back issues of *Electronics*, I was surprised to read in Issue 63, a topic on restoring vintage radios by Geoff Arnold, about the price of a '1929 Marconiphone receiver'. I must point out that the (1929, 18 Guineas price tag does not equate with £18.90 as printed, since the government of the day removed over 58% of the pound (one of the cons of the century) to the present day decimalisation system. Let me refresh his memory. Before decimalisation, the pound equalled 20 shillings. One guinea = 21 shillings. 1 shilling = 12 pence. Therefore, £1 = 240 pence, 1 guinea = 252 pence. 18 × 252 pence = 4,536 pence. At today's rate of 100p = £1, the correct price should be £45.15 (not £18.90). Whilst on the subject of vintage radios, I was also surprised that Geoff Arnold did not point out the dangers of some types of old radio sets to young enthusiasts, namely, AC/DC types. These sets had chassis and all metal parts at 240V mains potential – quite lethal. I well remember one day at work, some young employees had an old AC/DC set they listened to. I pointed out the dangers to them and to be careful using it, to which one young electrician scorned my advice. Eventually, I persuaded him to put his test prods on the metal parts and he was quite taken aback with his meter reading – it shook him. The dangers also apply to old television sets. Many of them have large capacitors that hold a lethal charge for quite a long time, even after switching off and disconnecting from the mains supply.

R. Howes, Bromley, Kent.

**Thank you for pointing out the potential hazards of working with older radio receivers. As for the currency conversion we seem to remember that 2·4d (old pence) equated to 1 new pence!**

## Up to Date

**Dear Sir,**

It's Wednesday 23rd October and as a subscriber, I've just received my December issue of *Electronics and Beyond*! I know this point has been raised before, but why isn't a December magazine sold in December, or at least, the end of November? I wouldn't mind too much, but Christmas in October? Next, you'll have trees and decorations in your shops in September to keep up with Woolworths! Talking of shops, I know Devon isn't the only area in the country without a Maplin store, and I don't expect you to open one in Torquay, but surely, University cities such as Plymouth or Exeter have a need for one? It would certainly save me the occasional 200-mile round trip to Bristol! I know there was an intention last year to open a shop in Plymouth, the address was even published in your catalogue. However, when I enquired about the opening date, I was told the deal on the property had fallen through. Has anything further been done? Going back to the December issue, I read with interest the letter from J. C. Cooke of Bovington, and also your reply. I guess if he'd waited for this latest issue he would have been even less happy with the magazine – only two projects. I, like Mr Cooke, have a great interest in building things, but a purely project based magazine would seem like all work and no play to me. There are other magazines out there which cover more projects, but the Maplin technical backup, and the availability of components from their own catalogue makes life far easier. I still have issues from when *Electronics* was available just four times a year, and it only went monthly in October 1991, yet it still manages to fill 70+ pages. Times change, and so do peoples' tastes, so *Electronics* has had to change slightly, yet is still selling well to such a fickle race. No, unlike Mr Cooke, my subscription to *Electronics and Beyond* is not in doubt, nor has it ever been. Oh, and what happened to the quality of the schematics in the December issue? They look like you used an old 24-pin dot matrix printer with 17 of its pins missing! As for the new look catalogue, congratulations for including all Maplin products in one catalogue for both business and private users. It may even be worth spending out twice a year just to keep up-to-date. However, please try to make the catalogue available on the date you specify, or even lie about the date. Yet again this year, my local WHSmith store said you were having trouble at the 'binders' and I finally bought my catalogue some two weeks later than expected. And finally! Has the cost of handling orders really almost doubled? Only the charge seems to have leapt from £1.55 to £2.95. I know that orders over £30 don't have this charge, but there must still be many customers who call Maplin to order a few components needed to make small changes to their latest project? Even, dare I say it, Farnell sell to credit-card customers over the phone and have free handling, etc. for orders of just £10.

P.S. How about a page or two dedicated to reader's ideas/projects with space in subsequent issues for other readers to comment?

Richard Rider, Torquay, Devon.

**Good to hear your appreciative comments on the magazine and thank you for your continued support. Subscribers always get their copy of the magazine at least several days before it appears on newsagents' shelves, by which time, perhaps, the cover date seems more relevant. For example, the December issue would reach the shelves by the beginning of November, to be replenished by the January issue at the beginning of December – so there is the possibility that a December issue could actually be sold in December! More Mondo superstores are being opened throughout the UK – details to be announced. See the corrigenda in Issue 109 for reproductions of the affected drawings from Issue 108. The increased handling charge for orders less than £30 dissuades small orders from non-MPS account holders which have the same administration costs as larger ones and can, unfortunately, be uneconomic to process unless the charge is levied. (MPS account holders get free carriage regardless of the order value). We currently have Circuit Maker, which is a forum for reader's circuit designs, one of which is featured in this issue, and readers are most welcome to voice their comments in *Air Your Views*.**

*In this issue, John White of Western Park, Leicester wins the Star Letter Award of a Maplin £5 Gift Voucher for his letter which struck a 'cord'!.*

