THE MAPLIN MAGAZINE

ELECTRONICS and Beyond

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JANUARY 1997 NO. 109 £2.25

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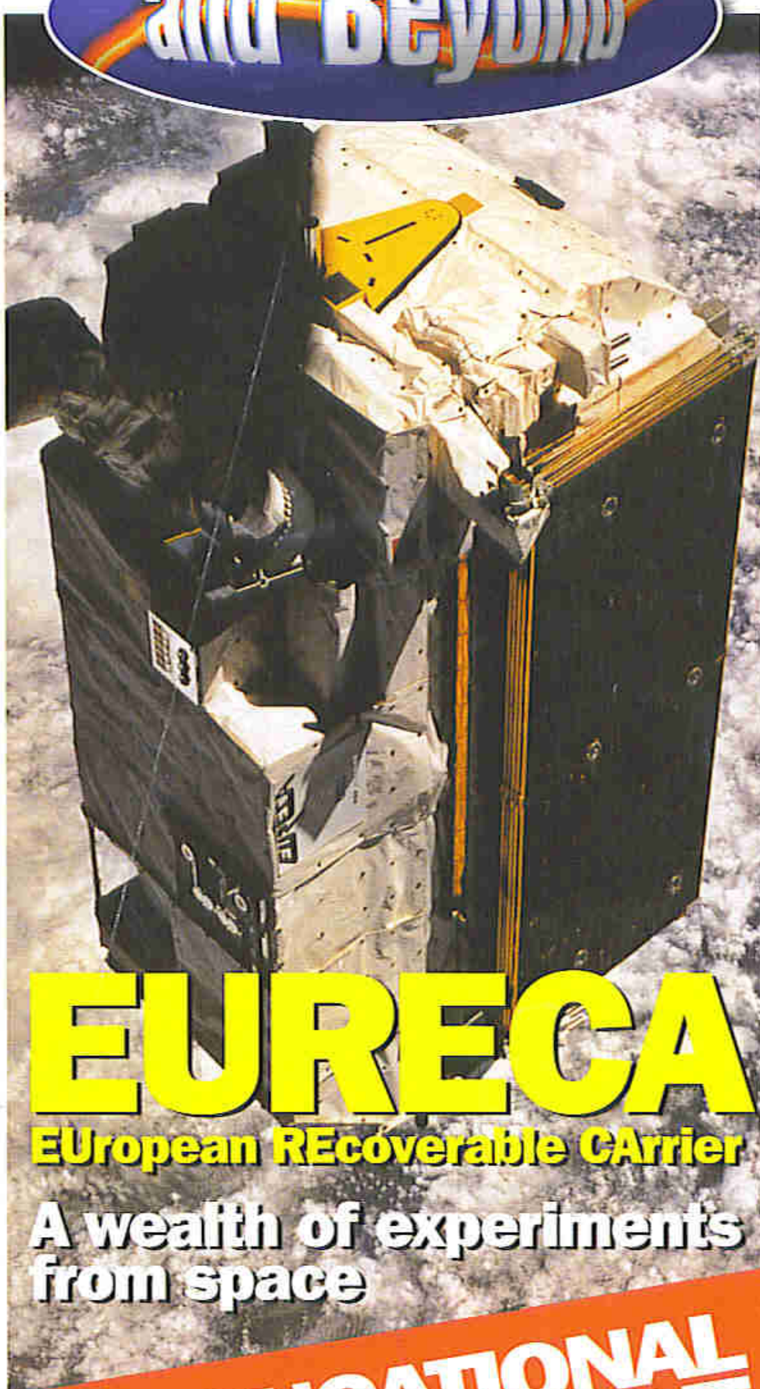
Digital Audio Broadcasting

The revolution is here

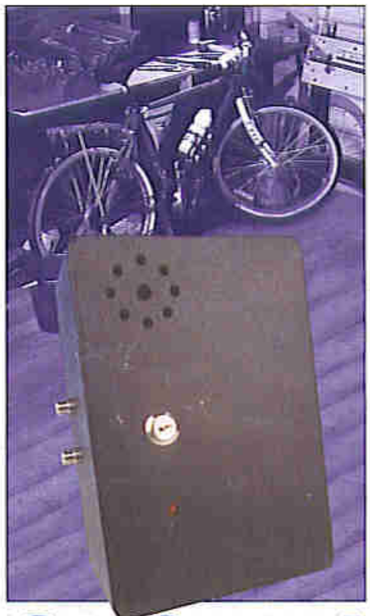
Optoelectronics Xplora



EURECA

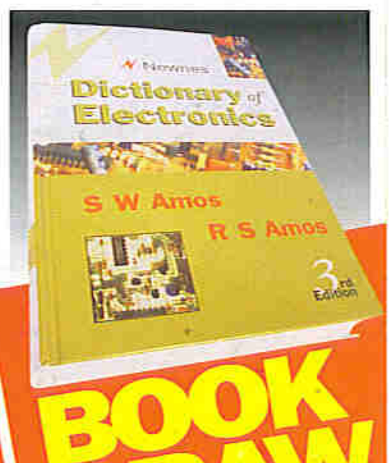
EUropean REcoverable CArrier

A wealth of experiments from space



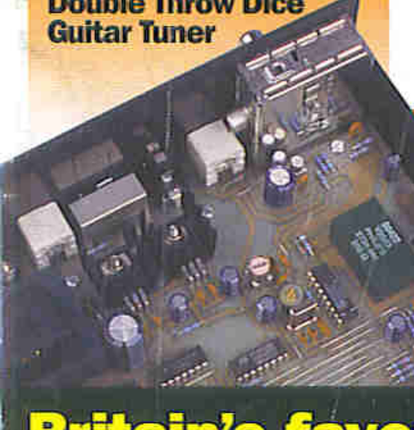
On Guard

A protective Loop Alarm



PROJECTS FOR YOU TO MAKE

Test Pattern Generator
Double Throw Dice
Guitar Tuner



EDUCATIONAL SUPPLEMENT

A selection of mini-circuits for education featuring Formula One Starting Lights for model cars

See centre pages

BOOK DRAW

Win a hard-back copy of Dictionary of Electronics

Britain's favourite monthly magazine for electronics!

THE MAPLIN MAGAZINE
ELECTRONICS and Beyond

January 1997 Vol. 16 No. 109

Projects

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Regulars


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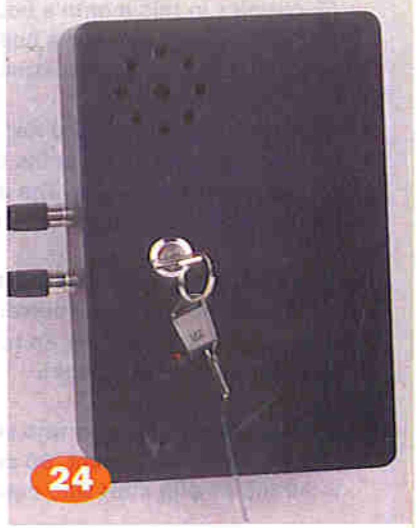
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Educational Mini Circuits Supplement
Featuring a variety of circuit projects for you to build.
See centre pages

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ELECTRONICS and Beyond

Hello and welcome to this month's issue of *Electronics and Beyond*! We wish all our readers a very happy New Year!

This month we have more mini-circuits from Robert Penfold and Maurice Hunt in our 8-page Educational Supplement (see centre pages). We have ten free hard-back copies of *Dictionary of Electronics* in this month's book draw. If you send the entries in promptly we hope to despatch winners' books out in time for Christmas.

Apologies for some of the low resolution drawings that appeared in last months issue. This was due to a production problem. The affected drawings have been reproduced this month on pages 45 and 46.

Over the last couple of months, the Maplin MPS team have been visiting universities up and down the country. Look out for an update on their travels in a later magazine.

A thank you to all those who visited the Maplin stand at Connect '96 and a special thanks to all the Maplin staff who manned the stand.

Robin Hall, Editor

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

ATM Alternative?

The Gigabit Ethernet Alliance, an association of leading networking, integrated circuit and computer companies committed to providing customers with open, cost-effective, and interoperable Gigabit Ethernet application, has announced several milestone events in the process of furthering the implementation of Gigabit Ethernet standards.

With the addition of the 24 companies who joined the four-month-old Alliance this month, total membership has climbed to 74 companies.

A recent meeting of the IEEE 802.3z Task Force indicated strong industry interest in and support for Gigabit Ethernet. The Task Force has adopted an aggressive schedule for implementation of a Gigabit Ethernet standard and expects to have the standard approved by early 1998.

For further details, check: `http://www.gigabit-ethernet.org`.

Contact: Gigabit Ethernet Alliance, Tel: (+1) 408 241 8904.

New Low Temperature Heat Shrink Tubing

ACAL Auriema has introduced Astratite ADM, a new range of mechanical and electrical grade heat shrink tubing, designed to shrink to half its inside diameter at just 65°C.

Virtually any heat source – infra-red lamps, convection or non-convection ovens, heat tunnels, hot water – will do, and the low shrink temperature speeds up the operation, reduces the risk of damage to temperature-sensitive substrates or components and saves energy.

Polymer-based Astratite ADM tubing is extremely flexible and well suited even to outdoor applications. It has a maximum operating temperature of 105°C and its inherent elastomeric nature gives it a unique brittleness temperature of below minus 70°C.

Contact: ACAL Auriema, Tel: (01628) 604353.

Panasonic Field PC

Panasonic has built a machine which it claims is resistant to water, dust, shock and vibration. The machine priced £2,999 incorporates a 133MHz Intel Pentium processor, 1·33G-byte hard drive, 8M-byte RAM. A lower specification 100MHz Pentium, 850M-byte hard drive and 8M-byte RAM is available at £2,699.

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

Contact: Panasonic, Tel: (0500) 853550.

MagnaRAM '97 Accelerates Applications

MagnaRAM '97 from Quarterdeck is a new memory utility that enables PC users to boost memory and increase the speed of loading 32-bit applications in Windows '95. MagnaRAM '97 keeps more data in faster RAM, instead of swapping it out to the hard drive.

Gary Sevounts, product manager of memory management products at Quarterdeck told *Electronics and Beyond*, "The enormous memory demands of today's more powerful PCs and software applications, system slowdowns are a common frustration for many users, even those with vast amounts of RAM. MagnaRAM '97 can alleviate these problems with many of the applications in Windows '95. For example, applications that work with highly compressible data such as word processors, Internet browsers, database and presentation software will benefit the most".

The expected street price of MagnaRAM '97 is £39.99. Users of MagnaRAM2 can upgrade to the new version at a cost of £24.99.

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

Contact: Quarterdeck, Tel: (0800) 973673.

Train Now Standing on Platform...

Docklands Light Railway and Gilden Research have teamed together to develop SMARTSOUND, a public address control system which makes announcements easier to hear at stations, airports and major sporting and entertainment venues.

SMARTSOUND automatically adjusts the volume of PA announcements so that messages can always be heard against constantly varying levels of background noise.

The system also includes a neat passive infra-red detector switch on each loudspeaker to ensure that only the loudspeakers immediately adjacent to people for whom an announcement is intended are active for any one announcement. This keeps unwanted noise intrusion to a minimum.

Contact: Docklands Light Railway, Tel: (0171) 363 9500.

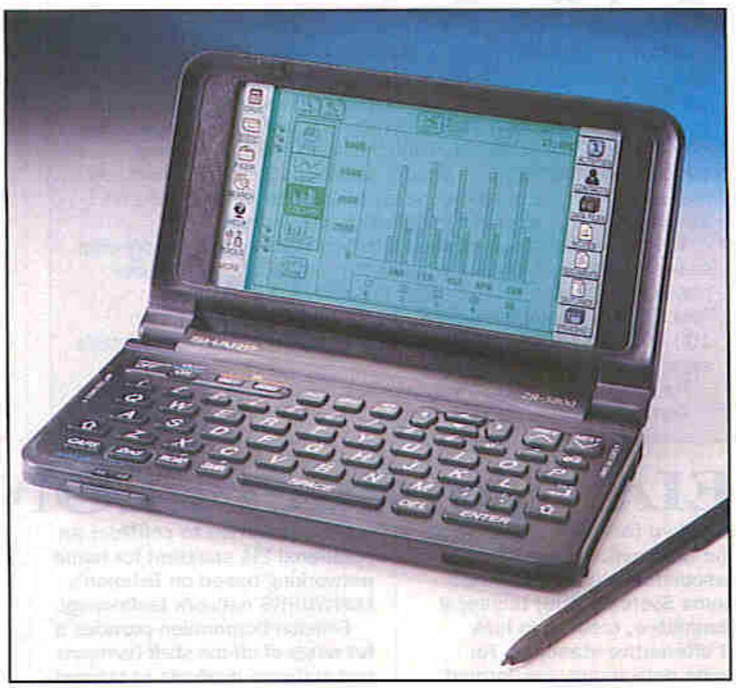
Take Two for Sharp in PDA Market

Building on the relative success of its ZR-5000 PDA, Sharp has launched two new models. The ZR-5700, priced £429.99, has 1M-byte of memory, whilst the ZR-5800, priced £529.99, has 2M-byte of memory and a backlit display. Both models offer CompuServe accessibility, wordprocessing, spreadsheet and diary functionality.

The ZR series combine both pen and keyboard input capability. The plastic pen-like device, in conjunction with the touch sensitive screen, acts as a pointer/ mouse for accessing functions in an easy-to-use writing tool in the scrap book and note-taking modes.

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

Contact: Sharp, Tel: (0800) 262958.



NEWS BYTES

Toshiba Enters European GSM Market

Toshiba has confirmed its intention to launch its first hand-held cellular GSM telephone in late 1996. Toshiba claim the new telephone, the TCP-6000 will be the slimmest on the market, and will incorporate an integrated antenna within its S-shaped case.

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

Contact: Toshiba, Tel: (01932) 825154.

Low Power 4-Channel ADCs

Maxim has introduced the MAX113 and MAX114 ADC converters – low-power, 8-bit, 4-channel devices designed for communications, data-processing and data-acquisition applications. Each includes an internal track/hold and a parallel data interface, compatible with many microprocessors and microcontrollers.

The MAX113 operates on 3V, converts in 1·8μs, and operates sample rates to 400k-bps. The MAX114 operates on 5V, converts in 600ns, and offers sample rates to 1M-bps. Both offer a 1·A power-down mode which is ideal for battery-powered applications. The MAX114's fast turn-on time allows that device to minimise power consumption by enabling shutdown between conversions.

Contact: Maxim, Tel: (01189) 303388.

Low Noise Regulators Extend Battery Life

National Semiconductor has made two additions to its line of low-dropout regulators. The new ICs, the LP2981 and LP2982, are designed to meet increased market demands for greater battery efficiency with improved operating levels and overall size reduction. National's LP2981 is the industry's first linear regulator specified for 100mA output current and 150mA transient peak output from a TinyPak SOT23 package. The space-saving SOT23 package occupies only one-third the printed circuit board space of a standard SO-8 package.

A second regulator – the LP2982 – is also housed in a TinyPak package, and reduces output noise to 30μV, nearly one-fifth the level of a typical micro-power regulator. This low noise output eases overall design and improves the performance of noise-sensitive applications such as RF circuitry in cordless and cellular phones.

For further details, check: http://www.national.com.

Contact: National Semiconductor, Tel: (+1) 800 272 9959.

NEWS BYTES

Racal to Equip Medium Support Helicopters

Racal Acoustics has won orders worth approximately £4million from GKN Westland and Boeing Helicopters to supply its latest generation of onboard voice communications systems, the RA 800 'Light' secure Communications Control Systems (CCS).

Adapted from the digitally controlled RA800 communication control system, in service in the BAe Hawk, the system was selected through competitive tender. The equipment is to be installed in the GKN Westland EH101 and Boeing Chinook which are to be supplied to the RAE as part of the Medium Support Helicopter programme announced last year. Deliveries for the 22 EH101 and eight Chinook aircraft will commence in around 12 months.

Contact: Racal, Tel: (01344) 288000.

The Ultra-Portable PC

HP's latest notebook – the OmniBook 800 – boasts a footprint smaller than an A4 piece of paper, and claims a Winstone '96 score of 58. The 3·75lb OmniBook 800 notebook PC includes a 133MHz Intel Pentium processor, 1·44G-byte hard drive and 10·4in. active-matrix display. Prices start at £2,200.

Other features include a SCSI-2 port, 4M-bps infra-red port, 256K-byte cache, 16M-byte EDO RAM, SVGA-out up to 1,024 × 768 and one Type-III or two Type-II Cardbus-ready PC Card (PCMCIA) slots.

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

Contact: Hewlett-Packard, Tel: (0990) 4747474.

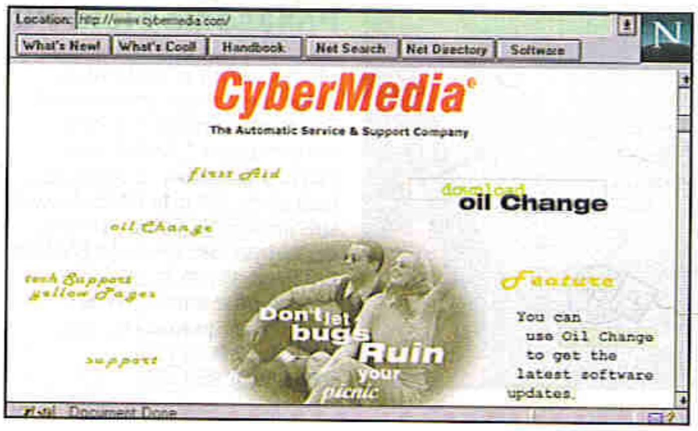
Cisco Scales the Internet

Cisco is making major enhancements to its Cisco StrataCom switches and 7500 series routers that will quadruple the performance of these systems. The company also plans to introduce a new Cisco IOS technology, called Tag Switching. Tag Switching will scale the Internet by integrating routing and switching on existing platforms.

These solutions extend the leading role Cisco has played, during the past 12 years, in building and scaling the Internet. According to the Yankee Group, Cisco routers now carry more than 80% of Internet backbone traffic.

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

Contact: Cisco, Tel: (0181) 818 1400.



Self Healing PC

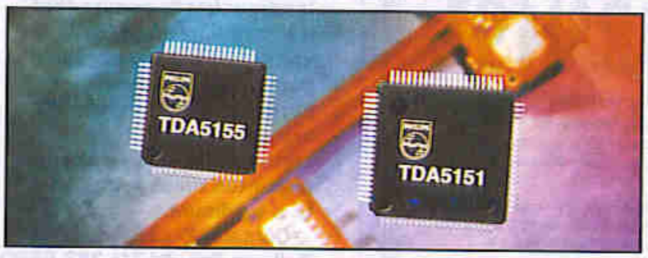
CyberMedia which makes a software diagnostics tool called First Aid, is working with Phoenix Technologies, which makes BIOS 4.0 (Basic Input/Output System) system-level diagnostic software, to create a package that enable PCs to figure out what's wrong with them, and fix themselves.

The collaborative package, called ActiveHelp, will be able to prevent a system crash from happening, and can change registry entries and replace damaged or missing drivers if needed. Phoenix plans to make ActiveHelp available to PC and motherboard manufacturers that license its BIOS chips, and the package should be available on PCs in the first half of 1997.

Meanwhile, Intel has launched a new line of products designed to eliminate much of the costly labour necessary to maintaining corporate PC support desks. The products include software and hardware that allow technicians to trouble-shoot and repair PCs from a remote location, and a microprocessor that tracks temperatures and voltage in PC networks.

For further details, check: `http://www.cybermedia.com` and `http://www.intel.com`.

Contact: CyberMedia, Tel: (+1) 310 581 4700; Intel, Tel: (01793) 403000.



Fastest Family of Magneto-Resistive Pre-amps

A family of high performance, low noise pre-amplifiers for dual-stripe magneto-resistive (DSMR) heads is now available from Philips. The new devices feature enhanced programmability, easy adaptation to a wide range of heads, and fewer external components than previously necessary.

The series – the TDA5151, TDA5153 and TDA5155 – covers the complete range of 12, 6 and 10 channels, respectively – from very high-end disk drives using two pre-amps and delivering 12 disks on the drive, down to six channels delivering three disks.

The devices incorporate a serial interface which makes the pre-amp easier to adapt and monitor, reduces the number of pins and lines previously necessary and increases the devices' functions and flexibility. The preamplifiers are suited for data rates ranging from 100 to 200M-bps and offer, together with DSMR heads, incomparable signal-to-noise performance.

For details, check: `http://www.oakridge.com/philips_semiconductors`.
Contact: Philips Semiconductors, Tel: (+31) 40 272 20 91.

Wireless Computing Initiative Drives GSM in Europe

Mobile computing and telecommunications companies have launched a joint effort to stimulate Europe's dormant mobile data market. The members of the Mobile Data Initiative will help European business to use the GSM network to provide its mobile PC users with wireless access to corporate data networks and the Internet, thereby improving the flow of business information, increasing business efficiency, and improving profitability and customer service.

According a report by Dataquest on behalf of the new initiative, Europe leads the world in wireless digital voice communications with a subscriber base of 19 million in 1996, growing to 66 million by the year 2000. However, in today's age of corporate networks and the Internet, Europe is not harnessing the GSM network for wireless computing.

Only 1 in 50 European GSM phone users has an adapter for connecting a mobile computing device to the GSM network. Data represented only 0·5% of traffic over the GSM network in 1995, compared to 46·3% of business traffic over European land lines. While Europe has 1·1 million more mobile professionals than the US, European business will deploy only two mobile PCs for every five shipped in the US in 1996.

The Mobile Data Initiative was formed by PC technology leader Intel; mobile telecommunications equipment leaders Ericsson and Nokia; notebook PC leaders Compaq, IBM and Toshiba; PC software leader Microsoft; and leading European GSM operators Cellnet, Mannesmann Mobilfunk, T-Mobil, Telia and Vodafone.

For further details check: `http://www.gsmdata.com`.

Contact: Intel, Tel: (01793) 403000.

EIA Considers LONWORKS

Standard for Home Networking

The Electronic Industries Association's (EIA) Integrated Home Systems (IHS) technical committee, created to look at alternative standards for home networking, has formed a sub-committee to consider an additional EIA standard for home networking based on Echelon's LONWORKS network technology.

Echelon Corporation provides a full range of off-the-shelf hardware and software products to support the development, installation and management of intelligent, open and interoperable control networks.

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

Contact: Echelon, Tel: (+1) 415 855 7400.

The Betacom PPF700 FACSIMILE MACHINE

The traditional fax machine has now become a staple feature of most offices; a fundamental business tool without which many companies would struggle. Indeed, the installed base of machines now numbers over 1 million units in the UK, with sales in 1996 alone expected to exceed half a million machines. This growth market is now undergoing the biggest revolution since the first commercially made fax machine went on sale back in 1982. Then, the average machine weighed about 40kg, took up half of your available office space and cost the princely sum of £3,000.

For that hefty investment, you would get a rather simply featured machine, capable of sending a standard A4 document in just under a minute, and would print received faxes on traditional 'thermal' paper, a particularly irritating medium that would fade, yellow and curl. Technology has moved on apace since then, of course, to the extent that fax machines that print out on ordinary cut sheet A4 plain paper are widely available at under £1,000.

Machines are getting smaller, more feature rich and handle documents with greater speed and efficiency. There is no better example of this than the new plain paper fax machine set to become the market leader, recently launched by the Telecoms company, Betacom. The product, named the PPF700, represents Betacom's entry into the plain paper fax market, and will complement their existing comprehensive portfolio of telecom products that range from simple telephones, through to digital answer machines and cordless phones, right up to headsets and payphones.

The PPF700 has been painstakingly researched and designed with the target customer's needs in mind. The key issues that influence potential buyers of fax machines, regardless of whether it be for the home office or a large multi-national company, are timeless and simple – a solid and relevant feature set, quality, reliability, ease of use, design and price. The Betacom product delivers on all fronts. The first striking impression on seeing the products is to marvel at how compact and attractive it is. This is of particular relevance to the small office home office (SOHO) sector, where desk and office space is at a premium, and bulky and unwieldy items are unwelcome. It is all the more surprising, given the product's size and apparent simplicity, that such an impressive array of features has been incorporated into the one desktop unit.

A Host of Features

This product features excellent paper handling capabilities, with an automatic 10-page document feeder and 100-sheet paper cassette, which means you are not constantly standing over your machine sending pages one by one, and don't have to restock the machine with receiving paper every five minutes. A host of other features, such as 10 one touch and 40 number speed dial facility, superfine resolution and 'grey scales' for enhanced reproduction of printed documents, delayed and confidential transmission, fax switch and answerphone interface, multi-copy facility, junk fax protection, integrated handset and LCD are all standard.

However, selecting a plain paper fax machine is not as simple as making sure the product has the right feature package. One of the key considerations in assessing the value for money offered by any fax machine has to be the total cost of ownership – in other words, how much does the machine cost and how much will it cost me to run? Plain paper fax machines offer an obvious benefit over thermal paper fax machines, in that it is no longer necessary to buy several rolls of special thermal paper, and you won't have to waste time and money photocopying the received, curled document in order to get it into a 'fileable' state. However, all plain paper faxes (like copiers and printers) require a 'consumable' change on an occasional basis (dependent on your usage pattern), in order for the machine to keep printing.

Ink Film Printing

There are a number of different print technologies used by plain paper fax machines, including laser (in which you will have to top up toner and change the product 'drum'), and ink jet, which you will need to swap out with fresh ink cartridges. The PPF700 utilises a technology called 'ink film' printing, which not only offers excellent print quality, but it is also the only technology to guarantee a constant 'cost per copy'.

In plain English, this means that when you buy a replacement ink film roll, you know exactly how many copies you are going to get out of it. With other systems, this will fluctuate wildly and be dependent on the amount of print coverage per page. Thus, a simple memo with a couple of lines of text on it may cost under a penny to receive; a complex and dense document with graphics would cost up to 30p! So, with the Betacom PPF700 from Maplin, you are not only getting a market beating price for a plain paper fax, you can also be reassured that with ink film technology, there are no nasty surprises after you've purchased the product. And speaking of after-sales, peace of mind is guaranteed with a full 12-month warranty, incorporating a 'repair, loan and return' service that means that in the unlikely event the product develops a fault and the Betacom Helpline are unable to resolve the problem over the phone, you will be devivered a brand new machine on loan until your own machine is repaired.

All in then, the new Betacom PPF700 from Maplin constitutes the perfect solution for the faxing needs of any size business, be it a one-person operation working from home or a large corporation wishing to increase their business efficiency without massive expenditure.

LIMITED OFFER PRICE!

PRICE INCLUDES FREE CORDELSS TELEPHONE

- Tel/Fax switch
- 10-page document feed
- 100-sheet paper cassette
- 16-character LCD
- 10 one-touch memories
- 40 two-touch memories
- Auto/Manual redial
- Mercury button
- Integral handset
- Hands-free dialling
- Delay transmission
- Confidential transmit
- Multi-copy
- Junk fax protection
- Superfine resolution
- Grey scales
- PABX compatible

While Stocks Last

PROJECT RATING 3

When servicing and repairing televisions and other items of video equipment, it can be helpful to have a stable and recognisable test signal. A colour bar pattern is often used for this, and indeed, many television and video recorder service sheets use this type of signal as a reference.

Colour TEST PATTERN GENERATOR

Design and Text by Paul Stenning

A variety of other patterns are used for specific tests. For example, a crosshatch is useful for checking picture linearity and convergence (colour gun alignment), while a checkerboard pattern or dots are ideal for setting up the focus.

The test pattern generator described here features these patterns as well as horizontal lines, vertical lines, dots, blank raster and white screen. The three primary colours are individually switchable. So, for example, the white screen can be switched to red, green or blue for checking colour purity.

There have been several designs for test pattern generators published in the past. Many of these are monochrome only and are often based on the ZNA234E IC. Published designs for colour units are often complicated, and therefore, probably too expensive for occasional home use.

The aim of this design was to produce a straightforward, reliable piece of equipment with no unnecessary frills and features. It should be possible to construct the unit for around £100 including the case, which is much cheaper than commercial units having a similar specification. Setting up is straightforward and requires no test equipment.

This unit is an improved and updated version of a project by the same author, which was published in the March 1994 edition of *Electronics in Action* magazine. The original design was one of the most popular projects in the magazine, with over one hundred PCBs being sold. Since *Electronics in Action* is, sadly, no longer being published, and a couple of the components used in the original design are now obsolete, it was felt that now is the right time to publish this revised version.

A major improvement with this version is that construction has been simplified. The circuit is built on two PCBs, and requires no interwiring. The white level can now be switched to either 75% or 100%, so that the colour bar pattern can give a proper white reference level. The original Astec modulator is no longer available, so this unit uses an Alps modulator from Maplin. Since this modulator has sound capabilities, a 1kHz audio tone generator has been added. Other modifications have been carried out to improve performance and reliability.

The instrument is mains powered. A standard composite video output is available (1V Pk-to-Pk into 75Ω), as well as UHF modulated (UHF channel E36). An oscilloscope trigger output is also available, which is switchable to either line or frame sync, or to the audio oscillator.

Circuit Description

The circuit diagram is shown in Figure 1. Most of the complicated stuff is handled by IC1 and IC2, which helps to simplify the remainder of the design. IC1 (SAA1043) is a universal sync generator, whose timing is controlled by XT1. In this design, it is configured for the UK standard 625-line interlaced PAL, and four outputs are used.

IC1 requires a supply voltage between 5·7 and 7·5V. The SAA1043 has been operated with a 5V supply in several published designs (including some Maplin projects and the original version of this design). However, experience has shown that a limited number of devices will not operate correctly at this voltage.

Since the current consumption of IC1 is very low (less than 1mA), it is powered by a 6V8 supply rail, which is derived from the 12V supply by a Zener diode (D3) and resistor (R14). The output signals from IC1 are reduced to suitable levels for the 5V logic circuits by means of resistors (R15 to R19) and diodes (D4-6 and 9).

A 5MHz clock signal is derived from XT1. This controls the first binary counter (IC3, 74HCT4040), which is reset at the end of each line by the CB (composite blanking) signal. 258 clock pulses are counted by IC3 between each blanking pulse.

A second binary counter (IC4, 74HCT4024) counts the 312 or 313 CB pulses within a frame. This counter is reset by the VERT signal at the end of each frame. The fact that the counter has a capacity of only 128 is irrelevant in this case, since it merely wraps round.

The various patterns are derived from the outputs of these counters with some logic and switching. I will come back to this in a moment, once I've described the inputs required for IC2.

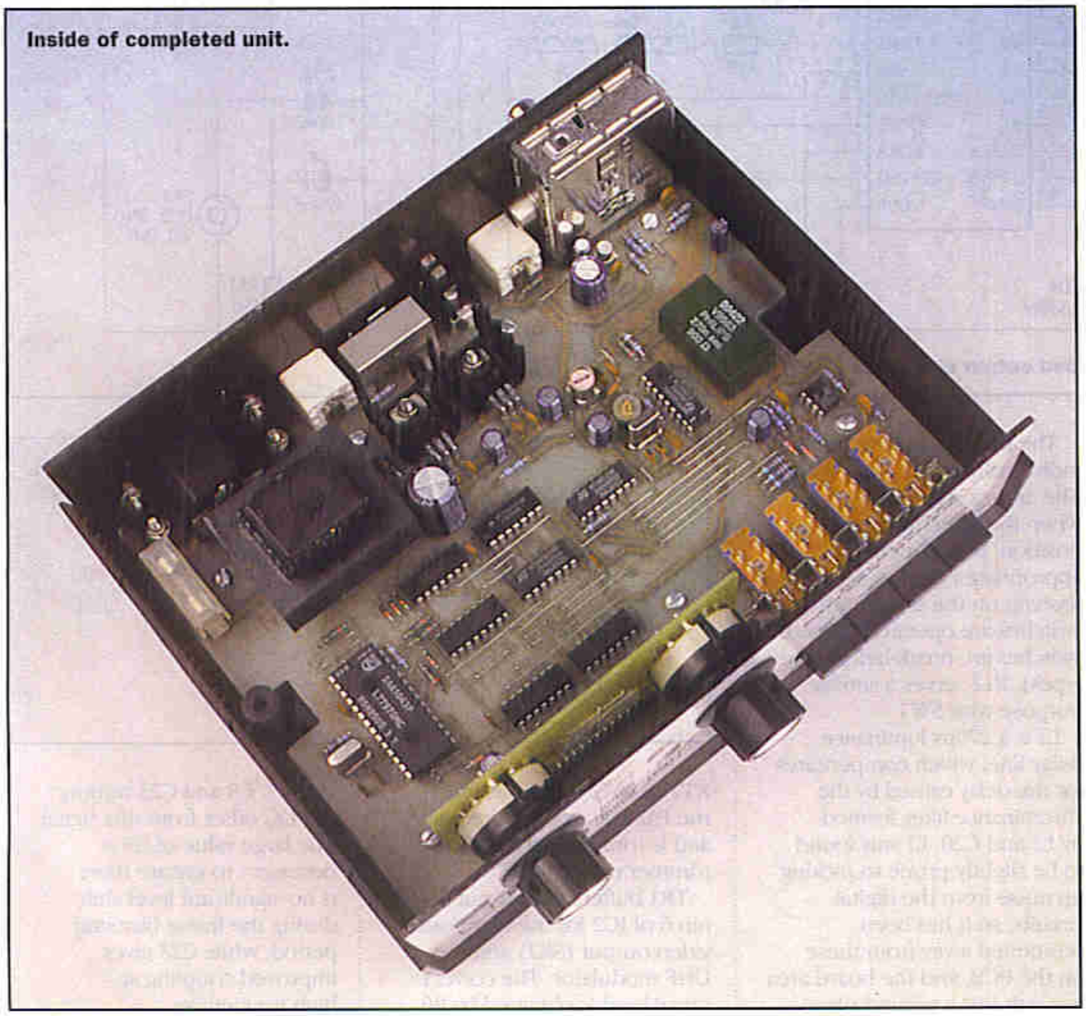
IC2 (TEA2000) is a colour encoder IC. To function, it requires composite sync and composite blanking signals that are supplied by IC1. The colour inputs set the output colour. There are six such inputs, two for each primary colour. Taking the red inputs for example, if R0 is high, a dark red is obtained, if R1 is high a brighter red is obtained, while if R0 and R1 are high, a very bright red results. These equate to 50%, 75% and 100% brightness, respectively. The device can produce 64 different colours, although only nine are used in this design.

For the colour bars, the R1, G1 and B1 lines are controlled in the appropriate sequence. For the black to white pattern, this is the binary output from three lines on IC3, while for the white to black pattern, these three lines are inverted by three gates in IC8. Output Q9 of IC3 is connected to the three gates in IC8 to prevent a brief white bar appearing at the end of the white-to-black colour bars when the count on IC3 exceeds 255. Three sections of SW2 select either of these colour bar patterns, or connects the three lines to the monochrome pattern logic.

The R0, G0 and B0 inputs to IC2 are controlled by IC11 and IC8:D. If SW7 is set to the 100% position, the output of IC8:D will go high when R1, B1 and G1 are all high. This gives a 100% white level. If SW7 is in the 75% position, the output of IC8:D will remain low. Although a four input NAND gate would have been sufficient for IC11, the 74HC133 is the only 74HC series NAND (or AND) gate with more than three inputs in the Maplin catalogue.

SPECIFICATION

Test patterns available:	Vertical bars Horizontal bars Crosshatch Dots Fine checkerboard Coarse checkerboard White screen Blank raster 8 Colour bars (white to black) 8 Colour bars (black to white)
White level:	Switchable 75% or 100%
Colour switching:	Primary colours individually switchable
Video system:	PAL (UK standard)
Composite video output level:	1V Pk-to-Pk into 75Ω
Audio tone frequency:	1kHz (nominal) sine wave
Audio output level:	1·2V Pk-to-Pk
UHF output channel:	Adjustable E30-E39, 6MHz sound subcarrier
Power supply:	230V AC, 50Hz, 6VA
PCB sizes:	Main – 192 × 145mm Front – 97 × 46mm
Overall size:	76 × 203 × 180mm (including knobs, etc.)
Weight:	850g (excluding leads)


Inside of completed unit.

With SW7 set to 100%, the white bar in the colour bar patterns will be brighter than the remaining colours (which are at 75%). This type of pattern is often specified in service manuals as the 100% white bar gives a true indication of the maximum video level, while the 75% colour levels are more representative of normal pictures. However, if the colour bar signal is, for example, being recorded to fill the end of a video tape, setting SW7 to 75% may give a more pleasing appearance.

For the monochrome patterns, the R1, B1 and G1 lines are taken high or low together, giving white or black. IC11 and IC8:D operate as previously, to give selectable white level. SW1 selects which pattern is displayed. The vertical bars are obtained from an OR gate on two outputs of IC3. The output of this OR gate is low

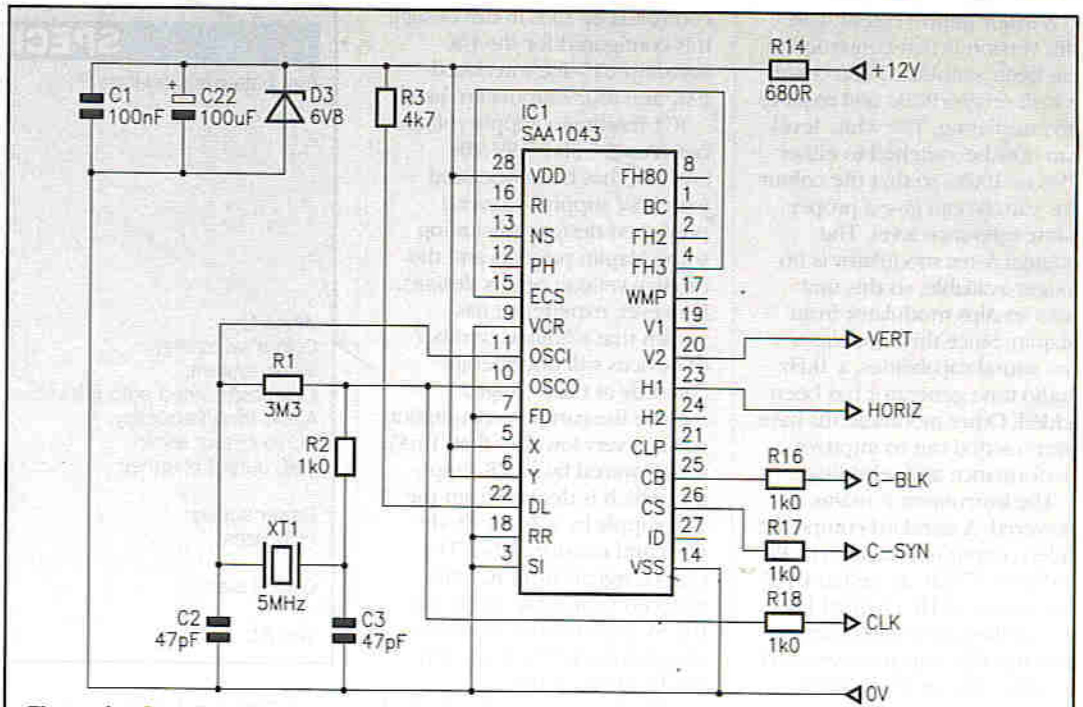


Figure 1a. Sync generator circuit diagram.

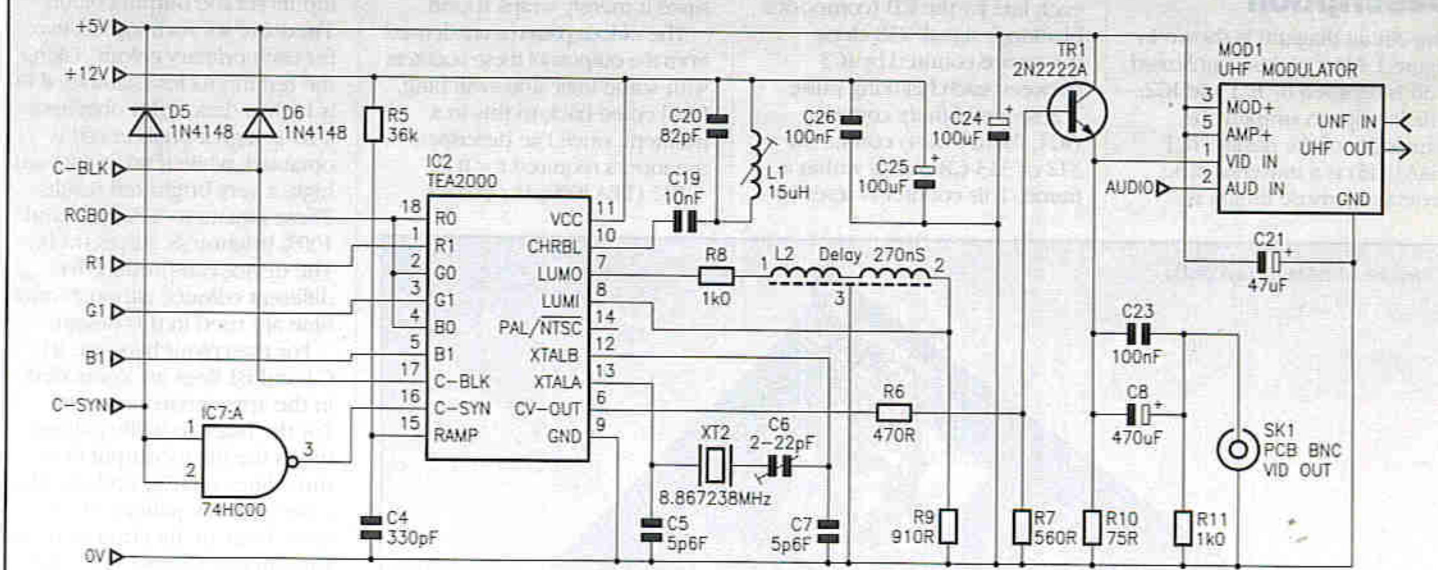


Figure 1b. Colour encoding and video output circuit diagram.

when the three lines are low, and this is inverted by the gate of IC6 after SW1. The horizontal lines are obtained by a similar arrangement on three outputs of IC4.

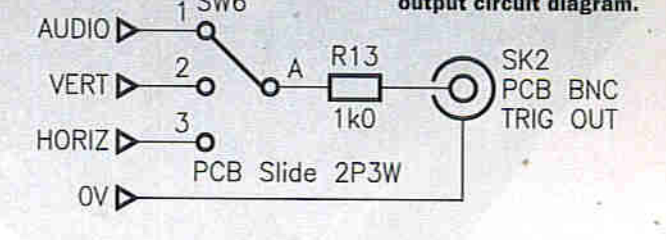
The crosshatch is obtained by an AND gate on the horizontal and vertical line signals, while the dot pattern is derived from an OR gate on these signals. The two checkerboard patterns are due to exclusive-OR gates on an output from each counter.

Two rotary switches (SW1 and SW2) were used for pattern selection, since the logic required to do the job with one switch would complicate the unit significantly, thereby adding to the cost. When SW2 is set to the "PAT" (pattern) position, the pattern selected by SW1 is displayed.

The three primary colours are individually switched by SW3-5. The appropriate colour is on when the switch is in the out position. R19-21 pull the appropriate lines low, to prevent flashing on the screen as the switches are operated (since the switches are break-before-make types). R12 serves a similar purpose with SW1.

L2 is a 270ns luminance delay line, which compensates for the delay caused by the chrominance filter formed by L1 and C20. L1 was found to be slightly prone to picking up noise from the digital circuits, so it has been positioned away from these on the PCB, and the board area beneath it is a ground plane.

Figure 1c. 'Scope trigger output circuit diagram.



XT2 (8·867238MHz) is twice the PAL colour burst frequency, and is trimmed by a 2-22pF trimmer capacitor, C6.

TR1 buffers the output from pin 6 of IC2 for the composite video output (SK1) and the UHF modulator. The correct signal level is obtained by R6 and R7. C8 and C23 remove the DC offset from this signal. The large value of C8 is necessary to ensure there is no significant level shift during the frame blanking period, while C23 gives improved coupling at high frequencies.

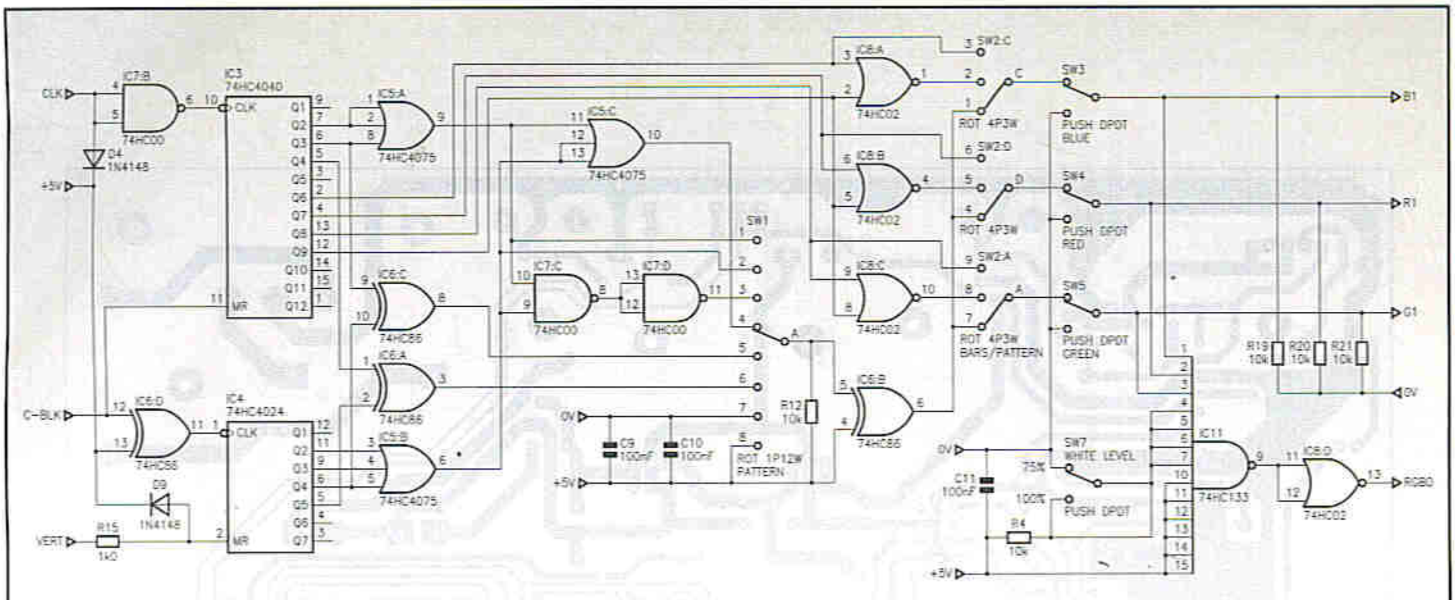


Figure 1d. Pattern generation logic circuit diagram.

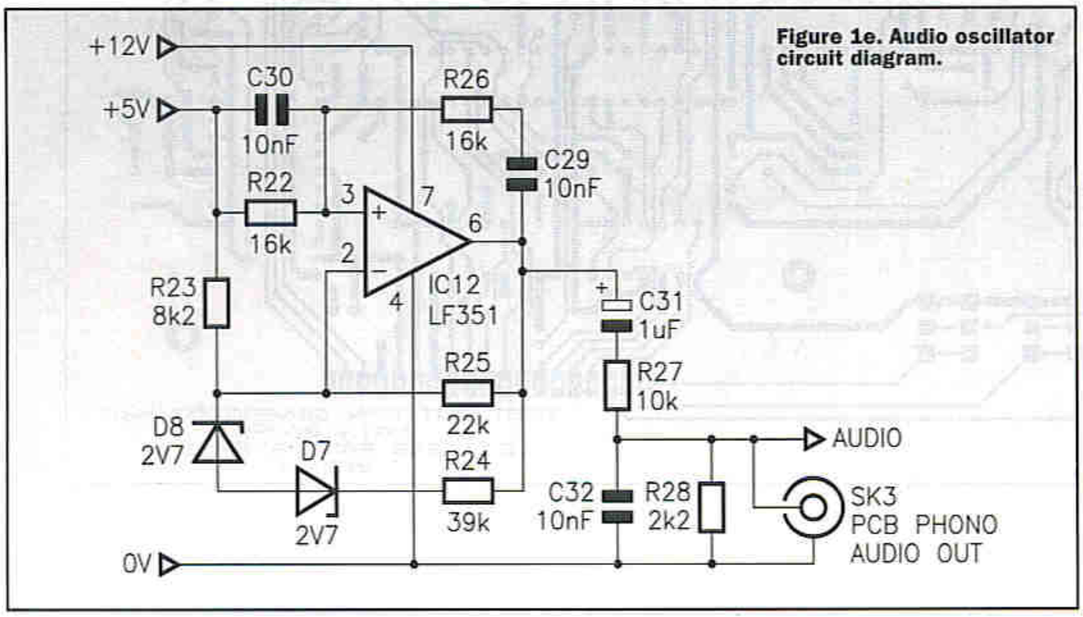


Figure 1e. Audio oscillator circuit diagram.

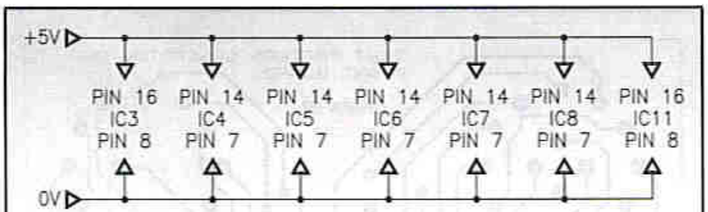
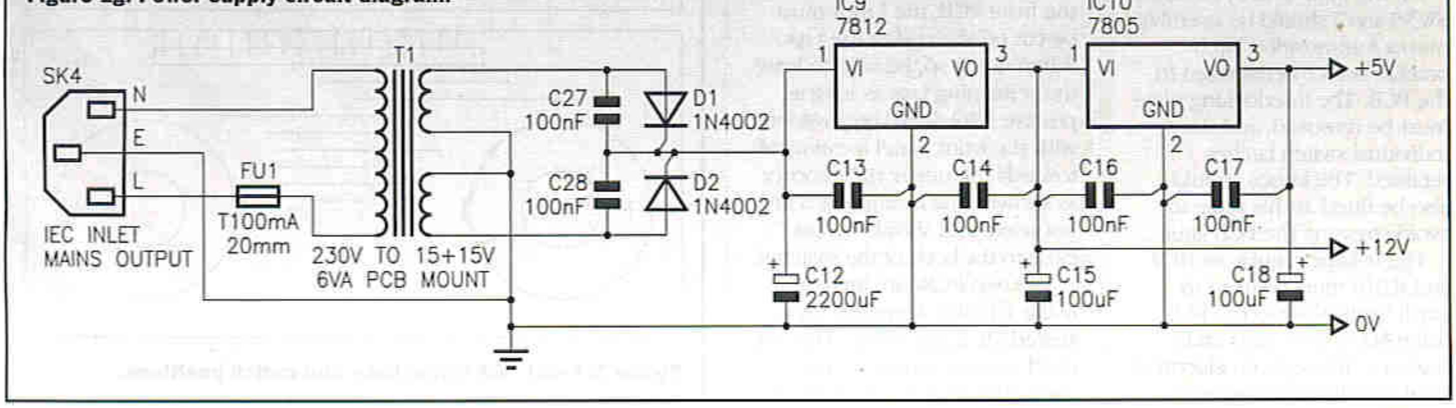


Figure 1f. Power distribution circuit diagram.

Figure 1g. Power supply circuit diagram.



The circuit around IC12 is a Wien bridge oscillator, operating at 1kHz. Two Zener diodes are used to control the amplitude of the waveform, since they are much cheaper than a bead thermistor. The Zener diode arrangement only works with fixed frequency oscillators, such as this. The distortion is around 2%, which is adequate for this purpose. Note that the modulator itself has an audio distortion figure of 3%, so there is no point in providing it with a very low distortion signal. R27 and R28 reduce the audio signal to the correct level for the modulator. C32 removes the high frequency noise which emerges from the modulator audio input pin. The audio signal is also made available on SK3.

SK2 is intended for connecting to the trigger input of an oscilloscope, so that a stable trace may be obtained. SW6 selects the signal provided by this output, to either audio, video line or video frame.

The circuit requires 5V at about 180mA and 12V at about 70mA. Most of this current is consumed by the UHF modulator (160mA at 5V) and IC2 (60mA at 12V). The power is provided by a 6VA mains transformer and a pair of 78 series voltage regulators, which are mounted on small heatsinks. For safety, the 0V rail is earthed.

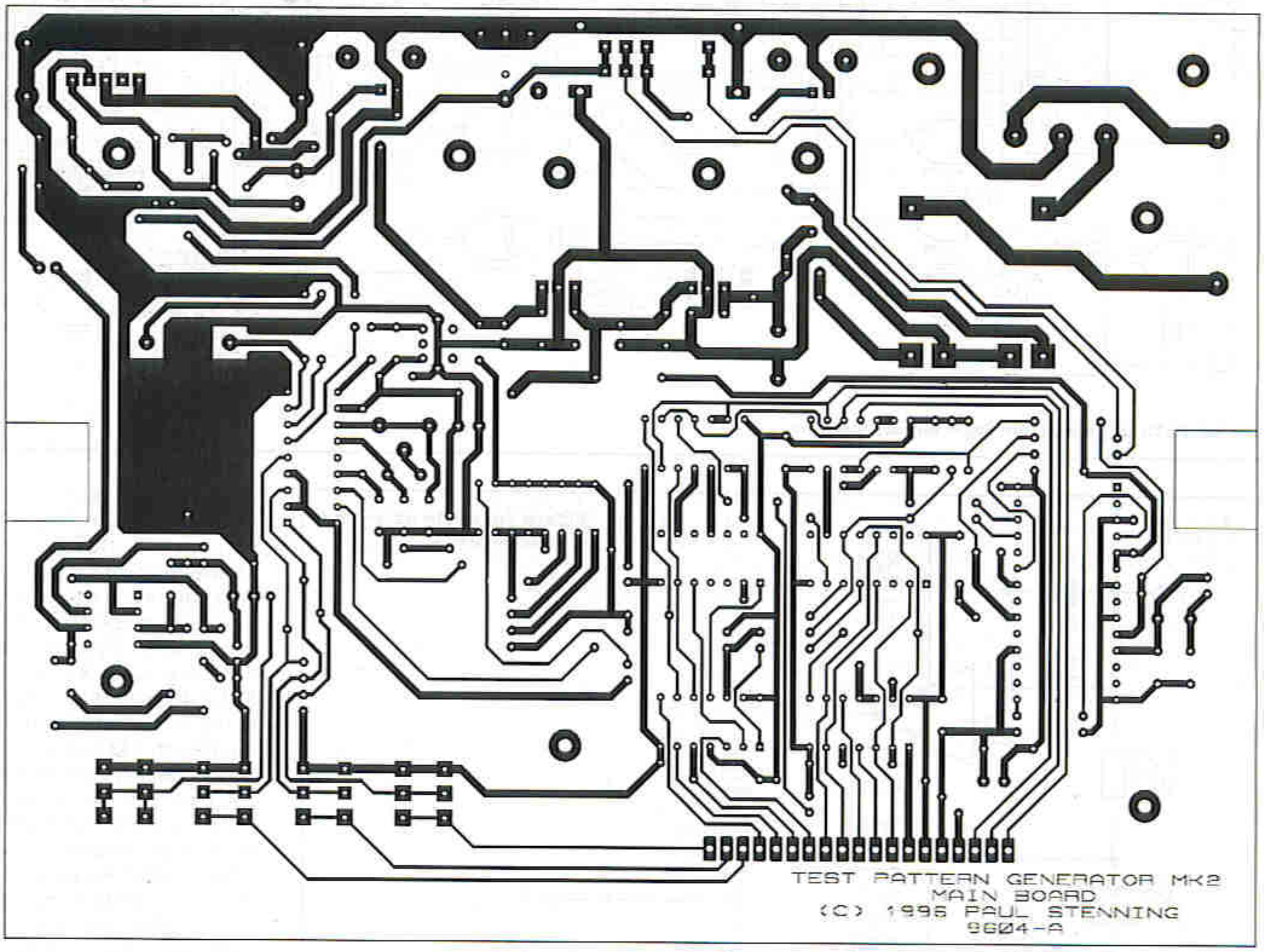


Figure 2a. Main PCB track.

PCB Construction

The circuit is assembled on two single-sided PCBs. The track layouts and component overlays are shown in Figures 2 and 3. Start with the wire links (use 24swg tinned copper wire), and then fit the components in the usual size order (starting with the smallest). Sockets may be used for the ICs if desired.

On the main board, switches SW3-5 and 7 should be assembled onto a four-position latch bracket before being fitted to the PCB. The interlocking plate must be removed, and the individual switch latches retained. The knobs should also be fitted at this stage to avoid stressing the PCB later.

The voltage regulators (IC9 and IC10) must be fixed to small heatsinks and the PCB using M3 screws, nuts and washers. Although no electrical insulation is necessary, an insulator between the device and heatsink will improve the thermal coupling.

SK1 must be fitted before the modulator, because of the (unused) phono socket on the side of the latter. SK4 (IEC mains inlet) should be fixed to the PCB with M3 hardware prior to soldering. The transformer should be fitted last, because of its size and weight.

Before fitting SW1 and SW2 to the front PCB, the loops must be cut off the end of the tags. When doing so, be sure to leave the remaining tags as long as possible. SW2 should be positioned with the front panel locating tab towards the upper right corner as shown. The locating tabs are not used, and should be cut close to the body of the switches.

The two PCBs are linked using a 19-way length of right-angled SIL header strip. This will need to be cut from a longer piece. The angled end of the pins

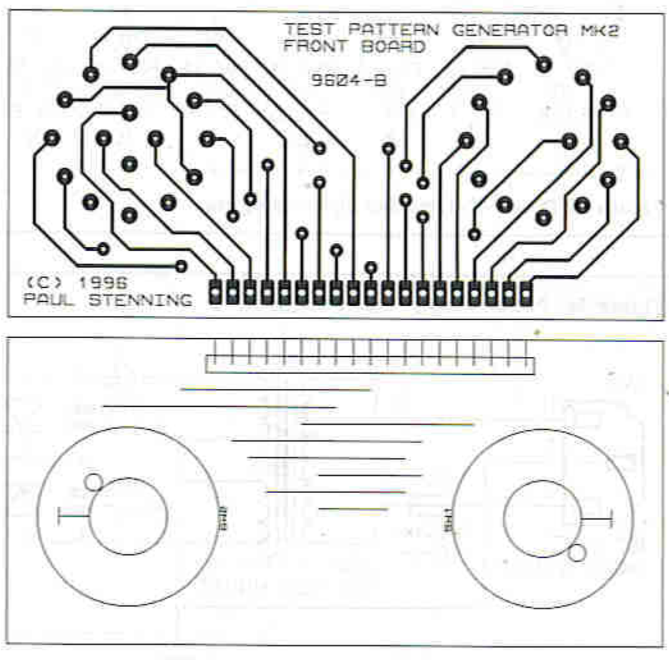


Figure 3. Front PCB wiring links and switch positions.

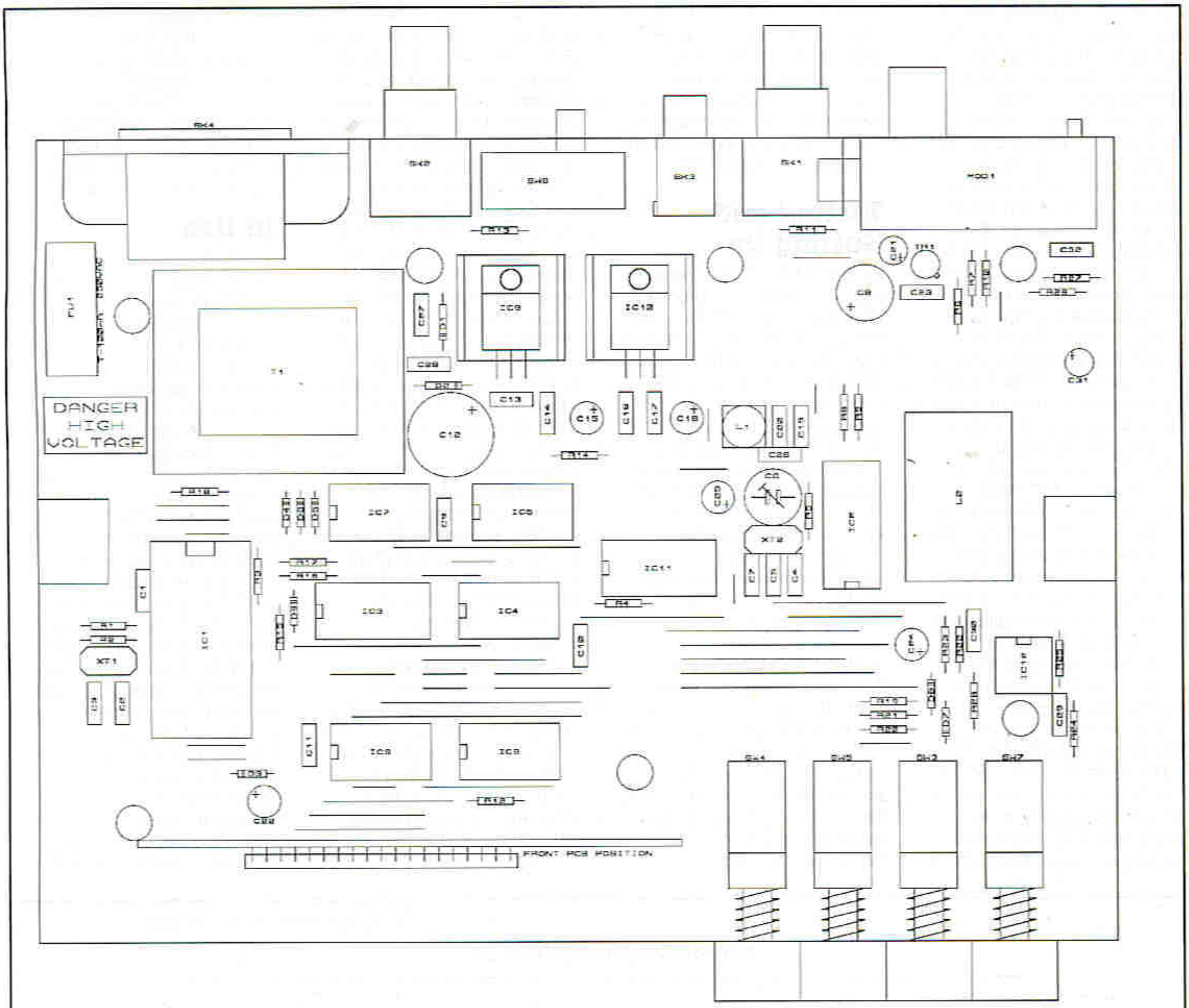
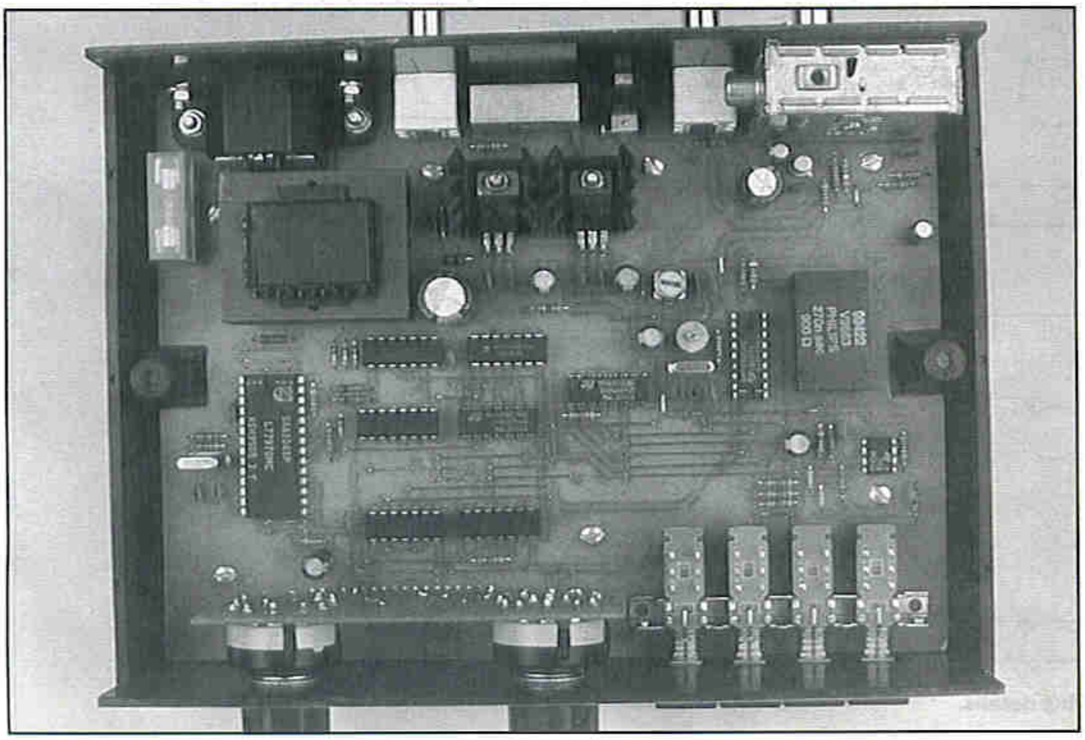


Figure 2b. Main PCB component positions.



must be fitted into the front PCB, so that the straight ends can then be fitted into the main PCB.

Case Assembly

The PCBs were designed to fit into the specified case. In the base of the case, there are two flat tags towards the back which must be removed.

There are also a number of PCB fixing posts, of which, only seven are used. The remaining posts must be shortened so that they do not foul on the underside of the PCB. This may be easily achieved using a sharp 8mm drill bit in a hand operated or SLOW electric drill (such as a rechargeable battery drill). Locate the tip of the drill bit in the hole at the top, and cut away each post until it is about half the original height.

Drilling details for the front and rear panels are shown in Figure 4. The rectangular holes may be cut by drilling holes in two opposite corners and then cutting out the remainder using a fret saw. This can then be finished with a small file.

Suitable overlays for the front and rear panels are shown in Figure 5. These may be photocopied onto a white A4 self-adhesive label and fixed to the appropriate panels. For durability, they should then be covered with clear self-adhesive vinyl. The label and vinyl can then be trimmed around the holes using a sharp craft knife or scalpel. You may need to chamfer the inside edges of these panels slightly to allow them to fit into the case, because of the extra thickness on the outside.

Set the end stop of SW1 to eight positions and SW2 to three positions, and then fit the front panel to the switches. The shakeproof washers supplied with the switches should be positioned between the switches and the panel. Cut the shafts down to about 8mm, then fit the knobs.

The rear panel should be fixed to SK4 using M3 hardware. The supplied nuts should be used to fix the panel onto SK1 and SK2 (discard the shakeproof washers).

The whole assembly should then be slotted into the base of the case. Depending on the accuracy of your drilling, you may need to ease the mounting holes in the PCB slightly, so that they coincide with the posts in the case. The PCB is held in place using seven 6·35mm long No.4 self tapping screws. Do not overtighten, otherwise the screws will strip the threads they have cut in the posts.

Testing and Setting Up

Providing the unit has been carefully constructed, there is no reason why it should not work first time. Connect the unit to the mains using an IEC mains lead. If a test meter is available, check the +12V and +5V rails are correct on the appropriate pins of the voltage regulators.

Take care, as there are mains voltages on the PCB. These are limited to the area around T1, FU1 and SK4, and are fairly inaccessible from above, providing the cover has been fitted to the fuse holder – but due care must still be taken.

Set the small slide switch on the back of the modulator to the upper position. Connect the UHF output to a television and tune in to UHF channel E36 (often used for video recorders and video games). You should be able to tune in two white vertical bars (this pattern is generated within the modulator). An audio tone should also be heard.

Set the switch on the modulator to the lower position. Ensure the four front panel push switches are out. Set SW2 fully clockwise and a set of colour (or monochrome) bars should appear. You may need to adjust the tuning on the television slightly.

Adjust C6 with a suitable trim-tool until the colour locks on. Adjust it back and forth to find the range of adjustment that gives a colour picture, then set it to the centre of this range.

Now adjust L1 for the clearest colours and a well defined edge where the colours change. This will probably be about a third of a turn up from the bottom. If an oscilloscope is available, this can be connected to the video output and L1 adjusted to peak the amplitude of the colour information on the signal.

If SW2 is turned to the centre position, the direction of the colour bar pattern should reverse. Operate SW7 (White), and the brightness of the white bar should reduce.

If SW2 is now set fully anticlockwise, the pattern displayed is controlled by SW1. Check SW1 works as expected, then set it to the white screen position and check SW3-5.

If the unit is left on for a while, the voltage regulators (IC9 and IC10), the TEA2000 (IC2) and the mains transformer (T1) will become warm. You may also notice a faint smell of varnish from the transformer the first couple of times it warms up. This is normal, and should not cause concern.

Finally, fit the top cover of the case, with the two plastic tabs to the rear.

In Use

The UHF modulator has a pass-through facility, similar to that on video recorders. The unit may, therefore, be connected between an aerial and the equipment being tested, so that the normal channels may be obtained without changing connections. Due to the digital nature of the unit and the signals produced, it may cause some interference on the normal channels unless the signal from the aerial is fairly strong. If this occurs, you could try using an aerial amplifier between the aerial and the unit, otherwise, you will need to use the unit separately.

The modulator UHF output is tuned to channel E36 when supplied. An adjustment screw on the back allows this to be adjusted between channels E30 and E39. This adjustment may be necessary if you are using the unit in conjunction with a video recorder or if you live in an area where Channel 5

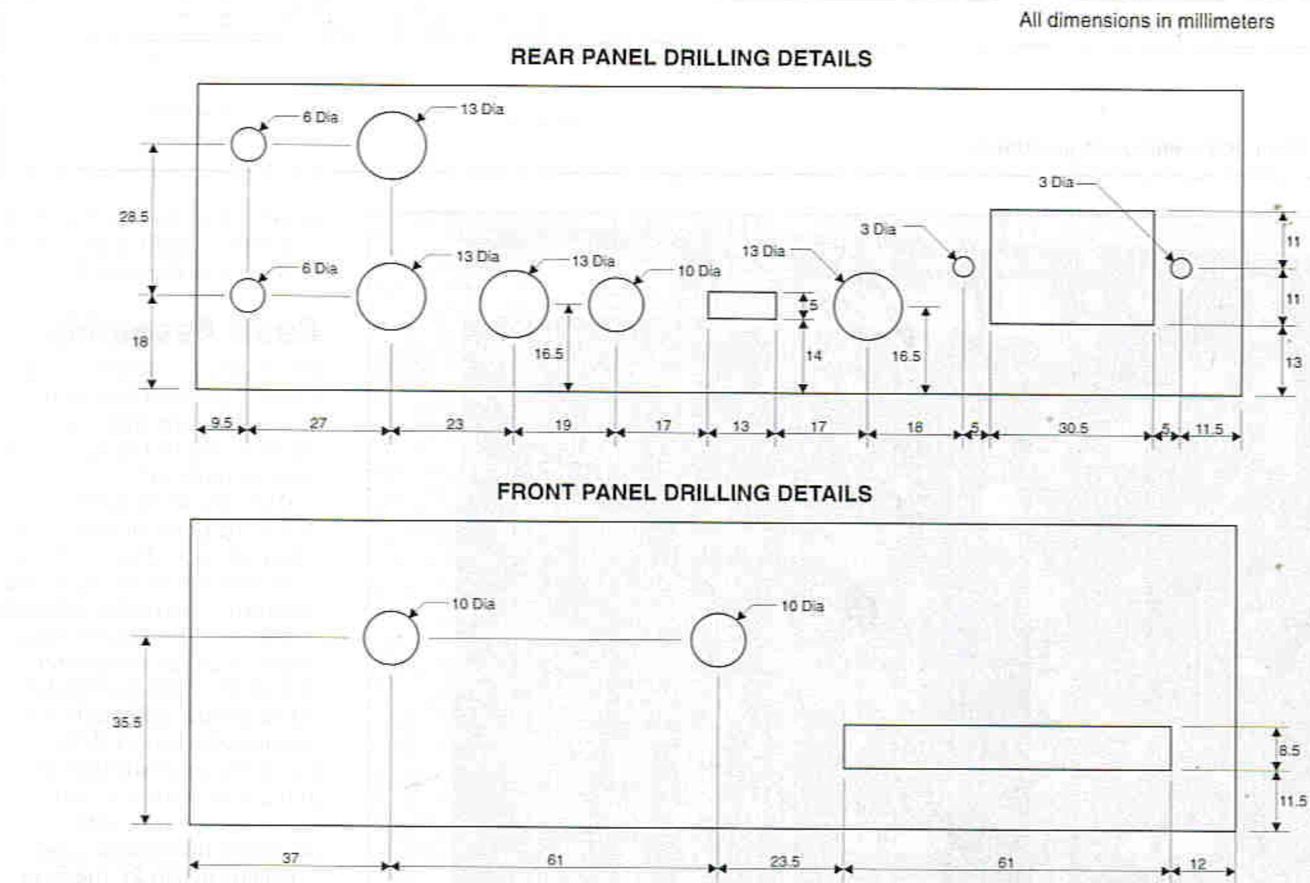


Figure 4. Front and rear panel drilling details.

is (or will be) broadcasting on channel E37.

The unit should be disconnected from the mains when not in use.

One final important comment – if you are working inside a television set or other piece of equipment with the power on, please be very careful.

Acknowledgements

The author would especially like to thank the former editor of *Electronics in Action* magazine, for granting permission to publish this design. He would also like to thank Maplin MPS for supplying the components used to construct the prototype.

Component Availability

The PCBs for this project are available as a pair from the author. Please write to Paul Stenning, 1 Chisel Close, Hereford, HR4 9XF (enclosing an SAE or IRC) for prices.

All other components are available from Maplin MPS. Order Codes are given in the parts list.

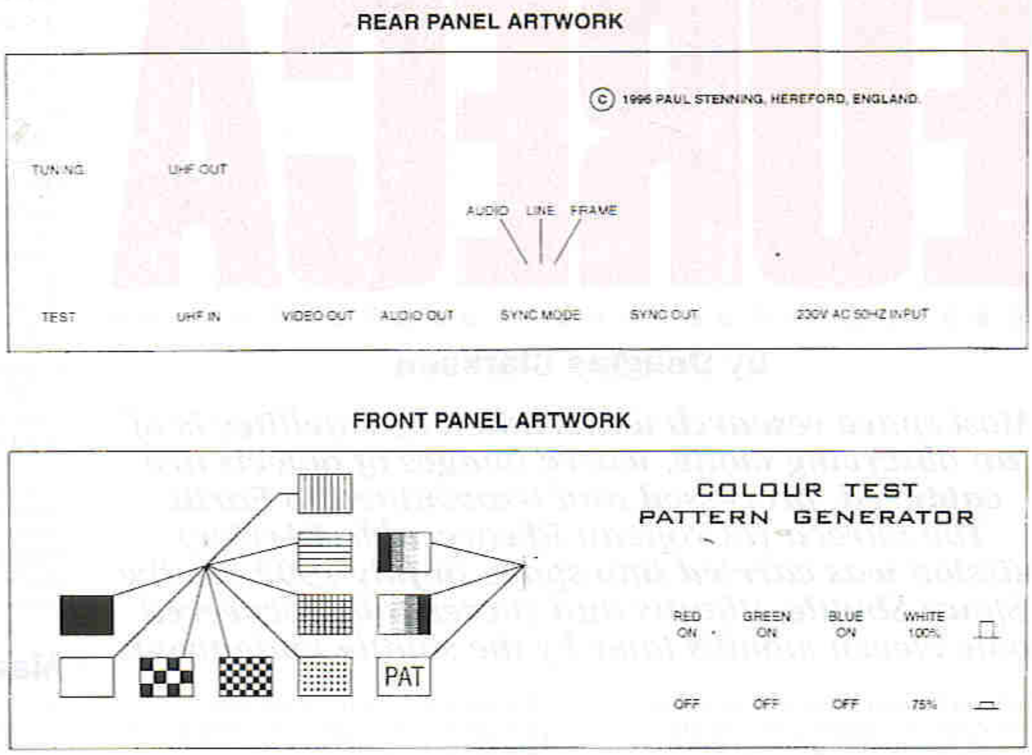


Figure 5. Front and rear panel artwork.

PROJECT PARTS LIST

RESISTORS: All 1% 0·6W Metal Film			
R1	3M3	1	(M3M3)
R2,8,11, 13,15-18	1k0	8	(M1K0)
R3	4k7	1	(M4K7)
R4,12,19, 20,21,27	10k	6	(M10K)
R5	36k	1	(M36K)
R6	470Ω	1	(M470R)
R7	560Ω	1	(M560R)
R9	910Ω	1	(M910R)
R10	75Ω	1	(M75R)
R14	680Ω	1	(M680R)
R22,26	16k	1	(M16K)
R23	8k2	1	(M8K2)
R24	39k	1	(M39K)
R25	22k	1	(M22K)
R28	2k2	1	(M2K2)
CAPACITORS			
C1,9-11, 13,14,16, 17,23,26-28	100nF Ceramic Disc	12	(BX03D)
C2,3	47pF Ceramic Disc	2	(WX52G)
C4	330pF Ceramic Disc	1	(WX62X)
C5,7	5p6F Ceramic Disc	2	(WX41U)
C6	2-22pF Trimmer	1	(WL70M)
C8	470µF 16V Radial Electrolytic	1	(AT43W)
C12	2,200µF 25V Radial Electrolytic	1	(AT53H)
C15,18,22, 24,25	100µF 16V Radial Electrolytic	5	(AT40T)
C19,29, 30,32	10nF Ceramic Disc	4	(WX77J)
C20	82pF Ceramic Disc	1	(WX55K)
C21	47µF 16V Radial Electrolytic	1	(AT39N)
C31	1µF 63V Radial Electrolytic	1	(AT74R)
SEMICONDUCTORS			
IC1	SAA1043	1	(UK85G)
IC2	TEA2000	1	(UH66W)
IC3	74HC4040	1	(UF02C)
IC4	74HC4024	1	(UF01B)
IC5	74HC4075	1	(UF11M)
IC6	74HC86	1	(UB23A)
IC7	74HC00	1	(UB00A)
IC8	74HC02	1	(UB01B)
IC9	7812	1	(CH36P)

IC10	7805	1	(CH35Q)
IC11	74HC133	1	(UH30H)
IC12	LF351	1	(WQ30H)
TR1	2N2222A	1	(UH54J)
D1,2	1N4002	2	(QL74R)
D3	6V8 500mW Zener	1	(QH10L)
D4,5,6,9	1N4148	4	(QL80B)
D7,8	2V7 500mW Zener	2	(QH00A)
MISCELLANEOUS			
SW1	1P12W Rotary	1	(FF73Q)
SW2	4P3W Rotary	1	(FF76H)
SW3-5,7	DPDT PCB Push	4	(FH67X)
SW6	2P3W PCB Slide	1	(FV02C)
SK1,2	PCB-mounted BNC Socket	2	(KE15R)
SK3	PCB-mounted Phono Socket	1	(HF99H)
SK4	PCB-mounted IEC Inlet Socket	1	(FE15R)
FU1	20mm T100mA Fuse	1	(UJ92A)
FU1	20mm PCB Fuseholder	1	(DA61R)
FU1	20mm Fuseholder Cover	1	(DA62S)
MOD1	UHF Modulator	1	(WC20W)
T1	230V to 15-0-15V 6VA PCB-mounted Transformer	1	(YJ55K)
XT1	5MHz Crystal	1	(UL51F)
XT2	8·867238MHz Crystal	1	(UH85G)
L1	15µH Adjustable	1	(UH86T)
L2	270ns Delay Line	1	(UH84F)
	Case	1	(BZ76H)
	RF Flylead	1	(GW61R)
	Mains Lead	1	(MK41U)
	SIL Right-angled Header Strip	1	(JW60Q)
	4-way Latchbracket	1	(FH78K)
	Push Switch Knob	1	(FH61R)
	Knob	1	(RW90X)
	Heatsink	1	(FL58N)
	Insulator TO220	1	(QY45Y)
	24swg Copper Wire	1	(BL15R)
	6·35mm No.4 Self-tapping Screw	1	(FE68Y)
	M3 × 10mm Pan Head Screw	1	(JY22Y)
	M3 Nut	1	(JD61R)
	M3 Washer	1	(JD76H)
	Main PCB (9604-A)	1	
	Front PCB (9604-B)	1	

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

EURECA

by Douglas Clarkson

Most space research undertaken by satellites is of an observing mode, where images of objects are captured, processed and transmitted to Earth. The Eureca (EUropean REcoverable CArrier) mission was carried into space in July 1992 via the Space Shuttle Atlantis and successfully recovered some eleven months later by the shuttle Endeavour.

In Photo 1, Eureca can be seen during the initial process of deployment by Atlantis. Initially launched into an orbit at 300km, Eureca was subsequently boosted into orbit 515km above the Earth.

This unique craft, designed as a reusable scientific platform, had on board a diverse set of experiments. Major projects were designed to investigate the use of micro gravity for crystal growth. A range of biological experiments to investigate the survival of micro organisms in space was also included. Other experiments included investigation of solar physics, Earth's atmosphere and sampling of cosmic dust (see issue 103 of *Electronics*).

In addition, various sets of new space technology including Radio Frequency Ion Thrust Assembly (RITA), an inter-orbit communication system and advanced solar GaAs array were tested under conditions of space. In particular, GaAs concentrator designs were investigated, where levels of focusing of the order of 100 were employed.

The recovery of the vehicle gave extensive opportunities to investigate how key components of the devices functioned in the demanding environment of space. This is why it proved such a valuable test bed for new space technology systems.

While results of various experiments have appeared in numerous scientific publications and this process is ongoing, a rather limited amount of information of the results of the mission has filtered out from the scientific community to the 'media'. This article seeks to touch on some aspects of the results of the Eureca mission – principally of the micro gravity experiments and survival of micro organisms in space.

The practical issues arising from the findings of these key investigations relate to the possible future industrial processing of materials in conditions of micro gravity, the possibility of contamination of planets in the solar system by micro organisms from Earth-launched space probes and the likelihood of micro organisms being able to migrate across the vast depths of space.

Photo 1. Initial deployment of Eureca by Atlantis.

ESA/NASA.

Micro Gravity

Within the Earth's gravitational field, a great many processes involving material fabrication are directly influenced by the Earth's gravity. Consider, for example, a melt of material being cooled during the process of crystal growth. Localised variations of temperature establish corresponding variations in density of material – giving rise to buoyancy effects of the denser components sinking and the lighter ones rising under gravity. If the same process was conducted in conditions of zero gravity, then the material would not be subject to such convective processes which can impair crystal growth and quality by increasing the number of sites of dislocations.

The set of micro gravity experiments on board Eureca was designed generally to test the advantages of the micro gravity environment for crystal fabrication and also to try to grow selected crystals (such as proteins) of sufficient size to allow determination of their complex molecular structures. While previous micro gravity experiments had been conducted on SKYLAB and on board shuttle missions, the key feature of Eureca was the long duration of several of its micro gravity experiments, which allowed a range of slow rate processes to be investigated for the first time.

Mass, Gravity and Weight

Not much has changed in our calculations in relation to gravity since Newton published his Principia in 1687. The attractive force, Fa on an object mass within the vicinity of the Earth is given by:

$$F_a = \frac{\textit{object mass} \times G \times \textit{mass of the Earth}}{(\textit{distance to Earth's centre})^2}$$

$$= \textit{object mass} \times g_o$$

where g_o = 9·81m/s² and is the acceleration due to gravity at the Earth's surface and G is the universal gravitational constant.

The gravitational force is considered to act on each particle within a specific mass. There is no known way of counterbalancing the effect of gravity (in a practical way) so that an opposing force acts equivalently and uniformly throughout the mass being considered. We have not yet developed anti-gravity fields.

For an object in free fall, however, its component atoms and molecules will only be subject to attraction/repulsion due to atomic/molecular forces. It is this state that micro gravity seeks to replicate.

A significant amount of astronaut training is undertaken on board aircraft that describe parabolic trajectories. Weightless conditions can be achieved in a Caravelle jet in parabolic flight for up to 30 seconds. Also, special drop tubes and drop towers have been developed to simulate weightless conditions.

The scope of such short duration weightless conditions is relatively limited for investigations of the full potential of the micro gravity state. The Eureca craft was specially designed to provide an optimum investigative platform for micro gravity. It will be seen, however, that the laws of physics can add some small but measurable components of apparent gravity to objects in orbit round the Earth.

Up and Away

Even well above the Earth's atmosphere at a height of 500km, the acceleration due to gravity is still significant. Figure 1 shows the variation of gravitational acceleration as a function of height above the Earth's surface.

The value of g_r is given by:

$$g_r = \frac{g_o R^2}{(R+H)^2}$$

Where R is the Earth's radius (nominal value 6,400km) and H is the height above the Earth's surface in km. Even at an orbital height of 500km, the orbit of Eureca, the acceleration due to gravity is around 86% of that at the Earth's surface.