£5 MAPLIN GIFT VOUCHER

# Star Letter

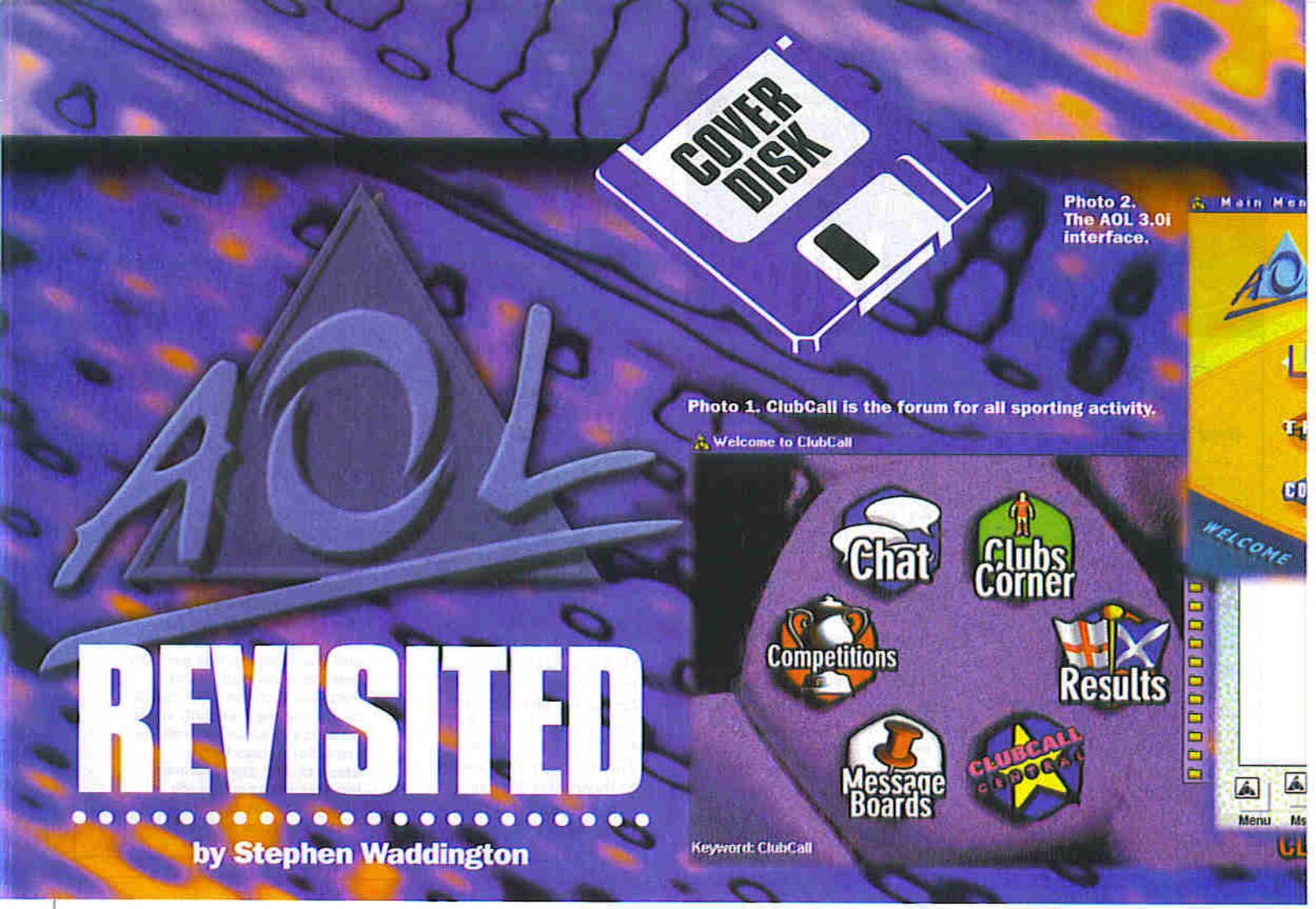
**Dear Sir,**

I am a long-term dabbler in matters electronic, starting with F. J. Camm's emergency wartime 'air-raid shelter' battery radios in *Practical Wireless*, one of which, with headphones, fitted into my army kitbag! I find your magazine of great interest, though I cannot do a lot of practical work nowadays as shaky hands give very unreliable soldering (and plenty of double key-presses on this old 286 PC!), but I try to repair things which no longer work and which I cannot make any worse! Hence, my first point below.

May I ask for help on a couple of topics in the hope that your readers have some answers?

1. Does anyone know where to get drive cord for radio dials nowadays. I cannot find any in your catalogue and I'm sure that radios still use it. I particularly want the very thin (0·015in.) cord as used by Grundig years ago. They cannot help me. The cord must be BRAIDED, not twisted, to avoid stretch.
2. When listening on the 80 metre Amateur Band with only a short indoor aerial, there is much intermittent interference which I am told is due to thermostats. As it is more evident in the winter months, this might explain it (thinking of domestic thermostats only), but I am very puzzled. I would hope that a good thermostat opens and closes cleanly, but hearing all the fizzing, I cannot understand how any contacts can fizz regularly and often for a couple of minutes at a time and have any sort of life expectancy. Any comments? I am sorry to see that your catalogue (1995-6 issue) no longer has, in its Aerial section, the lists of TV and FM stations with Channel numbers and information on the correct aerials to use. I have an old issue, 1993-4, where the lists take up only 7 pages. Surely, an updated list would not add much bulk to an issue of 1,100+ pages and could include 'Channel 5' transmitter channels. (I prefer the nomenclature which my Ferguson video recorder uses, where 'Channel 5' would be 'Programme 5'). The lists were very useful to those who, like me, are curious about these things. In my case, I wanted to know the actual channel for Programme 5 for my area (Leicestershire) as the video recorder gives its output on Channel 60 and so it would not be a problem, and all I would have to do is to tune it and the TV accordingly. I 'phoned the number given in the circular and was told that I should tune to Channel 31, which I did, both 'boxes' having informative displays of their own. With fingers crossed, I await the start-up date! Thank you again for an excellent publication and best wishes to all.

**Non-stretch, non-slip 0·56mm (0·022in.) diameter Drive Cord is available from Maplin (see page 383 of the latest MPS Catalogue), sold per metre under Order Code BL73Q. This should be suitable for most cord-driven radio tuning dial mechanisms. It is possible that the noisy thermostat contacts could be suppressed by connecting a suitably rated (in terms of value *and* voltage) capacitor across them, which should also improve the switching contact life. Your comments on the Catalogue have been noted.**




***AOL needs little introduction. After launching in the UK in February last year, it has taken rival CompuServe head-on and signed up over 50,000 users. Here, Stephen Waddington takes a look at the company's progress to date and reviews Version 3.0i of its client software included on this month's cover disk.***

The current score is CompuServe 300,000 – AOL 50,000. AOL has realised that it needs to innovate if it is to maintain its growth in the UK online market and steal market share from CompuServe. While the aggressive value added Internet Service Provider (ISP) has surpassed CompuServe in terms of consumer content, it has not yet knocked its mature rival from the UK top slot in terms of subscribers. A new software front end, coupled with an array of recent content signings such as *The Mirror* newspaper, *Time Out* magazine and *European Business News* in an attempt to build on its existing base.

But CompuServe isn't the only threat to AOL's growth in the UK. As the Web becomes consumer focused and increasingly intuitive, Internet users are moving across to pure Internet service providers that offer unlimited Web access for a flat fee, but do not provide any of the additional services such as e-mail, news feeds, Internet forums and chat channels.

## Flat Rate

In the US, AOL has attempted to counter this shift towards pure Web services by introducing a flat rate of $19.95 (£12.50) for unlimited usage or $14.95 (£9.50) per month for customers who pay for 2 years subscription in advance and $17.95 (£11.25) per month for those who pay for 1 year in advance. The company has also introduced a light-usage program offering 3 hours access to AOL per month for $4.95 (£3.00), with additional time priced at $2.50 (£1.60) per hour. Unfortunately, there are no plans to introduce this pricing structure to the UK market. The current UK membership fee is £5.95 per month, which includes 5 hours online time each month. Subsequent usage is charged at £1.85 per hour.

**The beauty of a value added Internet Service Provider is that you quickly learn where to go online for information.**

The beauty of a value added ISP such as AOL is that you quickly learn where to go online for information. By contrast, the Web requires a level of understanding. Search engines such as Alta Vista and Yahoo can help locate sites of interest, but for the unfamiliar user, it can be daunting. Such is the growth of the Web that Alta Vista returns more than 10,000 references in response to a keyword search. Boolean searches are not much better, reducing the response by maybe an order of magnitude.

## Comfort

AOL provides a comfort factor. Users know if they want to check the results of a football game, they head for the football forum. If you want to find a restaurant in Glasgow, check out Digital City or if it's a football score that's needed, head for ClubCall as shown in Photo 1 – the online sports forum. Time will only tell if value added ISP's such as AOL and CompuServe will survive. The harsh reality is that almost all of the content on AOL is available somewhere on the Web for free. The challenge is locating what you need. Ultimately, to maintain and grow market share, service providers such as AOL will need to keep their content innovative and fresh, while maintaining competitive cost models.

But for the time being, online service provision remains 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 and quality of client software are also important.

## High Speed Network

AOL has all the UK covered by a local call point of presence (POP). Through the introduction


Photo 3. Icons appear as folders while graphical material downloads.

Photo 4. The AOL Find function.

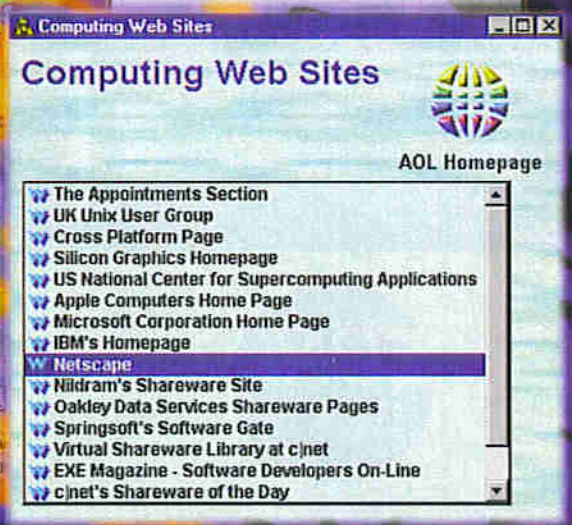




Photo 5. Hyperlinks enable AOL users to jump out onto the Web.

## AOL Version 3.0i

A new look – 3D graphics and arlimation is a more engaging and vivid interface.

- **Faster art delivery**
  No more dreaded blue bar.
- **Better navigation**
  Find features, integrated hyperlinks.
- **Enhanced Web browser**
  Support for HTML 3.0i and Netscape extensions.
- **Improved performance**
  Web pages download up to 35% faster.

**Table 1. Highlights of AOL Version 3.0i**

of a new 0845 number, subscribers can dial a single number from any UK location and get online with AOL at local call rates. AOL also has local dial-in access from 600 cities in more than 90 countries worldwide. What makes AOL even more appealing is the fact that all connections points are at 28·8k-bps, allowing users with high speed modems to make full use of available bandwidth. And AOL is one of the ISPs to sign-up to US Robotics x2 standard, so it's possible – given a modem from US Robotics – to get a connection at 56k-bps over a standard telephone line.

## Enhancements

So what's new about AOL 3.0i? As we reviewed the original version of AOL – version 2.5i – in April 1996, consequently, we've picked out some of the key enhancements of AOL 3.1i against its predecessor. The principal features are shown in Table 1.

The first change you'll notice in AOL 3.0i from Version 2.5i is the dynamic new look, which incorporates 3-D graphics and animation and offers a more vivid and engaging interface, as shown in Photo 2. For starters, the new Welcome screen provides streamlined navigation from a single, intuitive interface to the most popular areas on AOL and the Internet.

## Faster Art Delivery

Art delivery enhancements give you the best of both worlds: the ability to quickly explore AOL while receiving a wealth of eye-catching graphics. The annoying blue bar accompanied by the message 'Please wait while we add new art to AOL' has disappeared – but not totally. It appears occasionally when you need to load large files such as the Web browser. On these occasions, you are not charged for online connect time.

In the past, members have been reluctant to explore new areas of AOL, because downloading images could be time-consuming. AOL 3.0i addresses this problem by employing image rendering, which lets members enter an area before the images have finished downloading. While graphics are transferring in the background, temporary icons appear as folders as shown in Photo 3, allowing members to move ahead even as the images are downloading.

As AOL continues to add new content areas, it will continue to offer members the option to receive art. Progressive rendering is one solution to speed the way members receive dynamic new art and multimedia, while preserving the online experience for the many members who continue to access AOL using lower speed modems.

**AOL 3.0i includes a Find function to help members locate areas of interest on AOL faster and easier.**

## Toolbar

The toolbar has been completely transformed for AOL 3.0i, but not for the better. AOL reckon it is larger and more clearly identifiable. We reckon it's completely nasty. The graphics are completely unrecognisable as the functions they are supposed to represent. Fortunately, the software has been written initially for Windows '95 and includes the Microsoft specification pop up menu bar descriptions. When the cursor is held over, a menu icon on a text bar appears describing the function of the icon.

AOL 3.0i includes a Find function, as shown in Photo 4, to help members locate areas of interest on AOL faster and easier. Amazingly, this was not provided in version 2.5i. Find is divided into three broad categories: People, Places and Things, and Events. These categories provide access to an enhanced directory of the thousands of areas on AOL. Using this directory, members can locate members online, find software files containing sound clips, search for the latest Web sites, and look up live chats taking place across AOL.

## Automatic Updates

The new Update Tool on Demand feature in AOL 3.0i ensures that members are using the latest updates and features. AOL can now update any part of the AOL software on a member's hard disk, directly through the modem connection. Previously, new tools could be added, but existing tools could not be updated. Now updates are automatically handled by AOL, without requiring the member to reinstall the AOL client software.

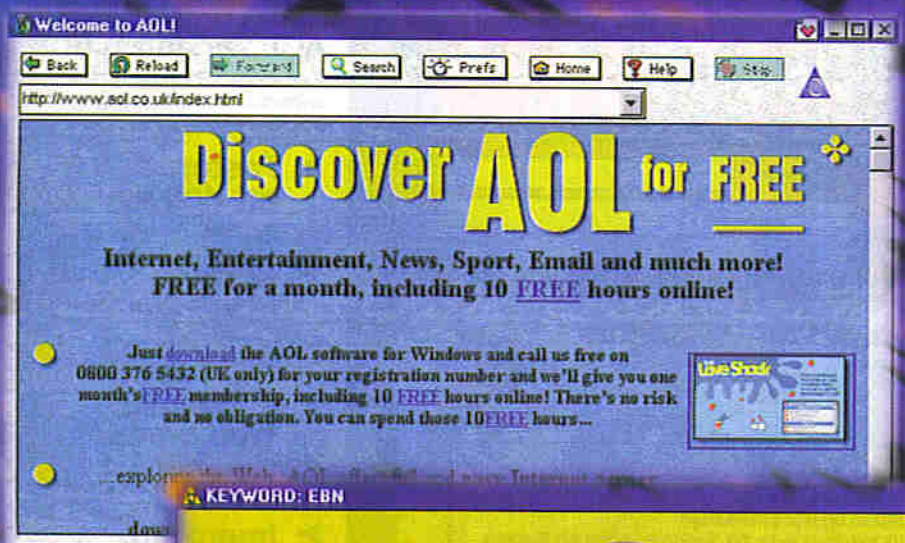
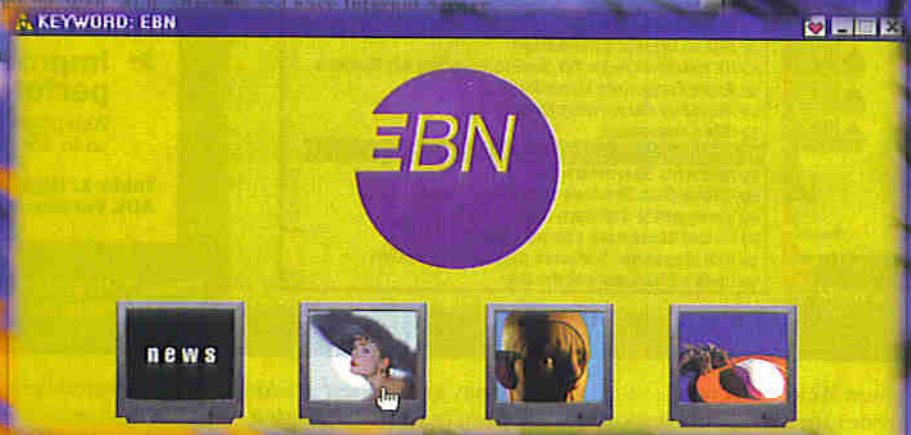