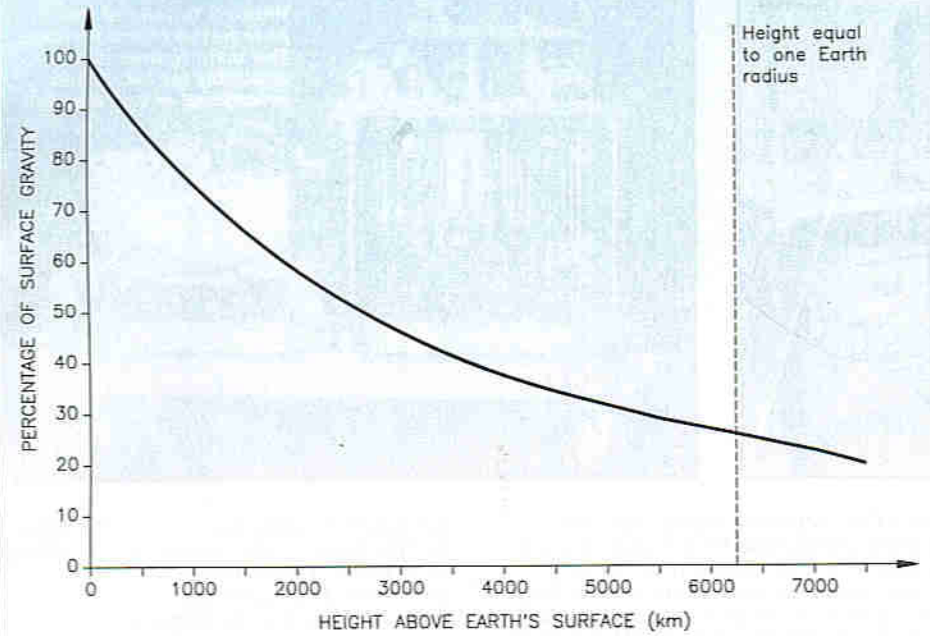


Figure 1. Variation of acceleration due to gravity as a function of height above the Earth's surface.

An object in orbit around the Earth can be considered as 'free-falling around the Earth' and where the force of gravity is equal to the centrifugal force, F_c, on an orbiting mass. The value of Fc is given by:

$$F_c = \frac{object\ mass \times (orbital\ velocity)^2}{distance\ to\ centre\ of\ rotation}$$

By equating this to the force of gravity, the orbital velocity is related to the height, thus:

$$orbital\ velocity = \sqrt{\left(\frac{g_e R^2}{R+H}\right)}$$

In practice, however, such an environment does not provide an 'absolute zero' of gravity. The term micro gravity is more apt, implying that residual components of accelerating force may be active. These residual components will, in turn, be reviewed with reference also to how the design of Eureca sought to minimise them.

Tidal Acceleration

In practice, a satellite consists of a number of mass components spread around the centre of mass (COM) of the satellite. Components above the centre of mass will be travelling faster than the value to contain them in an orbit (due to centrifugal force) at the craft's centre of mass.

The magnitude of so-called tidal acceleration, a_t at orbital height H, can be expressed as:

$$a_t = g_e \times \frac{3 \times R^2}{(R + H)^3}\ m/s^2/m$$

Note that the units are of acceleration per metre displacement from the craft's centre of gravity. This term contains one component due to the reduction in gravity with change in height and another component due to the corresponding change in centrifugal force.

For an orbiting craft at 500km, the value is equivalent to around $4 \times 10^{-7} g_e$ per metre of distance from the centre of mass. Thus, an object released 1m above the centre of mass of the craft will experience micro gravity acceleration and travel about 18cm in five minutes.

Similarly, an object released at rest below the centre of mass will not be travelling fast enough to keep in its orbit and will fall towards the Earth with the equivalent amplitude of acceleration.

Residual Drag

While the ambient pressure of gas at an orbit of 500km is only around 10^{-11}kg/m², the high orbital velocity of 7·6km/s acts to de-accelerate vehicles in orbit by a small amount. This is caused by the momentum change of the particles colliding with the surface of Eureca. For Eureca, this is around $8 \times 10^{-8} g_e$. Objects would be seen to drift about 3cm in five minutes in the horizontal direction of flight. What is happening is that Eureca is being made to imperceptibly slow down in relation to objects inside the frame of reference of the craft.

This residual drag, moreover, will remain constant in its line of action. The effect of residual drag can be minimised by reducing the cross-section of the satellite and flying at higher levels, where the number of atmospheric particles would be reduced.

Radiation Pressure

As photons of light from the sun strike a craft such as Eureca, they transfer their momentum to the object they intercept. The momentum of an individual photon of radiation is given by its energy divided by the speed of light.

The radiation pressure per unit area of surface, R_p can be expressed as:

$$R_p = \frac{(1 + reflectivity) \times solar\ constant}{velocity\ of\ light}$$

Values of reflectivity vary from 0 for a totally absorbing surface to 1 for a perfect reflector. The solar constant is the energy incident on unit area in unit time.

For the particular configuration of Eureca, the maximum value is around $10^{-8} g_e$. The direction of application of this acceleration will change, however, depending on the position in Earth's orbit in relation to the sun. When Eureca is on the dark side of the Earth, this component will vanish.

The design of Eureca seeks to minimise various of these micro gravity components. Experiments are grouped together and as close to the centre of mass as possible, to minimise tidal acceleration effects. By making the craft design relatively compact, this reduces components of aerodynamic drag and also radiation pressure. Figure 2 indicates the mode of action of micro gravity forces acting on orbital satellites.

A satellite such as Eureca is also subject to perturbations of movement from its own set of onboard experiments. Such experiments have been carefully designed to minimise the effects of moving parts, such as closing the furnace door of an on-board experiment.

Satellites also have a tendency to spin. A satellite of 5m diameter rotating at only one turn in 10 minutes will establish a centrifugal acceleration of $3 \times 10^{-5} g_e$. This is around 1,000 times greater than the contributions previously described. A key part of Eureca's design is to detect system rotation using gyroscopes and actively minimise any rotation of the craft.

In addition, where experiment components are being moved, this can act to disturb the orientation of the satellite. These significant movements can be corrected by Eureca's attitude control system using on-board thrusters. Where experiments involve moving parts, the relative motions are designed to involve very smooth accelerations. Also, counter-rotating masses can be installed to nullify any effect of movement of unbalanced components.

Micro Gravity Investigations

As referenced previously, density gradients are induced by thermal gradients in liquids and gases. In conditions of Earth's gravity, this results in buoyancy driven convention. A key aspect of Eureca's micro gravity experiments involved investigating crystallisation under conditions of micro gravity. Experiments involving the Automatic Micro Furnace (AMF), the Multi Furnace Assembly (MFA) and the Solution Growth Assembly (SGA) were used to produce an extensive range of crystals during the mission. These were extensively studied on successful recovery of the payload by the shuttle Endeavour in 1993.

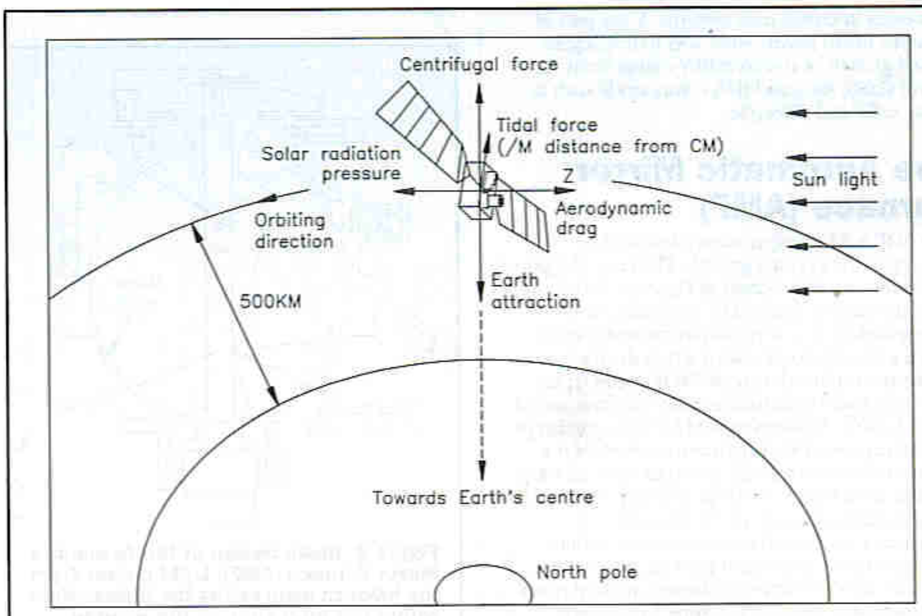


Figure 2. Mode of interaction of micro gravity forces acting on an orbital satellite.

ESA

Photo 2: ESA. Photo 3: Dornier Deutsche Aerospace.

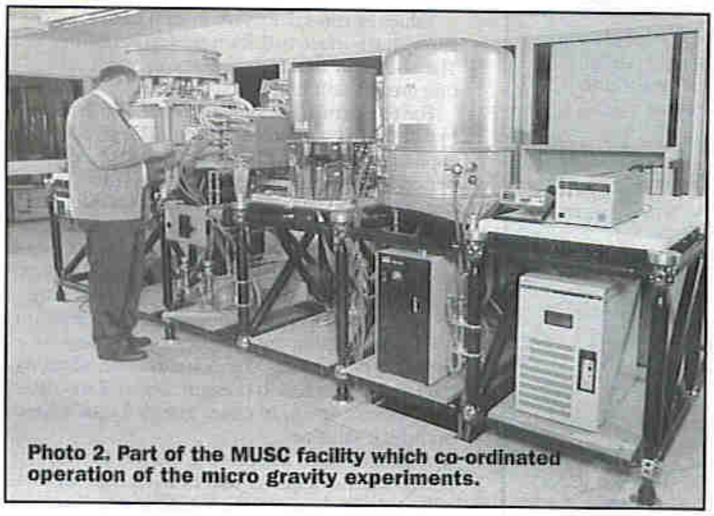


Photo 2. Part of the MUSC facility which co-ordinated operation of the micro gravity experiments.

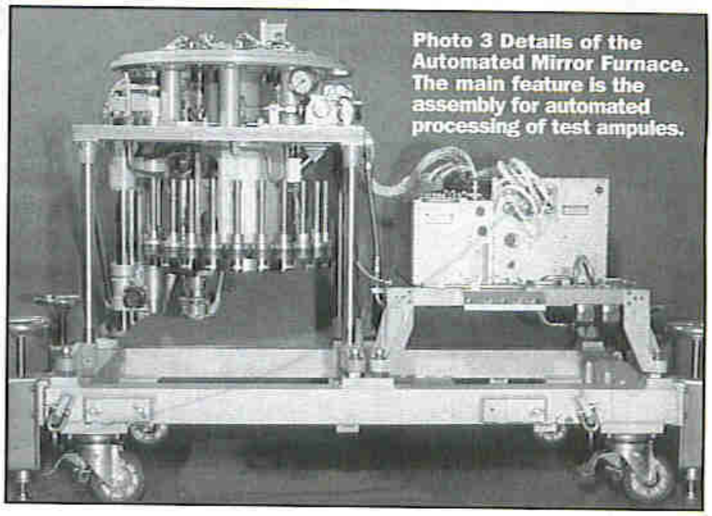


Photo 3 Details of the Automated Mirror Furnace. The main feature is the assembly for automated processing of test ampules.

A key group involved in the design, testing and operation of the micro gravity experiments was MUSC (Micro Gravity User Support Centre), in Cologne. A major role of this group was also the monitoring of the micro gravity environment onboard Eureca to ensure that it remained within the required operational limits. This, in turn, was important in achieving optimum results from the various experiments. Photo 2 shows part of the MUSC facility.

Mass Transport by Diffusion in Liquids

The unique micro gravity conditions of space provide an opportunity to investigate diffusion processes in liquids. While some initial work had been undertaken by Spacelab flights, key experiments require a duration of around 10 days to demonstrate effects. Such diffusion studies typically involve observation of transport of components in mixtures subject to a heating stimulus. The thermomigration or Soret effect leads to segregation of different species according to their density. This process can achieve separation of different isotopes of an element.

Crystal Growth of Electronic Materials

The fabrication of a range of crystals for electronic and technical applications such as integrated circuits and infra-red detectors is an increasingly important aspect of industrialised economies. Many of the key growth rates of crystal formation, however, are masked by gravity-based convection processes in crystal melt systems. A key part of Eureca's micro gravity work was to investigate crystal growth of so-called III-V compounds such as InP, GaSb, AsCs and II-VI compounds such as CeTe, CaSe and (PbSn)Te.

The Automatic Mirror Furnace (AMF)

The AMF is a key experiment, designed for investigation of crystal growth. The basic design of the furnace is indicated in Figure 3. Radiation from the lamp is focused by the inner cavity mirror surface to a zone within the test sample, which is in turn slowly drawn across the melt zone.

Lamps employed were 300W Halogen types, and were able to produce ampule temperatures of up to 1,200°C. Facilities existed for replacing lamps during experiments. The drawing speed of the sample holder was typically 2mm per day – allowing around 20 different crystal growth experiments to be undertaken in a six month mission.

Figure 4 indicates the various zones within ampules during the crystal growing phase. This indicates how the travelling heater method heats the material in the solution zone with grown crystal being increased and polycrystalline feed supplied at a slow rate. Studies also involved samples grown from metallic solutions and deposition from the vapour phase. Photo 3 shows the AMF module prior to its integration into Eureca.

The experiment consisted of a series of 21 test samples and two calibration samples. The AMF was developed for ESA by Dornier GmbH in Germany.

Crystal Growth from Low Temperature Solutions

There is an inherent advantage in growing crystals from low temperature solutions. In particular, thermal stresses are largely eliminated. Also, some thermally unstable materials such as various types of non-linear crystals used in optical technology can only be produced using this method.

The Solution Growth Facility (SGF) of Eureca, shown in Photo 4, consists of three principal reactors for crystal growth experiments. In such systems, solution is fed from reservoirs containing reactant solutions into a central buffer chamber. In conditions of Earth gravity, convection currents established due to differing densities of solutions tend to disrupt crystal formation. One of the experiments sought to grow crystals of amorphous tricalcium phosphate (ACP). This compound is thought to be involved in the mineralisation of vertebrate hard tissue and also a factor in the demineralisation of unloaded bone tissue (osteoporosis). A second system was used to grow calcium carbonate crystal, in order to provide an insight into crystal growth in bio environments.

A third system was used to investigate the crystallisation of zeolites – compounds used extensively as a catalyst in the chemical and petrochemical industry. Zeolites, used as heterogeneous catalysts, are expected to have a key role in technologies such as catalytic cracking and methanol to gasoline processes. The production of sufficiently large crystals will, hopefully, allow their structure to be usefully studied by processes such as X-ray diffraction.

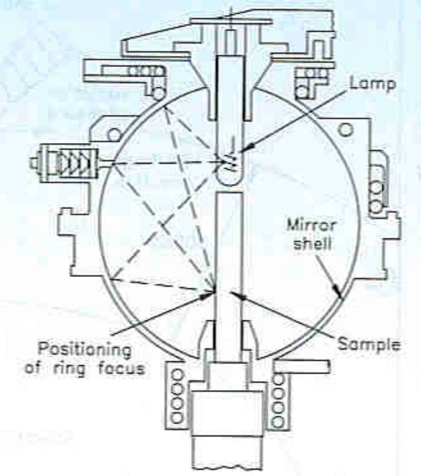


Figure 3. Basic design of the Automatic Mirror Furnace (AMF). Light output from the halogen lamp raises the temperature within the melt zone of the ampule being processed to around 1,200°C.

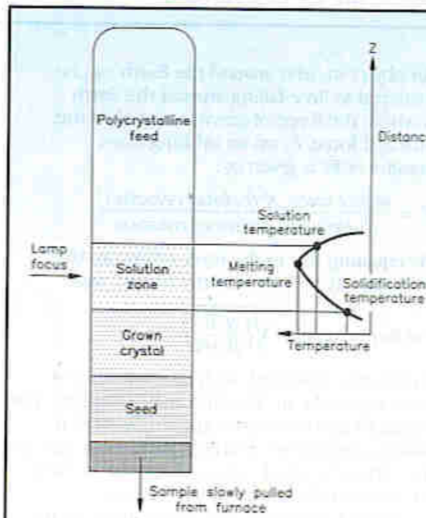


Figure 4. Various zones within ampules during the crystal growing phase.

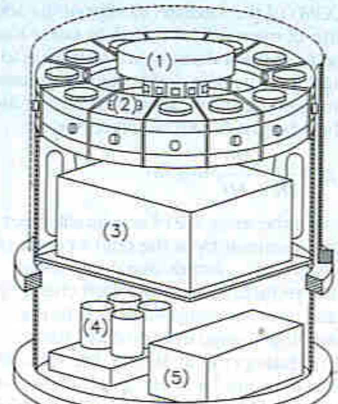


Figure 5. Design of the Protein Crystallisation Facility (PCF) of Eureca showing the upper set of 12 growth reactors and the video observation system.

ESA.

Dornier Deutsche Aerospace/ERNC.

Crystal Growth of Biological Macromolecules

The characterisation of the molecular structure of biological macromolecules such as proteins is a key aspect of medical research. The activity of drugs is primarily related to their ability to attach to receptor sites in such molecules.
An understanding of the protein structure plays a key role in configuring an agent that will be efficient in therapeutic processes.

The Protein Crystallisation Facility (PCF) of Eureca, shown in Photo 5, is a multi-user facility, in which twelve independently controlled, low temperature, long duration solution growth experiments were carried out simultaneously. To initiate the crystal growth process, the chambers connecting salt solution and protein were connected to a buffer solution where crystallisation took place. The instrument was specifically designed to minimise temperature variations during launch, deployment and recovery. Video images of a number of reactors indicated the presence of crystals, though some damage was done to the crystals during a phase of unintentional transient warming. The schematic design of the unit is shown in Figure 5.

Proteins investigated included RNA-based complexes lysozyme and B-galactosidase, Rhodophin, A-crusacyanin and Bacteriorodhopsin.

Crystals of A-crusacyanin were successfully grown using two separate reactors – reactor A and reactor B. Crystals in both reactors were observed on video display after 24 hours of the 9 day reaction process. The reactor temperatures suffered some random heating and cooling during the mission, but visual observing of the crystals indicated their structure did not appreciably change. On recovery, it was found that a glass plate on the base of reactor B had cracked and its contents largely lost. The structure of the crystals of reactor A was examined using synchrotron radiation, though a powder diffraction pattern was revealed. This indicated that the use of micro gravity with the method of crystal production had not resulted in improved molecular ordering in the protein.

The process of analysis of other samples remains on-going, using a broad range of investigative methods.

Investigating RITA

One of the key units of technology tested during the Eureca mission was RITA (RF Ion Thruster Assembly). There is a general requirement for thrust units for Earth orbit satellites – in particular, for geostationary satellites with long operational lives. Conventional chemical thrusters tend to have limited life and add weight to launch payloads. RITA has been developed for this role by researchers at the University of Giessen in Germany, with preliminary work undertaken during the 1970s. The Eureca mission provided an opportunity to test the ion thrust under the demanding conditions of space. While a working unit that used Mercury was available in 1982, to test fly in space, subsequent designs were modified using Xenon as the propellant gas.

The unit tested in Eureca, which is shown in Photo 6, established an accelerating voltage of 1,500V to produce ions at a velocity of 47km/s and delivered a thrust of between 5 and 10mN. Considering a mass of Eureca of 4,000kg, the maximum acceleration developed would be around $2{\cdot}5 \times 10^{-}$g. – of the same order of the values of components of micro gravity. The key components of RITA is shown in Figure 6.

Initially, electrons released from the electron gun (lower left corner) are drawn up into the plasma holder by an electric field. When these electrons are accelerated by the RF field, they are sufficiently energised to ionise Xenon molecules introduced into the plasma holder. After initiation, the discharge is self-sustaining through the action of the RF field. The application of the full accelerating field then ejects the Xenon ions at their high velocity.

RITA was extensively tested during the mission. On the 131th test firing, the unit ceased to function. On examination of RITA after successful recovery,

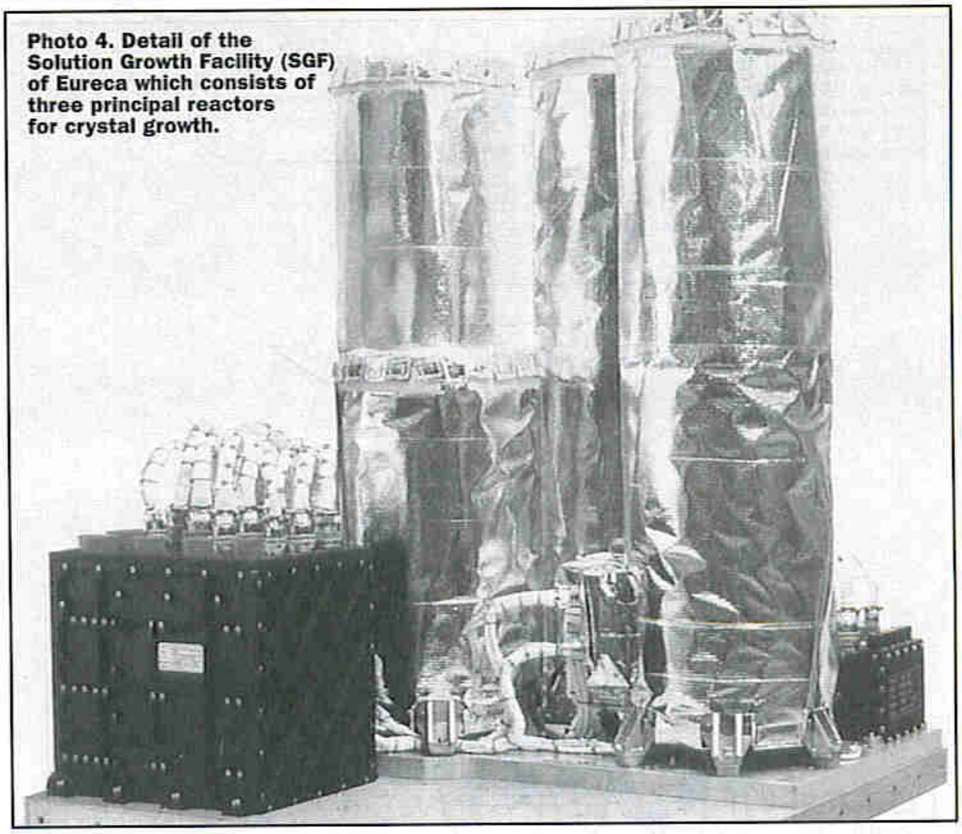


Photo 4. Detail of the Solution Growth Facility (SGF) of Eureca which consists of three principal reactors for crystal growth.

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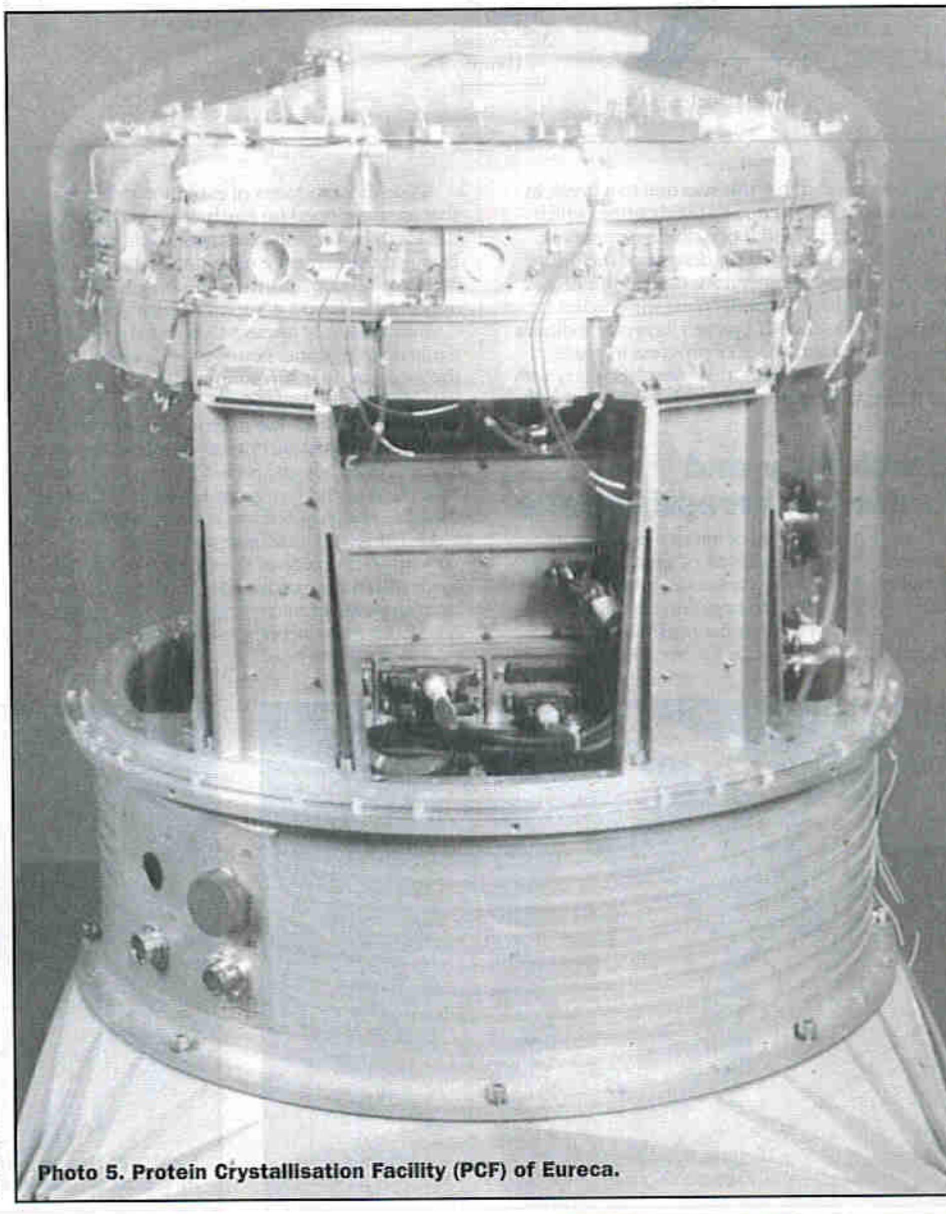


Photo 5. Protein Crystallisation Facility (PCF) of Eureca.

DORNIER DEUTSCHE AEROSPACE/ERNC.

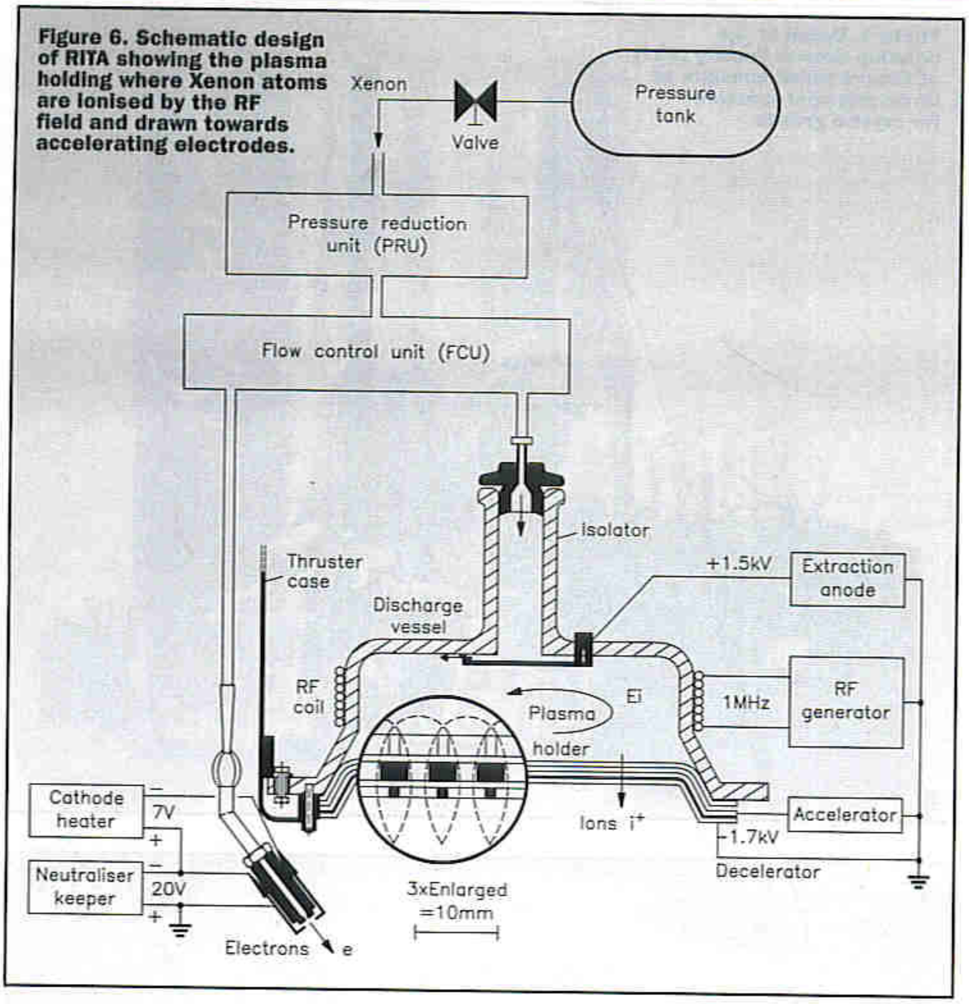


Figure 6. Schematic design of RITA showing the plasma holding where Xenon atoms are ionised by the RF field and drawn towards accelerating electrodes.

Dornier Deutsche Aerospace.

it was discovered that this was due to a break in circuit in the RF coil due to overheating, which in turn, caused a failure of a diode component. The key lesson learned for designs of the future was to minimise temperature rises in the RF coil and use conductive connections with higher melting points. The RITA project, however, indicates the slow yet steady pace of progress in space technology, where things 'new' must also carry with them acceptable and demonstrable levels of reliability.

Exobiology and Radiation Investigations

The study of the ability of micro organisms to survive the harsh conditions of space is certainly of interest to all those curious about the origins of life on Earth. Did life begin on Earth in isolation from all other influences? Or was it carried here – from much further afield?

While most theories of evolution determine that life developed on Earth, to some biologists, the Earth of 4 billion years ago would hardly favour the emergence of life. Also, the ancient monocellular organisms of this epoch already appeared to have a complex cellular structure.

Anaximande of Ancient Greece (610 to 546 BC) maintained that the 'germs of life' originated in the moisture that surrounded the Earth, which in turn, fell as rain. In 1865, the German physician, Richter, suggested that micro organisms could be picked up by passing comets or meteorites and transported through space. Comets, as we know, have the potential to migrate between different star systems – as if propelled by a cosmic pin ball machine.

Also, it is a general observation that catastrophic meteor or comet impacts on the Earth within geological time could have cast large amounts of micro organisms into space – like a cosmic breath of wind blowing against a dandelion seed head.

Previous experiments to investigate these questions have taken place using balloons, rockets and spacecraft. Extensive laboratory experiments simulating the conditions of outer space have also been carried out. The most severe test was that of the Long Duration Facility (LDEF), in which bacterial spores were exposed to the harsh environment of space for 2,107 days.

The Exobiology Radiation Assembly (ERA) experiment of Eureca provided an opportunity to expose a range of biological material to the harsh conditions of space. The severe environment of space is characterised by a high vacuum as low as 10^{-12}Pa, a solar electromagnetic spectrum extending from 2×10^{-11}m to 2m and external temperatures determined by the deep space temperature of 4K. In addition, the galactic component of cosmic radiation can be characterised as 86% protons, 12·7% He ions and 1·3% heavy ions.

Photo 7 shows the Exobiology and Radiation Assembly or ERA. When deployed, the 'lid' of the experiment rotates back to allow solar irradiation of the compartments. Figure 7 shows a schematic diagram of ERA in the launch/recovery configuration. ERA was developed under ESA contract by SIRA Ltd. of Chiselhurst, UK.

The ERA experiment subjected a range of samples to combinations of environments, which included space vacuum, argon atmosphere at 1,000mbar with combinations of various levels of exposure of solar radiation. The thermal conductivity of the ERA exposed surface was, however, less than anticipated. This resulted in the temperature of the front 'lid' part of the experiment rising to 50°C – leading to the de-activation of most of the samples held in this section.

Within the ERA, in 'dark' conditions, a range of modes of environment were available for testing. Spores of Bacillis subtilis survived 327 days in the vacuum of space at up to 25% for one strain and without any degree of protection as a monolayer of spores on a test surface. Survival is increased to as high as 80% when protected by a layer of glucose. This is thought to stabilise the structure of the cellular macromolecules during the dehydration process experienced by the spores.

This data confirms the result of the LDEF experiment, that with samples protected by glucose, survival rates of 86% were observed within almost a six year period. The condition of 'dark' outer space, however, represents a hostile environment where even tough organisms from Earth would, over relatively long periods of exposure, be killed. The spores used for the experiments are so-called dryness resistant organisms or anhydroints. A comparable set of controls were monitored in a similar ground-based experiment.

In space, unprotected spores are rapidly de-activated – most succumb to 10 seconds of solar radiation, though there tends to be a small residual fraction that can survive. The action of the extraterrestrial solar UV radiation is mutagenic and induces strand breaks in the DNA. Maximum sensitivity is at around 260nm, which corresponds

Photo 6: Dornier Deutsche Aerospace. Photo 7: SIRA Ltd.

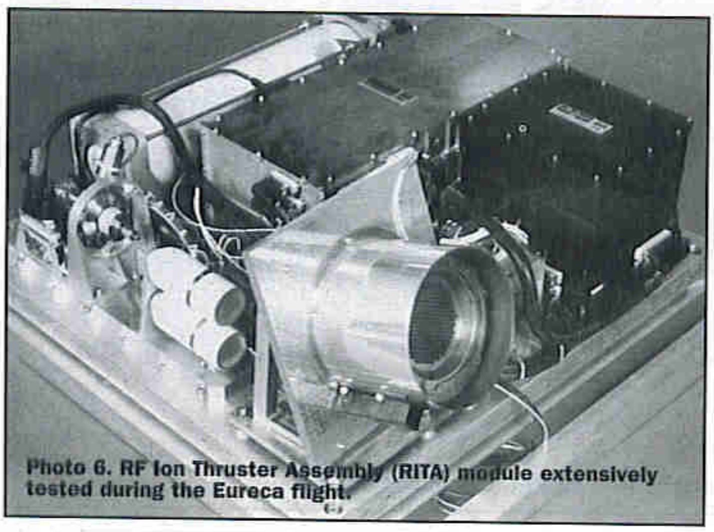


Photo 6. RF Ion Thruster Assembly (RITA) module extensively tested during the Eureca flight.

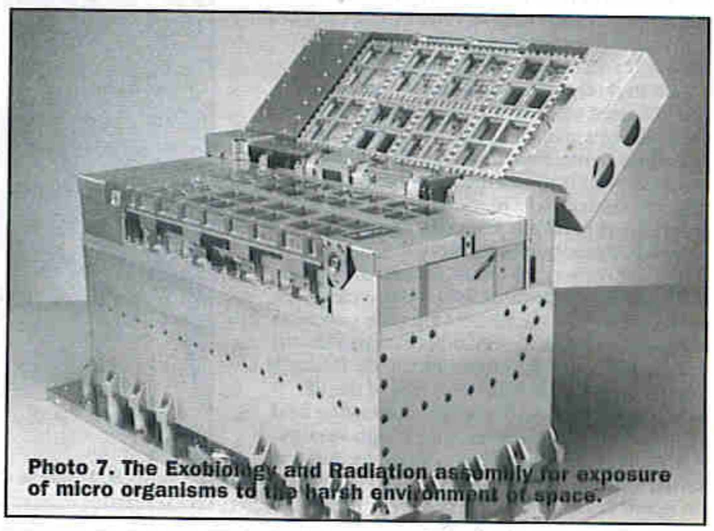


Photo 7. The Exobiology and Radiation assembly for exposure of micro organisms to the harsh environment of space.

to the maximum DNA absorption. On Earth, unprotected spores have to be exposed to solar light for 3 to 15 hours to achieve equivalent population reductions.

Putting it another way, extraterrestrial solar radiation can seriously damage your genes. Recovery of biological material from Eureca also gave the opportunity to determine the extent of DNA damage in recovered samples.

The set of filters on Eureca was used to estimate a relative 'action spectrum' of extra terrestrial solar UV radiation. Figure 8 indicates the general form of such an action spectrum. On Earth, the presence of ozone in the atmosphere acts to filter out the highly damaging rays below 290nm. If for any reason, the Earth's atmosphere provided no UV protection, then life on Earth would be radically different and certainly much less abundant.

Short wavelength and highly damaging UV radiation tends only to penetrate about 0·1mm into biological samples, and so lower layers of organisms are protected. An individual free-floating organism, however, would very likely soon be deactivated. Samples would also be exposed to cosmic rays, which would, over long periods, tend to de-activate micro organisms on exposed surfaces of comets and meteorites.

The findings of this work provide insight into two separate questions. One is the understanding of the ability of life to wander through the galaxy in the forms of highly resistant spores of micro organisms. The other is the risk of contamination of other planets/moons of the solar system by probes from Earth. The evidence so far is that there is a high chance that micro organisms on space probes could be transferred to other sites. Thus, spores protected from solar radiation could easily survive in a space craft mission of one or two years to a destination such as Mars. In particular, it is felt by various workers, that the COSPAR Planetary Protection Rules should be seriously observed and in particular, for Mars missions. Will this be a new agenda item for Greenpeace?

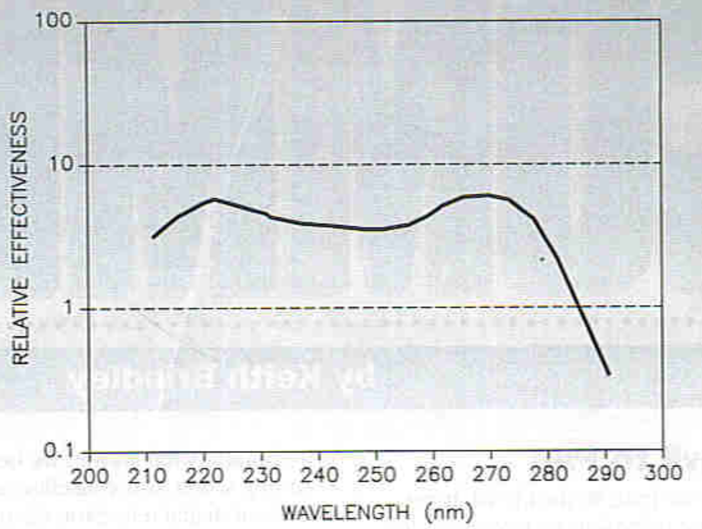


Figure 8. 'Action spectrum' of extraterrestrial Ultra Violet radiation indicating peak of sensitivity at around 260nm.

Inter Stellar Grain Experiment

While comets excite considerable scientific curiosity in relation to their transient passage through the solar system, there is increasing interest also in the origin of the diverse complex organic molecules known to reside within their ice mass structures. A key factor of the process is considered to be bombardment by UV photons in deep space of small embryonic nuclei in interstellar space. It is considered that comets are formed when such nuclei are somehow collected together. This underpins the interest by ESA in the future ROSETTA mission, which seeks to recover material from a passing comet.

The ERA experiment provided an opportunity to 'condition' so-called first generation organics which may exist in interstellar dust clouds. It is thought that in such regions, volatile ice accretes over small silicate particles and that the chemistry of these particles is modified by the very low levels of UV radiation present in deep interstellar space. As part of the Eureca experiment, a cocktail of first generation organics water, carbon monoxide, ammonia, methane, methanol and acetylene were deposited on a small block of Aluminium at 10K. This in turn was exposed to a laboratory source of ultraviolet light for between 22 to 68 hours.

This 'yellow strip' compound was then placed on board the ERA module to receive high levels of solar UV radiation for 4 months. This relatively brief exposure is estimated to be equivalent to a period of exposure of 10 million years in interstellar space. Even laboratory sources of 'extraterrestrial' UV are several orders of magnitude weaker than actual solar exposure in space.

On recovery of the various sets of material (16 in total), the yellow appearance had changed largely to brown. This was associated with a general carbonisation of the material following depletion of oxygen, nitrogen and hydrogen in the samples.

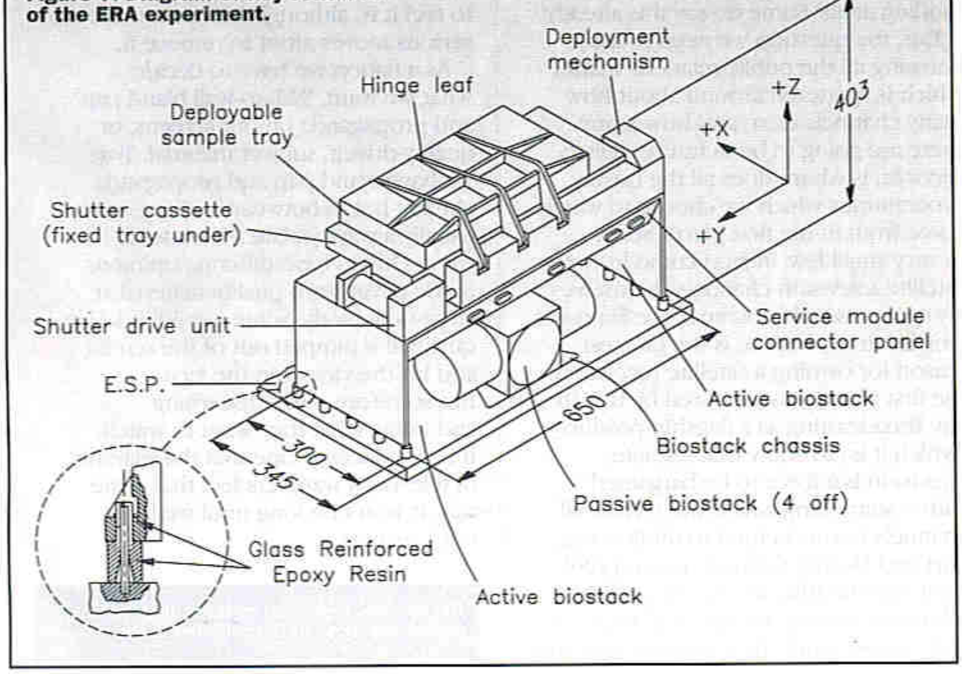
When the absorption spectra of the recovered material was observed back on Earth, there was a good degree of matching over the part of the spectrum of Galactic Centre IRS 6E source, thought to be typical of interstellar dust grains. The significantly extended scope of ISO (Infra Red Space Observatory) will further allow 'real' data to be tested against the simulated material obtained from the ERA platform of Eureca.

Summary

Eureca, therefore, has provided scope for scientific research in a broad range of topics and also allowed the development and test of components of commercial satellites of the future. The principle of various industrial and academic groups in projects such as Eureca is important for maintaining the general 'competence' of Europe in leading edge areas of technology.

Reflecting on the 'exobiology' experiments of the ERA module, it is a curious thought that not only have we exported space craft beyond the outer limits of the solar system – in all probability, we have exported our organisms as well.

Figure 7. Diagram of key features of the ERA experiment.



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Point of Contact

Public Information, ESA Publications Division, ESTEC, Noordwijk, The Netherlands.