**Photo 6. The AOL 3.0i Web browser.**




**Right: Photo 7. European Business News.**

**Below: Photo 8. Inside Soap for soap addicts.**



**Photo 9. Planet Ealing.**

## Hyperlinks Within AOL Content

With the introduction of AOL 3.0i, members will find more content on AOL that includes hyperlinks. These enhancements are aimed at helping members navigate to related areas in AOL or on the Web more efficiently by using links, as shown in Photo 5.

A really neat feature of AOL 3.0i is the ability to include hyperlink within an e-mail message. Web sites can be referenced by including the URL in the text of the message. To view the Web site, the recipient simply clicks on the URL on the link to go to that place.

## Web Capabilities

AOL has revised its Internet browser. The AOL 3.0i Web browser, as shown in Photo 6, embraces existing standards with support for HTML 3.2 and Netscape Extensions. These additions to the HTML markup language include tables, frames, centring, backgrounds, alignment, text wrapping around images, font styles, and client-side image maps.

The AOL 3.0i Web browser and servers have been optimised for even faster performance. AOL claims that it is up to 35% faster than the browser in Version 2.5i. AOL's Web technology uses compressed graphics so images on Web pages download quickly. As images are downloaded from a Web site, they are sent through an AOL server before appearing on your screen. At the AOL server, the images are compressed to speed their transmission to members.

If you would prefer to use Netscape Navigator or Microscope Explorer to browse the Web, then either of these applications will sit on top of AOL 3.0i. Whenever you log onto AOL 3.0i, it immediately creates a connection to the Internet. Other Internet software can access this connection directly from the PC. IP addressing and interfacing to the Internet is handled seamlessly by the AOL server.


## New Content

What sets AOL ahead of its competition in terms of consumer appeal is its content. According to Jonathan Bulkeley, managing director, AOL UK, "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."

AOL's UK service has been fuelled by a potent combination of its members, its home grown areas and services, and the great contribution that its third party information providers have made. These organisations include: The All England Tennis Club (Wimbledon); Haymarket Publishing (*What Car?*, *AutoSport*); Club Call (Sports reporting); Deadline (Tank Girl); Terris; Anglia Multimedia (Education) and Mirror Group Newspapers (*Daily Mirror*, *The Independent*, *Daily Record*). And there's more.

## Online Business News

AOL has teamed up with EBN (European Business News) to carry news and programming from an entirely European perspective, as shown in Photo 7. EBN on AOL offers a genuinely interactive service to appeal to the business person in everyone, via their laptop, office or home PC. In addition to EBN's regular service currently available on cable and satellite, AOL subscribers will also have access to World Market Outlook – an upbeat summary of world news and markets, News Focus – a topical look at the world of business, and Special Events.

**The AOL 3.0i Web browser and servers have been optimised for even faster performance.**

EBN delivers the most up-to-date business news, weather, travel and information. As part of the Dow Jones global television network, EBN can draw upon an impressive array of news-gathering sources, including the Wall Street Journal bureaux and the AP-Jones Newswire.

## Soap Online

Soap aficionados everywhere can relax. *Inside Soap*, shown in Photo 8, is the nation's only authoritative fortnightly guide to every British and imported soap opera. It is now available 24-hours a day on AOL, the world's largest online service provider. All the facts, plot-lines, gossip and pics., plus interviews with all your favourite soap stars, can be accessed at the click of a button.

**AOL has added several features that allow members to customise and personalise their online experience to suit their tastes**

So, even if you've lost the thread of *EastEnders*, the scandal down the Street, the hang of *Home and Away* and are missing Terry from *Brookside*, the interactive nature of AOL means that you can hold your own in any soap-based chat that might come up; whether at home, the office or in the pub. It's even possible to swap views and opinions with fellow fans via the chat rooms and message boards online.

## Films

Meanwhile, Planet Ealing, as shown in Photo 9, contains up-to-the-minute reviews and listings of the latest film releases, as well as a valuable archive of over 10,000 movies from the *Time Out Film Guide*. In addition to the service's reference sections, there are forums in which movie goers can discuss their last trip to the cinema, albums of movie stills and soundbytes, and multimedia film clips. There's also a monthly competition, with the opportunity to win highly coveted movie trivia and memorabilia, and easy access to the Internet Web sites of leading film production companies and studios, including Disney, Paramount, MGM and Universal. Additionally, an area covers new and forthcoming releases.

## Customise AOL

Over the years, AOL has added several features that allow members to customise and personalise their online experience to suit their tastes. Within AOL 3.0i, these features are grouped together in a service called My AOL, a one-stop shop for making the most of your membership. My AOL includes the basics steps for new members: passwords, screen names and basic preferences. There's also a special section on FlashSessions, which allow members to save online time and money by composing and reading mail offline. FlashSessions also automate file up/downloading, and Internet newsgroup usage.

Finally, My AOL has customisable features that members can use to make AOL work directly for them. These include personal publishing on the Web, news clipping services, a personal address book, parental controls and member-created AutoTours of AOL and the Web.

Perhaps this personalised feature is AOL's ultimate weapon. None of the other value added ISPs provide anything similar. A recent report from Forrester Research examined the new online trend away from the Internet as a broadcast mechanism to a personalised medium that addresses consumers' individual needs and preferences. Forrester claim that the advent of lower-cost site personalisation will generate Web-wide changes. As the general content of the Web gets broader, individuals will cease aimless surfing activity and gravitate toward sites that deliver products and services customised to their needs. Sites must plan now to respond to this expectation or risk being left behind as the Web changes to a personal medium. AOL might just be at the forefront of this trend. BEYOND

### AOL Contacts

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

### Recommended System Requirements for AOL 3.0i

| | |
|---|---|
| CPU | Intel 486 or Pentium |
| Operating System | Microsoft Windows 3.1 or Windows '95 |
| Memory (RAM) | 8M-byte |
| Hard Disk Space | 15M-byte |
| Modem | 14-4k-bps |

### Getting Online with AOL 3.0i

If you already using AOL 2.5i, then upgrading to AOL 3.0i is straightforward. Follow the installation procedure below. The setup routine will copy over all the personal information from AOL 2.5i. After this, you can remove AOL 2.5i from your system by deleting the folder c:\aol25i and its contents. The AOL 2.5i icon can be removed from your desktop by highlighting it using the cursor and then pressing the delete key.