SIRA Ltd.

COMMENT

by Keith Brindley

The Devil to Pay

As a nation, we have to decide what we want. Satellite television services (and for that matter future digital terrestrial services) hang on the fact that programmes are cheap to produce. No, I will qualify that, they are *relatively* cheap to produce – relative to programmes produced for terrestrial television services, that is. However, if you look at it add up the figures, quality television programming is expensive.

Don't get me wrong. Many satellite programmes are excellent. I'm not trying to put satellite television down in any way. But, for example (my role here is as devil's advocate, you understand) many satellite programmes are re-runs of yesterday's terrestrial programmes. There is nothing wrong with that but it's an ideal starting point to the topic I'm going to lead into. Yesterday's terrestrial television programmes can still be today's quality programmes – however old they are, particularly if they were quality programmes back then. On the other hand, many re-runs are poor, they might have been always poor, or they might have been good for their time but just not up to the standard we have been led to expect in recent times.

At the time of writing there are some 51 satellite television channels transmitted in English from the single Astra satellite. (Yes, I know there are several satellites co-located at 19.2° east, where the Astra slot is, but to go into that would over-complicate an already tricky argument, so let's keep it simple and say it's just a single one – which to an independent user is the way it appears.) If you add together the channels from Astra with those of all other satellites located at the multitude of positions around the satellite arc and watchable from the UK, the total number of accessible English-speaking satellite television channels a UK television watcher can pickup amounts to well over 100. But, hey, who's counting? Once you get to numbers like these, it becomes largely irrevelant, doesn't it?

Well, no actually it's not irrelevant. That's the whole point, we should be counting. Doesn't the fact that there is so much choice available on satellite mean something in its own right? And if that's not enough, what should we be counting when future satellite and terrestrial digital television channels start transmissions? Literally hundreds of channels will be available, all transmitting similar programmes from similar services.

When satellite television was in its infancy, the four terrestrial channels were the only real choice we had. The television license fee was acknowledged as being the best way to pay for the television services we had. After all, the BBC (for whom the television license fee is administered) represented 50% of all television services in the UK. The independent television channels were always funded by advertising, and should always be so. When Astra came along though, the situation began to change. More and more satellite television channels mean that viewers have an increasing right to gripe at having to pay the television license fee for what effectively is a decreasing proportion of the total television channel choice.

Once we reach the state where the BBC channels are a small minority of the total number of channels (remember that presently only 4% of television channels are run by the BBC) then don't we have a right to think that there should be less and less reason why the BBC should get funding at all? Some do say this already.

But, the question we need to ask, knowing all the public relations matter which is spattered around about how many channels exist, and how many there are going to be in future digital services, is where does all the quality programmes which we choose to watch come from in the first place? Some (a very small few, in fact) come from the satellite television channels themselves. My own personal favourite is The Simpsons, which I firmly believe is the greatest reason for owning a satellite receiver in the first place, was procured by British Sky Broadcasting as a flagship product (which it is) to show that satellite television is a force to be bargained with – something which the terrestrial channels never seemed to think it was. Bart and Homer Simpson proved BSB right and the BBC wrong. As satellite television services expand and improve, and consequently increase their revenues from subscribers as subscriber numbers grow, then more and more quality programmes will result from their control.

On the other hand, most existing quality television programmes (new or re-run) come straight from the existing terrestrial broadcasters' productions. While this balance between service providers will change over the short-term as satellite television service providers' revenues increase, and they produce (or pay for, at least) more and more quality programmes, the long-term results will still – I am sure – show that the existing terrestrial broadcasters will continue to produce the majority of quality programmes.

And now, to my point. Do we care enough for these quality programmes to continue paying for them by funding the BBC through the license fee? Some would suggest that the license fee is not a feasible demand to make of a satellite watching, television-viewing public. Some one in five households currently have satellite television services – still a minority, but over the next few years likely to become a majority. Once we all have hundreds of television channels is a license fee appropriate at all? That's a rhetorical question incidentally. I for one hope we continue to feel it is, although I suspect there are serious moves afoot to remove it.

As a nation we have to decide what we want. Wall-to-wall bland pap and propaganda on our screens, or quality-driven, subject material. True, we have bland pap and propaganda already, but in between it all, we can usually always isolate the material we want. Others have differing opinions. Some never want quality material at all or only rarely. Some wouldn't know quality if it jumped out of the screen and hit the viewer in the face. But some are more discerning and know what they want to watch. It is my sincere hope that the majority of television watchers feel that same way. It won't be long until we find out I suspect.

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

PROJECT

This alarm system was originally designed to protect the contents of a garden shed, although it would also be ideal for other outside buildings. In addition, it would offer a good basic security system for small residential areas, such as flats and bedsits. It may be installed without drilling or attaching to the building, which could be an advantage in rented accommodation.

SPECIFICATION

Number of zones	2 (Entry/Exit and Loop Cable)
Maximum Loop Length	Unlimited
Exit Time	5 to 30 seconds (set by internal preset)
Entry Time	5 to 30 seconds (set by internal preset)
Alarm Time	16 minutes (typical)
Entry/Exit Warning	Pulsed Buzzer and Flashing Status LED
Alarm Sounder	Piezo Siren (110dB @ 1m)
Supply Voltage	9V nominal (PP9 Battery)
Low Battery Indicator	Status LED extinguished below 6·5V
Supply Current (Armed)	1mA (typical)
Battery Life	6 months (typical)
Remote Output	Optional changeover relay
PCB Size	172 × 75mm
Overall Size	177 × 120 × 83mm
Weight	500g

The unit features two separate protection arrangements. The entry/exit is protected using standard normally open and/or normally closed sensors such as magnetic switches and pressure mats. Entry and exit delays are independently adjustable, from 5 to 30 seconds, during which time, a warning sounder operates and a status LED flashes.

Valuable items are protected by a wire loop system similar to that used in shops, etc. This uses a two-core cable which is threaded through the items to be protected, and the alarm will be triggered immediately if either core becomes open-circuit or if the two cores are shorted together. Suggestions are given later for making the system even more tamper-resistant.

The loop system can be used independently from the entry/exit system. This would be useful if a shed or garage needs to be left open when working in the garden, while still providing protection for valuable bicycles and power tools.

The unit is battery powered, and will give at least six months of continuous operation from a PP9 battery. The alarm sounding period is limited to about sixteen minutes, to conserve battery life and reduce annoyance, but the status LED remains on after this period to indicate that the alarm has been triggered. An optional relay output can be connected to an extra sounder or household alarm system.

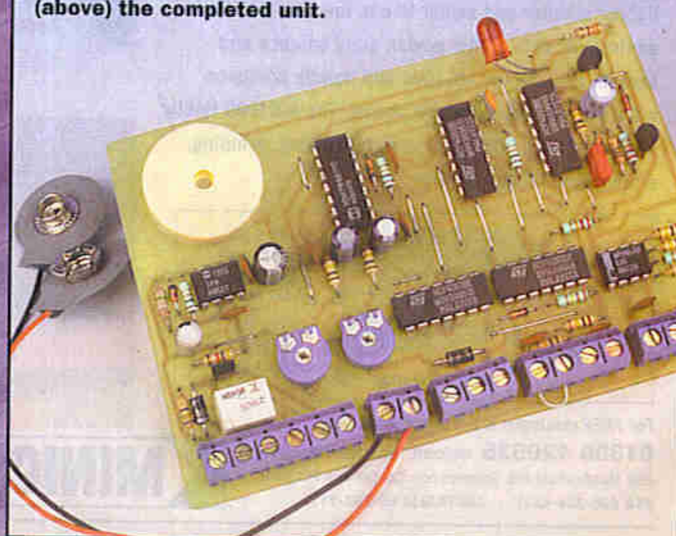
Block Diagram

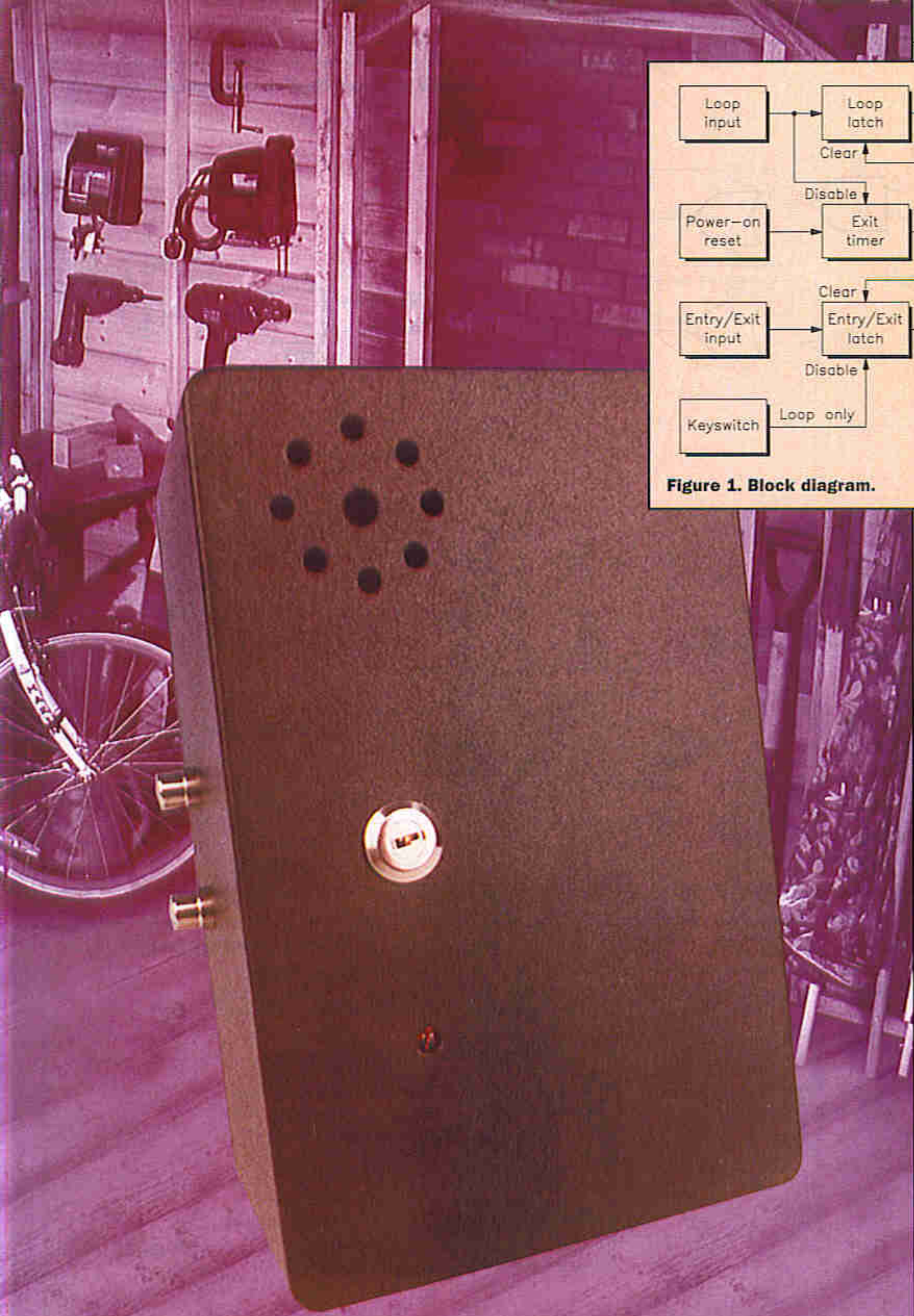
Referring to the Block Diagram shown in Figure 1, the Loop Input and Entry/Exit Input are both followed by Latches to hold the alarm state even if the input reverts to normal. The Entry/Exit Latch can be disabled by setting the keyswitch to the Loop Only position.

The Loop Latch operates the Alarm Timer and Driver immediately. The Entry/Exit Latch triggers the Entry Timer which drives the Warning Sounder. If the unit is not switched off by the end of the Entry Timer period, the Alarm Timer and Driver are operated.

When the unit is switched on, the Power-On Reset circuit triggers the Exit Timer. During this period, the two Latches are cleared and the Warning Sounder operates. If the Loop is not connected correctly, the Exit Timer will not operate.

The completed PCB and (above) the completed unit.





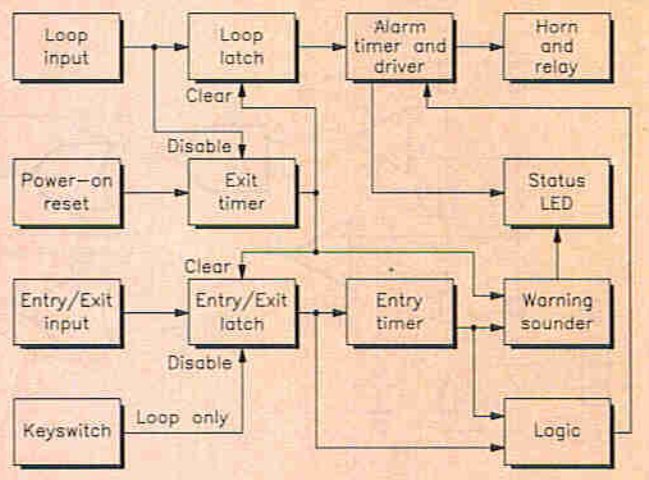


Figure 1. Block diagram.

On Guard LOOP ALARM

by Mark Price

The Status LED flashes while the Warning Sounder is operating, and is lit steadily when the Alarm is or has been sounding.

Circuit Operation

The circuit diagram (see Figures 2 and 3) contains a number of inter-connected sections. To simplify the diagram, the various sections are shown separately, with interconnections indicated by labelled arrows.

The loop input and latch are shown in Figure 2A. The far end of the loop is terminated by a 100kΩ resistor (R5) which, when the loop is connected, forms a potential divider with R4 to give a voltage equal to half the power supply voltage on pins 2 and 6 of U1 (4·5V with a 9V battery). C1 removes any noise that may be picked up along the loop wire.

U1:A and U1:B (LPC662 dual op-amp) form a window comparator. R1, R2 and R3 set the top and bottom ends of the acceptance range. With a 9V battery, the voltage on pin 3 of U1:A is about 5V and that on pin 6 of U1:B is about 4V. If the voltage from the loop potential divider should become outside this range, the appropriate output of U1 will go low, giving a high level on pin 4 of U2:B. The LPC662 op-amp has the lowest current consumption in the range of devices offered by Maplin that will operate down to 6V.

U3:C and U3:D form an S-R (Set-Reset) Latch. This is cleared by the Exit Delay timer when the unit is switched on. If the output of U2:B should go high, even momentarily, the latch will change state, triggering the alarm.

The Entry/Exit input is shown in Figure 3A. In the normal state, pin 1 of U2:A is held high by the N/C (Normally Closed) sensors,

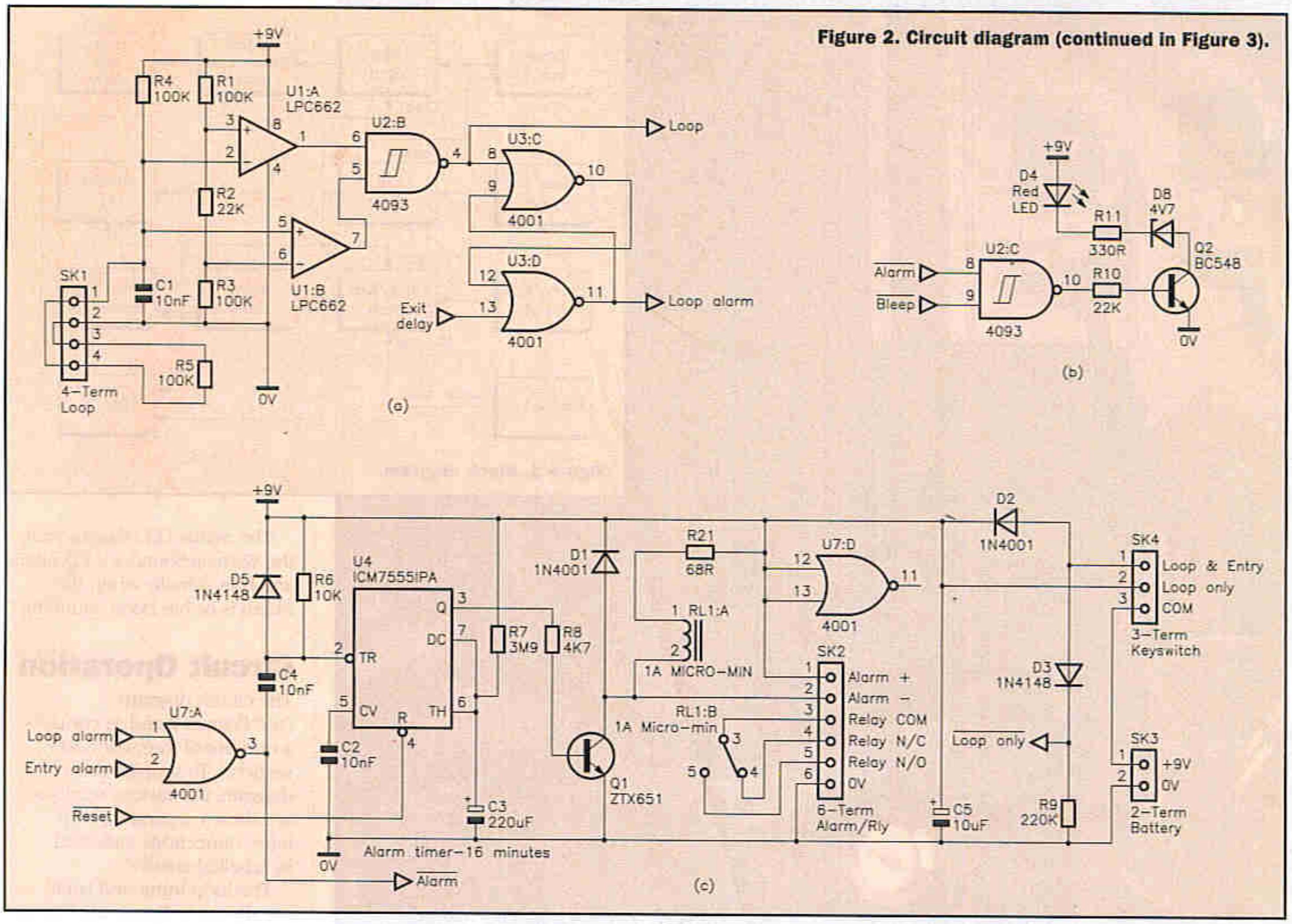


Figure 2. Circuit diagram (continued in Figure 3).

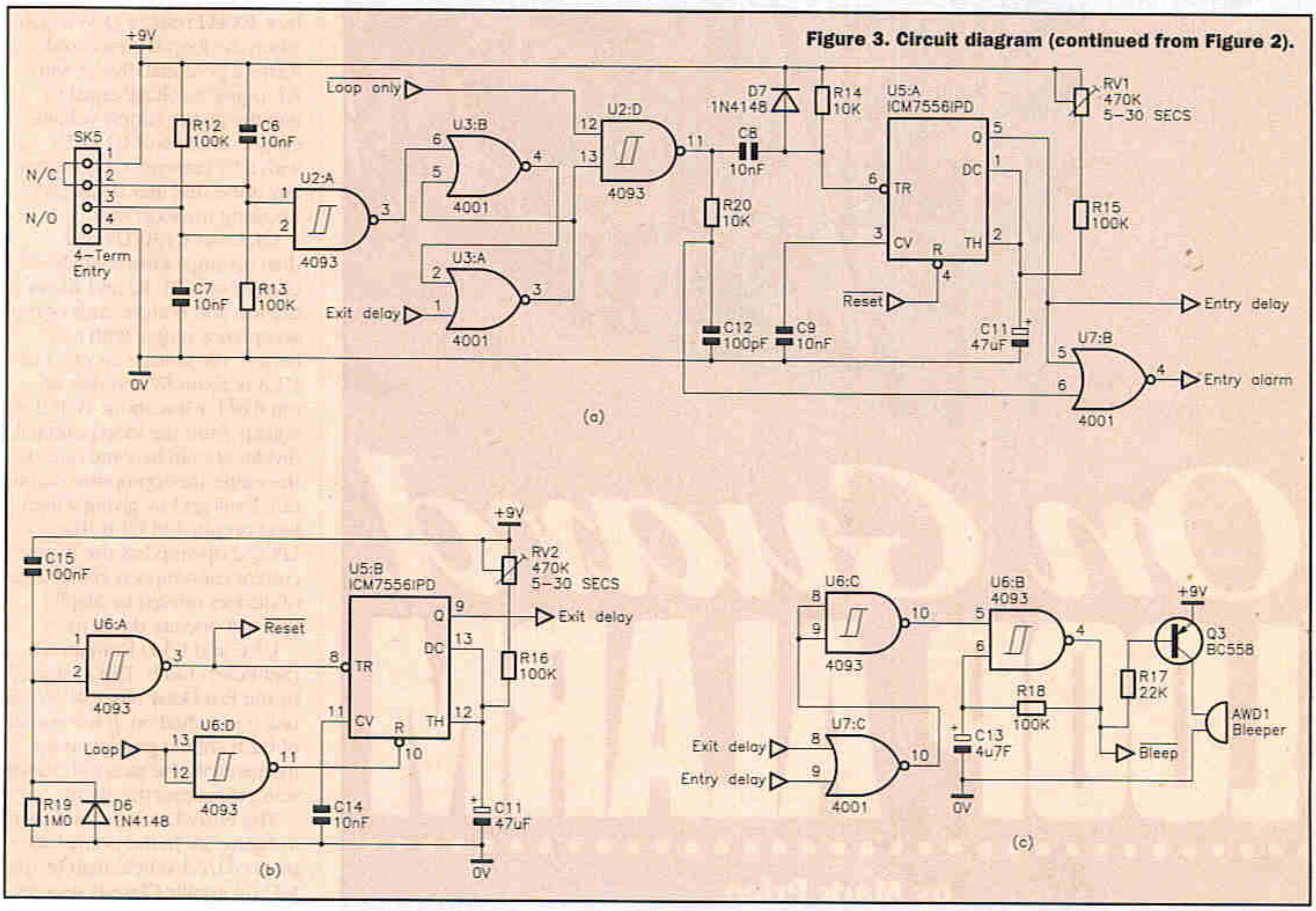


Figure 3. Circuit diagram (continued from Figure 2).

and pin 2 is held high by R12. If a sensor on the N/C circuit should operate, pin 1 will be taken low by R13, while if a N/O (Normally Open) sensor were to operate, it would pull pin 2 low. Note that both N/O and N/C sensors may be used simultaneously (providing they are connected correctly), and either will trigger the alarm. C6 and C7 remove any noise which may be picked up along these connections. U3:A and U3:B form a latch which operates in the same manner as that used for the Loop input.

The active-low Loop Only signal on pin 12 of U2:D comes from the keyswitch. When the line is low, it prevents the signal from the latch from reaching the Entry Timer.

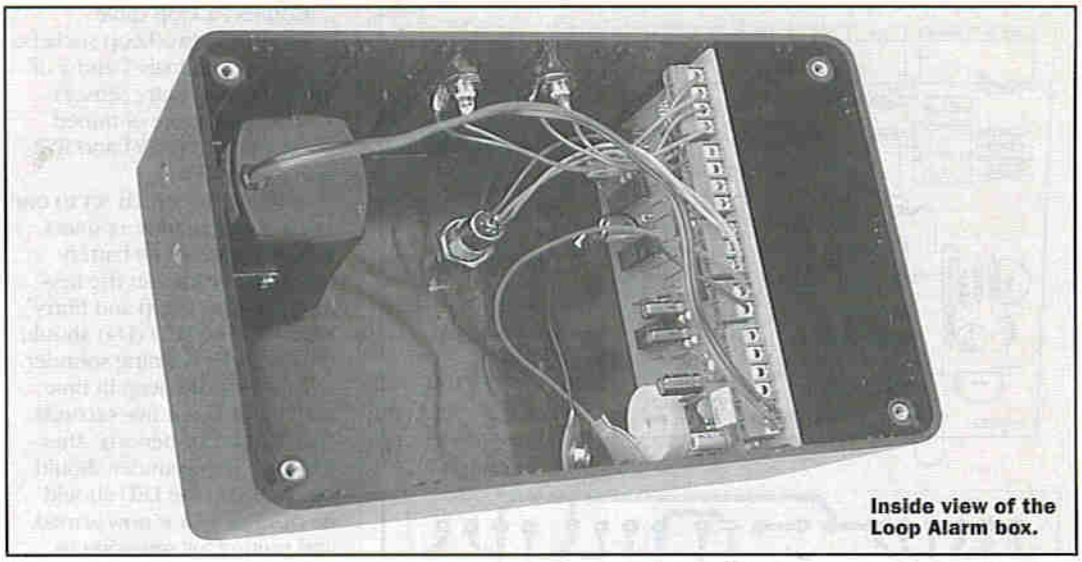
U5:A is the Entry Timer, which is triggered by the negative going output of U2:D. RV1 sets the entry delay period from 5 to 30 seconds. The output on pin 5 of U5:A is high during the entry delay period. U7:B gates the signals from U2:D and U5:A to give an output that is high when the Entry Latch has operated and the Entry Timer has timed out. R20 and C12 provide a very short delay to compensate for the propagation delay of U5:A.

The Alarm Timer and output are shown in Figure 2B. When either the Entry Alarm or Loop Alarm line goes high, the output of U7:A goes low, triggering the Alarm Timer (U4). The values of R7 and C3 give a calculated time period of 16 minutes, although in practice, this may be a minute or two longer due to the minute leakage current in C3. Even in this case, the alarm period will be less than 20 minutes, which is now a legal requirement.

During the alarm period, Q1 is turned on, driving the alarm sounder connected to terminals 1 and 2 of SK2 and the optional relay (RL1:A). D1 protects the transistor from the back-emf produced by the relay when it is switched off. The relay contacts are brought out to terminals on SK2, together with the circuits 0V rail, for connection to a remote sounder or alarm system if required. If this option is not used, RL1 and R21 should be omitted to conserve battery life.

Gate U7:D is unused, so both inputs are connected to the 9V rail and the output is left unconnected.

The battery (9V PP9 type) connects to SK3 and the keyswitch to SK4. When the switch is set so that terminals 1 and 3 of SK4 are linked, power



Inside view of the Loop Alarm box.

is connected to the circuit via D2 and the active low Loop Only line is taken high via D3. When the switch links terminals 2 and 3, power is connected directly to the circuit and the active low Loop Only line is low.

The Power-On Reset circuit and Exit Timer are shown in Figure 3B. When the unit is switched on C15 will be discharged, holding the inputs of U6:A high. C15 will charge via R19 within half a second. The output of U6:A will, therefore, be low for a brief period when the unit is switched on, giving a suitable signal to trigger the Exit Timer (U5:B), and reset the entry and alarm timers. The device used for U6 has Schmitt trigger inputs to give reliable operation with an input signal that does not conform to digital levels.

U6:D inverts the signal from the Loop input, so that the Exit Timer (U5:B) is held reset and, therefore, disabled, if the loop is not connected. RV2 sets the Exit period from 5 to 30 seconds (approximately).

The Warning Sounder is shown in Figure 3C. During the Exit and Entry periods, the output of U7:C will be low. This is inverted by U6:C, giving a high level to U6:B. This enables the oscillator formed by U6:B, R18 and C13, which operates at a frequency of about 2Hz. This drives a self-contained audible sounder (AWD1) via Q3, so that the sounder beeps twice every second. For this type of oscillator to operate, an IC with a Schmitt trigger input is specified.

The Status LED is shown in Figure 2B. The output of U2:C goes high in sympathy with the warning sounder, and also when the alarm has operated. Thus, the LED flashes during the Exit and Entry periods, and lights steadily when alarm is (or has been) triggered. In the normal operating state, it remains off to conserve battery life.

D8 (4V7 Zener) in conjunction with the forward voltage drop of D4 (red LED) act as a basic low battery indicator. The LED brightness will reduce as the battery runs down, and it will not illuminate if the battery voltage is below about 6·5V, although the Warning Sounder will continue to operate. The remainder of the circuit will operate with a battery voltage as low as 6·0V, but prompt battery replacement is recommended when the LED fails to light or becomes very dim.

The circuit consumes under 1mA in the armed state. Most of this is due to U1, U4 and U5. The unit will give typically six months continuous operation from a high capacity 9V battery such as a PP9. A large battery is also more able to operate the alarm sounder.

PCB Construction

The circuit is constructed on a single-sided PCB which is designed to fit into the guides in the recommended case – refer to the PCB legend and track drawing, shown in Figure 4. PCB assembly should be carried out following the normal guidelines and recommendations.

There are several wire links which should be fitted first. IC sockets should be used for the ICs, as they are static sensitive. Do not fit the ICs into the sockets until all other components have been fitted.

SK1 to SK5 are PCB mounting terminals, and should be fitted with the cable entries towards the edge of the PCB. The LED needs to protrude through a hole in the case, so you may prefer to wait until after the case has been drilled so that you can get the leads the right length.

AWD1 must be fitted with the correct polarity. You may prefer to leave this out until after the circuit has been tested as the noise can become rather irritating (particularly for others). If the relay output is not required, omit RLY1 and R21.

When construction is complete, the PCB should be cleaned with a suitable solvent to remove the flux. At this stage, it is a good idea to check your work, in particular, the soldering.

Assembly

The general layout of the components in the case may be seen from the photographs. Looking from the rear, the alarm sounder is positioned as close as possible to the left to leave sufficient room for the battery to stand beside it.

The sounder is held to the base of the case with two M3 countersunk screws and nuts. Part of one of the PCB guides should be removed so that the sounder sits level. Fitting the sounder will require a pair of long-nosed pliers to hold the nuts – and some patience! A pattern of holes should be drilled in the case in front of the sounder (before the sounder is finally fitted) to let the sound out.

The PCB is fitted in the second set of slots from the top with the components downwards. A 5mm hole is required for the LED. The keyswitch may be fitted midway between the PCB and the sounder. On the prototype, the phono sockets for the Loop were fitted to the side of the case above the sounder.

Additional holes will be needed for the cables connecting to the remote sensors. The layout of the

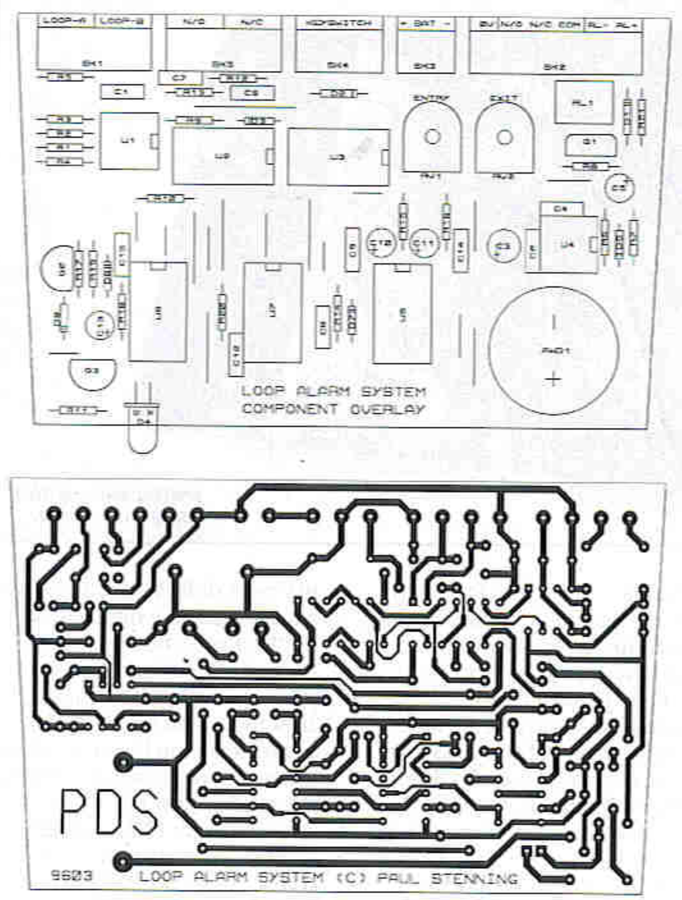


Figure 4. PCB legend and track.

components within the case is not critical and may be varied to suit individual needs. Check that everything will fit inside as you intend before drilling any holes.

The prototype was attached to the wall by means of two keyhole shaped holes in the rear panel (lid) of the case. The unit can, therefore, be fitted over two suitable screws once the back is fitted.

Wiring

The interwiring is shown in Figure 5. The leads from the alarm sounder will probably be excessively long and may be shortened to suit. Because of the noise, you may prefer to leave this disconnected until after the rest of the unit has been tested.

The battery is connected using a pair of PP9 type battery connection leads, ensuring correct polarity. All other connections are made with 7/0·2mm hook-up wire as shown.

The connections on the keyswitch can be confusing. In any position, the centre contact is connected to the pin towards the back (flat) edge of the key. On the prototype, the first (anticlockwise) and third positions were Off, so the relevant tags were not connected. The second position is 'Loop & Entry', so the relevant tag is connected to terminal 1 of SK4. The fourth position (fully clockwise) is 'Loop Only', and the relevant tag is connected to terminal 2. The centre tag on the switch connects to terminal 3. The two operating positions on the key-switch MUST be separated by an 'Off' position to ensure the unit resets correctly when changing mode.

You will also need to make up a lead for the loop cable. This should be made using cheap single-core screened cable, fitted with a phono plug at either end. To prevent an intruder from simply unscrewing the covers of the plugs to link out the cable, secure the covers with a small amount of super-glue once the unit and cable have been tested. If a long length is required, it may be more convenient and flexible to make up two or three shorter leads, and join them with in-line connectors having a phono socket at either end.

Testing

The unit does not require any setting up, apart from adjusting the entry and exit delay periods to suit your installation. The testing, therefore, involves nothing more than checking the various functions of the unit.

Connect a loop cable between the two Loop sockets. Also, link terminals 1 and 2 of SK5 (The N/C entry sensor) with a short piece of tinned copper wire. Set RV1 and RV2 fully anticlockwise.

With the keyswitch set to one of the Off positions, connect a PP9 battery to the battery connector leads. Set the key-switch to the 'Loop and Entry' position. The LED (D4) should flash and the warning sounder (AWD1) should beep in time with it, for about five seconds (this is the Exit period). After this time, the sounder should be quiet and the LED should be off. The unit is now armed, and waiting for someone to break in!

Momentarily link terminals 3 and 4 of SK5 with a piece of wire. The LED and warning sounder should operate as before, for five seconds (the Entry period). After this time, the main alarm sounder should operate, the relay (RL1) should pull in and the LED should remain on (not flashing). Set the keyswitch to off.

Try this again, but this time, trigger the alarm by disconnecting the link between terminals 1 and 2 of SK5. The unit should operate as before.

Set the keyswitch back to the 'Loop and Entry' position, and wait until the end of the Exit period. Now unplug one end of the loop cable. The alarm sounder and relay should operate immediately (no entry delay).

Switch off, and then back to 'Loop and Entry' without reconnecting the loop cable. This time, the Exit delay will not operate, and the LED should remain on (not flashing) to indicate that something is amiss.

Switch off, reconnect the loop cable, and switch back to 'Loop and Entry'. After the Exit period, trigger the alarm by short circuiting the inner and screen of the loop cable at one end (bridge the terminals of the socket inside the case with a screwdriver). Again, the alarm sounder and relay should operate immediately.

Switch off, then switch to 'Loop Only'. After the exit period, link terminals 3 and 4 of SK5. This should have no effect. Now unplug the loop cable, which should trigger the alarm as previously.

If you wish you can leave the alarm sounding, and check the timing of the alarm timer – which should be between 15 and 20 minutes. At the end of this time, the sounder should silence and the relay should release, but the LED should remain lit to tell the user that the alarm has been set off.

Installation

Since every installation is different, I can only give some general comments about installation. The main unit should be wall mounted if possible. Alternatively, it may be free standing in a steady position. You may wish to hide it so that it is not immediately visible but can still be accessed quickly for disarming.

Cables need to be run from the main unit to the entry/exit sensors being used. In many cases, one or two normally closed magnetic reed switch sensors mounted on the entry doors and possibly windows would be adequate. Normally closed sensors must be connected in series, so that if any operate, the circuit becomes open. Connect to terminals 1 and 2 of SK5.

If it is not possible or desirable to screw sensors to the doors, pressure mats may be used underneath carpets or rugs. These generally have normally open contacts, and must, therefore, be connected in parallel to terminals 3 and 4 of SK5.

The connections should ideally be made with 4-core alarm cable, which will fit tidily into the sensors. Alternatively, you could use any convenient thin two-core cable. Hide the cable out of sight where possible.

The loop cable should be threaded through or attached to the items to be protected. For example, with bicycles, thread the cable through both wheels and the frame.

Some items, such as televisions and Hi-Fi equipment have no obvious gaps to thread the cable through, and will, therefore, call for some ingenuity. If you are sure you know what you are doing, and the item is out of guarantee, you may be able to remove the back or cover and thread a piece of cable through a couple of the ventilation slots before fitting plugs to the ends. Alternatively, you could fix a section of the cable to the item with a suitable adhesive such as Araldite.

If you don't want to mark the item, the best option might be to securely tie the loop cable to the unit's mains cable. A few cable ties can be useful here. Another possibility is a P-clip under a suitable screw on the unit.

External Alarm or Sounder

The relay contacts may be connected to an additional sounder or a separate household alarm system if required. The additional sounder may be a similar type to that used in the unit, mounted in an outdoor enclosure and powered by its own battery.

The unit may be connected to any convenient zone on an alarm panel, depending on the type of protection required. The Panic button input would be suitable if you wish the alarm to operate whether or not the main alarm is set. If you have a monitored alarm system, you may need to contact the monitoring company before connecting this unit to the system.

Greater Tamper Resistance

No alarm system is 100% secure and completely resistant to any attempt to defeat it, and this unit is certainly no exception. However, it should be adequate in most cases.

The following suggestions are offered to more experienced constructors who may wish to customise their system and installation to suit their individual circumstances.

If the unit is connected to an external alarm system, as described earlier, this will continue to sound if an intruder attempts to smash this unit once it has triggered.

The main concern will probably be attempts to defeat the unit to prevent it being triggered. Normally, this would involve trying to bypass the loop, close to the alarm unit, so that it may be disconnected. The system operates by sensing the resistance of the terminating resistance via the loop. This resistance need not be a single component at the far end, it could be made up of a number of resistors along the loop.

If R5 is reduced to 33kΩ, and two additional 33kΩ resistors are added inside connection plugs along the length of the loop, any attempt to bypass the loop at the alarm end would trigger the unit. I would suggest that one of the additional resistors is in the core connection and the other is in the screen. The only drawback of this is that you have to remember to use all the pieces of loop cable, but this could be ensured by using a different type of connector for each joint. You could use any number of resistors, providing the total resistance is between 90 and 110kΩ.

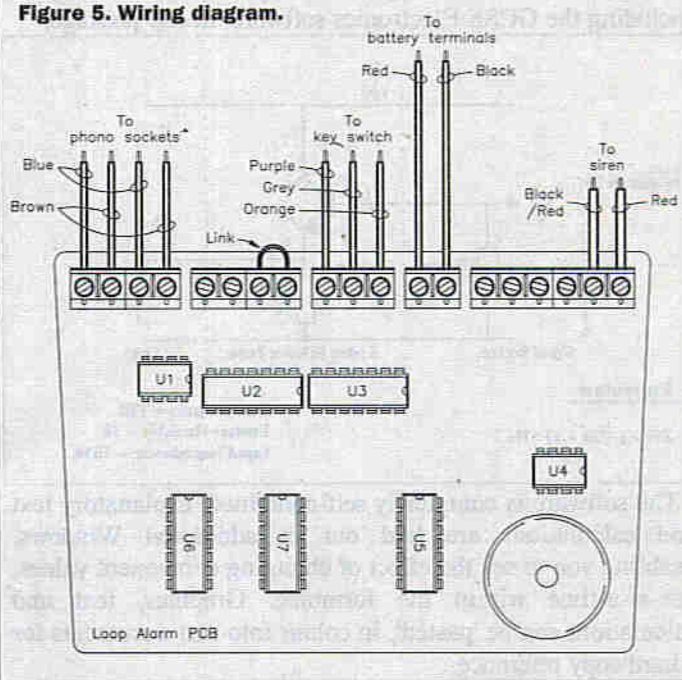
The other likely tampering method would be to disassemble the box and disconnect the battery. This could be sensed by either a tilt switch or micro-switch suitably positioned within the box. The micro-switch would be held operated by the lid, such that it is released when the lid is removed. Fix it inside the case with glue, as the screw-heads on the outside of the box would be a give-away! In either case, the connections that are closed when everything is OK are connected in series with the Loop connections inside the box.

Printed Circuit Board

The PCB required for this project is available from the author. For ordering information and price, please write, enclosing an SAE (UK) or IRC (overseas), to: Paul Stenning, 1 Chisel Close, Hereford, HR4 9XF, England.

All other components are available from Maplin, and the Order Codes are given in the parts lists.

Figure 5. Wiring diagram.