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 you 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.
- AOL for Windows Setup will boot-up and run through some preliminary hardware tests before installing AOL 3.0i to the hard disk.
- The installation routine takes approximately 5 minutes. Once complete, an AOL icon will be added to your program manager. To get online, double-click on the AOL icon.
- AOL 3.0i will guide you through a series of initialisation menus to set-up the modem connection before signing on to AOL.
- Once online, insert your registration number and password from the cover disk.
- 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.
- Finally you need to choose a password. This is required each time you go online, so choose something familiar, but not 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.

**Apple Platform**
Apple users can download the US version of AOL 3.0i from the AOL Web site at `http://www.aol.com` by selecting the Download button from the home page

# @Internet


**AOL version 3 is more-or-less out on general release, on both Windows and Mac operating system platforms. Well worth the download time, it clears up many anomalies in aspects of the AOL interface and gives many new features worth having. It's now got an integral Web browser (rather than the previous separate application) which bears more than just a passing resemblance to Microsoft's Internet Explorer. A nice touch is that you can use your own preferred Web browsers (as well as any other third-party TCP-based software such as e-mail and file transfer protocol programs) once you're online via the standard AOL setup procedure.**

**This new version brings AOL bang up-to-date with what you might expect an online service to be. Microsofts own online service, the Microsoft Network (MSN), shifted the goalposts rather when it launched not too long ago, but the other main on-line services – AOL and CompuServe – saw the writing on the wall and initiated the development to match Microsoft's intentions. When Microsoft announced it was to reposition the Microsoft Network as an Internet provider with an albeit graphical front-end, AOL and CompuServe both announced similar intentions. With AOL version 3, the repositioning is complete for AOL users.**

**Of the three, AOL wins in terms of ease-of-use. It has a much simpler interface, yet is fully adaptable to suit personal requirements. To help, AOL's network of local call high-speed national access points, together with – as yet – an underused backbone network (it has fewer numbers of users to date) mean that it is currently also the fastest of the three – by far. Finally, the allowance of up to five mailboxes means AOL can be used by the whole family, say, or by individual members of a small business.**

## This is a Stick-up

Believe it or not, WebTV set-top boxes which let users surf the World Wide Web from the comfort of their armchairs are dangerous – and that's official!

The boxes, made by Sony and Philips, and for sale in the US for a couple of months now, use technology which, in the eyes of the US Department of Defense, is too good to allow them to be sold outside of the States. As a result, and to prevent them being sold abroad without a difficult-to-obtain export license, they have been classified as *munitions*. The technology involved is state-of-the-art encryption, which allows users to shop electronically on the Internet by sending credit card and banking information securely. This ability is a strong feature in the devices, of course, and without it, the manufacturers wouldn't want to market the boxes anyway.

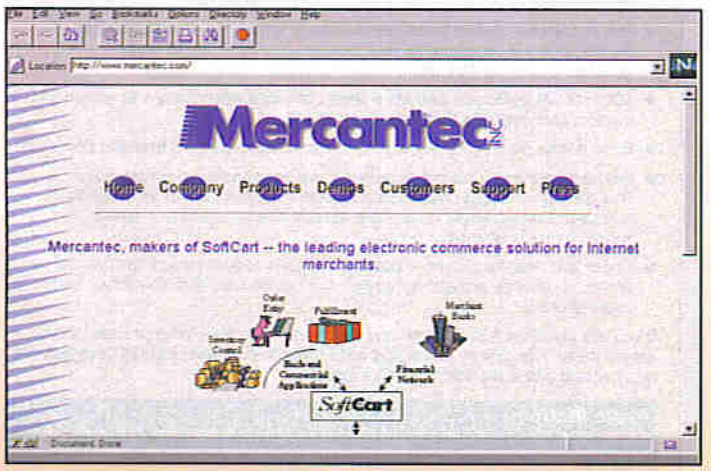
If the encryption systems become commonplace, the Department of Defense fears it won't be able to unscramble messages sent in coded form between society's nastier elements like terrorists, drug smugglers and so on. So, we may have to wait for a while yet before we see these devices in the UK.

## Floppy Recycling

Once you've loaded this month's cover disk, check out **http://www.neosoft.com/nikki**. This site is packed full of alternative ideals for recycling computer disks, particularly those from AOL. It includes Blue Peter project-type ideas such as a clock, Christmas decoration and pen holder. AOL is renowned in the US – and increasingly in the UK – for bombarding consumers with free cover disks.

Alternatively, you could send your unused floppies to 'The Floppies for Kiddies Recycled Diskette' Project at **http://www.usacitylink.com/disks**. This project is being organised by CityLink at **http://www.usacitylink.com** who are appealing for unused, but still usable, floppy disks for schools and other non-profit organisations that use computers.


## Web reveals Credit Card details




Web shoppers using the SoftCart transaction software application have recently had their worst fears about electronic commerce confirmed – the credit card information they trustingly typed into Web templates was accessible by anyone using a conventional Web browser. The sites affected had improperly installed the SoftCart server application, developed by Mercantec to handle financial transactions over the Web.

"Our standard documentation clearly explains how to avoid these security break-ins", Andrew Parker, president, Mercantec told *Electronics and Beyond*. The problem was attributed to human error, which occurred when inexperienced installers failed to place completed order forms in directories not accessible to Web browsers.

For further details, check: **http://www.mercantec.com**.

Contact: Mercantec, Tel: (+1) 630 305 3200.

## Psion gets wired


Psion and CompuServe Network Services (CNS) have teamed up to provide PsiMail Internet users with Internet access. Users of PsiMail Internet can create, send and receive e-mail messages – even messages with files and documents attached.

The PsiMail Internet suite includes a web browser and a complete set of Internet tools that test if a host is responding and show the route taken by data as it travels across the Internet.

PsiMail Internet allows users to access the net through any Internet service provider. For those who do not currently hold an Internet account, the software will run a registration utility that will connect to the Internet via CompuServe Network Services' global dial-up network.

By using this network, users can get on the net with a local phone call from almost anywhere in the world. Signing up for an Internet account can be done directly from the Psion palmtop.

For further details, check: **http://www.psion.com**.

Contact: Psion, Tel: (0171) 317 4100.

## AOL Combats Junk E-mail

Following complaints from users over junk e-mail, AOL has launched, a new tool – PreferredMail – that gives each member an easy way to decide whether or not to receive junk e-mail from certain sites.

"Junk e-mail is the number one complaint from our members", said Steve Case, chairman and CEO of America Online. "We have a strict policy against AOL members sending unsolicited mass mailings and we want to give them the tools to protect themselves from junk mail sent from outside AOL. PreferredMail is a strong and fair response to the junk e-mail problem. It's easier to use and more powerful than the mail controls currently available to AOL members, and flexible enough to allow individual members to receive junk e-mail if they wish."

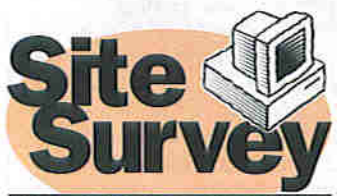
The PreferredMail tool prevents the receipt of e-mails from a regularly updated list of notorious junk e-mailers. The targeted junk e-mailers routinely send mass quantities of unsolicited e-mail and have elicited a large number of member complaints over a short period of time.