PROJECT PARTS LIST

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

R1,3-5,12, 13,15,16,18	100k	9	(M100K)
R2,10,17	22k	3	(M22K)
R6,14,20	10k	3	(M10K)
R7	3M9	1	(M3M9)
R8	4k7	1	(M4K7)
R9	220k	1	(M220K)
R11	330Ω	1	(M330R)
R19	1M0	1	(M1M0)
RV1,2	470k Horizontal Preset Potentiometer	2	(UH08J)

CAPACITORS

C1,2,4, 6-9,14	10nF Ceramic Plate	8	(WX77J)
C3	220µF 16V Radial	1	(AT41U)
C5	10µF 63V Radial	1	(AT77J)
C10,11	47µF 16V Radial	2	(AT39N)
C12	100pF Ceramic Plate	1	(WX56L)
C13	4µ7F 63V Radial	1	(AT76H)
C15	100nF Disc Ceramic	1	(YR75S)

SEMICONDUCTORS

U1	LPC662IN Dual Op-Amp	1	(AX63T)
U2,6	4093 Quad NAND Gate	2	(QW53H)
U3,7	4001 Quad NOR Gate	2	(QX01B)
U4	ICM7555IPA Timer	1	(YH63T)
U5	ICM7556IPD Dual Timer	1	(CP96E)
Q1	ZTX651 Transistor	1	(UH47B)
Q2	BC548 Transistor	1	(QB73Q)
Q3	BC558 Transistor	1	(QQ17T)
D1,2	1N4001 Rectifier	2	(QL73Q)
D3,5-7	1N4148 Diode	4	(QL80B)
D4	5mm Red LED	1	(WL27E)
D8	4V7 500mW Zener	1	(QH06G)

MISCELLANEOUS

AWD1	PCB Buzzer	1	(KU58N)
SK1,5	4-way 5mm PCB-mounting Terminal Block	2	(KE55K)
SK2	6-way 5mm PCB-mounting Terminal Block	1	(KE57M)
SK3	2-way 5mm PCB-mounting Terminal Block	1	(FT38R)
SK4	3-way 5mm PCB-mounting Terminal Block	1	(RK72P)
	Case MB7	1	(KC98W)
	Battery PP9	1	(ZB67X)
	PP9 Clips	1	(HF27E)
	4-way Keyswitch	1	(CJ95D)
	Micro Piezo Siren	1	(JK42V)
	Chassis Phono Socket	2	(YW06G)
	Single-core Screened Cable	As Req.	(XR12N)
	Tinned Copper Wire	As Req.	
	Hook-up Wire 16/0·2mm	As Req.	
	M3 × 10mm Countersunk Screw	2	
	M3 Nut	2	
	PCB (9603 – see text)	1	

OPTIONAL

R21	68Ω	1	(M68R)
RL1	1A 5V Micro-miniature Relay	1	(DC51F)
	In-line Phono Connector	As Req.	(HH05F)
	Phono Plug Black	As Req.	(HQ54J)
	Reed Switch Surface	1	(YW47B)
	Pressure Mat	1	(YB91Y)
	Alarm Cable 4-core	As Req.	(XR89W)

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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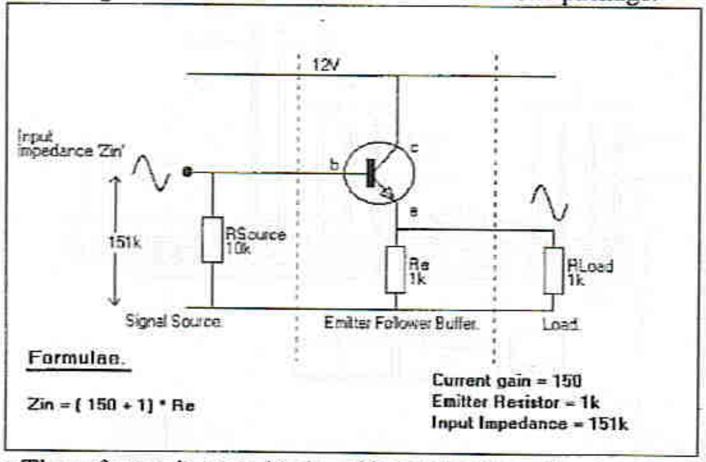

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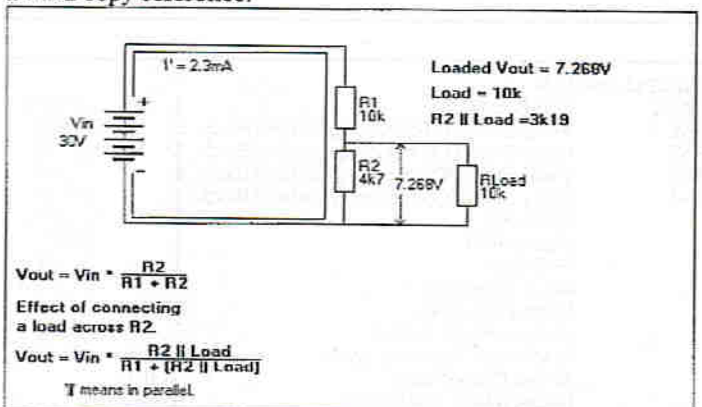

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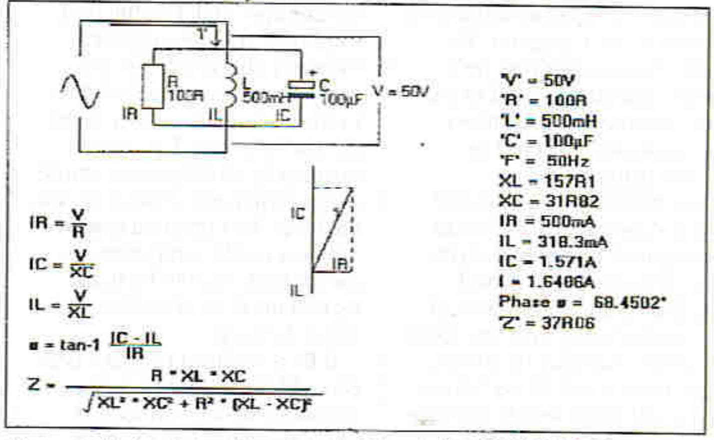

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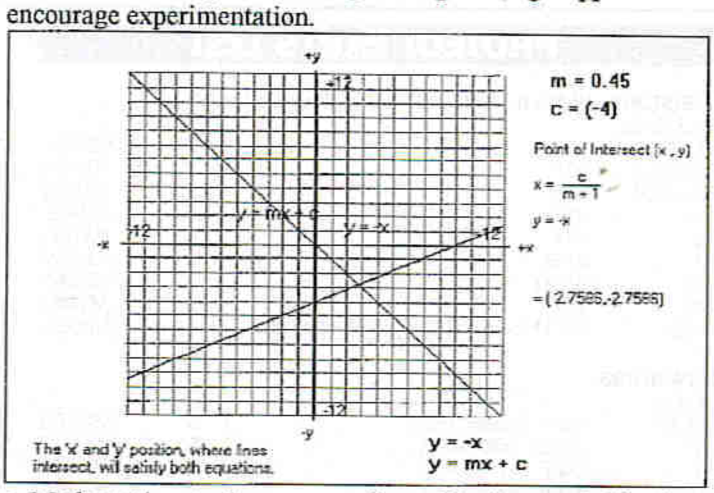

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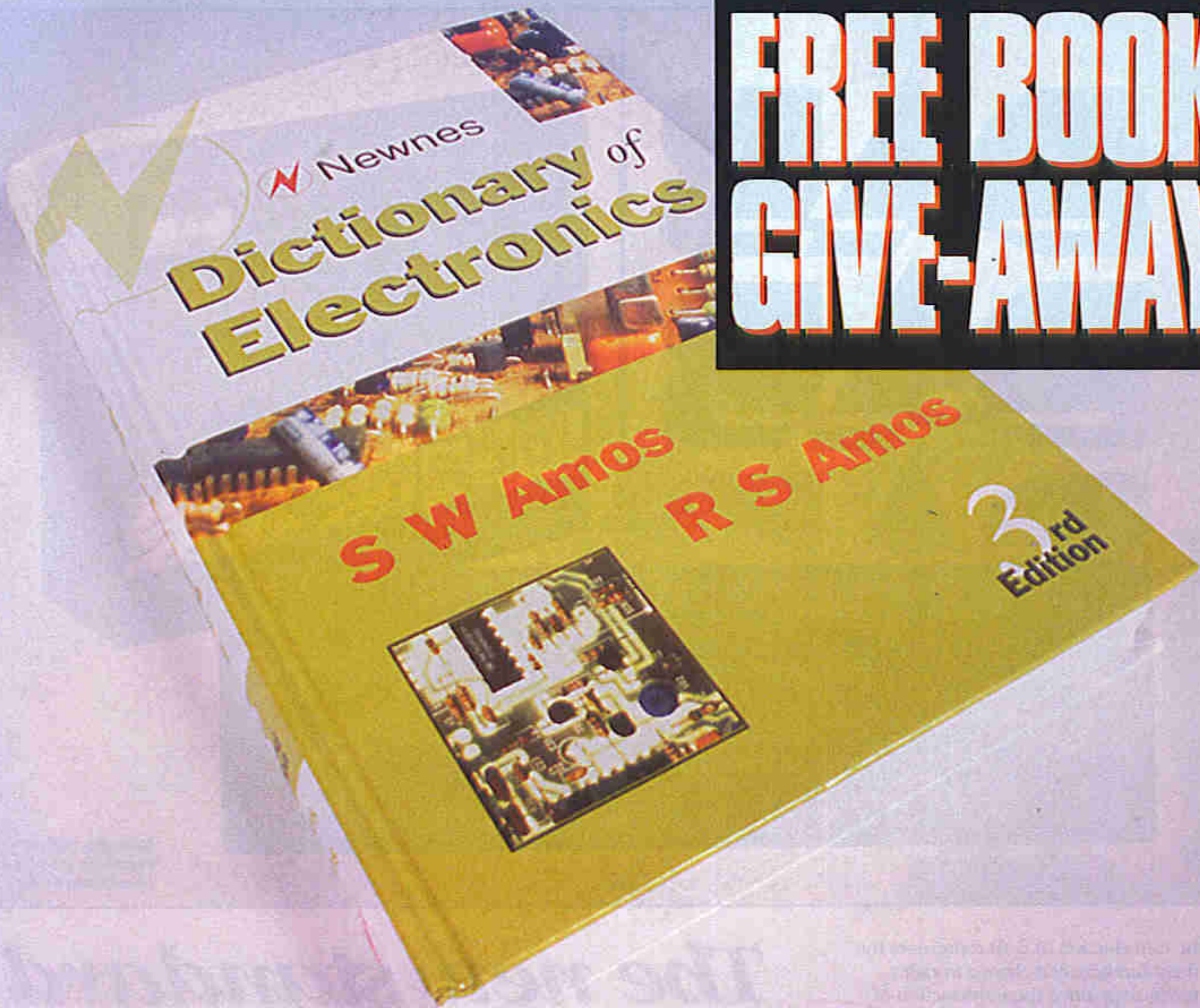

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GRUNDIG INTERNATIONAL

The new standard in Radio technology

DIGITAL AUDIO BROADCASTING

by Ian Poole

Radio broadcast technology has made a quantum leap with the introduction of Digital Audio Broadcasting (DAB) by the BBC last year. With this new system, CD quality audio is being transmitted, and those annoying dead patches encountered when listening in cars where the signal becomes very noisy and distorted can be a thing of the past. In addition to this, the new system offers many features which will enable it to keep up with the benefits of today's technology.

The introduction of DAB represents the most fundamental change in radio technology since the introduction of FM stereo. In fact, many would argue it is the most fundamental change that has ever taken place since the first sound broadcasts were made. The way in which the new system works is totally different to any existing systems, and the new radios will be far simpler to tune and use. Coupled to this, audio quality will be very much higher and many new and exciting facilities will be available.

Existing Systems

The first type of signal to be used for broadcasting was amplitude modulation (AM). Here, the amplitude of the signal is varied in line with the audio signal, as shown in Figure 1. This is still used on the long, medium and short wavebands. It has the advantage that it is easy and cheap to make sets which can receive these signals. However, the audio quality is poor, and signal propagation often means that the stations are subject to interference and fading.

As a result of the poor quality on medium wave, many stations have seen a gradual move of listeners from the medium wave to the better quality VHF frequency modulated (FM) stations. In some countries, attempts have been made to improve the quality of the old AM signals. In the USA, a number of systems for adding stereo have been implemented, and one called C-QUAM has gained almost universal acceptance now.

This system is also used in a number of other countries, including Australia and South Africa. It has even been tried in he UK, but there are no plans for its introduction at the moment.

The VHF FM service gave the best quality signals until the arrival of DAB. With FM, the frequency of the signal is changed in line with the modulating signal, as shown in Figure 2. For sound broadcast applications, the signal is varied by ±75kHz, allowing for high fidelity transmission and reception. The fact that most interference manifests itself as amplitude noise means that any amplitude components on the signal can be removed, leaving only the frequency variations. As a result, frequency modulated transmissions can give much lower noise reception once a certain minimum signal strength has been reached.

These transmissions have been very successful since they were first introduced over thirty years ago. Now all but the very cheapest sets are capable of receiving FM and people recognise the improved quality it can give over the older AM services. However, there are a number of disadvantages which users will recognise.

Originally, FM broadcasts were intended for reception by receivers with rooftop aerials. Since the introduction of this system, radios have become far more portable and most cars today are fitted with a radio. As a result, the receiver has to cope with a signal that is often weaker than the receiver needs or it is a combination of the direct signal combined with reflections from hills, buildings or other objects. The weak signal combined with the multipath effects means that signals often fade in and out very rapidly when the car is in motion, or it is difficult to set the aerial on the set to a suitable position in the room. Even when it has been set correctly, people moving in the room can upset reception – see Figure 3.

A further problem arises from the success of these services. There is a large amount of pressure on the frequency allocations which are available. Anyone tuning the FM band will be hard pressed to find much available space, especially around London, where there is the greatest concentration of stations. Frequency re-use is difficult because the two stations have to be out of range of one another. This results in national services like the BBC radios 1, 2, 3, and 4 requiring a full 2·2MHz of spectrum to enable them to cover the UK without having stations on the same channel interfering with one another.

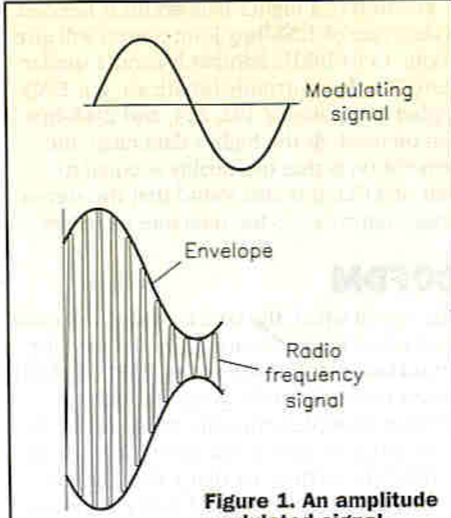


Figure 1. An amplitude modulated signal.

Cars moving from the service area of one transmitter to the next need to re-tune. The radio data system (RDS) has overcome this to a large degree, but this is a late addition to the capabilities of the system and not all radios have RDS as standard.

Digital System

Digital systems are taking over from analogue based ones in many areas. The area of mobile phones is one application where this is happening. Initially, analogue systems were introduced, whereas newer digital based systems are becoming more widespread. In the audio field, the compact disc is possibly the most well known. This format took over from vinyl discs and cassette tapes for high fidelity reproduction and gave a quantum leap in performance. Now it is the accepted standard for recorded music.

A digital radio system similarly gives a large increase in performance. CD quality over the radio brings about great improvements in some areas. Coupled to this, it is necessary to retune the set between the service areas of different stations and simple push button tuning could be achieved. Finally, the introduction of a digital service brings the possibility of passing other forms of data, possibly to give a narrative on the programme or provide a number of other services. These were the broad aims of the DAB system when design was started.

First Thoughts

In the initial investigations, a number of ideas were investigated. Around this time, the NICAM digital audio system for televisions had been introduced. This had proved to be very successful. However, it was recognised that NICAM would not be a viable option for radio applications. Television uses fixed receivers with directional aerials. On the other hand, a large proportion of radios are portable sets or used in cars. Both of these use nondirectional aerials and receive the signal over a number of signal paths. This leads to problems when trying to decode the data. The signal being received via a direct path will arrive first, and any reflections will follow on afterwards. It does not need to be a long delay before the one data bit interferes with the next, as shown in Figure 4. To give some idea of the extent of the problem, NICAM uses a data rate of 728k-bits per second (bps). This corresponds to a symbol period of 2·7μs. With data rate of this speed, it is found that the reflections must be delayed by no more than 0·7μs, otherwise one symbol merges into the next and the receiver cannot decode the data. To give a measure of this problem, a delay of 0·7μs corresponds to a reflection from only 100m behind the antenna. Clearly, this is not viable for a portable or mobile radio. In fact, for the system to be able to operate satisfactorily under typical conditions, delays of at least 35μs need to be accommodated.

To overcome this problem, the rate at which data is being sent must be reduced by a large degree. This can be achieved in a number of ways. One is to process the audio to reduce the amount of data which needs to be transmitted. The other is to share the data between a number of different signals. Both of these methods are used by the DAB system, and they enable the data rate to be reduced to only 800bps, allowing more than sufficient guard band between the different symbols, as well as allowing different transmitters to be able to transmit on the same frequency without mutual interference.

Audio Tailoring

A number of systems exist for reducing the amount of data required to transmit or store audio signals. Two examples are the Sony MiniDisc using the ATRAC system, and the Phillips digital compact cassette, which uses PASC.

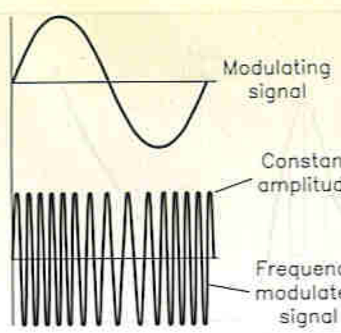
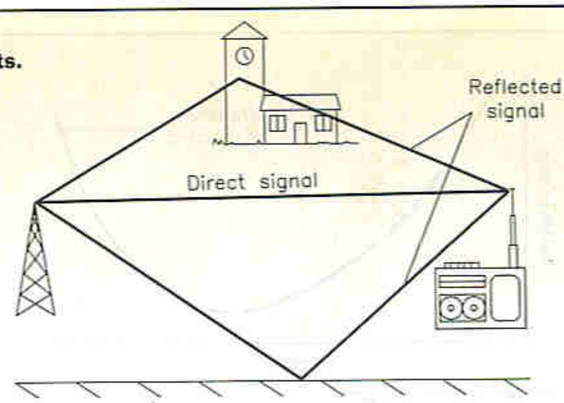


Figure 2. A frequency modulated signal.

Figure 3. Multipath effects.



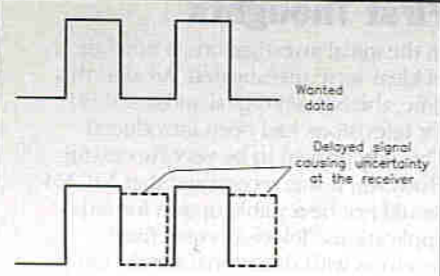


Figure 4. Data corruption caused by multipath reception.

The way in which this is achieved is to only look at the sound which the ear can hear. Under quiet conditions, the ear has a limit of hearing threshold. Below this, no sounds can be heard. Any sounds which fall below this threshold can be discarded straight away.

It is also found that when a large sound is present, then the threshold of hearing rises around this sound, as shown in Figure 5. This means that less intense sounds close to the loud sound will not be perceived and need not be encoded.

Digital audio broadcasting uses a system called MUSICAM. This splits the audio band into 32 equally spaced sub-bands. Each of these sub-bands is digitised separately and the levels are analysed to see which sounds are required, and which can be ignored. By adopting this approach, the digitising of the signal can be digitised very coarsely, and sent with information about the level. This considerably reduces the amount of information which needs to be sent. Using this system, it is possible to send a reasonable quality audio signal using a data rate of only 128k-bits, which is about a sixth of the rate required for a linear coding system like that used for CDs.

In order to achieve the maximum amount of flexibility, it is possible to alter the sampling rate. For a high quality music transmission, a higher rate can be chosen, whereas for a low quality speech service, a lower sample rate may be used. This enables the available bandwidth in the transmission to be used to its greatest efficiency. DAB mono services will use data rates of 48, 56, 64, 96 or 128k-bps. Obviously, the higher the data rate, the better the quality. A data rate of 64k-bps gives an audio bandwidth of about 7·5kHz, whereas 128k-bps gives 18 to 20kHz, and at this rate, most listeners will not be able to detect any difference from the source material.

For stereo, a higher bandwidth is needed. A data rate of 128k-bps Joint Stereo will give about 13 to 14kHz bandwidth and a similar stereo to that currently broadcast. For DAB, higher data rates of 192, 224, and 256k-bps can be used. At the higher data rates, the perception is that the quality is equal to that of a CD. It is also found that the stereo image improves as the data rate increases.

COFDM

The way in which the data is modulated onto the radio frequency carriers is also new for sound broadcasting. Known as COFDM which stands for coded orthogonal frequency division multiplex, the data which has to be transmitted is shared out amongst a number of different carriers. By doing this, the rate at which data is carried on each signal is reduced to the level where reflections and other signals on the channel do not cause a problem.

The spacing and phase relationship between the carriers is organised so that adjacent carriers do not cause mutual interference. In this way, the carriers are orthogonal to one another.

The fact that the carriers only support a very low data rate means that they are very insensitive to multipath interference. This factor is improved still further by the addition of a guard interval which is added at the beginning of each symbol period. This means that when the reflected signal has a delay less than the time of the guard interval, it will combine constructively with the main signal, and thereby improve the received signal.

The system has a number of other advantages. Advanced methods of error detection and correction are employed and this enables the sound to be recovered, even though some of the carriers are not received correctly. This feature is very useful when there are severe multipath effects, because this generates very deep nulls in the received signal and a proportion of the carries may not be received properly. The error detection enables the signal to be recovered even though interference levels are high.

From this, it will be seen that the COFDM system is far more complicated than normal AM or FM signals. As a result, it means that the receivers used for DAB will need to be significantly different. Digital signal processing is necessary to pull all the carriers together and extract the data. As a result, DAB receivers will be totally different inside to any broadcast receivers which are on the market today.

Transmission Standards

The carriers used for the transmission carry data at a very low rate to give the required insensitivity to multipath effects. The system is also organised so that several services are provided by one block of carriers. A total of just over 1,500 carriers are grouped together to give a total transport bit rate of just over 2·4M-bps. This means that up to six high quality audio programmes or 20 restricted quality mono programmes can be transmitted. The data rates for the individual programmes being carried on a transmission can be changed as required. This means that if one programme only requires a low data rate at any time, this can free up capacity for other services on the multiplex. Additional data services may also be included if required.

The way in which this is achieved allows for the receiver to decode the information correctly without any needs for external operator intervention. All the information required for the demodulation is transmitted in the DAB signal.

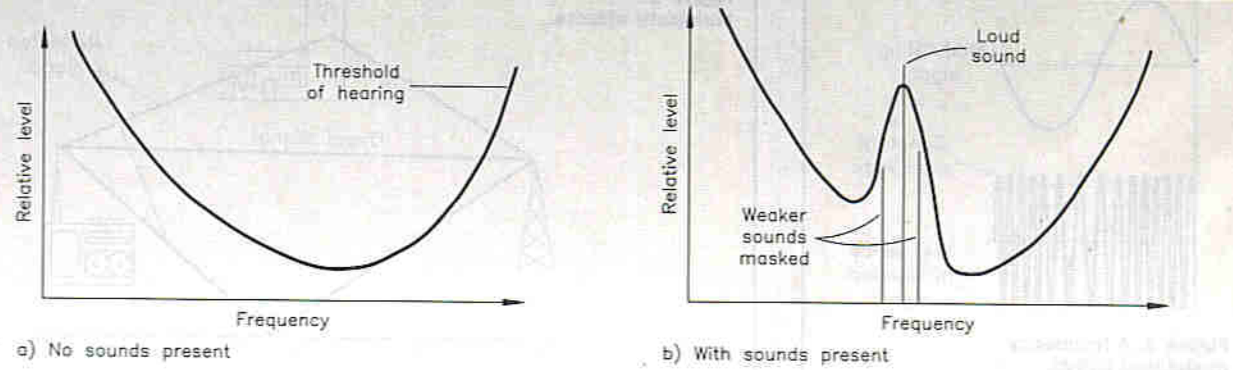
Data Services

In line with current trends, DAB allows for data to be transmitted. This can be used for a variety of purposes. Each programme or service carries programme associated data. This has a variable capacity and may be anywhere between 667bps and 65k-bps. This is used to carry data which is associated with the programme being transmitted. It may be the title of the song, or possibly a score for an opera. It is also used for dynamic range control of the audio. All of this data is encrypted with the audio and is contained within the audio frame.

Other types of data may also be transmitted. Data may be transmitted as a separate service. This may be used to carry services from a traffic message channel to an electronic newspaper. Data for these services can be carried in distinct 24ms frames or they may be inserted as packets. For the services requiring a higher information rate there is a Fast Information Channel. This would be used for the services requiring more data to be sent.

Using the data facilities, it is even possible to arrange conditional access services. Like the pay to view systems used on satellite television, similar schemes may be used in the future and this has to be taken into account.

Figure 5. The threshold of hearing in the ear.



The possibilities for the data services are phenomenal. It is expected that with more people using multimedia systems, these can be linked into a DAB receiver to provide additional services. It is no coincidence that some of the first DAB tuners for home use are planned around PC cards that will be able to take advantage of the data facilities of the system.

Bandwidth

Any new broadcasting system must make very efficient use of the frequency spectrum it uses. Currently, national networks on the VHF FM band are not particularly efficient. A single FM transmission uses a deviation of ±75kHz and with the sidebands, this means that each transmission occupies a total of 200kHz, and then further space is needed between this and the next transmission. If a national network is to be set up, the transmitters using the same channel must be out of range of one another. This means that in the UK, a total bandwidth of 2·2MHz is required for a national service like the BBC radios 1, 2, 3 and 4, or Classic FM.

DAB is very much more efficient. Each block of just over 1,500 carriers occupies a bandwidth of about 1·5MHz, and looks a little like the diagram shown in Figure 6 when viewed on a spectrum analyser. To allow sufficient space between adjacent transmissions, a guard band of 250kHz is used. This results in an overall bandwidth of 1·75MHz being required.

This would not give a saving if transmitters in adjacent areas had to use different frequencies. However, one of the major advantages of DAB is that as a result of its resilience to multipath effects, the transmissions can also cope with interference with other stations. Accordingly, there is no need for adjacent stations to use different channels, making this system what is termed a single frequency network or SFN. This gives a significant improvement in spectrum usage, with up to ten times for national or regional services. Local services are also improved by factors of up to six times because frequency re-use distances are substantially reduced.

In view of the way in which DAB frequencies can be used, the frequency allocations have been split up into seven blocks, as shown in Figure 7. These have been provisionally allocated for various uses. The BBC has channel 12B in England, and independent national radio has 11D. Other channels are allocated for different areas. Local radio is also allocated channels.

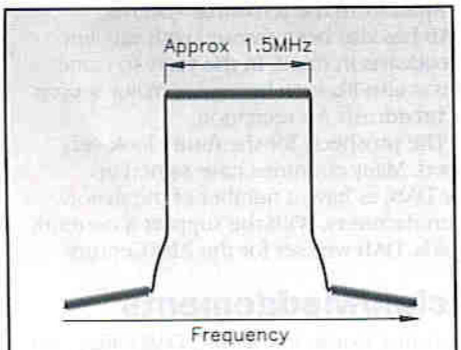


Figure 6. Spectrum of a DAB transmission.

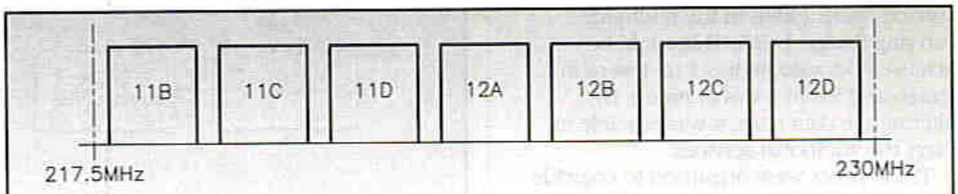


Figure 7. DAB Frequency allocations.

Another advantage of DAB is that transmitter powers can be significantly reduced when compared to the VHF FM services. This can result in major savings in running costs, as transmitter powers for the large national services run into hundreds of kilowatts. Just imagine paying the electricity bill for that!

It is also easy to install repeater stations to fill in small gaps in coverage. It will be possible for these stations to pick up broadcasts from a main transmitter, and then rebroadcast them without the need for an intermediate stage of demodulation and remodulation. This will give advantages in terms of the station complexity.

Data Format

To enable the receiver to decode the signal, the transmitted signal is organised with a frame structure as shown in Figure 8. Each transmission frame starts with a null signal to give approximate synchronisation. This s followed by a phase reference for the demodulation process. After the references, the next symbols of data are reserved for the Fast Information Channel and then the remaining ones are used for the MSC or main service channel. Each programme or service within the MSC section of the frame is allocated its own time slot for decoding purposes.

The total length of the frame for the transmissions currently being made is 96ms, although for other applications and frequencies, this can be altered to either 48 or 24ms so that the optimum performance can be achieved.

On Air

There is a large amount of interest in DAB throughout the world and in 1992, a DAB forum was set up to promote the development and interest in digital radio. In the United Kingdom, a number of tests have been carried out. In 1995, the Government set aside 12·5MHz of spectrum in VHF band III between 217·5 and 230MHz, providing sufficient space for seven DAB blocks. Each of these is capable of carrying six high quality stereo transmissions as well as providing a number of additional mono audio and data services.

On 27th September 1995, the world's first official DAB services were inaugurated. One multiplex was set up by the BBC around London, and the other was in Sweden. This was the fulfilment of many years work by the BBC, and showed their commitment to remain as one of the world's leaders in radio technology. It started these transmissions well ahead of receivers being available, to give a lead to the receiver manufacturers. It was also intended to make a move into digital broadcasting more attractive for commercial broadcasters.

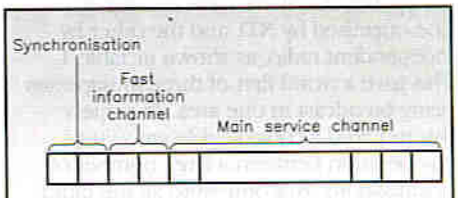


Figure 8. Data frame structure.

The London area is served by five transmitters and enables about 20% of the UK population to be covered. A further 27 transmitters are planned to be operational by March 1998, bringing DAB to more than 60% of the population. Service areas of these transmitters will include the major population centres, as well as the main motorway and trunk routes.

DAB offers broadcasters much greater flexibility, and during the first years of operation, the BBC and other broadcasters will experiment with the new facilities which DAB has to offer. At the moment, the BBC are broadcasting their five national programmes – Radios One to Five Live as well as BBC Parliament, BBC World Service and Five Live Sports Plus (a sports commentary). This was all available on the single multiplex with the data rate altered for each service to give the required quality.

Whilst the BBC was the first to set up a multiplex in Britain, Independent radio was by no means slow off the mark. Seeing the value of being in at the beginning, many of the major names are eager to join in the experiments in a great air of co-operation. A multiplex of seven stations was launched in London by National Transcommunications Limited (NTL). This multiplex was viewed as a long term test bed for commercial DAB services and carried a number of stations, including Virgin, Classic FM and a number of the other independent stations from the London area.

A number of other pilot schemes ran in July for a few hours each day. Four music pilot schemes were set up for different times, including BBC Jazz, BBC Country, BBC Opera and BBC Top 40. There were also three speech pilots, including BBC Comedy, BBC Weather and BBC Now – a rolling ten minute service of news, sport, business news, travel and weather which was continually updated with the latest information. And if you don't think there is a market for a 24-hour radio weather service, the States and Canada have a 24-hour television weather channel which thrives!

Two other pilot schemes were set up to experiment with sending text, data and still images. The first was a live Radio Text system alongside the Jimmy Young Show on Radio 2. The second was to transmit Internet pages digitally, to provide a live news and information service. These services were added to the multiplex carrying Radios 1 to 5. This could be achieved because Radios 1 to 4 were in stereo and Radio 5 was in mono. By altering the data rates, it was possible to carry the additional services.

These pilots were organised to coincide with the Radio Academy's annual festival which is held this year in Birmingham. Not only was a new BBC multiplex being set up, but also there were two others, one organised by NTL and the other by independent radio, as shown in Table 1. This gave a world first of three multiplexes being broadcast in one area. To achieve this required a considerable amount of co-operation between a large number of organisations. Not only were all the radio stations involved, but service providers including NTL, and the BBC were involved. Also, the transmitters were provided by Harris, and the programme links were set up by BT. The view of many in the broadcasting industry was that this was a great success, showing what can be achieved when a large number of parties co-operate together.

The Independent Radio Multiplex
Channel 11C 220·352MHz
Classic FM
Virgin
Talk Radio
GEM (AM)
WABC
London News Radio (FM)
Heart (London)

BBC National Radio Multiplex
Channel 12B 225·648MHz
BBC Radio 1
BBC Radio 2
BBC Radio 3
BBC Radio 4
BBC Radio 5 Live
BBC Country
BBC Opera
BBC Top 40
BBC Jazz
BBC Comedy
BBC Now
BBC Weather
BBC Parliament
BBC 5 Live Sports plus
BBC Extra
BBC World Service
BBC Radio Text
BBC Digital Text

The NTL Multiplex
Channel 12D 229·072MHz
Classic FM
Heart 106.2
Kiss 100 FM
Melody FM
Sunrise Radio
Talk Radio
Virgin FM
additional text and graphics

Table 1. Stations on the tree station multiplex at Birmingham.

Other Countries

DAB experiments are not just confined to Britain. A number of other countries across Europe have multiplexes set up and similar experiments are being undertaken to those in the UK.

Even though most of the DAB activity is centred in Europe, other countries outside the continent are investigating its use. Canada currently has experimental multiplexes in Montreal, Toronto, Ottawa and Vancouver. Australia also has multiplexes in three cities, and more are planned. Other countries including India and Mexico are also running pilot schemes.

Finally, the USA has undertaken a number of tests in Las Vegas and San Francisco. Although they are investigating some of their own systems, many industry observers believe that they will have to follow the rest of the world by adopting the DAB system.

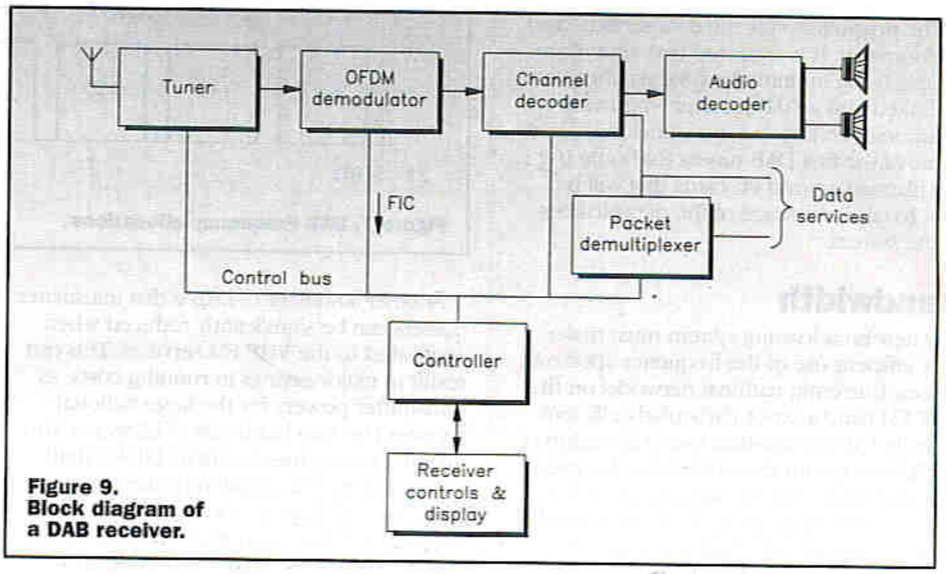


Figure 9. Block diagram of a DAB receiver.

Receivers

The receivers which will be used for DAB reception will be totally different to those currently used for AM and FM reception. Currently, all sets use analogue technology for the signal path. Signals enter the receiver and they are converted to a fixed intermediate frequency stage using the superhet principle. After being filtered and amplified, the signals are demodulated, i.e. the modulation or audio is removed from the radio frequency carrier, and the resulting audio is amplified and applied to the headphones or loudspeaker.

For DAB receivers, the radio and intermediate frequency stages will be very similar, but from the demodulator onwards, the set will be totally different, as shown in Figure 9.

After the tuner, the signal enters the orthogonal frequency division multiplex demodulator. This produces the raw data, which is further processed to produce the audio for amplification, or data for display or other uses.

There are very few radios available at the moment, and those which can be bought are very expensive; this is because of the advanced circuitry which is required. However, most of this is digital circuitry and will be incorporated onto VLSI chips.

However, the circuitry required to cope with the new system is very complicated. Typically, the processor will need to be able to handle over 100 million mathematical operations per second. It is partly for this reason that costs are high at the moment. It is estimated that at least half the costs are in the digital signal processing sections of planned receivers. If they are to become viable for the mass market, these costs have to be reduced.

To overcome this problem, various projects are looking at different ways of implementing the required architecture. This may trade off some flexibility in some areas, but would enable DAB to gain a real foothold in the market place. Once this has happened, further development can take place as the technology becomes available.

The Future

DAB is a quantum leap in radio broadcasting technology. It provides up-to-the-minute facilities, and improved ease of operation. No longer will anyone have to tune across the broadcast band until they think they might have the correct station. Instead, this will all be taken care of by the receiver itself. Station selection will be far easier, possibly selecting the name from a menu. Data services will also be available, although the exact format of these will depend upon the trials being undertaken at the moment.

However, the main question is whether it will catch on. Will it be like some of the other schemes which have hit the market place with a flurry of activity, never to be heard again. The answer must be that it will catch on. The shortcomings of existing radio broadcasts are only too obvious, making the radio market ripe for a new and improved system. DAB performance is far better than the existing AM and FM systems, and it offers many new facilities, keeping it in line with current expectations.

Also, there are too many countries co-operating together for it not to succeed. Of the major players, only the States has not come on board yet, and many feel that if they go their own way, they may be left behind.

Apart from the terrestrial systems, DAB has also been devised with satellite broadcasts in mind. In the years to come, this is also likely to become a major source of broadcasts for reception.

The prospects for the future look very good. Many countries have signed up for DAB, as have a number of the major manufacturers. With the support it currently holds, DAB well set for the 21st Century.

Acknowledgements

Particular thanks to the BBC DAB Office, and to Alex Lakey of Virgin Radio for their help in the preparation of this article.

Educational Mini Circuits

8 PAGE SUPPLEMENT

'Formula One' STARTING LIGHTS

by Maurice Hunt

PROJECT RATING 2

FEATURES

- Authentic 'Formula One Grand Prix' starting lights sequence
- Low power consumption
- Easy to build and use

APPLICATIONS

- 'Scalextric' car racing sets
- Model race tracks
- Go-kart race tracks
- General-purpose visual timer

SPECIFICATION

Operating voltage:	7 to 16V DC (9V nominal)	
Operating current:	Dependent on number of LEDs lit;	
	LD1 lit	– 12·5mA
	LD2 lit	– 12·5mA
	LD2 + LD3 lit	– 21mA
	LD2 + LD3 + LD4 lit	– 26mA
	LD2 + LD3 + LD4 + LD5 lit	– 30mA
	LD2 + LD3 + LD4 + LD5 + LD6 lit	– 33mA
Main board dimensions:	100 × 55mm	

As seen by millions of motorsport fans the world over, the Formula One racing circuit starting lights show a pattern of mind-focusing lights that come on progressively one at a time. They then hold in an all-reds-on-at-once state, until finally, after what seems an agonising delay, they all extinguish and the race begins in frantic earnest.

Add a touch of realism and pre-race suspense to your model car racing setup or go-karting track! This project simulates the starting lights seen at the starting grid of Formula One Grand Prix racing, and features the correct sequence and timing of the lights changes. Table 1 and Photos 1a-g show the lighting sequence generated by the circuit.

The project is simple to construct and is ideal for building onto stripboard (as was the prototype shown in the photos). The circuit also has other uses, for example, as a handy visual timer for use in games, as an egg-timer, etc. The timing delays are easily altered to suit the chosen application by changing the values of just a couple of components – read on for details!

Counter Output	LD6 Red	LD5 Red	LD4 Red	LD3 Red	LD2 Red	LD1 Green	As per Photo
0	Off	Off	Off	Off	Off	On	1a
1	Off	Off	Off	Off	On	Off	1b
2	Off	Off	Off	On	On	Off	1c
3	Off	Off	On	On	On	Off	1d
4	Off	On	On	On	On	Off	1e
5	On	On	On	On	On	Off	1f
6	Off	Off	Off	Off	Off	Off	1g

Table 1. Starting lights sequence.

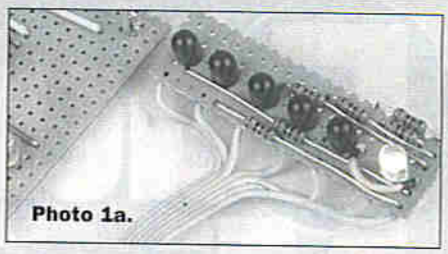


Photo 1a.

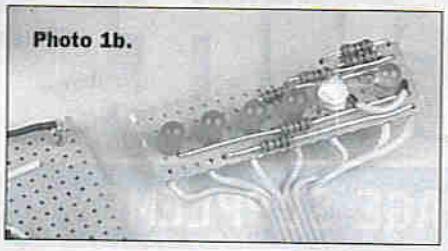


Photo 1b.

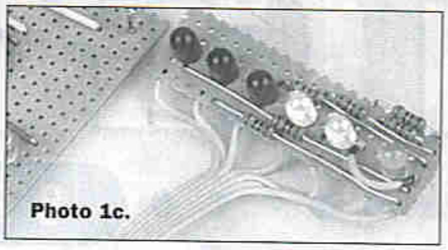


Photo 1c.

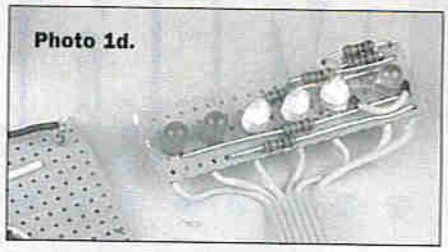


Photo 1d.

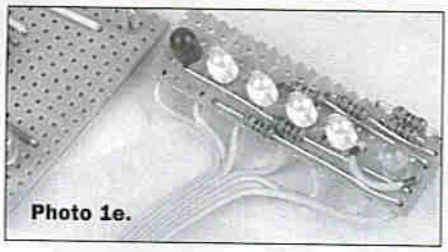


Photo 1e.

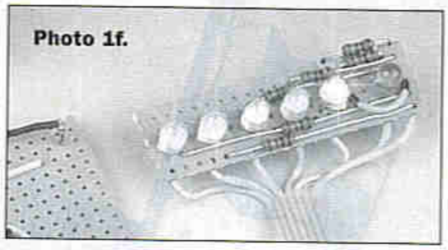


Photo 1f.

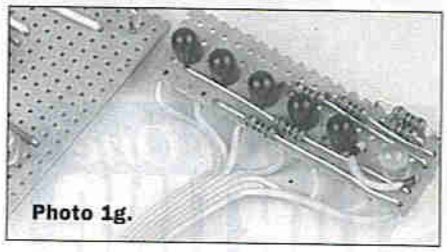


Photo 1g.

Circuit Description

Refer to the block and circuit diagrams, shown in Figures 1 and 2, respectively. The circuit is based around a 4017BE Decade Counter chip (IC2), which in its normal operation mode, counts from 0 to 9 on application of clock pulses to its CLOCK input (pin 14). The clock pulses are obtained from an NE555 timer chip (IC1), configured as an astable multivibrator (oscillator) with a clock frequency equal to $1{\cdot}44/[(R1 + 2R2) \times C1] \approx 0{\cdot}33$Hz.

The count value appears on the relevant (0 to 9) output pin of IC2. However, in this circuit, the counter is made to stop after the sixth count, that is, it counts from 0 through 6, and output 6 (on pin 5) is used to force the CLOCK INHIBIT (pin 13) high, thus preventing further counting.

A power-on reset is provided by C2 & R3, which hold the RESET line (pin 15) high for a fraction of a second (the time that the capacitor takes to charge) following initial switch-on. This ensures that the counter is reset to zero, so that the starting lights will always commence in the proper sequence.

Output line 0 is passed via R4 into the base of transistor TR1, which is used as a buffer to switch on the green LED when the counter is reset (on zero). Thus, the green LED (LD1) lights immediately following switch-on, and goes off when the counter value is 1 or higher.

The other output lines (1 to 5) are also connected to buffer transistors (TR2-6), but diodes D1-10 are interconnected between the output lines to alter the way in which the remaining (red) LEDs (LD2-6) are lit. Without the diodes, the LEDs would light one at a time, in order of the progressing counter value. However, the addition of the diodes results in all five red LEDs coming on progressively, one at a time commencing with LD2, until finally, they are all on. Effectively, the diodes are used to pull up preceding output lines (which have returned to their off state) by an output line which is in its on state.

Thus, when output line 2 (pin 4 of IC2) is high, output line 1 (pin 2) is also pulled up by diode D1. Similarly, when output line 3 (pin 7) goes high, output lines 1 and 2 are pulled up by diodes D2 & D3. When output line 4 (pin 10) goes high, output lines 1 to 3 are pulled high by D4-6. Finally, when output line 5 (pin 1) goes high, output lines 1 to 4 are also pulled high by diodes D7-10.

The transistor buffers are essential to avoid overloading the outputs of IC2, since the LEDs in addition to the diodes D1-10 would otherwise 'bog down' the operation of the counter, particularly when all five red LEDs are required to be lit.

Power to the circuit can be between 7 and 16V DC (no higher, else IC1 will be ruined), and diode D11 prevents circuit damage if the power supply polarity is inadvertently reversed. Capacitor C3 provides an adequate degree of decoupling. Don't attempt to increase the value of this capacitor, as the counter will not always fully reset on initial switch-on if you do, resulting in strange lighting sequences!

Construction

The stripboard should be prepared before assembly. Always score the board on both sides using a sharp craft knife before attempting to snap it to the required size. Use a spot face cutter or drill bit to cut the tracks at the points shown in the drawing. Note that the LEDs were mounted on a separate small board, to make it easier to fit them into the overhead starting grid gantry of a model car racing track. On the prototype, the main board was 39 strips × 22 holes, and the LED board was 19 strips × 6 holes.

The board should be assembled in order of ascending component size/height, ensuring the correct polarity of polarised components – diodes, LEDs, transistors and electrolytic capacitors. Note the specified transistors are housed in a TO18-style package, the metal can of which has a tag indicating the emitter lead.

It's advisable to install the two DIL holders before fitting the taller components – solder in two opposite corner pins, then press the holder (face down on a flat surface) while heating the joints, so as to get the holder flush onto the board, before soldering the rest of the pins. Get the end notch of the holders the correct way round! Don't install the ICs until preliminary testing of the completed board has been carried out.

Component lead offcuts could be used for the wire links, or use tinned copper wire if available. Cutting/bending the links to the correct length/shape makes for a neater appearance and easier faultfinding. Use insulated lengths of wire for the longer links, or where they are in close proximity to other links/components, to reduce the risk of short circuits.

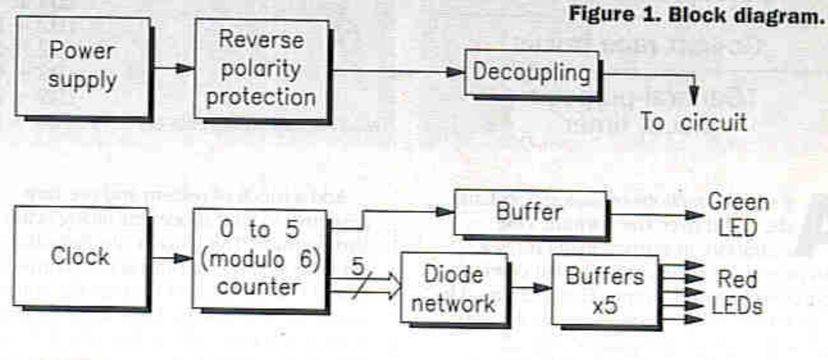


Figure 1. Block diagram.

Referring to the wiring diagram shown in Figure 3, the LED board is connected to the main board by means of 7-way ribbon cable; one connection is for linking the common anodes to the positive supply rail, and the other six are to drive the LED cathodes.

PCB pins should be used for the wiring terminals. However, if the specified transistors are used, the connections to the LEDs can be soldered directly to the top of the transistors' metal cans (i.e., used as an alternative to the transistor collector leads) – it's often more convenient (in the author's opinion) than using PCB pins! Don't keep the soldering iron on the transistor bodies for longer than necessary though, as the n-p-n junction within won't appreciate it.

On completion of the boards, check your work carefully for mistakes, solder whiskers, bridges or dry joints, then clean excess flux off the board using a suitable solvent. It is also good practice on completion of stripboard projects to run a craft knife or sharp instrument between the copper tracks while blowing on them, to clear out any lurking traces of potentially short-circuit inducing metallic specks.

Testing

The ICs should, at this stage, still be sitting in their protective packaging. Referring to the wiring diagram (Figure 3), power up the board using a 7-16V DC supply (9V is ideal), observing correct polarity. Using a multimeter set to read DC volts (up to 20V DC), test for the voltage levels between pins 8 ('+' lead) and 1 ('–' lead) of IC1's DIL holder, and pins 16 ('+' lead) and 8 ('–' lead) of IC2's; the readings should be equal to the supply voltage, minus 0·7V or so (the voltage drop across D11 accounting for this).

With the supply still connected, use a fly lead connected to the positive supply rail, and apply the other end to the IC2 holder pins 3, 2, 4, 7, 10 and 1, respectively. The LEDs should be seen to light in the order indicated in Table 1. Failure for them to do so (particularly if the LEDs partially work as expected) most likely indicates a fault with the diode network (D1-10), so the first check (having disconnected the supply) would be to ensure all the diodes (including the LEDs) are connected the correct way round. The transistors (TR1-6) should also be checked for correct orientation – the casing tag denotes the emitter. Carefully check the position of the wire links if problems persist.

Next, fit the NE555 timer chip (IC1), with its end notch aligning with the holder. Leave IC2 out for the time being. Power up the board again. Using the multimeter set to read 0-20V DC, connect its '–' lead to the 0V supply rail, and the '+' lead to pin 3 of IC1. The meter reading should be seen to fluctuate between 0V and close to supply level at a rate of approximately 0·33Hz (every three seconds), indicating that the oscillator is working.

Disconnect the supply, and plug IC2 into its socket, taking suitable anti-static precautions (it is a CMOS device), and aligning its end notch with the holder's.

Figure 2. Circuit diagram.

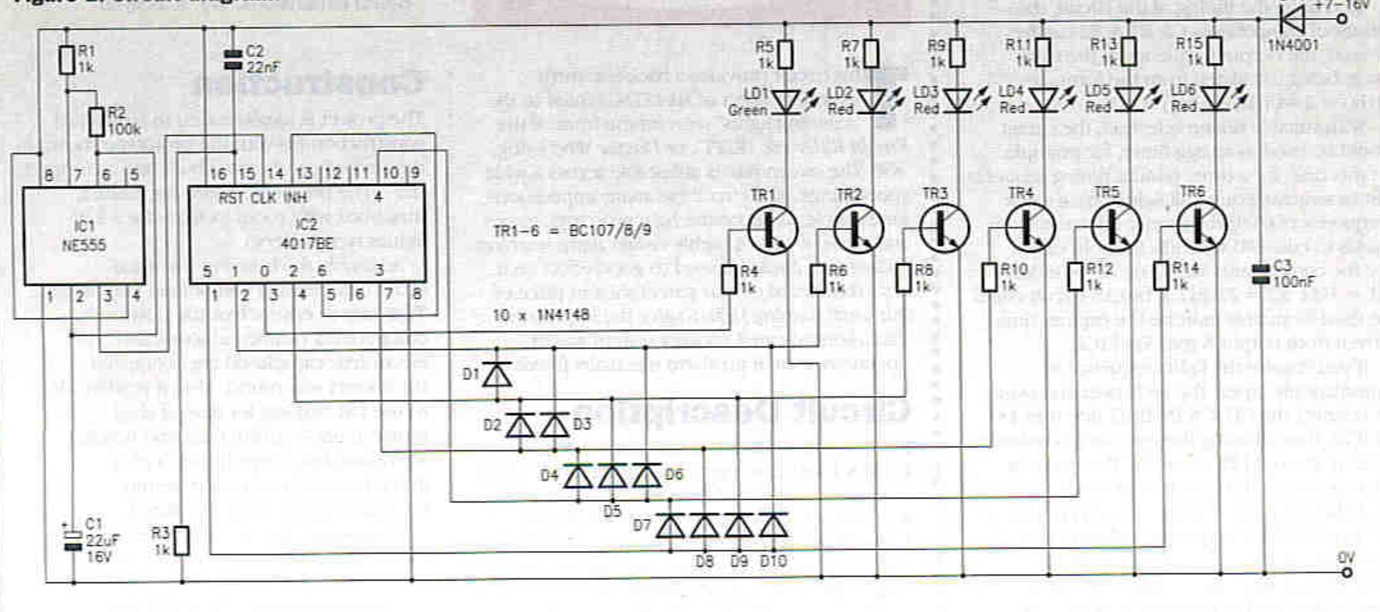
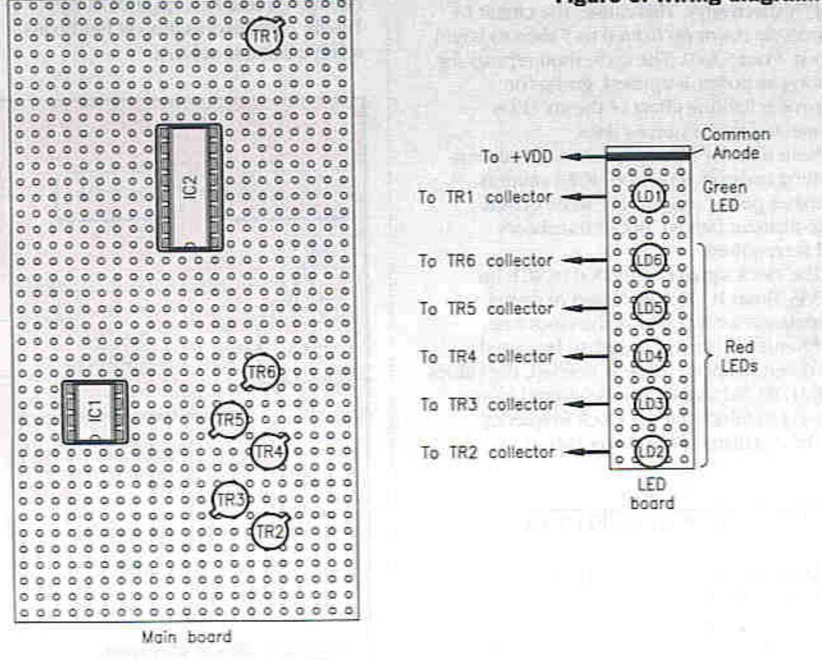


Figure 3. Wiring diagram.



Now power up the board again, and the lights should be seen to automatically cycle through the sequence shown in Table 1. Note that when all the red LEDs go off, no further lights will be seen, unless the supply is disconnected then reapplied. Check that the green LED is always the first to be lit on initial powering-up of the board, even when the power is switched on and off in rapid succession; this confirms that the power-up reset action is working properly.

(Note. If a PSU is being used to power the circuit, its internal smoothing capacitor may hold enough charge for the timing sequence to continue even when the supply is switched off and the LEDs go off – you will thus need to DISCONNECT the PSU from the board, to ensure counter resetting takes place.)

If all LEDs operate as expected, the project is ready for use.

Using the Project

The suggested board layout, with a separate board for the LEDs, enables simple installation of the LEDs into the required position, connected to the main board by means of 7-way ribbon cable – which can be as long as needed (within reason!).

The main board can be installed into a suitable casing, which could also contain a battery (9V PP3 type is ideal) or DC power connector and an on/off switch of your choice connected in the supply line – a slide or rocker switch is suitable. If the circuit is to be battery powered, an alkaline battery is recommended for its longer life.

If you have a Scalextric set or similar, you may wish to have an automatic starting lights system, whereby the lighting sequence commences when the cars are lined up on the start line. This could be achieved by using a light beam breaker detector circuit to switch on the starting lights circuit (via a relay), or possibly reed switches embedded in the track, triggered by magnets attached to the underside of the cars.

The circuit could be used to operate larger (filament) lamps if required, by using the output transistors (TR1-6) to drive (9V) relays having contacts of a rating appropriate to the loads being driven. Don't forget to add a reverse-biased diode (e.g. 1N4148) across each relay coil, else the back emf generated will destroy the transistors.

To change the timing of the circuit, the values of components C1, R1 & R2 can be altered, the output frequency of the clock stage being calculated from the formula $f(Hz) = 1{\cdot}44/[(R1 + 2R2) \times C1]$.

With suitable timing selection, the circuit could be used as an egg-timer, for example. In this case, for a three-minute timing sequence (from switching on to all lights off), a clock frequency of 0·033Hz is required, i.e., 6 clock cycles to take 180 seconds. Suitable values for the components would be C1 = 100µF, R1 = 1kΩ, R2 = 220kΩ. A buzzer circuit could be used to audibly indicate the expired time, driven from output 6 (pin 5) of IC2.

If you require the lights sequence to automatically repeat the cycle over and over, disconnect the CLOCK INHIBIT line (pin 13 of IC2), thus allowing the counter to continue after all the red LEDs have lit. There would then be a period (equal to four clock cycles) of no lights on at all, until the green LED comes on again, and the sequence recommences.

With a bit of practice using this project, your starting technique could soon be as finely developed as the likes of Messr's Hill, Schumacher, et al!

FORMULA ONE STARTING LIGHTS

RESISTORS: All 0·6W 1% Metal Film			
R1, 3-14	1kΩ	14	(M1K)
R2	100kΩ	1	(M100K)
CAPACITORS			
C1	22µF 16V Radial Electrolytic	1	(AT37S)
C2	22nF Ceramic Disc	1	(BX01B)
C3	100nF Ceramic Disc	1	(YR75S)
SEMICONDUCTORS			
D1-10	1N4148	10	(QL80B)
D11	1N4001	1	(QL73Q)
LD1	Green 5mm LED	1	(WL28F)
LD2-6	Red 5mm LED	5	(WL27E)
TR1-6	BC108	6	(QB32K)
IC1	NE555 Timer	1	(QH66W)
IC2	4017BE Decade Counter	1	(QX09K)
MISCELLANEOUS			
	8-pin DIL Holder	1	(BL17T)
	16-pin DIL Holder	1	(BL19V)
	Flat IDC Cable	As Req.	(XR73Q)
	Single-core Wire (Black)	As Req.	(BL85G)
	22swg 0·71mm Tinned Copper Wire	1 Reel	(BL14Q)
	9V PP3 Battery Clip	1	(HF28F)
	9V PP3 Alkaline Battery	1	(FK67X)
	Single-ended PCB Pins	As Req.	(FL24B)
	Stripboard 3939 (39 strips × 39 holes)	1	(JP49D)

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

LED SWEEPING LIGHTS

by Maurice Hunt

PROJECT RATING 2

FEATURES

Compact – matchbox sized

Adjustable sweep rate

Wide operating voltage range

APPLICATIONS

Models

Toys and Games

Alarm system warning lights

SPECIFICATION

Operating voltage:	5 to 16V DC (9V nominal)
Operating current:	16mA @ 9V
	25mA @ 12V
Board dimensions:	47 × 33mm

This circuit provides a back-and-forth sweeping effect of six LEDs, similar to the 'scanning lights' seen on the front of the *Knight Rider* car, 'KITT', or *Doctor Who*'s dog, 'K9'. The sweep rate is adjustable across a wide speed range. The circuit has many applications, for example, as decorative lighting in toys, games and models, or as a highly visible alarm warning indicator. It could be used to good effect on a car's dashboard or rear parcel shelf in place of the usual flashing LED, to give the impression that a sophisticated security system was in operation, even if no alarm is actually fitted!

Circuit Description

Refer to the block and circuit diagrams, given in Figures 1 and 2, respectively. The circuit is based around the 4017BE CMOS Decade Counter chip, IC2. This would normally be used to count from 0 to 9 on application of a clock signal on pin 14, causing the relevant pin (one of ten) to go high, while the others remain low.

However, in this application, some of the outputs (6, 7, 8 & 9) are connected such that when high, they pull up the low output to which they are connected (outputs 4, 3, 2 & 1, respectively). This causes the circuit to effectively count up from 0 to 5 then to count down, from 5 to 0. The cycle then repeats for as long as power is applied, giving the sweeping lighting effect of the six LEDs connected to the output lines.

Note that the LEDs are driven via current-limiting resistors R3-8 from IC2's outputs. If higher power outputs are to be driven (e.g. filament lamps), buffer transistors will be required.

The clock signal is provided by IC1, an NE555 Timer IC. The inclusion of preset potentiometer RV1 allows the clock rate, and hence the sweep speed, to be varied. If a different speed range is needed, the values of RV1, R1, R2 and C1 can be altered to suit, bearing in mind that the clock frequency can be calculated from the equation:

$$f\,(Hz) = \frac{1{\cdot}44}{(RV1 + R1 + 2R2) \times C1}$$

Where RV1 is the value that the potentiometer is set to.

Capacitors C2 and C3 provide high and low frequency decoupling, respectively, of the power supply.

Construction

The project is ideally suited to stripboard construction (as with the prototype shown in the photos), and can be built into a compact size. (The prototype board fits inside a matchbox with room to spare for a 12V lighter type battery.)

Assemble the board in the usual order of ascending component size/height. Take care to ensure that the polarised components (semiconductors and electrolytic capacitors) are connected the correct way round. Also, it is advisable to use DIL holders for ease of chip replacement – ensure their end notches are orientated correctly. Don't plug in the ICs until preliminary testing has been satisfactorily completed.

Insulated cable should be used for the longer wire links, or where they cross over others, to avoid short circuits.

Having assembled the board, check carefully for any mistakes, solder whiskers, bridges or dry joints. Use a pointed instrument to clear any debris lying between tracks of a stripboard layout. Finally, clean excess flux off the board using a suitable solvent.

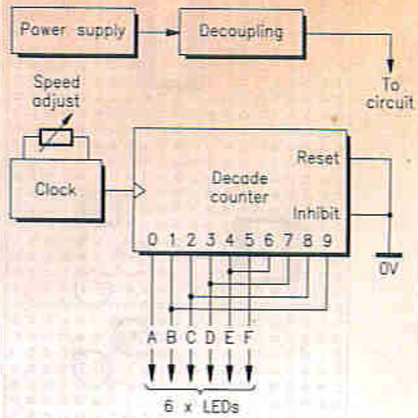
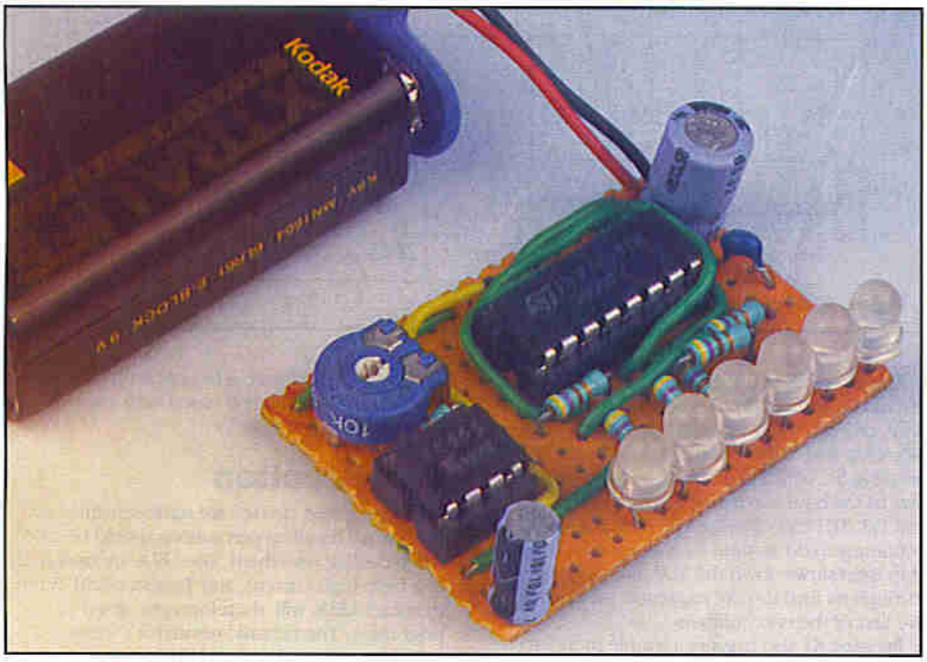


Figure 1. Block diagram.



Testing and Use

With the ICs left aside for the time being, power up the board using a suitable DC supply. Using a multimeter set to read DC volts, test the voltage between pins 1 ('–' lead) and 8 ('+' lead) of IC1's socket, and between pins 8 ('–'lead) and 16 ('+' lead) of IC2's socket; both readings should be at supply voltage.

Using a fly lead, connect one end to the '+' supply rail, and use the other end to probe the pins 3, 2, 4, 6, 10 & 1 on IC2's socket; you should see LEDs LD1-6 light in succession.

Disconnect the supply, and plug in IC1, the NE555 Timer chip, aligning its end notch with that of the holder. Reapply the power, and connect a fly lead between any of the LED terminations on IC2's socket (numbered above) and pin 3 of IC1. The selected LED should be seen to flash, and the rate should be adjustable by altering potentiometer RV1.

Disconnect the power again, and plug IC2 into its socket, aligning its end notch to the holder's (use suitable anti-static precautions when handling this CMOS device). Power up the circuit, and each of the LEDs should light one at a time in a back-and-forth sweeping pattern. Again, the sweep speed should be adjustable by means of RV1.

If everything works as described above, the circuit is ready for use in the chosen application.

LED EFFECT SWEEPING LIGHTS

RESISTORS: All 0·6W 1% Metal Film (Unless Stated)			
R1	1kΩ	1	(M1K)
R2	2k2Ω	1	(M2K2)
R3-8	470Ω	6	(M470R)
RV1	10kΩ Horizontal Enclosed Preset Potentiometer	1	(UH03D)
CAPACITORS			
C1	10μF 16V Radial Electrolytic	1	(YY34M)
C2	100nF Ceramic Disc	1	(YN75S)
C3	100μF 16V Radial Electrolytic	1	(RA55K)
SEMICONDUCTORS			
IC1	NE555 Timer	1	(QH66W)
IC2	4017BE Decade Counter	1	(QX09K)
LD1-6	5mm Superbright Red LED	6	(CZ34M)
MISCELLANEOUS			
	8-pin DIL Holder	1	(BL17T)
	16-pin DIL Holder	1	(BL19V)
	Single-core Cable (Black)	As Req.	(BL85G)
	22swg 0·71mm Tinned Copper Wire	1 Reel	(BL14Q)
	PP3 Battery Clip	1	(HF28F)
	Alkaline PP3 Battery	1	(FK67X)
	Stripboard 2939 (29 strips × 39 holes)	1	(JP47B)

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


Photo 1a.


Photo 1b.


Photo 1c.


Photo 1d.


Photo 1e.


Photo 1f.


Photo 1g.


Photo 1h.


Photo 1i.


Photo 1j.

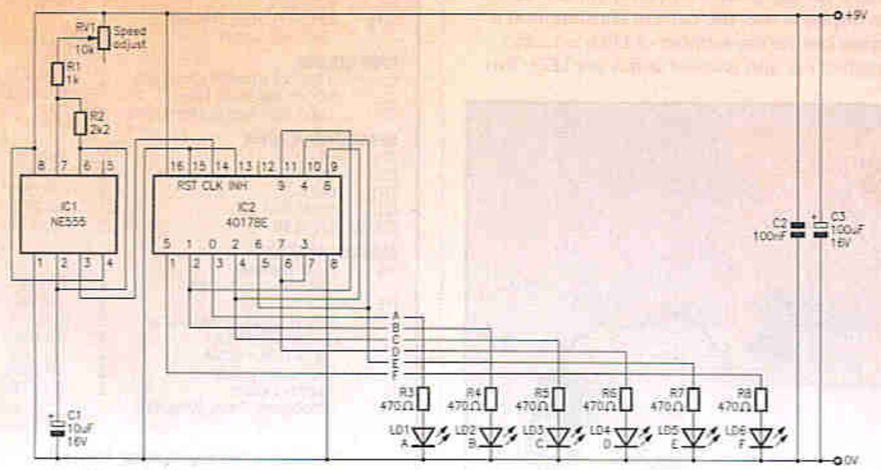


Figure 2. Circuit diagram.

Double-Throw DICE

by Robert Penfold

PROJECT RATING 2

At one time, it required a fair amount of logic circuitry to produce a good electronic simulation of a dice. These days, it can be done using a dedicated dice chip and a handful of passive components. The HT2070 dice integrated circuit (IC1) forms the basis of this electronic dice, the circuit for which appears in Figure 1. The HT2070 drives a seven LED display, and two display modes are available. The more simple of these has one LED flash on and off at the 'roll' rate of the dice, while the other six form a sort of 'dot' mode bargraph. If (say) a five is 'thrown', the fifth LED in the display will be left on once the dice has finished 'rolling'.

The Circuit

The more interesting mode of operation has the LEDs in an 'H' formation, and it produces the appropriate dice pattern for the number 'thrown'. For example, 'throwing' a five would result in the middle and four corner LEDs being switched on. The required mode, is obtained by connecting pin 11 to the negative supply for the 'dot' mode bargraph, or to the positive supply if conventional dice patterns are required. In this case, pin 11 is connected to the positive supply so that the normal dice spot patterns are produced.

The basic action of the HT2070 is quite elaborate. The dice is 'rolled' by pulling pin 12 low. This sets the display cycling through its six states at a rate which is too high to perceive properly. It does not simply cycle through one to six sequences, but instead operates in a pseudo-random fashion. When pin 12 is allowed to return to the high state, the dice 'rolls' at a decreasing rate until it finally comes to a halt. The display then flashes the appropriate dice pattern for a second or two, after which the display 'freezes' for a further second or two. The display is then switched off, and the chip closes down.

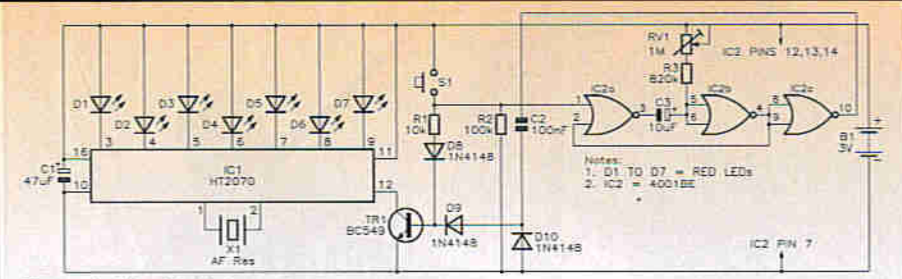


Figure 1. Circuit diagram.

This circuit takes things a step further by having the dice automatically 'throw' itself for a second time, giving a double dice action from a single dice chip and display. The dice is activated by pressing S1, which biases TR1 into conduction due to the base current that flows through R1 and D8. TR1 then pulls pin 12 of IC1 low, and it continues to do so until S1 is released. The dice chip then slows down the 'roll' rate and goes through its final display sequence, producing the first of the two numbers.

Pressing S1 also triggers a simple monostable circuit formed from two of the CMOS two input NOR gates in IC2. The other gate (IC2c) acts as a simple inverter/buffer stage at the output of the monostable. This gives an output that is normally high and goes low for the duration of the output pulse. The length of the pulse is controlled by timing components C3, R3, and VR1. The pulse duration is approximately 0·65CR seconds, and VR1 therefore enables the pulse length to be varied from about five seconds to around 12 seconds.

In practice, VR1 is adjusted so that the pulse comes to an end shortly after IC1 closes down after the first 'throw' of the dice. As the pulse ends and the output of IC2c returns to the high state, a positive pulse is supplied to the base of TR1 via C2 and a simple rectifier circuit (D9 & D10). This pulse briefly turns on TR1, which in turn activates IC1 and produces the second 'throw' of the dice.

Note that one gate of IC2 is left unused, but its inputs are connected to the positive supply rail to prevent spurious operations. X1 is an (optional) ceramic resonator which gives high-pitched 'beeps' at the 'roll' speed of the dice. X1 must be a ceramic resonator and not an ordinary moving coil loudspeaker. There is insufficient drive current available for an ordinary loudspeaker, and a component of this type could overload the outputs of IC1. With some ceramic resonators, the volume might be quite high, but a resistor of a few kilohms in series with X1 should reduce the volume to a more acceptable level.

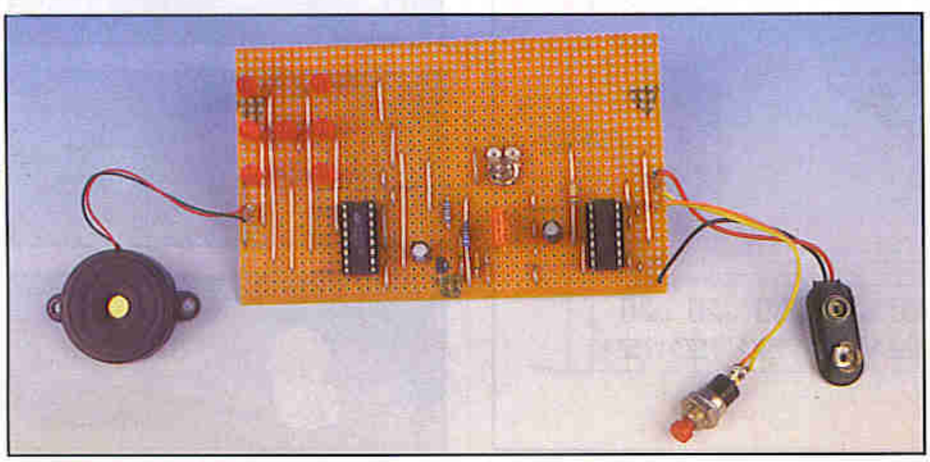
The current consumption of the circuit is insignificant unless the display is active, making it unnecessary to have an on/off switch. With the display active, the current consumption is dependent on the number of LEDs actually switched on, and is about 20mA per LED. Two HP7 (AA) size cells are adequate to supply this. The circuit should not be used with a supply potential of more than 3V.

Construction

Both integrated circuits are static-sensitive, and the normal handling precautions should be taken when dealing with them. The LEDs are operated at a fairly high current, and 'bog standard' 5mm diameter LEDs will, therefore, give good brightness. The ceramic resonator's leads might be coloured red and black, but it is not a polarised component, and it can be connected either way round. Ideally, C3 would be a tantalum bead capacitor, but satisfactory results are obtained using a good quality electrolytic type. A plastic holder is used for the two batteries, and the connections to the holder are made via an ordinary PP3 style battery clip.

The prototype was built with the LED display on the stripboard panel, but it is equally valid to have panel-mounting LEDs on the front panel of the case, and to hardwire them to the component panel. Multi-coloured ribbon cable makes it easy to produce error-free wiring from the display to the component board, and also gives a neat finish. If the LEDs are mounted on the stripboard panel, the case must be drilled with a pattern of seven holes to take the LEDs. The circuit board is then mounted just behind the front panel, with the LEDs fitting into the holes.

It is a matter of using trial and error to find a suitable setting for VR1. If it is set too low in value, the second 'throw' of the dice will start before the first one has come to a proper conclusion. Setting VR1's resistance too high will give an excessive gap between the first and second operations of IC1. There should be a small range of in-between settings that give good results.



DOUBLE-THROW DICE

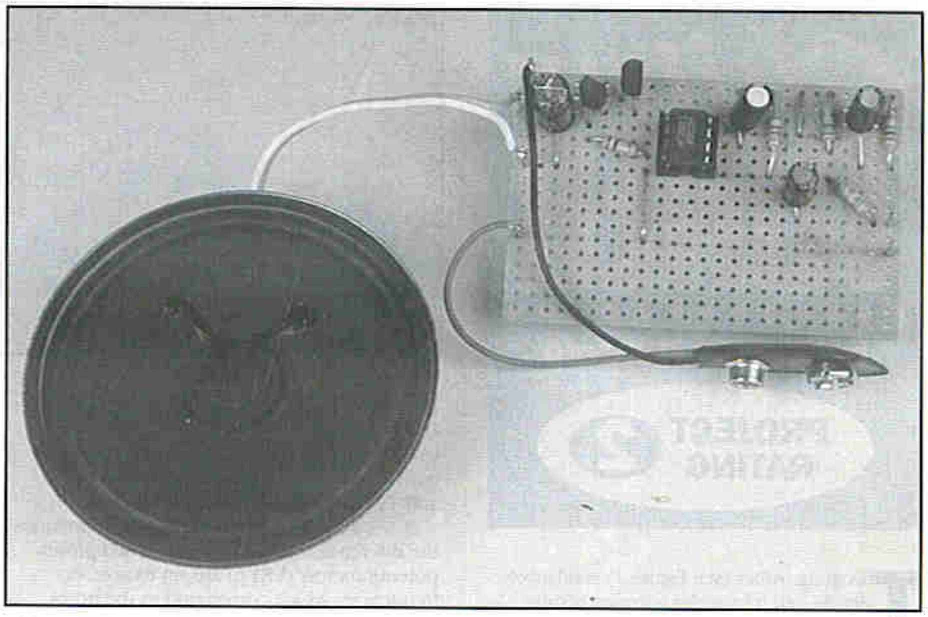
RESISTORS: All 0·6W 1% Metal Film (Unless Stated)			
R1	10kΩ	1	(M10K)
R2	100kΩ	1	(M100K)
R3	820kΩ	1	(M820K)
VR1	1MΩ Horizontal Preset Potentiometer	1	(UH09K)
CAPACITORS			
C1	47µF 25V Radial Electrolytic	1	(FF08J)
C2	100nF Polyester Layer	1	(WW41U)
C3	10µF 63V Radial Electrolytic	1	(AT77J)
SEMICONDUCTORS			
IC1	HT2070	1	(AE16S)
IC2	4001BE	1	(QX01B)
TR1	BC549	1	(QQ15R)
D1-7	5mm Red LED	7	(WL27E)
D8-10	1N4148	3	(QL80B)
MISCELLANEOUS			
S1	Push-to-make Pushbutton Switch	1	(FH59P)
B1	2 × AA Cells	2	(JY48C)
X1	Cased Ceramic Resonator	1	(FM59P)
	14-pin DIL Holder	1	(BL18U)
	16-pin DIL Holder	1	(BL19V)
	PP3 Battery Clip	1	(HF28F)
	Battery Holder	1	(CL17T)
	Stripboard, Case, Wire, Etc.		

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

Inhibited DOOR BELL

by Robert Penfold

PROJECT RATING 2



This electronic doorbell is based on the HT2811 sound generator chip, which can produce a reasonably realistic imitation of a standard 'ding-dong' style door chime. The circuit diagram is shown in Figure 1. On the face of it, the circuit only has to produce a short burst of tone, followed by a second burst at a slightly lower pitch. In reality, the sound produced by a conventional door chime is quite complex. Unlike the string of a guitar or violin, the mechanical resonators in a conventional door chimes do not simply generate a fundamental frequency plus harmonics (multiples) of that frequency. The three dimensional resonator of a door chime produces a much more complex sound than that of an essentially two-dimensional resonator such as a string. There are effectively two or more fundamental frequencies and their harmonics, plus further frequencies generated by the mixing of the fundamental and their harmonics.

To simulate this type of sound requires two or more tone signals to be mixed together using what is generally called a 'ring modulator' in electronic music circles. This is a form of balanced modulator, which suppresses one or both of the input signals, and generates sum and difference frequencies. It is this complex mixing of signals that is used to generate the 'heavy metal' sound. The HT2811 has built-in tone generators and a mixer which produces the desired effect, and gives a reasonably convincing 'metal' sound.

In order to obtain a convincing chime sound, it is essential to use appropriate envelope shaping. Each 'ding' and 'dong' sound has a fast attack but a much slower decay. Again, the HT2811 has a built-in envelope shaper which gives each burst of sound suitable attack and decay times.

The Circuit

The HT2811 has an extremely low standby current consumption of only about 1μA. The circuit, therefore, has no on/off switch, and is permanently connected to the 3V battery. Taking pin 1 high triggers the device into action, and it then goes through two 'ding-dong' sequences. In order to prevent over-zealous callers 'taking it out' on the doorbell, this design includes an inhibitor circuit which prevents the doorbell being triggered more than about once every 10 seconds or so. Operating S1 causes pin one of IC1 to be pulsed high as C2 charges via R2. C2 discharges via R1 when S1 is released, but due to the high value of R1, the discharge time is quite long. The circuit cannot be triggered again until C2 has largely discharged, and this gives the required hold-off.

C3 and R3 control the decay time of one of the envelope shapers. R5 and C4 provide the same function in the second envelope shaper. R4 is the only discrete timing component in the tone generator circuitry. The drive current available from pin 5 of IC1 is quite low, but a low impedance loudspeaker can be driven via a Darlington pair connected as a common emitter switching stage (TR1 and TR2). With only a 3V supply, the output power is not very high, but adequate volume is obtained, provided the loudspeaker has a diameter of about 66mm or more. Do not use the circuit with a supply potential of more than 3V. The current consumption of the circuit is up to about 40mA when activated, and a couple of HP7 (AA) size batteries are more than adequate to supply this.

Construction

Construction of this circuit is very straightforward, but IC1 is a MOS device which requires the standard anti-static handling precautions. The two batteries are fitted into a plastic holder, and the latter connects to the circuit board via an ordinary PP3 style battery clip. Obviously, S1 is the bell push, and is connected to the main unit via a length of twin cable. If mains-borne noise spikes, etc. give problems with spurious triggering, reducing the value of R2 might eliminate the problem. Using a screened lead to connect S1 to the main unit is the most effective method of combatting this type of problem though. The outer braiding of the cable carries the connection to the positive supply rail, and the inner conductor carries the connection to R1 and C2.

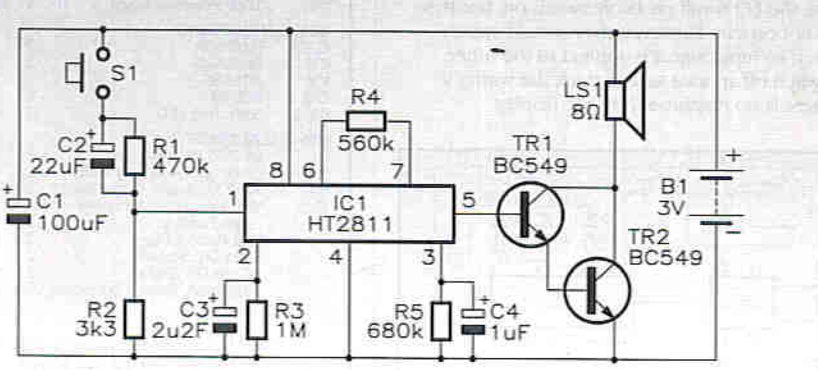


Figure 1. Circuit diagram.

INHIBITED DOOR BELL

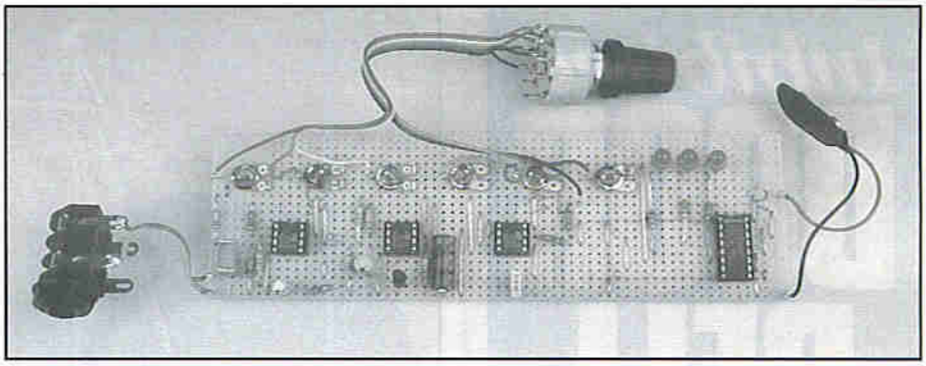
RESISTORS: All 0·6W 1% Metal Film			
R1	470k	1	(M470K)
R2	3k3	1	(M3K3)
R3	1MΩ	1	(M1M)
R4	560k	1	(M560K)
R5	680k	1	(M680K)
CAPACITORS			
C1	100μF 10V Radial Electrolytic	1	(FF10L)
C2	22μF 25V Radial Electrolytic	1	(FF06G)
C3	2μ2F 100V Radial Electrolytic	1	(FF02C)
C4	1μF 100V Radial Electrolytic	1	(FF01B)
SEMICONDUCTORS			
IC1	HT2811	1	(BH69A)
TR1,2	BC549	2	(QQ15R)
MISCELLANEOUS			
LS1	66mm 8Ω Loudspeaker	1	(WB13P)
S1	Bell-Push	1	(FS17T)
B1	2 × AA Cells	2	(JY48C)
	8-pin DIL Holder	1	(BL17T)
	Battery Holder	1	(CL17T)
	PP3 Battery Clip	1	(HF28F)
	Stripboard, Case, Bell Wire, Etc.		

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

Guitar TUNER

by Robert Penfold

PROJECT RATING 2



This guitar tuner (see Figure 1) is relatively simple, but it provides accurate results and is very easy to use. The LED display shows the beat rate between the note from the guitar and the built-in reference oscillator. The guitar's tuning is adjusted for the lowest possible flash rate from the display. A basic display of this type enables very accurate tuning to be obtained, since an error of well under 1Hz is clearly indicated. The only problem with this method is that it does not indicate the direction in which the tuning is 'out'.

The guitar tuner featured here overcomes this problem by using three LEDs which provide a form of 'moving' light display. With the guitar on precisely the right frequency, the display is stationary with two LEDs on and one switched off. If the guitar is slightly too high in frequency, the light that is switched off 'moves' across the display from left to right. With the guitar fractionally too low in frequency, the display 'moves' in the opposite direction. With this type of tuner, it is even possible for someone who is literally tone deaf to tune a guitar with a very high degree of accuracy.

The Circuit

The signal from the guitar must be amplified to a high enough level to operate a switching transistor. Output levels from guitar pickups seem to vary enormously, but this circuit has sufficient gain to accommodate low output types. IC1 is used in a preamplifier circuit that provides a voltage gain of 11 times and an input impedance of 50kΩ. This stage is a conventional non-inverting amplifier. It is direct coupled to a second amplifier which is based on IC2, and utilises the inverting mode. This stage provides a higher voltage gain of some 100 times. The overall voltage gain of the two amplifier stages is over 1,000 times, which is sufficient to produce a heavily clipped output signal from IC2.