Any members who wish to receive mail from these sites can turn off the PreferredMail tool using a simple process. By using keyword: PreferredMail, members can view a list of sites and choose to receive mail from those sites with one click of their mouse.

In the past, AOL had blocked all junk e-mail to all AOL accounts from a limited number of sites that had been the subject of vast numbers of member complaints. Those blocks have been lifted now that the PreferredMail safeguard is in place.

For further details, check: **http://www.aol.com**.

Contact: (0800) 279 1234.




See page 78 for this month's destinations



## US Robotics Shatters Speed Barrier

Internet Service Providers (ISP) have clamoured to sign-up to US Robotics' x2 technology after Netcom became the first ISP to endorse the proprietary standard last month. The x2 protocol increases the top speed of a standard modem for downloading data from 28·8 or 33·6 to 56k-bps – equivalent to the speed of many Integrated Services Digital Network (ISDN) connections.

US Robotics submitted a proposal for 56k-bps modem speeds to the ITU-T in September. As a key contributor to many past standards, the company plans to lead the effort to standardise 56k-bps technology worldwide. However, because of the typically lengthy time to bring a standard to fruition, US Robotics has brought x2 to market immediately.

Surfing the World Wide Web has become immensely popular, but the increase in complex graphical content on web sites has slowed the downloading process – x2 substantially speeds up the delivery of information and reduces time wasted waiting for information, thereby increasing productivity for users.

Because of US Robotics' flexible software-based modem architecture, the company also has the capability to add both proprietary protocols and standards to its products, ensuring compatibility and connections with other products at the highest speeds available. In many cases, individuals will be able to obtain a simple, inexpensive upgrade for their US Robotics modems. Existing US Robotics Sportster modems can be upgraded to x2.

For further details, check: **http://www.usr.com**.

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

## Orange makes Three

UUNET PIPEX has become the only Internet Service Provider to offer direct cellular Internet access via the UK's three largest cellular networks – Orange, Vodafone and Cellnet. This announcement follows the launch of Orange Internet Direct – a service which provides direct connectivity from the range digital cellular network to the UUNET PIPEX dial-up network.

Direct cellular Internet access provides customers with a faster and more economical way of reading and sending e-mail, as well as accessing the Web using the Internet and a mobile phone.

With the launch of Orange Internet Direct, PIPEX Dial customers sending mobile data via the Orange network can

now benefit from faster connection times as well as calls charged at Orange to Orange rates – half the cost of the standard cellular call charge. Before the direct connection between the two networks, the normal route for data transmission involved data being transferred via a modem and a separate telephone network.

For further details, check: **http://www.pipex.co.uk**.

Contact: UUNET PIPEX, Tel: (0500) 474739.

## UK Education Forum Debuts on CompuServe

The edIT Exchange, a new charity promoting information technology in education, has launched an online forum on CompuServe for people working and interested in education.

"For far too long now, teachers and schools have been reinventing the wheel in isolation – even where there is a similar school across the road", said Michael O'Meara, education director of The edIT Exchange.

"We want to see educational resources shared efficiently and effectively across the whole UK – there are nearly 30,000 IT teachers alone, many working within similar structures and objectives. If all teachers have access to their peers, parents and quality models of policy documents, they will be able to put many hours of time and energy back into the classroom. What better way to improve our standards of education", added O'Meara.

For further details, check: **http://www.compuserve.co.uk**.

Contact: CompuServe, Tel: (0800) 000200.

# @Internet


## Cafe Menu From Apple

In partnership with Mega Bytes International, a firm owned by London real estate developers, Apple is opening an international chain of 'cybercafe' restaurants offering customers Web access, desktop videoconferencing, and a full menu of international foods.

The restaurants will also be used to sell Macintosh software, and will be designed by Landmark Entertainment, a theme-park development firm that has undertaken such projects as 'Jurassic Park – The Ride'.

For further details, check: **http://www.apple.com**.

Contact: Apple, Tel: (0181) 569 1199.

## BT, MCI and Microsoft Develop Global Intranet Services

BT, MCI and Microsoft have expanded their alliances to develop a new range of global intranet services. The new services will be marketed worldwide by BT and MCI and offered by Concert, the existing BT and MCI joint venture global communications company. An intranet is a private Internet environment with access limited to a specific audience, such as employees of a corporate organisation.

The portfolio of intranet services will combine the global networking expertise of BT, MCI and Concert with the leading network and desktop applications offered by Microsoft. It will include Concert managed data networking services, available from more than 800 cities in more than 50 countries, provided by BT and MCI.

Stephen Von Rump, MCI's vice president of Enterprise Marketing, told *Electronics and Beyond*, "The obstacle facing our global customers is not in determining if an intranet makes sense, but rather, how they are going to build it without losing momentum and integrate it with their existing complex enterprise environment."

"We have built intranet applications for hundreds of our customers with locations in the US, both as stand-alone networks and as part of larger enterprise solutions, and now look forward to extending the benefits of intranets to our customers on a global basis", Von Rump added.

For further details, check: **http://www.bt.com**.

Contact: BT, Tel: (0171) 406 8314.

# Site Survey

## The month's destinations

If you're looking for a new or second user car, cut down your travel by letting your fingers do the walking on your computer keyboard. A new site, The Virtual Showroom, at **http://www.virtual-showroom.co.uk** is a Web-based car showroom which interacts directly with nationwide car dealers' networks. So far, some 500 car dealers up and down the country have joined The Virtual Showroom and names like Network Q, Inchcape, Arnold Clark and so on are all on board.

While not a new concept – as you'd expect, similar Web sites have been around for a while in the States – it's the first of its kind in the UK. Literally all the stock held by car dealers on the network is accessible to on-line users, as part of a database based on the dealers' own dealer management systems (DMS).

For someone looking to trade in a car to buy a new or second-user vehicle, it's a simple matter of entering your car's details in a forms-based series of Web pages, together with the details of the car you want. Your trade-in price comes back, and a list of available vehicles to your requirements is displayed, along with the dealers holding the vehicles.

Checkout **http://www.digichem.co.uk/welcome.html**, where you'll find the home of the Digital Chemistry Company in Australia. DigiChem produces a serious organic chemistry database and you can find details of it here. However, for personal, home, or educational use, DigiChem also produces a couple of neat shareware products. Periodic is a database which contains some 27 data fields of information for each of the currently known elements. All data can be viewed graphically by period, group, or individually. MoleCalc is a sister program which lets you enter and display formulae using chemical notation, as well as calculate atomic weights and uncertainties. These are Mac-only products (that is, they're not available for other computers) and you can download them from any Info-Mac archive mirror sites around the world. Try: **ftp://mirrors.aol.com/pub/info-mac/**.


**Above: The Virtual Showroom.**

**Below: DigiChem home page.**

# ELECTRONICS and Beyond next issue

**Another entertaining assortment of easy-to-make projects and essential electronics information aimed at the novice constructor.**

## Educational Mini Circuits

**PLUS** Air Time Billing from Alan Simpson takes a close look into how the telecommunications industry goes about the deft art of billing its customers.