TR1 is the switching transistor, and it is driven from the output of IC2 via R9 and R10. This potential divider ensures that TR1 is (more or less) switched on during positive output half cycles, and switched off during negative half cycles. The three display LEDs (D1 to D3) have their cathodes connected to earth via TR1, and a display LED can only switch on if the output driving it is high, and TR1 is switched on.

IC3 is a low power 555 timer which provides the reference tones. The six switched preset potentiometers (VR1-6) are set to give six frequencies which correspond to the notes obtained from the open strings of a guitar. VR1 provides the lowest tone and VR1 provides the highest tone. The output frequencies are actually four times higher than the guitar frequencies, due to an effective divide-by-four action through the display driver circuit. A 555 astable has good frequency stability, with changes in supply voltage having no significant effect on the output frequency. However, C5 must be a high quality capacitor if really stable results are to be obtained.

The output from IC3 drives the clock input of IC4, which is a CMOS 4018BE presettable BCD counter. In this circuit, the basic action it provides is to switch on the display LEDs in the sequence D1 alone, D1 plus D2, D2 plus D3, D3 alone. Of course, a LED will only be switched on if TR1 is switched on at the same time, and it is this interaction of the input signal and the reference signal that gives the required 'moving' LED display. The current consumption of the circuit is about 7mA, and an ordinary PP3 size (9V) battery is adequate to supply this.

Construction

The 4018BE used for IC4 is a CMOS device, and the usual anti-static handling precautions should be observed when dealing with this component. The display LEDs are driven at a fairly low current of about 5mA. 'Bog standard' 5mm diameter LEDs give usable results, but 'high brightness' LEDs give a brighter display that is easier to use. The LEDs should be mounted in a line on the front panel, with D2 in the middle, D1 to its left, and D3 to its right. S1 is a 6-way 2-pole rotary switch, but in this circuit, one pole is left unused. The lead from the circuit board to JK1 does not have to be a screened type, provided it is reasonably short.

The guitar is connected to JK1 via a standard screened guitar cable. When the unit is switch on, the LEDs will probably switch on, but this is not certain. However, they should switch on if an input signal is applied to the tuner. Switch off at once and recheck the wiring if there is no response from the display.

One way of giving the preset potentiometers suitable settings is to first tune the guitar as accurately as possible 'by ear' against pitch-pipes, a piano, or any other instrument that provides suitable notes and is in tune. Select VR1 using S1, play the lowest string on the guitar, and adjust VR1 for a steady display. This process is then repeated for VR2 to VR6 using the other five strings. Alternatively, the unit can be tuned against an electronic keyboard instrument that is accurately in tune. If a choice of sounds is available, choose something simple like a flute sound, as this will give a clearer display than a complex sound.

When used with a guitar, the unit should provide an unambiguous display, despite the fact that the output waveform from a guitar is fairly complex. If the flashing of the LEDs is rather weak, the probable cause is that the appropriate preset potentiometer has been set to produce the wrong harmonic of the guitar's frequency. Repeat the calibration process for that string to find a setting that gives more vigorous flashing from the display.

Note that the guitar's tuning must be within about 25Hz of the right frequency before the display will perceivably flash. When tuning a newly fitted string, or one that has slipped badly out of tune, either tune the string roughly 'by ear' first, or use trial and error to obtain a flashing display. The tuner can then be used to get the string precisely in tune.

GUITAR TUNER

RESISTORS: All 0·6W 1% Metal Film (Unless Stated)			
R1,2	100k	2	(M100K)
R3	47k	1	(M47K)
R4	4k7	1	(M4K7)
R5	3k3	1	(M3K3)
R6,7	22k	2	(M22K)
R8	330k	1	(M330K)
R9	18k	1	(M18K)
R10	2k7	1	(M2K7)
R11	15k	1	(M15K)
R12	10k	1	(M10K)
R13-15	1k	3	(M1K)
RV1-3	220k Horizontal Preset Potentiometer	3	(UH07H)
RV4-6	100k Horizontal Preset Potentiometer	3	(UH06G)
CAPACITORS			
C1	100μF 16V Axial Electrolytic	1	(FB48C)
C2	220nF Polyester Layer	1	(WW45Y)
C3	1μF 63V Radial Electrolytic	1	(AT74R)
C4	4μ7F 63V Radial Electrolytic	1	(AT76H)
C5	10nF Polyester Layer	1	(WW29G)
SEMICONDUCTORS			
IC1,2	TL071CP	2	(AV59P)
IC3	TS555CN	1	(RA76H)
IC4	4018BE	1	(QX10L)
TR1	BC549	1	(QQ15R)
D1-3	5mm Red LED	3	(WL27E)
MISCELLANEOUS			
B1	9V PP3 Battery	1	(JY60Q)
S1	6-way 2-pole Rotary Switch	1	(FF74R)
S2	SPST Miniature Toggle Switch	1	(FH97F)
JK1	¼in. Mono PCB-mounted Jack Socket	1	(HF90X)
	PP3 Battery Clip	1	(HF28F)
	8-pin DIL Socket	2	(BL17T)
	14-pin DIL Socket	1	(BL18U)
	Stripboard, Case, Connecting Wire, Etc.		

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

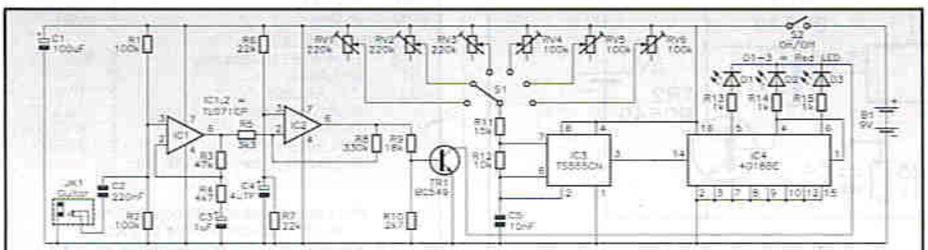


Figure 1. Circuit diagram.

ELECTRONICS CORRIGENDA

December 1996/Issue 108

News Report

Page 4

The telephone number for Maxim, which was included in the article 'Serial DAC offers Lowest Power' was given incorrectly. It should read: Tel: (01734) 303388.

Electronics and Beyond **apologise for the reproduction quality of some drawings in Issue 108. This was due to a production problem which was beyond our control. The drawings which were affected have been reproduced here. Please detatch this page from the magazine and insert into your copy of the December 1996 issue for future reference.**

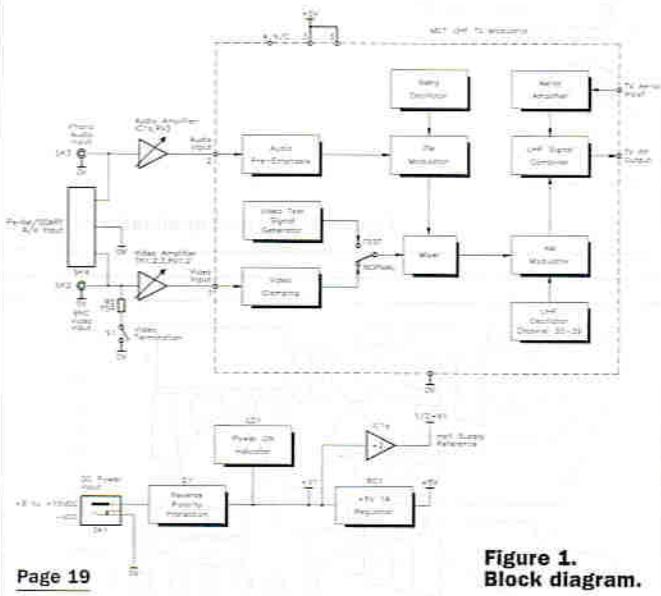


Figure 1. Block diagram.

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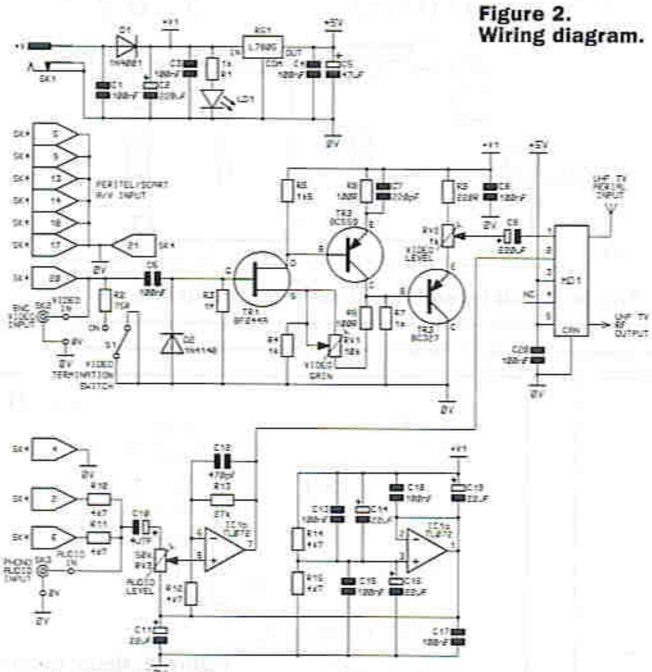

Figure 2. Wiring diagram.

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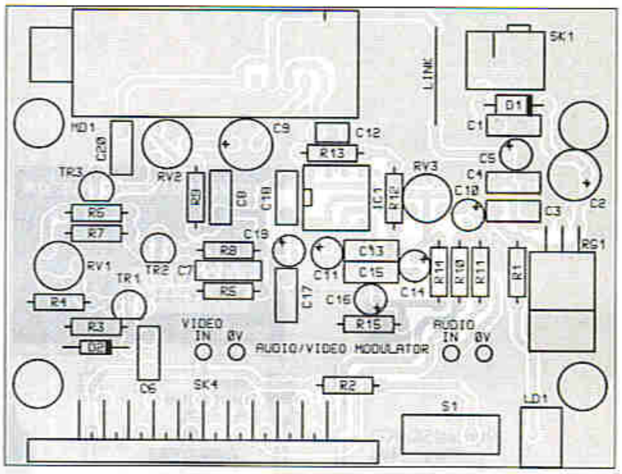

Figure 3. PCB legend and track (reduced to 85%).

Page 21

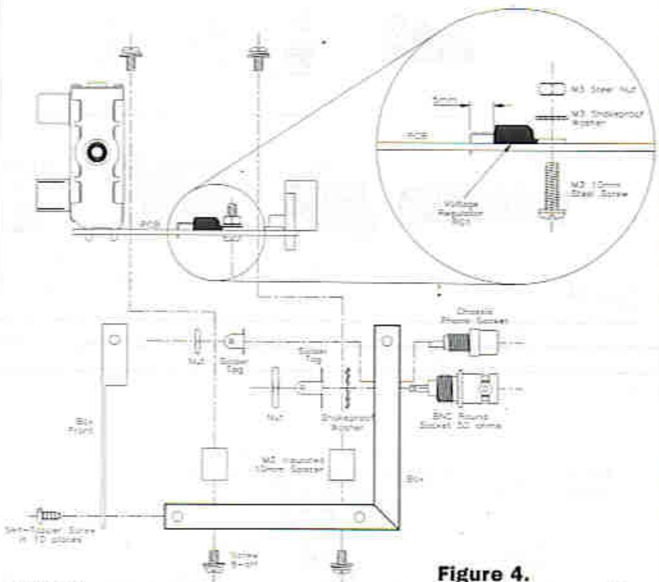

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Figure 4. Exploded assembly.

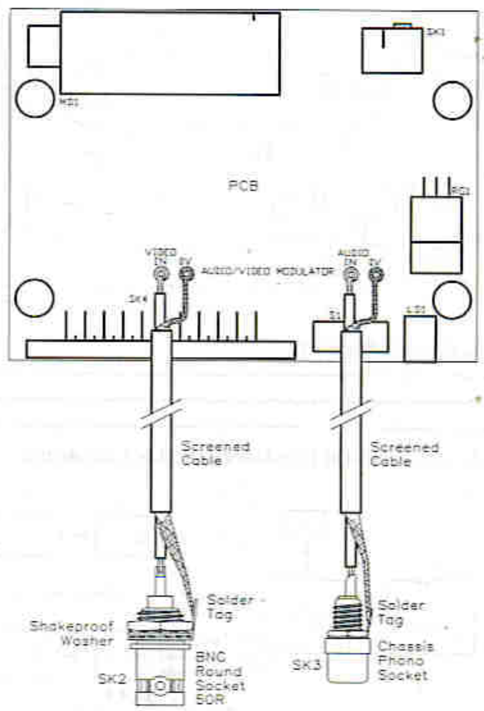

Figure 5. Internal Wiring

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CUT ALONG DOTTED LINE

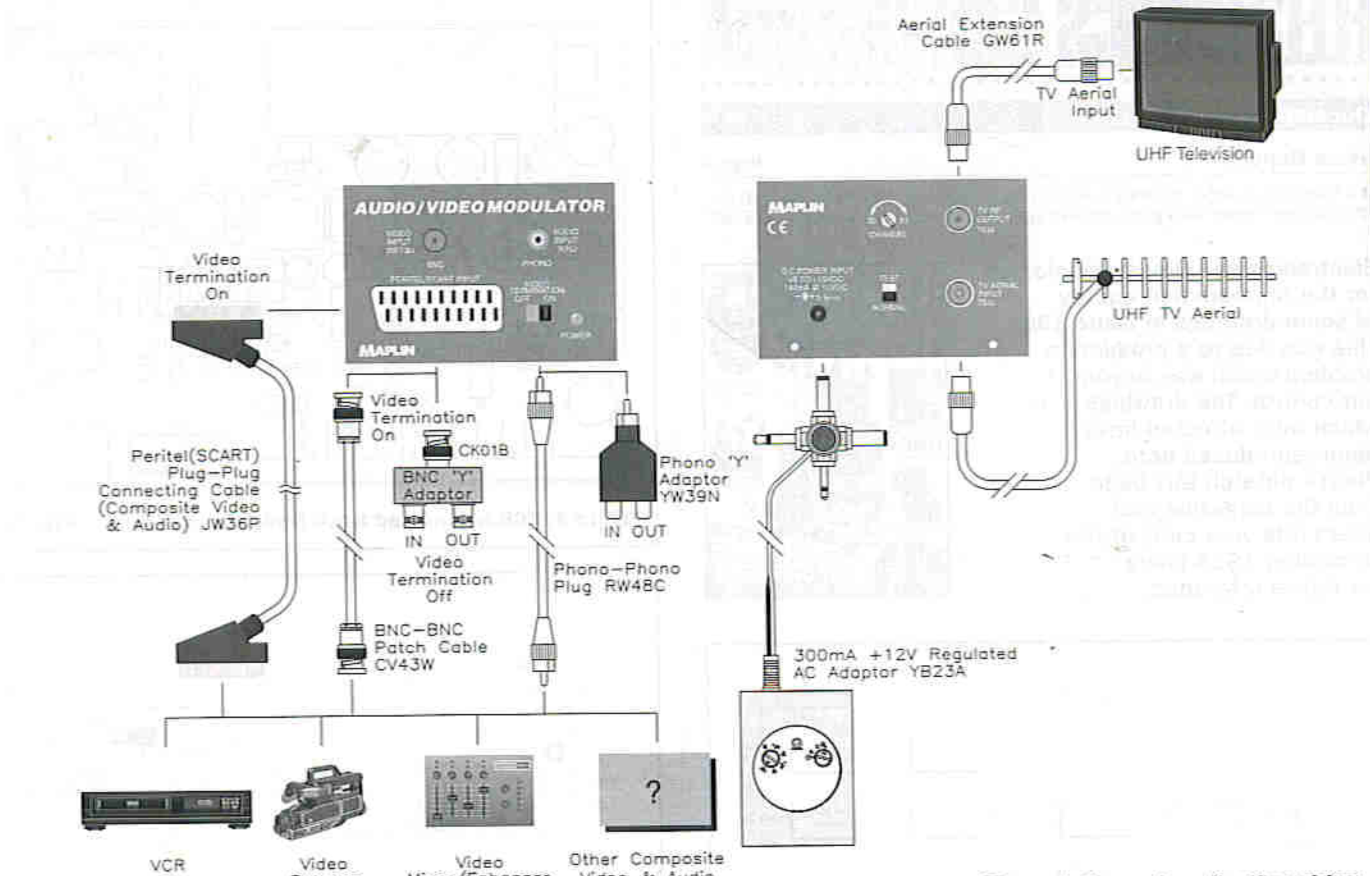

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Figure 6. General application wiring.

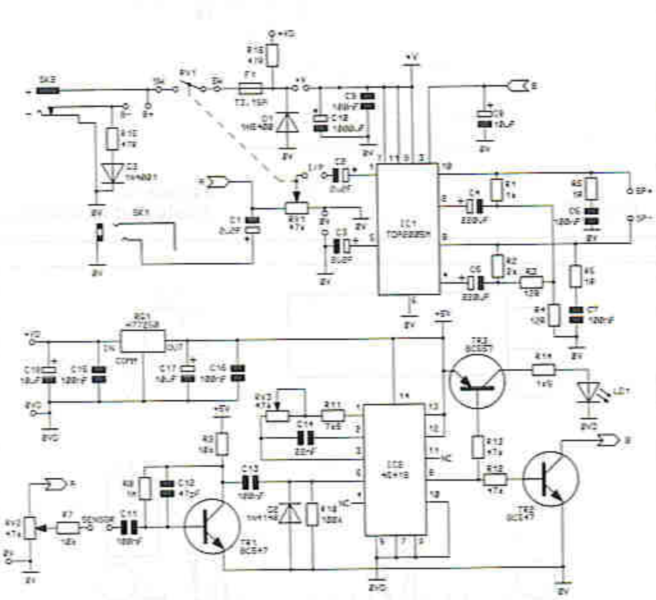

Figure 2. Circuit diagram.

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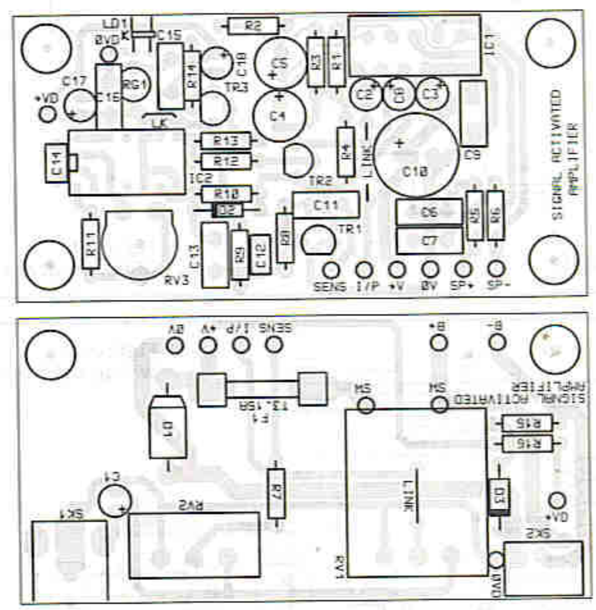

Figure 3. PCB legend and track (reduced to 85%).

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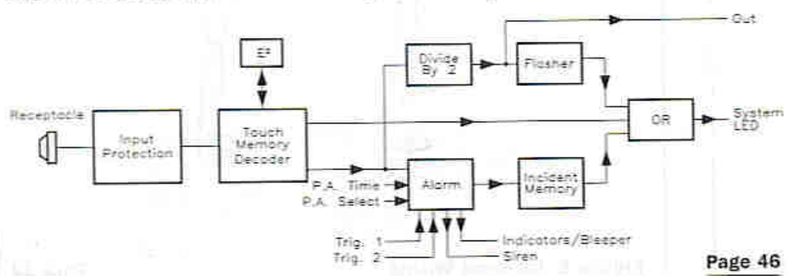
Figure 1. Touch hybrid functionality block diagram.



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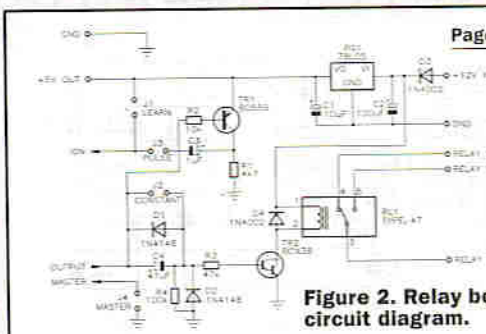


Figure 2. Relay board circuit diagram.

CUT ALONG DOTTED LINE

CIRCUIT MAKER

Fox Wireless Security Alarm FSS7500 Arm/Disarm Repeater

by E. T. Moss

The installation of a number of these alarm systems by the writer has demonstrated total success as regards their operating characteristics and reliability. Nevertheless, in one instance it has exposed that the size of the subject premises involving two widely separated entry/exits which are being used at approximately the same frequency produced some communication difficulties.

The owner understandably preferred the convenience of the keyfob method of system control and although the range of the transmitter was quite adequate for use at the exit remote from the control centre, the distant arm/disarm signals could not be heard with certainty. This resulted in some lack of confidence that the system had responded to the input.

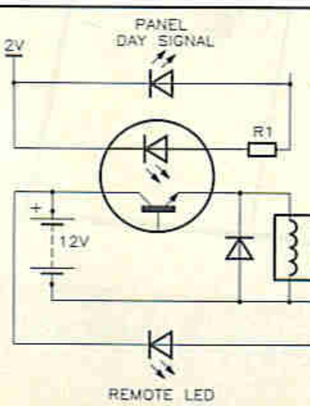
It was, therefore, desirable to provide an 'add-on' circuit which eliminated this problem. The amber DAY signal at the control panel being the visual signal which changes state according to the mode of the system (extinguishing when the system is armed) is the obvious output for driving the remote control indicator. The former LED is driven by a 2V supply which is also adequate for driving the IR emitting diode of a DIL optocoupler, the phototransistor providing the output for remote signalling using the 12V supply from the system standby lead acid battery.

Refining of the circuit includes, in particular, the inversion of the remote signal to indicate by LED illumination when the system is ARMED, which is the opposite mode from the panel DAY signal. This function is easily achieved by driving a miniature relay from the phototransistor and utilising its normally closed (nc) contact for the remote signal.

Secondly, a resistor is needed in the optocoupler diode circuit to 'balance' this with the parallel panel LED, to ensure that there is adequate power to drive both these devices. Finally, if a flashing LED is preferred for the remote signal, a series resistor may be needed in this circuit to reduce the voltage, as this type has a tendency to glow continuously at the higher end of its voltage range.

In order to reduce complexity, the system described above utilises hard wiring between the control panel and the remote signal in twin 0·5mm single-core telephone cable.

The schematic circuit is shown below, together with a list of components which can be assembled on a 38 × 20mm stripboard, having flying lead connections terminating with 2A blocks.



ITEM		ORDER CODE
Optocoupler	–	WL35Q
Relay	–	DC37S
Diode	–	QL73Q
Resistor 1	–	M51R
Resistor 2	–	M1K
LED	–	UK30H

Figure 1

Circuit Maker is a forum for reader's circuits, items and tips. Maplin cannot support in any way, the information presented here.

Touch Memory

THE KEY TO THE FUTURE

PART 3

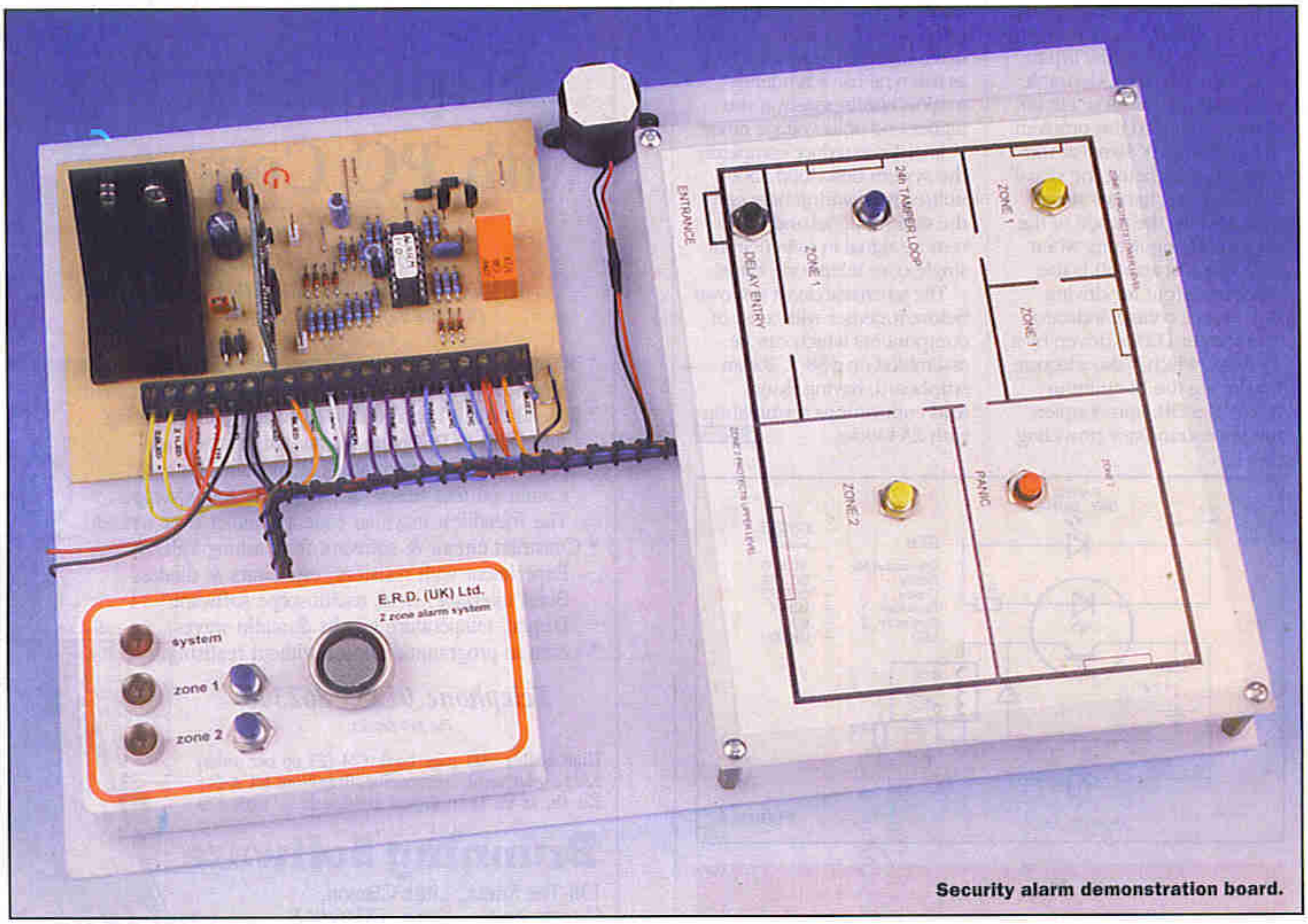
Key Alarm System Project

by Tony Ellis

In the second of our Touch Key Hybrid constructional projects, we detail a full featured touch key alarm system that can be used in both domestic and small commercial applications

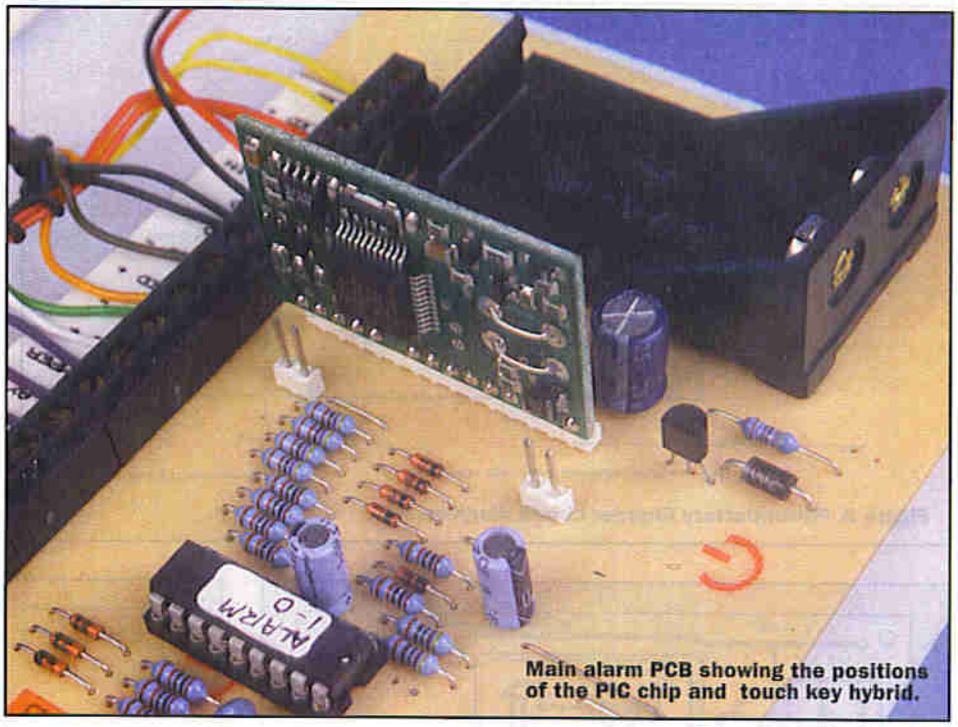
In order to produce an efficient, compact design with all the described features, we decided to augment the touch hybrid (which, of course, is microcontroller-based!) with a second micro from the Arizona Microchip PIC range. The full specification for the system is given below.

- Ultra high security (over 200,000 billion key differs)
- Codes laser etched (never repeated)
- Keys are passive (i.e., no battery required)
- System can learn up to eight keys at any one time
- Lost keys can be 'locked-out' by legitimate owner
- Replacement keys can be taught by legitimate owner
- Keys are virtually indestructible
- Same user key can be learnt to other touch key products
- 1 Zone with entry delay – 30 seconds
- 2 Instant Zones
- Zone exclusion option
- Tamper loop
- Panic button
- LED indication of excluded zones
- LED indication of system triggered
- Buzzer sounds on entry/exit
- Relay output to drive siren
- 2 Button keypad for system control
- The system configuration yields high security, as the only part of the system that is easily attacked (the receptacle) cannot be shorted or bypassed in any way, as can security key pads or keyswitches.



Security alarm demonstration board.

The simplest of the PIC family range is the microcontroller we have chosen, the PIC 16C54, which is an 18-pin dual in-line IC that could very easily be mistaken for a simple logic gate package. But this is far from the truth, for it is, in fact, a very powerful 8-bit RISC microcontroller based on the Harvard Architecture (this essentially means that there are separate internal busses for both memory and data) which is capable of operating at clock speeds of 20MHz. A further excellent feature of the PIC's are the 12 or more bit addressable I/O port lines, which can easily supply enough current to illuminate a standard LED. The PIC16C54's internal program memory is 512 words (12-bit), with an additional 32 bytes of RAM which serves as general purpose 'working file' registers.



Main alarm PCB showing the positions of the PIC chip and touch key hybrid.

Circuit Description

The PIC16C54 microcontroller, U1, is driven by a simple clock circuit consisting of resonator X1 which is a 4MHz type, and together with capacitors C2 and C3, forms the on-chip oscillator. There are two I/O (input/output) ports, one 8-bit and the other 4-bit. Their I/O line designation is as follows:

The four lines of Port A are set up as outputs and the 8 lines of Port B are inputs. All the other parts shown in Figure 1 are general support and driver components.

The touch hybrid and PIC microcontroller require a +5V stabilised supply. This voltage is obtained by regulator U2, with capacitors C5 and C6 providing decoupling. Diode D11 and resistor R18 form a simple 'trickle charger' for the board-mounted 9V Ni-Cd battery.

A 12V DC regulated supply (mains adaptor type) is recommended for the project, and it is essential that your selection takes into account the total current consumption of the system, especially with regards to the siren (low current piezo types are recommended).

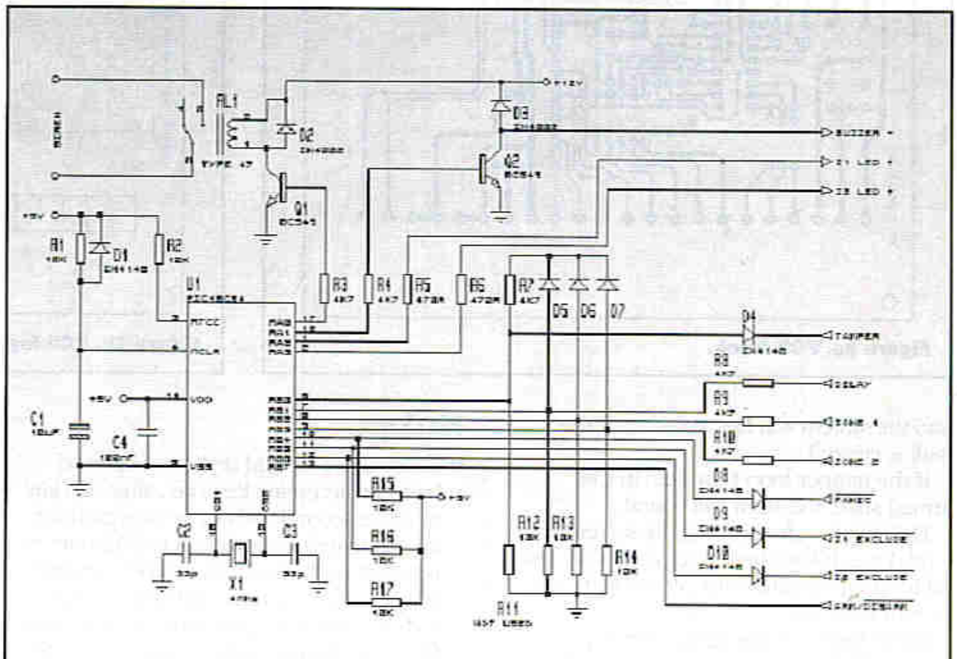


Figure 1. Main alarm circuit diagram.

PCB Assembly

Refer to Figure 3, showing the PCB legend and track whilst assembling the board – removing a misplaced component can be tricky and may damage the component(s), so always double-check the type, value and polarity before soldering.

Construction

Because the PIC microcontroller and the touch hybrid integrate all the essential elements of a sophisticated alarm system into a few tiny components, the design of the printed circuit board (PCB) is made very simple. All the components mount directly on to a reasonably small single-sided PCB. Begin construction by inserting the low profile components first, such as wire links, resistors and diodes, paying particular attention to the orientation (polarity) of the latter. Next, install a good quality IC socket (preferably turned pin type, which are more durable) for U1. Fit the capacitors, observing the correct polarity for electrolytic types; the polarity for these are indicated by a plus sign (+) on the PCB legend. However, the majority of electrolytic capacitors have their polarity designated by a negative symbol (–), in which case, the lead nearest the symbol goes into the hole opposite to the positively designated one.

Next, install the transistors and voltage regulator U2, making sure that its flat surface conforms to the package outline on the PCB legend, then solder programming links J1 to J3, followed by the interlocked screw terminal blocks 6 × 3-way and 2 × 2-way. Install the PP3 Ni-Cd battery holder and relay. Finally, carefully solder in the touch hybrid.

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.

Once you are satisfied with the construction, insert the programmed PIC16C54XT into the 18-pin IC socket.

Alarm System Operation

The touch alarm system's general functions are as follows:

Zone Exclude – to exclude a zone that is not required, press the appropriate button; the system buzzer will sound for approximately 0·5s, and the chosen zone LED will light. Arm the system as usual, and the excluded zone LED(s) will be extinguished.

To reset excluded zones, arm and then disarm system. All zones are reset on system disarm.

Panic – if the panic button is pressed, then the siren will sound for approximately 5 minutes. Using valid touch keys will not stop the siren in panic mode. This function is active in armed and disarmed modes.

Tamper – tamper input MUST be held to GND during normal use.

If the tamper loop is broken in the disarmed state, both zone exclude LEDs will flash,

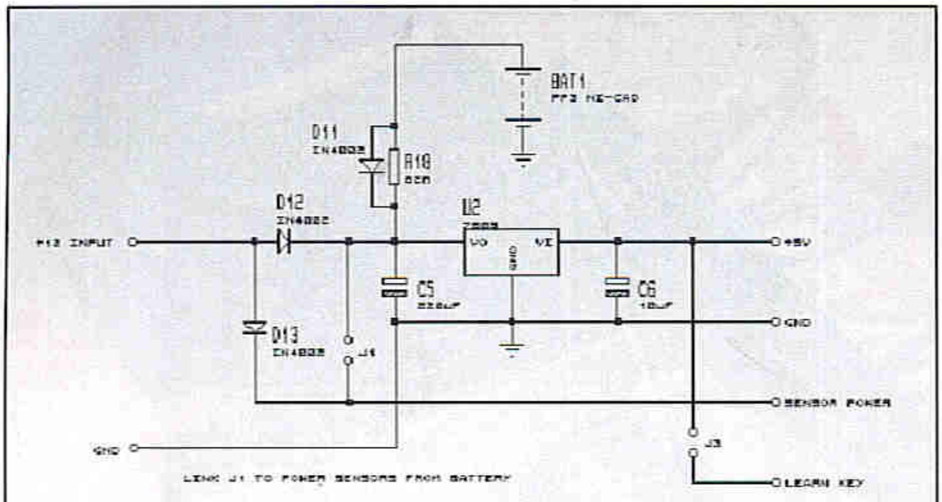


Figure 2. Power/Battery Charger circuit diagram.

◆ The Master Key cannot be 'learnt' as a User Key.

◆ The unit can learn up to four/eight keys – the system always remembers the last four/eight keys taught to it. Selection of four or eight key mode is via the key number program pads on the rear (non-component side) of the Hybrid, e.g., open circuit is 4 key mode.

◆ The same User Key can be taught to the systems more than once, this is a useful mechanism to 'lock out' lost keys. For instance, if the user wants the system to work off one key only, they can teach one key to the system four times, this will then become the only valid system key. Further, if the user wants two keys to be valid but to void a third key, then teach key one (once) and key two three times.

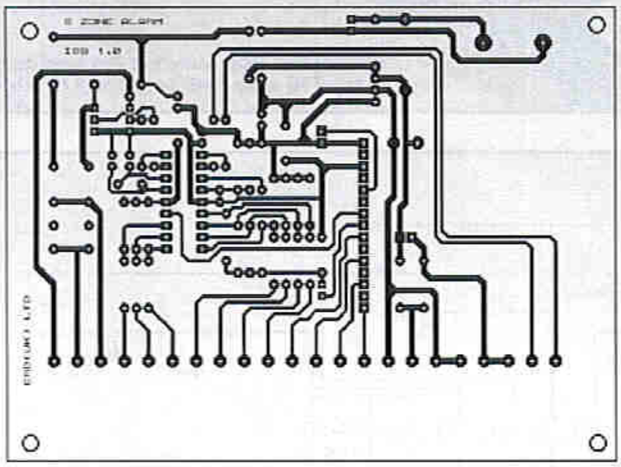


Figure 3a. PCB track.

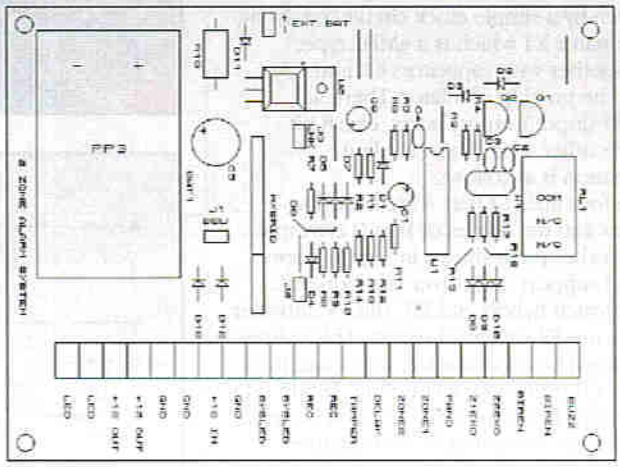


Figure 3b. PCB legend.

and the system will not rearm until the fault is cleared.

If the tamper loop is broken in the armed state, the siren will sound.

Delay Exit – after arming the system with a valid touch key, the buzzer pulses on and off for approximately 30s, after which, the system is armed.

Delay Entry – if the delay entry input is triggered, the buzzer pulses on and off for approximately 30s, after which, the alarm will sound the siren if a valid key is not presented to the system within this time.

Touch Key Learning Procedures

Learn Master Key

Not necessary with Maplin Hybrid as Master Key is pre-learnt.

Learn User Key

1) Apply power to alarm board.
2) Install learn jumper J3.
3) Touch Master Key on receptacle, LED will flash at approximately 5Hz.
4) Touch Key to be learnt on receptacle, LED will go out.
5) Remove J3, hybrid will now switch on/off with keys.

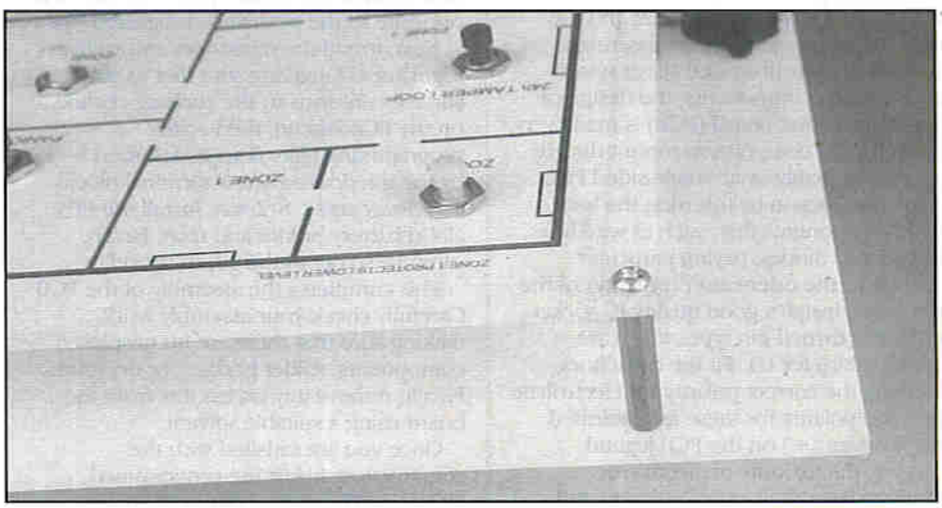
Repeat steps 2 to 4 to learn further keys.

Notes

◆ There is a 4 second de-bounce period between accepting keys, i.e., after one key touch, a second will not be accepted for approximately 4 seconds. It is important to note that touch keys are meant for momentary action (i.e., touch and withdrawn); never leave the key in contact with the receptacle for more than a couple of seconds, as the output will toggle on and off or vice-versa. As a guidance, communication (to decoder) + acceptance of an authorised touch key is generally in less than 100ms ($^1/_{10}$th of a second).

Software

The software source and object codes for the touch key alarm system are available on a 3·5in. disk from E. R. D. (U. K.) Ltd., K & K House, Station Approach, Rickmansworth Road, Watford, Herts WD1 7LR, for £8.50. Alternatively, a pre-programmed PIC16C54XT OTP (one time programmable) microcontroller is also available at a cost of £12.50. Prices include VAT and postage.