Lightning: Its Nature is a 2-part feature by Greg Grant, covering past and present understanding of lightning, its causes and effects.

Magnetic Resonance Imaging by Douglas Clarkson examines advanced body scanning technology used in the diagnosis and treatment of patients.

Shortwave Listening Today from Ian Poole tunes into the fascinating world of amateur and CB radio, and reveals the meaning behind Q, RST, SINPO and Morse codes.

Video Projectors are growing in popularity as the cheapest means of showing large images. Reg Miles investigates the technology and forthcoming developments.

Part 3 of Audio Delay Line Systems by Ray Marston inspects modern digital audio delay line systems and explains their operating principles.

The fifth episode of PIC Programming by Stephen Waddington covers the instruction set for the PIC16C84 and the development of microcontroller-based applications.

In Part 2 of What's in a Name?, Greg Grant chronicles how the terms Baud and Erlang came into being, and how their values are calculated.

Surface Mount Technology Today and Tomorrow from Ian Davidson picks and places present and future developments in component miniaturisation.

Maplin Catalogue Keycode Number Translator is a BASIC program written to convert Maplin Catalogue Order codes into Keycode system codes, to make telephone ordering quick and easy.

## Programmable Centronix I/O Interface

**A general-purpose I/O card suitable for most computers, designed to connect directly to the Centronix printer port.**

## Polarity Checker for Mains

Test wiring concealed behind mains wall sockets quickly and safely with this handy checker that highlights polarity and earthing faults by means of triple neon lamps.

## Video Optical Isolator

*Eliminate interference and hum from video equipment and improve the quality of your replayed pictures using this useful project.*

## Circuit Maker

An Alarm Zone Filter to reduce false triggering of household burglar alarm systems.

**Issue 111 on sale Friday 7th February**

ELECTRONICS and Beyond

BRITAIN'S BEST MAGAZINE FOR ELECTRONICS

### Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:


Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering, side cutters, pliers, wire strippers, and screwdriver). Test gear not required and no setting up needed.


Easy to build, but not suitable for absolute beginners. Some test gear (e.g. multimeter) may be required, and may also need setting-up or testing.


Average. Some skill in construction or more extensive setting-up required.


Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.


Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

### Ordering Information

Kits, components and products stocked at Maplin can be easily obtained in a number of ways: ❶ 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, telephone (01702) 554002. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance; ❷ Write your order on the form printed in this issue and send it to Maplin Electronics PLC, P.O. Box 777, Rayleigh, Essex, SS6 8LU. Payment can be made using Cheque, Postal Order, or Credit Card; ❸ Telephone your order, call the Maplin Electronics Credit Card Hotline on (01702) 554000; ❹ 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, telephone (01702) 554002 and we will happily issue you with one. Payment can be made by credit card; ❺ If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place your 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; ❻ Overseas customers can place orders through Maplin Export, P.O. Box 777, Rayleigh, Essex SS6 8LU, England; telephone +44 1702 554000 Ext. 376, 327 or 351; Fax +44 1702 554001. Full details of all the methods of ordering from Maplin can be found in the current Maplin Catalogue.

### Internet

You can contact Maplin Electronics via e-mail at `<recipient>@maplin.co.uk` or visit the Maplin web site at `http://www.maplin.co.uk`.

### Prices

Prices of products and services available from Maplin shown in this issue, include VAT at 17.5% (except items marked NV which are rated at 0%). Prices are valid until 28th February 1997 (errors and omissions excluded). Prices shown do not include mail order postage and handling charges. Please add £2.95 to all UK orders under £30.00. Orders over £30.00 and MPS Account Holding customers are exempt from carriage charges.

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If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics and Beyond*, the Technical Sales Dept. may be able to help. You can obtain help in several ways: ❶ Over the phone, telephone (01702) 556001 between 9.00am and 5.30pm Monday to Friday, except public holidays; ❷ By sending a facsimile, Fax (01702) 554001; ❸ Or by writing to Technical Sales, Maplin Electronics PLC., P.O. Box 777, Rayleigh, Essex, SS6 8LU. Don't forget to include a stamped self-addressed envelope if you want a written reply! Technical Sales are unable to answer enquires relating to third-party products or components which are not stocked by Maplin.

### 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 777, Rayleigh, Essex, SS6 8LU. Enclose a cheque or Postal Order for the servicing cost (minimum £17) as indicated in the current Maplin Catalogue. 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.

# TECHNOLOGY WATCH

**with Martin Pipe**

I'm dedicating this month's column to an old friend – the Apple Macintosh – and looking at where both platform and originator are headed. In 1984, the Mac was launched with a big-budget quasi-Orwellian advert that marked the users of other personal computers as 'slaves to the machine'. But they were right. The IBM PC, launched in the UK officially that year, was a boring old machine that made no concessions to ease of use. To use Microsoft's MS-DOS operating system – a development of an early 8-bit operating system known as CP/M – one would normally keep referring to the manual to ensure that the syntax was correct.

A single mistake, and an infuriatingly-nonsensical (if you were computer-illiterate) error message would be returned. The PC display was text-only, and its green screen had a high persistence to reduce the effects of flicker. You could opt for a colour screen, but the quality of the text display was so appalling that eyestrain became the order of the day (I used an Amstrad 1512, which used this CGA standard, for nearly two years and can attest to this!). Nevertheless, corporates loved the IBM name and lots of PCs were sold. Then the cloners (the first of which was Compaq) moved in, driven by the lure of juicy corporate accounts. PC prices were driven lower – and the rest, as they say, is history.

The Mac, however, took a different approach. The operating system (now known as 'System' or 'Mac OS') was based largely on research done in the early 1970s by Xerox at its Palo Alto research centre. This centred on making computers easy to use – and the concepts then developed are now taken for granted.

A mouse to move a pointer around the screen, to select menus or open program windows (another Xerox concept). Programs represented by easily understandable visual icons. You could also cut and paste data between open windows. Macintosh was the first computer to make use of this now-commonplace system, known as a GUI (Graphical User Interface). Microsoft's early versions of Windows, and another system familiar to Atari owners as Gem, tried to emulate MacOS – but they all fell short. Microsoft has only finally caught up with the Mac through Windows '95, and even now, it's not quite as good.

Hardware-wise, the Mac also shone as the first genuine 'plug and play' computer. Peripherals were attached via SCSI – the Mac was the first personal computer to use this – or you could connect another Mac via the serial port (known as AppleTalk) and network them together. Ergonomically, the Mac was ahead of its time – here was a machine that didn't look out of place amongst office equipment or domestic furniture – and Apple's PowerBook laptops greatly influenced notebook PC designers.

Other innovations included the pioneering use of Adobe's PostScript page description language for printers, 'what you see is what you get' word-processing, and the concept of fonts. In the mid-1980s, there was nothing to touch the Mac in the then-new desktop-publishing (DTP) market, and Macintosh became the de-facto choice for graphic designers and publishers (something cemented through the introduction of two industry-standard applications – Adobe's Photoshop image-retouching package and Quark's XPress DTP software – both of which were exclusively-Mac for years).

The increasing sophistication of PCs and software became a headache for Apple. PC vendors became extensive in number, helping to force prices down. In the UK, companies like Amstrad made PCs affordable, and they became accessible to small businesses and even home users. Apple, in contrast, was the sole producer of Macintoshes, and the lack of competition allowed them to sell their wares for silly money. They sold, but mainly to the prosperous creative industries that thrived on them (and their ease of use).

Meanwhile, PC technology was catching up fast – the Windows 3.1 GUI had become established, along with powerful 486 processors and colour displays. Most of the applications previously exclusive to the Mac were ported across to the PC, which was no longer the user-unfriendly bugger it once was. PCs were also much cheaper to upgrade than Macs, since standardised components (such as motherboards and cases) were generally employed. Today, the PC is by far the best-supported computer ever. And thus began Apple's downfall. It started to lose its market share to PCs, although the artistic types remained loyal. In 1994, it had a brainwave – and not before time. Why not licence the MacOS and motherboard designs to third parties? It would make money on each machine, through the sale of custom chips, BIOS ROMs and the operating system. We are now beginning to see the fruits of this. You can now buy MacOS-compatible PowerPC-based computers from not only Apple, but also Power Computing, DayStar, Umax and Motorola. Many give, in raw computing terms, Intel's Pentium Pro a run for its money. Even PowerPC co-developer IBM is developing a platform – it has hitherto used the processor in its midrange systems (read 'minicomputers'). The IBM system will run not only MacOS but also Microsoft's high-end NT operating system.

Competition among MacOS systems has produced many benefits. The obvious is that prices have dropped. A low-end Mac, such as the Umax Apus 2000 (120MHz PowerPC 603e), now sells for around the same £1,200-odd as a new 120MHz Pentium. For the first time, would-be PC buyers now have a choice. Motorola's machines use standard PC mice, keyboards, ATAPI CD-ROMs and IDE hard disks, helping to bring costs down. The core technology responsible for this, a motherboard design known as Tanzania, was co-developed by Apple and Motorola. Motorola envisages a standard-size motherboard that would fit in a PC case. At the top-end, we have DayStar's multiprocessing architecture (nPower), which has been licensed back to Apple. DayStar's top machine has four 200MHz 604e chips, and has been designed for high-end applications such as desktop video production. Multiprocessor support isn't yet common, but acceptance among developers is increasing.

So what of Apple itself? It recently introduced its first affordable Mac for years (the sub-£1,000 4400, although that doesn't include a monitor), and has slashed the price of its other models by up to 35%. One cannot rule out Apple changing into a technology and licensing company, rather like the ARM RISC microprocessor company in which it has a stake. It would then be free to develop new products – such as network computers, the Newton and E-mate PDAs, new Mac motherboard designs and other operating systems. Even now, Apple is rumoured to be in talks with the oddly named Be, a company formed by an ex-Apple employee. Be designs PowerPC-based personal computer systems and operating systems, unhindered by the need for backwards-compatibility. There's a chance that BeOS features might end up in a future version of MacOS.

E-mail your comments or suggestions to Martin Pipe at whatnet@cix.compulink.co.uk.

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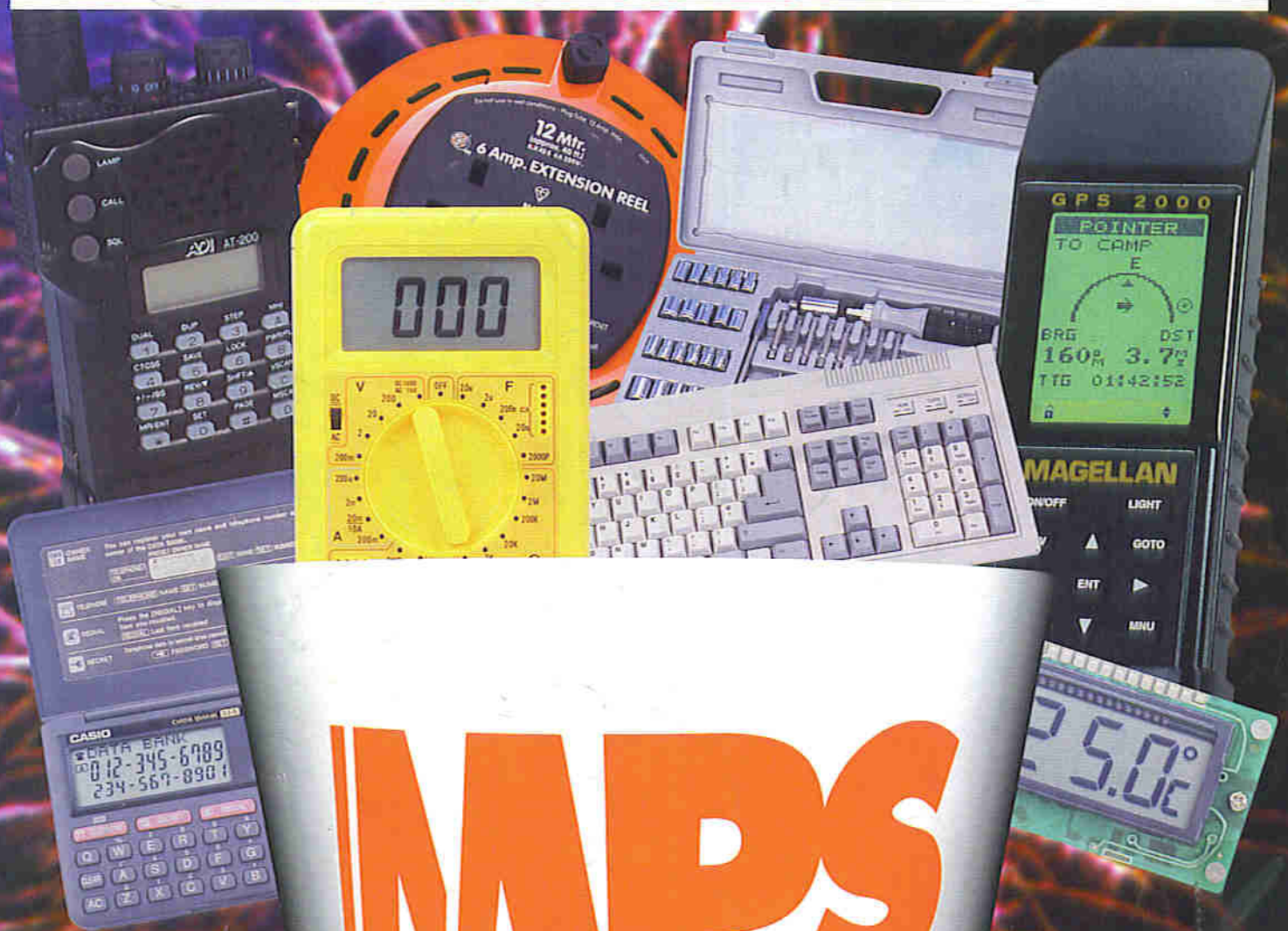


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