PROJECT PARTS LIST

RESISTORS All 0·6W 1% Metal Film			
R1,2,12-17	10k	8	(M10K)
R3,4,7-10	4k7	6	(M4K7)
R5,6	470Ω	2	(M470R)
R11	*Not Used*		
R18	82Ω	1	(M82R)
CAPACITORS			
C1,6	10µF 16V Radial Electrolytic	2	(AT98G)
C2,3	33pF Ceramic Disc	2	(WX50E)
C4	100nF Ceramic Disc	1	(YR75S)
C5	220µF 16V Radial Electrolytic	1	(AT41U)
SEMICONDUCTORS			
D1,4-10	1N4148	8	(QL80B)
D2,3,11-13	1N4002	5	(QL74R)
Q1,2	BC549	2	(QQ15R)
U1	PIC16C54 Pre-programmed PIC Microcontroller	1	*See Text*
U2	7805	1	(QL31J)
HY1	Touch Key Decoder Hybrid	1	(CK41U)
MISCELLANEOUS			
RL1	12V BT (Type 47) SPDT Relay	1	(DC80B)
BAT1	PP3 Ni-Cd Battery	1	(AG33L)
	PCB-mounted PP3 Battery Holder	1	(CK65V)
	PPB Battery Clip	1	(HF28F)
	3-way 5mm PCB-mounting Interlocking Terminal Block	6	(RK72P)
	2-way 5mm PCB-mounting Interlocking Terminal Block	2	(FT38R)
PCB	Ready made PCB (not available from Maplin)	1	

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

The above items are not available as a kit.

SNA AND INTERNETWORKS

by Frank Booty

Most big business today runs with SNA (synchronous network architecture). There are some 50,000 IBM mainframe-based and over 400,000 AS/400-based SNA networks worldwide, carrying mission critical applications traffic – over 95% of SNA traffic is mission critical. But the networks linking these revenue generating systems are increasingly based on TCP/IP. That's the problem. SNA has no network layer that routers can use, so it can't be routed across TCP/IP backbones. Does one maintain two networks?

Yes, the Internet and Intranet phenomena are looming, with the potentials of Java, Jam, Hypermedia P-code, Amazon, and ActiveX in the wings. But for now, it has to be accepted that SNA traffic and router networks are not a good mix. SNA is unroutable.

End user messages do not include the network layer address the router requires to move data twixt LANs and WANs. So what do harassed network managers do? Many bridge, stretching the SNA network to include LAN attached end stations.

However, bridging brings in scalability and reliability issues. It cannot reroute around failures. It generates too much broadcast and logical link control layer 2 (LLC2) message overhead. It suffers from LLC2 timeouts often. What else is there? Encapsulate SNA messages inside a routable protocol, thus providing more reliability and scalability (than bridging).

Current encapsulation technologies comprise gateways which place SNA messages into packets of routable protocols such as TCP/IP or IPX; data link switching (DLSw) enabling a router to place SNA messages into IP packets; dependent logical unit requester/server (DLUR/S) which carries SNA messages over APPN; and frame relay using IETF RFC 1490, which defines the way frame relay access devices (FRADs) and routers can sandwich SNA messages between frame relay headers for transmission across frame relay links. There is no best way to handle SNA traffic in today's complex routed internetworks. Any approach chosen has to support the devices and protocols required to solve the particular SNA problem (see Table 1).

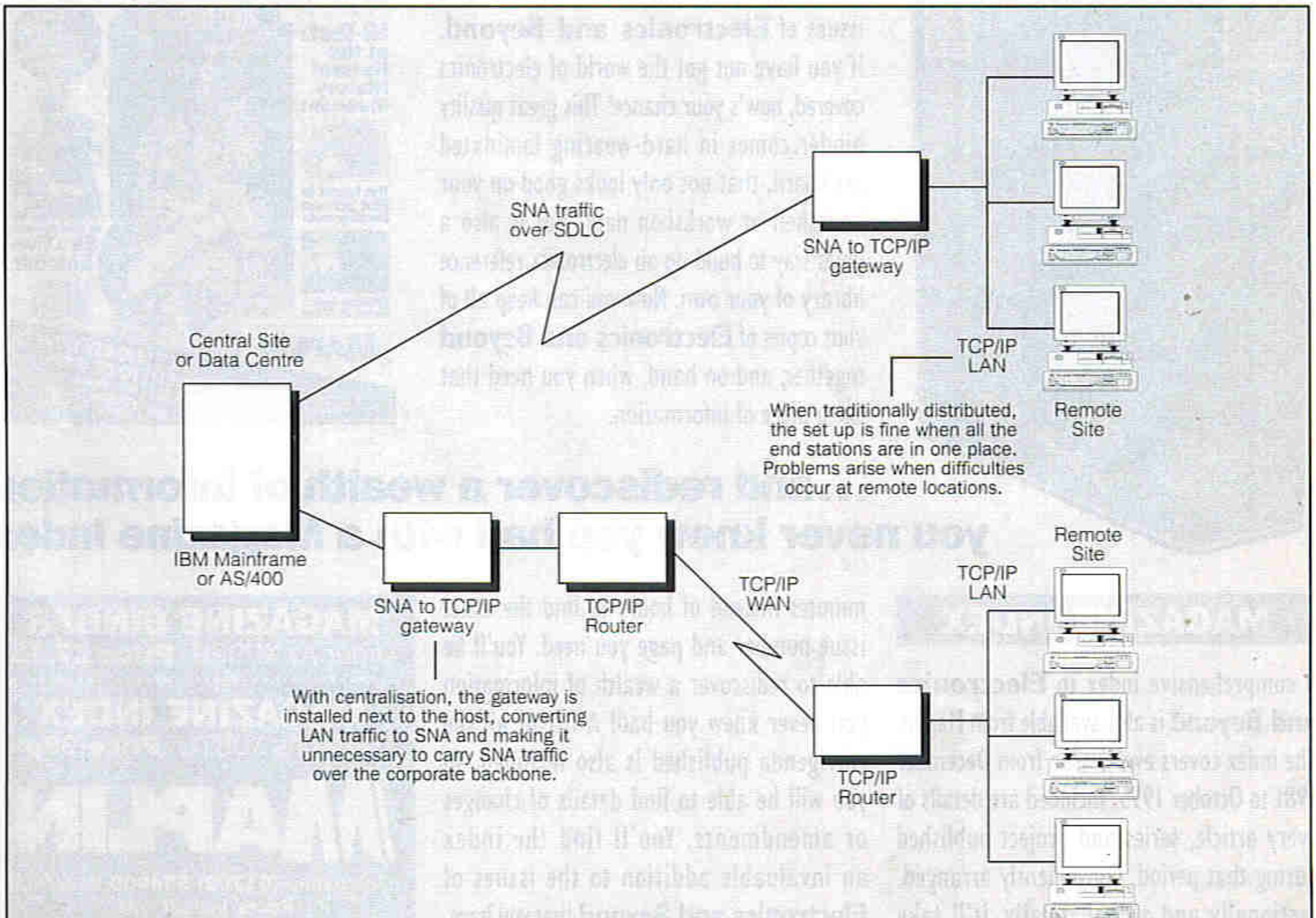


Figure 1. Gateways.

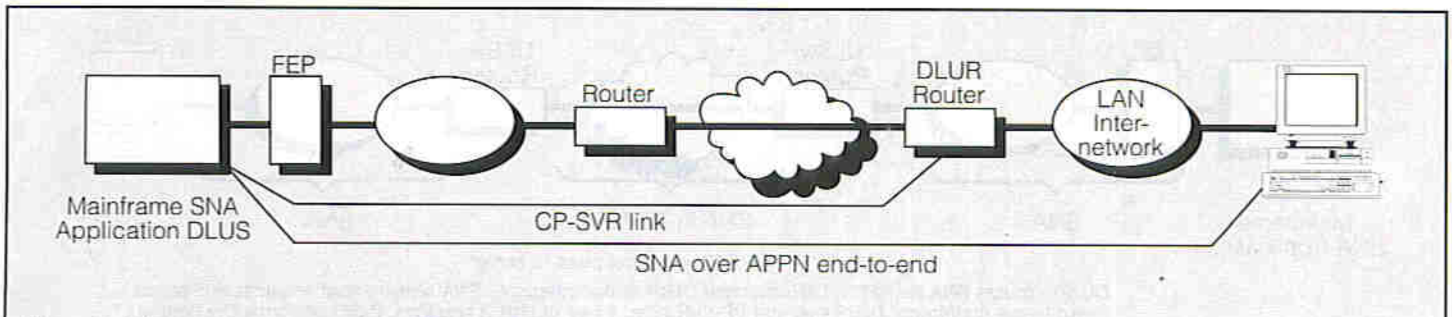


Figure 2. DLSw routers encapsulate SNA in TCP/IP.

	Bridging	Gateways	DLSw	DLUR/S	Frame Relay (RFC 1490)
Protocol used for routing	None	TCP/IP,IPX	TCP/IP	APPN	None
Supports all SNA devices	Yes	No	Yes	Yes	Yes
Reroutes around failures	No	Yes	Only High-Performance Routing (HPR)	Yes	If supported by frame relay service
Reduces broadcast overheard	No	Yes	Yes	Yes	Yes, via local termination
Reduces LLC2 session and keep alive overheard	No	Yes	Yes	Yes	No
Reduces LLC2 timeouts	No	Yes	Yes	Yes	Yes, via local temination
Requires software changes to end user device or LAN	No	Yes	No	No	No
Routes messages directly to SNA application	No	No	No	Yes	No

Table 1. SNA internetworking schemes.

Bridging

Bridges and PC-based terminal emulation software have been used by network managers for years to build bridged networks for SNA users. These solutions work at the data link layer, unlike the router-based options, and try to bypass problems caused by SNA's lack of routing. The most common supported bridging technique here is source route bridging, where the transmitting device uses broadcast messages to work out a route through the network, and then puts that route in the messages it sends. This is generally used with Token Ring LAN environments. With a technique called transparent bridging, each bridge learns the best port to use in reaching a given destination and forwards the messages out of the appropriate port. This technique is usually used with Ethernet LANs.

Bridges are regarded as working well in smaller networks, but there are significant limitations. These include a lack of dynamic rerouting capability; broadcast overhead due to the discovery process of source route bridging; LLC2 acknowledgement and keep-alive overhead can create up to 15% overhead, increasing line use and needing more frequent line upgrades; and LLC2 connection timeouts, which can be the most serious problem associated with bridged SNA networks. Generally, these problems are linked with large SNA networks and a smaller network should work without serious difficulties. Also, bridges are available to support compression algorithms, which slash the impacts of broadcast and LLC2 overhead.

Gateways

Large router-based internetworks that have to integrate SNA traffic call for alternatives to simple bridging. Currently, the most popular involve encapsulation of SNA messages within a protocol such as TCP/IP (or IPX) that provides network layer addressing. First to market were SNA gateways, which are sold in several varieties. The basic architecture is the same for all – see Figure 1.

Software in the end user's unit maps the higher layer of SNA to a similar function in IP (or IPX), or encapsulates the higher level SNA within the routable protocol. The latter then transports the SNA data across the router based internetwork. At the SNA host, the gateway translates the encapsulated message into a pure SNA message, which is subsequently delivered to the SNA application.

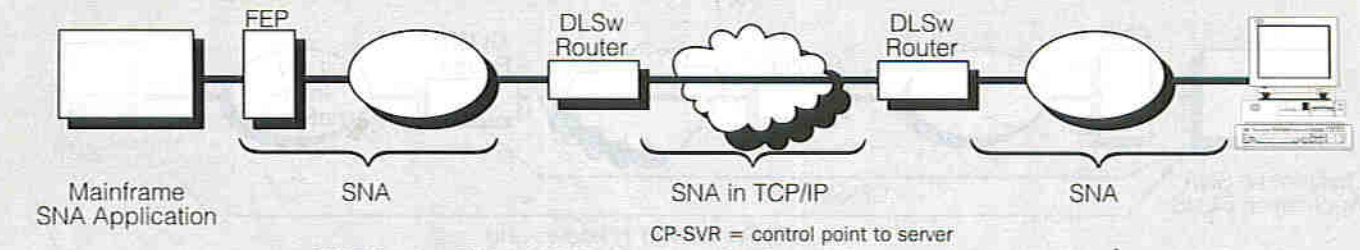
Gateways using unroutable protocols like Netbios don't solve SNA's bridging related problems – so anyone contemplating utilising these products should not view them as viable options.

When deployed correctly, gateways do solve most of the issues associated with SNA bridging, e.g. using a routable protocol to handle SNA traffic gives dynamic routing around network failures. Scalability problems are eliminated as gateways do not use LLC2 between end user units and the gateway. Result? End user devices don't transmit source routing broadcast messages looking for the front end processor.

Instead, the protocol uses broadcast messages only when seeking out the closest router. Unlike a bridge, the router doesn't forward the broadcast throughout the network, but responds to end users' broadcasts. Problems encountered on the internetwork side of the gateway are mostly related to the routable protocol, not to SNA.

While the basic architecture of gateways is identical for most, there are some key design and implementation differences which differentiate products in functionality and performance:

- The routable protocol used (typically it's TCP/IP or IPX).
- SNA devices and systems supported. Unlike other SNA integration solutions, not all SNA hosts/devices may be supported, although most proprietary gateways and client applications address the full line-up of SNA kit. But some (e.g., those based on Tn3270) don't support every kind of printer found on an SNA network.
- SNA client or terminal emulation software supported. The only standard SNA client solutions are the Tn3270 and Tn3270E SNA terminal emulation standards, which enable TCP/IP networks to carry SNA application data using TCP/IP's telnet capability. All other gateway solutions use proprietary techniques (which doesn't have to mean single vendor, e.g. NetWare for SAA stuffs SNA messages into IPX packets, and is supported by client applications from such vendors as Attachmate, WRQ and Wall Data).
- SNA file transfer protocol supported. Two main file transfer protocols are used in SNA: IND$FILE file transfer and the APPC protocol (advanced program-to-program communications). Not all gateways support both. The former is used only with mainframes, while APPC (offered with VTAM 4.1) can be used in both mainframe and AS/400 configurations. Managers must ensure client software supports the protocol they want to use.
- The number of concurrent sessions supported may be restricted by a preset maximum or the performance capability of the gateway's platform. Yet, gateways cannot always support the number of logical units they allow managers to define. A second gateway may have to be configured, bumping up cost and admin headache.
- The administrative and configuration requirements differ, depending on how gateways are connected to the mainframe. Many provide a channel connect solution which lets them bypass the FEP and send messages direct to the mainframe. Eliminating the FEP cuts costs significantly but also causes problems for multiple mainframe environments. The gateway sends all SNA messages to one mainframe. If the required application isn't running there, the mainframe (and not the FEP) must reroute the message to the correct location. Expensive. Why? Mainframe CPU cycles have to be used



DLUR/S routes SNA via APPN. LAN-attached DLUR router intercepts SNA session start requests and sends them to the mainframe DLUS over the SP-SVR pipe, a pair of LU6.2 sessions. DLUS performs the normal SNA set up functions so data can flow between DLUR and the target application.

Figure 3. DLUR/S.

for rerouting, and mainframes are inefficient routers. Some companies, e.g. CNT, can work round these issues.

Gateways are not the optimal solution for every SNA environment. With Windows and ubiquitous PCs, users could install full-stack SNA implementations on each end user device. Great. Traffic from users could be bridged directly to the FEP. No need for a gateway. But the thorny issues of broadcast and LLC2 overhead problems associated with bridging arise. Router vendors developed encapsulation techniques to overcome bridging's limitations without requiring gateway software.

DLSw

The DLSw standard is a popular technique for encapsulating SNA messages in TCP/IP packets, and is usually implemented in routers – see Figure 2. Its approach is to act like a bridge to SNA devices, responding to the source routing broadcast and LLC flows. It also routes messages through the network between DLSw routers by encapsulating SNA traffic within TCP/IP packets. When the traffic reaches the DLSw router stuck on the destination SNA FEP or mainframe, it's unscrambled and bridged to the appropriate SNA application.

DLSw looks at the media access control (MAC) address in a LAN environment; as it routes traffic according to the data link address, it means with SNA that it doesn't have to look at the LU, physical unit (PU), or any SNA address field. Indeed, DLSw can be considered a data link, or bridge level, router. Why? It routes data link traffic, satisfying data link layers plus the problem of data link protocols in a WAN, while also providing router networking functionality.

Timeout problems are solved and broadcast overhead problems alleviated – LLC2 sessions from user devices are terminated at the first DLSw router, which supplies LLC2's acknowledgements and keep-alive messages as if it were the destination FEP. As the DLSw router is normally located near the user device (and also on the same LAN), timeouts are much less likely. Further, as all SNA sessions going to the same FEP or mainframe are multiplexed over a single TCP/IP session, session overhead falls.

Broadcast traffic on the network is also cut, as DLSw learns from the first broadcast which DLSw router in the network is nearest the target device. As with bridging, the first broadcast session request for a given device in a DLSw network passes to all devices, which ensures the request reaches its destination. All broadcast requests for it will be sent to the router, obviating any requirement to broadcast to the whole network.

Such information is stored in DLSw routers in a table, which is purged after a vendor-preset time to prevent it from becoming too unwieldy or getting stuffed with obsolete data. If the device is moved, there are procedures for relearning, etc.

There are drawbacks to this rosy scenario. Reduced scalability is the classic. Each router has to set up a TCP/IP session with every other DLSw router in the network. If there are 200 DLSw routers in the network, each router has to maintain 199 sessions. Routers stuck at FEP locations can be swamped with simultaneous location requests. As the number of routers in the network increases, the number of TCP/IP sessions grows too, which results in a capacity problem. Which begs the question: how many routers can handle the overhead linked with thousands of concurrent TCP/IP sessions? Not a lot.

Problems are naturally being addressed by vendors. Take the branch office routers chucking out TCP/IP sessions galore. New versions create sessions only when there is actual session traffic, instead of maintaining a TCP/IP session to all other DLSw routers in the network. TCP/IP's multicast capability holds the key, in that it can deliver broadcast and locate requests. Yet, too many TCP/IP sessions emanating from the FEP's router is an issue. Solution? Buy a powerful router. For now.

Vendors in the pool here include ACC, Bay, Cisco, Digital, IBM, and 3Com.

DLUR/S

When the routable follow-on to SNA – APPN – was introduced by IBM, older SNA devices were not supported. Hence, new ways of supporting SNA in multiprotocol environments, e.g. DLSw, found it easy to penetrate the SNA market. IBM subsequently brought in DLUR/S, which – as with DLSw – utilises the routable nature of another protocol to support SNA traffic without needing alterations to SNA applications or user devices. The prime differentiator twixt DLUR/S and DLSw, though, is the choice of routable protocol – DLSw uses TCP/IP while DLUR/S uses APPN. Figure 3 shows the DLUR/S structure.

APPN is intended for those units that do not need the intervention of mainframe services to set up sessions between user devices and applications, i.e. independent LUs. However, SNA needs dependent LUs. Mainframe services must set up each session between a user device and an application. DLUR/S consequently exists as two parts. The dependent LU server (DLUS) runs as a VTAM application on the mainframe and sets up SNA sessions. The dependent LU requester (DLUR), meanwhile, runs in a device – e.g. a router – near the user device and forwards session requests to the DLUS.

With a DLUR/S set up, the DLUR initiates a pair of LU6.2 sessions to the DLUS. As a virtual connection, it's used only for session controls, not for data messages between session partners. When an SNA user device wants to start a session, the DLUR cuts into the session start request and transmits it to the DLUS. The DLUS passes the data required to establish the session to VTAM, which subsequently carries out the routine SNA session setup activity. Once VTAM sets up the SNA session, and DLUS tells DLUR the session has been established, all data flows directly twixt DLUR and target application.

DLUR/S solves many scalability issues linked with SNA bridging, as with gateways and DLSw. User device LLC2 sessions are terminated at the router or device running the requester. As with a local DLSw router, the requester responds locally to LLC acknowledgements and keepalive messages. Similarly, with source routing discovery broadcast messages. With a user device calling for a connection, DLUR responds as though it were the destination and then utilises APPN's directory services and search functions to locate the destination.

The advantages from the DLUR/S approach are lacking in the other SNA integration techniques. For example, it doesn't interfere with IBM's Netview network management flows, as APPN is fully integrated with Netview. DLUR/S can also route SNA traffic directly to the application. All the other schemes call for traffic to pass through the FEP or mainframe first.

Vendors in the DLUR/S pool include Cisco, Bay, IBM, Nortel, and 3Com.

Frame Relay

The problems and limitations linked with SNA bridging can be overcome with gateways, DLSw, and DLUR/S. However, the solutions are as complex as they are comprehensive. With many SNA shops, common source route bridging still offers the simpler, more practical solution. Now, galloping over the hill, fresh from successes of frame relay services in WAN environments, come the FRAD vendors who have worked out solutions which enable conventional bridged solutions to benefit from frame relay's virtual circuit and dynamic rerouting capabilities. Well, theoretically, certainly.

FRAD and router vendors came up with a simple SNA encapsulation scheme, working with the IETF, known as the RFC 1490 specification – see Figure 4. This defines a standard way for FRADs and routers to encapsulate SNA messages between frame relay headers and then shunt them across frame relay permanent virtual circuits (PVCs). While RFC 1490 solutions don't remove all problems associated with bridged solutions, they do offer the useful attributes of access to low cost frame relay links and the ability to segregate SNA traffic onto its own PVC so that other LAN traffic does not interfere with delivery.

The problems not eliminated include LLC2 timeouts and the fact that dynamic rerouting is not universally available. Further, the frame relay route looks superb on paper, but most router implementations offer very limited congestion control.

Along the way, three variants appeared: the basic RFC 1490 specification and two enhancements. Boundary network node makes the FRAD resemble an SNA peripheral device, and boundary access node lets traffic from the FRAD resemble traffic from a FEP attached LAN, so simplifying configuration.

There are said to be many network managers who rely on mostly IBM kit for their SNA networks, who are combining routers, converters, and frame relay services to get rid of FEP software and the FEPs themselves. Exorbitant licensing fees for FEP software are the root of the anguish. Frame relay has a lot going for it. It's also offered through the IBM Global Network.

Conclusions

It is difficult to decide which of the solutions listed here is best for any given SNA network. The key issue to consider when selecting a solution is what protocol is the most appropriate for the internetwork: TCP/IP, frame relay, or APPN. For TCP/IP environments, gateways and DLSw routers make the most sense. For frame relay networks, it's RFC 1490 compliant FRADs or routers. For APPN environments, DLUR/S is the best selection.

It's necessary to eliminate anything that does not solve a particular problem the network might have, e.g. if the network uses printers which gateways do not support, gateways are not the correct choice. If LLC2 overhead is a key worry, source route bridging or RFC 1490 over frame relay will not work. If routers do not support APPN, then DLUR/S is not in the picture.

Independent analyst, Jay Fogelman, speaking at seminars organised by Computer Network Technology (CNT), considers the merits of running TCP/IP alongside an SNA network. "There are obvious problems associated with duplication – management and technical issues, and cost. Yet, most people take this route because the SNA network is critical and the TCP/IP network is vital for future developments. An alternative? Get rid of SNA. But that's impractical. We have both because we need both. The key to future success is coexistence and integration."

TCP/IP is used today as the networking protocol on LANs and WANs, on the backbone and at the client level. However, in the near future, there will be no LAN or WAN, just the network. To save money, many large network users are looking to standardise on one protocol and TCP/IP is the obvious candidate.

According to Fogelman, there are seven key questions managers must ask: What will the three most important applications be five years hence? Who will your users be over this time period? How many protocols are running today? How many protocols should users be running in five years time? (It should be 'fewer' for the last question). What are our programming skills? Where does our mission critical data reside today? Who will the strategic vendors be for the next five years?

"Answer these seven questions and you're on the way to developing a corporate network architecture", says Fogelman.

The problem with SNA and TCP/IP integration is that there are lots of possible start points and routes, but no obvious right answer. Yet, within IBM is a department dedicated to playing with Sun's Java – most enthusiastically. Given IBM's much-vaunted interest in the Internet, and equal amount of salivations over Java, it would come as no surprise if all sorts of interconnectivity solutions do not spill out onto the market soon, if they haven't already done so, in beta test.

Earlier this year at a Networld+Interop exhibition, a Java-based Web server doubling as a gateway for clients running Java compatible Web browsers was demonstrated. It gives clients real time interactive access to legacy systems via 3270 and 5250 terminal emulation. As long as the clients have a Web browser, they do not have to install third party emulation software. And that's only the tip of the iceberg.

SNA Gateways

According to market researcher CIMI Corp, SNA accounts for over 60% of business traffic. Yet, with the explosive growth in departmental LANs, Unix workstations and attached PCs, integration is flavour of the moment. Enter gateways. Gateways perform application layer conversions from the SNA protocol stack to a LAN protocol stack like IP or IPX.

There are over 18 companies plus OEMs in the market pushing their products. Loads of choices, and lots of potential for confusion.

There are four types of gateways: hardware/software gateways; software only devices; units built into networking devices like FRADs and routers; and mainframes. Aside from the choice, managers have to consider: whether or not a gateway can handle centralised networking, which LAN protocols it can convert, which gateway-to-client emulation protocol and SNA host environments are supported; whether the vendor sells its own client emulation software to run on end stations; what management features are offered – SNMP, mainframe Netview, proprietary, etc; and cost.

Hardware/software combination gateways lend themselves to those who like the simplicity of turnkey solutions. There is guaranteed interoperability between software and hardware, single vendor support, and a higher performance than software only solutions, allowing for more users and sessions. The disadvantages are that the proprietary hardware cannot be used for other applications; no integration with network operating system services; and lock in to a single vendor.

Software-based gateways work with standard network operating systems and operating systems, are scalable, and work with any host or LAN interface. The disadvantages are they usually require a dedicated server and extra hardware interfaces.

Special function gateways lower costs by consolidating gateway functions in a networking device. There is guaranteed interoperability between software and hardware, integrated management, and single vendor support. The disadvantages are lock in to a single vendor, and no integration with network operating services.

Mainframe gateways can be problematical. Many users find out the hard way that running TCP/IP on a mainframe is CPU intensive, and might call for processor or memory upgrades to the host.

SNA gateways have traditionally been distributed, i.e. located next to the end station. This is fine when all the end stations are together, but troublesome when they're all remote. Enter centralisation. The gateway is located next to the host, converting LAN traffic to SNA and making it unnecessary to carry SNA traffic over the corporate backbone.

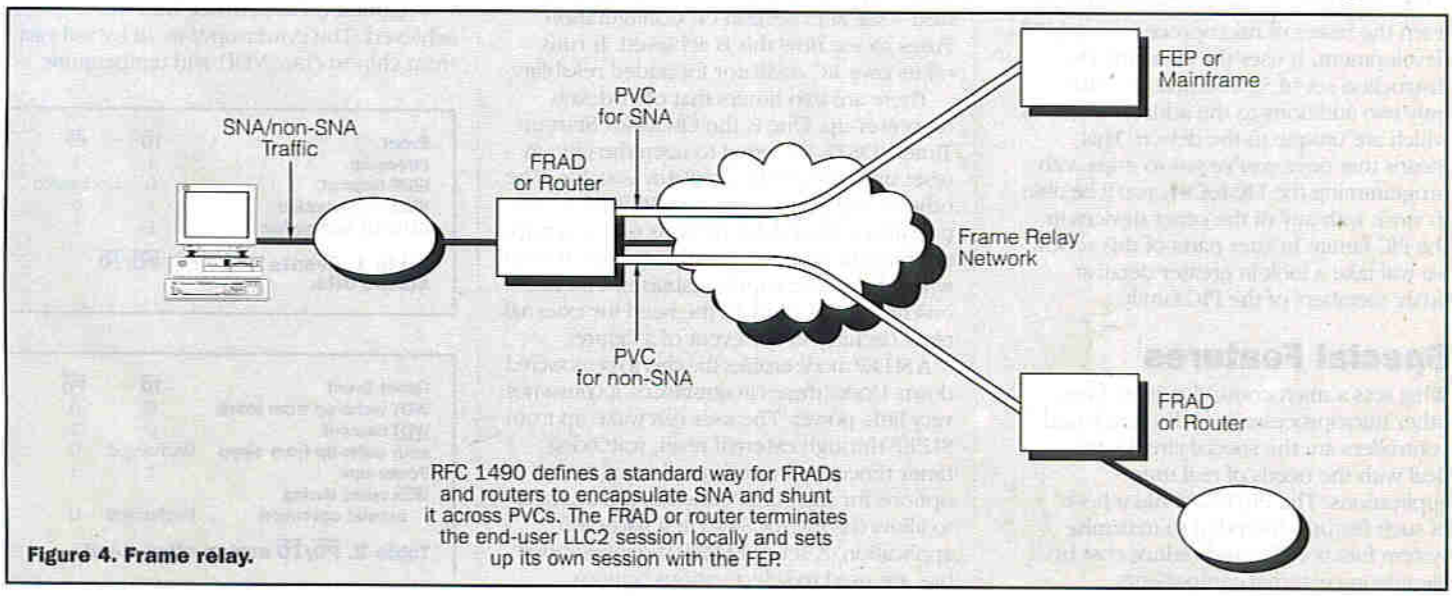


Figure 4. Frame relay.

DEVELOPING APPLICATIONS AROUND THE PIC ARCHITECTURE

PART 3

More Than Just a Microprocessor

by Stephen Waddington

Last month, we started to look at the PIC microprocessor from the application developers' perspective. Here, Stephen Waddington continues to explore this theme, and outlines some of the special hardware features of the PIC microprocessor.

First, a quick spot of revision. Initially, I have chosen to focus 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, which are unique to the device. This means that once you've got to grips with programming the PIC16C84, you'll be able to work with any of the other devices in the PIC family. In later parts of this series, we will take a look in greater detail at other members of the PIC family.

Special Features

What sets a microcontroller apart from other microprocessors or discrete based controllers are the special circuits to deal with the needs of real time applications. The PIC16C84 has a host of such features intended to maximise system functionality and reduce cost by eliminating external components.

Overview

The special features range in functionality from reset circuitry through to a watchdog timer, which resets the micro controller in the event of a system crash. The on-chip watchdog timer can only be shut off through an EEPROM fuse – see later section on Configuration Fuses to see how this is achieved. It runs off its own RC oscillator for added reliability.

There are two timers that offer delays on power-up. One is the Oscillator Start-up Timer (OST), intended to keep the chip in reset until the crystal oscillator is stable. The other is the power-up timer (PWRT), which provides a fixed delay of 72ms on power-up, designed to keep the microcontroller in reset while the power supply stabilises. The two on-chip timers alleviate the need for external reset circuitry in the event of a failure.

A SLEEP mode enables the chip to be powered down. Under these circumstances, it consumes very little power. The user can wake up from SLEEP through external reset, watchdog timer timeout or interrupt. Several timer options for the SLEEP function are available to allow the PIC16C84 to fit a particular application. A set of EEPROM configuration bits are used to select various options.

Reset

Figure 1 shows a simplified block diagram of the on-chip reset circuit for the PIC16C84. It differentiates between various kinds of reset, as follows:

- Power On Reset (POR)
- $\overline{MCLR}$ reset during normal operation
- $\overline{MCLR}$ reset during SLEEP
- WDT timeout reset during normal operation
- WDT timeout reset during SLEEP

Some registers are not reset – they are unknown on Power On Reset (POR) and remain unchanged in any other reset situation. Most other registers are reset to 'reset state' on POR, on $\overline{MCLR}$ or WDT reset during normal operation and on $\overline{MCLR}$ reset during SLEEP. They are not affected by a WDT reset during SLEEP, since this reset is viewed as the resumption of normal operation.

There are a few exceptions to this situation: the PC is always reset to all 0's (0000h); and $\overline{TO}$ and $\overline{PD}$ bits are set or cleared differently in different reset situations as indicated in Tables 1 and 2. These bits are used in software to determine the nature of reset. See Table 3 for a full description of reset states of all registers.

Power On Reset (POR)

A POR pulse is generated on-chip when a VDD rise is detected in the range of 1·2 to 1·8V. To take advantage of the POR, the $\overline{MCLR}$ pin should be tied directly to VDD. This will eliminate external RC components usually needed to create a reset on power-up. The POR circuit does not produce an internal reset when VDD drops.

Power-Up Timer (PWRT)

The power-up timer provides a fixed 72ms timeout on power-up only from POR. The power-up timer operates on an internal program counter oscillator. The chip is kept in reset as long as PWRT is active. The PWRT delay allows the VDD to rise to an acceptable level. A configuration fuse, PWRTE can enable or disable the power-up timer – see later section on Configuration Fuses to see how this is achieved. The power-up time delay will vary from chip to chip, VDD and temperature.

Event	$\overline{TO}$	$\overline{PD}$
Power-up	1	1
WDT timeout	0	Unchanged
SLEEP instruction	1	0
CLRWDT instruction	1	1

Table 1. Events affecting $\overline{PD}$/$\overline{TO}$ status bits.

Reset Event	$\overline{TO}$	$\overline{PD}$
WDT wake-up from sleep	0	0
WDT timeout	0	1
$\overline{MCLR}$ wake-up from sleep	Unchanged	0
Power-upn	1	1
$\overline{MCLR}$ reset during normal operation	Unchanged	U

Table 2. $\overline{PD}$/$\overline{TO}$ status after reset.

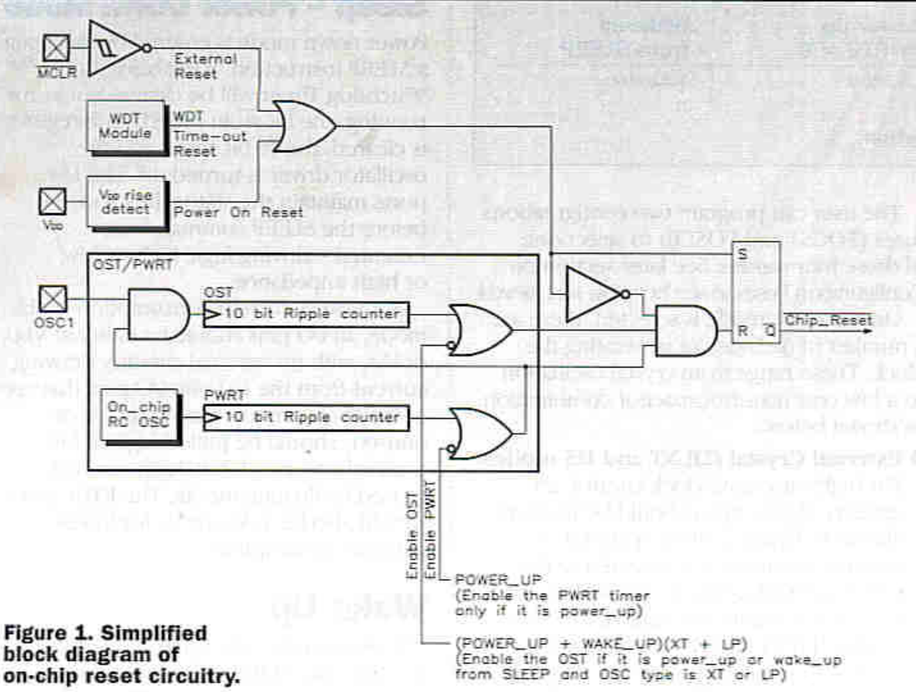


Figure 1. Simplified block diagram of on-chip reset circuitry.

Oscillator Start-up Timer

The Oscillator Start-up timer provides 1,024 oscillator cycle delay after the PWRT delay is over. This guarantees that the clocking device be it crystal oscillator or resonator has started and stabilised. The OST time-out is invoked only for XT, LP and HS modes and only on Power On Reset or wake-up from SLEEP. Please refer to later section on Clocking for details of Clocking modes.

Timeout Sequence

On power-up, the timeout sequence is as follows. First, PWRT timeout is invoked after POR has expired. Then, TOST is activated. The total timeout will vary based on oscillator configuration and the PWRTE fuse status. For example, in RC mode with PWRTE set to '0', there will be no time out at all. Table 4 shows the timeout sequence for a variety of situations. See later section on Configuration Fuses to see how the PWRTE fuse is set.

Since the timeouts occur from POR pulse, if $\overline{\text{MCLR}}$ is kept low long enough, the timeouts will expire. Then, bringing $\overline{\text{MCLR}}$ high will begin execution immediately. This is useful for testing purposes or to synchronise more than one PIC16C84 operating together.

Watchdog Timer

The watchdog timer is a free-running on-chip RC oscillator which does not require any external components. That means that the WDT will run even if the clock on the OSC1 and OSC2 pins of the device has been stopped, for example, by the execution of a SLEEP instruction. A WDT timeout generates a device RESET condition. The WDT can be permanently disabled by programming the configuration fuse WDTE as a '0' – see later section on Configuration Fuses to see how this is achieved.

The WDT has a nominal time-out period of 18ms. The time-out periods vary with temperature, VDD and process variations from device to device. If longer timeout periods are desired, a prescaler with a division ratio of up to 1:128 can be assigned to the WDT under software control by writing to the OPTION register. Thus, time-out periods of up to 2·3 seconds can be generated.

The 'CLRWDT' and 'SLEEP' instructions clear the WDT and the prescaler, if assigned to the WDT, and prevent it from timing out and generating a device RESET condition.

Register	Address	Power On Reset (POR)	WDT timeout reset during normal operation	WDT timeout reset during SLEEP	$\overline{\text{MCLR}}$ reset during normal operation	$\overline{\text{MCLR}}$ reset during SLEEP	Wake-up through Interrupt
W	–	xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
		xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
INDIR	00h	–	–	–	–	–	–
TMR0	01h	xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
		xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
PC	02h	0000h	0000h	PC +1	0000h	0000h	PC +1
STATUS	03h	0001	0000	uuu0	000u	0001	uuu1
		1xxxx	1uuu	0uuu	uuuu	0uuu	0uuu
FSR	04h	xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
PORT	05h	xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
A		xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
PORT	06h	xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
B		xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
TRIS	85h	—1	—1	—u	—1	—1	—u
A							
TRIS	86h	1111	1111	uuuu	1111	1111	uuuu
B		1111	1111	uuuu	1111	1111	uuuu
OPTION	81h	1111	1111	uuuu	1111	1111	uuuu
		1111	1111	uuuu	1111	1111	uuuu
EEDATA	08h	xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
		xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
EEADR	09h	xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
		xxxx	uuuu	uuuu	uuuu	uuuu	uuuu
EECON1	88h	—0	—0	—u	—0	—0	—u
		0000	?000	uuuu	?000	?000	uuuu
EECON2	89h	–	–	–	–	–	–
PCLATH	0Ah	—0	—0	—u	—0	—0	—u
		0000	0000	uuuu	0000	0000	uuuu
INTCON	0Bh	0000	0000	uuuu	0000	0000	uuuu
		000x	000u	uuuu	000u	0000	uuuu*

– Unimplemented, reads as '0'.
u Unchanged from previous state.
x Unknown.
* In the event of wake-up through Interrupt, one or more Interrupt flags will be set. Other bits in INTCON will remain unchanged.
? WRERR (bit 3) will be set if reset occurred during EEPROM write, otherwise reads as '0'.

Table 3. Reset conditions for registers.

Oscillator Configuration	Power-up PWRTE = 1	Power-up PWRTE = 0	Wake-up from SLEEP
XT, HS, LP	72ms + 1,024tosc	1,024tosc	1,024tosc
RC	72ms	–	–

Table 4. Timeout period versus clock configuration.

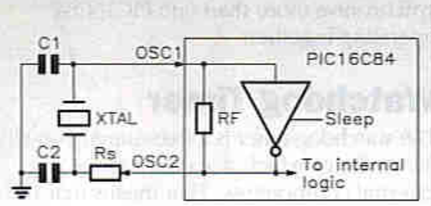


Figure 2. Crystal or ceramic resonator operation.

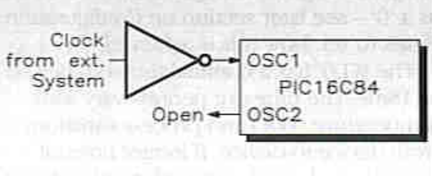


Figure 3. External clock input operation.

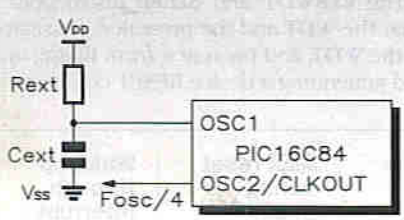


Figure 4. External RC oscillator clock.

The status bit $\overline{TO}$ in STATUS register will be cleared upon a Watchdog Timer timeout. It should also be taken in account that under worst case voltage and temperature conditions (VDD = Min; Temperature = Max; and WDT prescaler = max), it may take several seconds before a WDT time-out occurs.

Clocking

Like all devices in the PIC family, the PIC16C84 can be operated in up to four different oscillator options: LP; XT; HS and RC. The most appropriate mode is selected by the user to optimise clock speed; power consumption; and external components. Table 5 outlines the benefits of each operating mode.

The user can program two configurations fuses (FOCS1 and FOSC0) to select one of these four modes. See later section on Configuration Fuses to see how this is achieved.

Once a clock mode is selected, there are a number of methods of generating the clock. These range from crystal oscillation to a low cost resistor/capacitor combination, as shown below:

◆ **External Crystal (LP, XT and HS modes)** For highly accurate clock control, an external clock circuit should be used, as shown in Figure 2. Here, a crystal or ceramic resonator is connected to the OSC1 and OSC2 pins to establish a clock. Crystal resonators are suitable for all clock modes (LP, XT and HS modes), while ceramic devices can only be used for higher operating speeds (XT and HS modes). Tables 6 and 7 highlight this distinction.

◆ **External Clock (LP, XT and HS modes)** The PIC microprocessor can be driven using an external clock, as shown in Figure 3. This option is ideal for systems where a clock already exists. The clock mode is selected by applying selecting the appropriate fuse combination, and applying an external clock pulse within the appropriate tolerance bands.

◆ **Internal Components (RC mode)** For timing insensitive applications, an external RC clock offers component and cost savings. The RC oscillator frequency is a function of the supply voltage, the resistor (Rext) and capacitor (Cext) values, and the ambient temperature. Figure 4 shows how the R/C combination is implemented. For Rext values below 2·2kΩ, the oscillator operation may become unstable, or stop completely. For very high Rext values above say 1MΩ, the oscillator becomes sensitive to noise, humidity and leakage. Microchip recommend that Rext is kept between 3 and 100kΩ.

Although the oscillator will operate with no external capacitor (Cext = 0pF), a value above 20pF should be used for noise and stability reasons. With no or a small external capacitance, the oscillation frequency will vary dramatically due to changes in external capacitances, such as PCB trace capacitance or package lead capacitance. For these reasons, it is recommended that the novice developer use either a crystal or ceramic clock, since this avoids unnecessary complication.

Sleep – Power Down Mode

Power down mode is entered by executing a SLEEP instruction. If enabled, the Watchdog Timer will be cleared but keeps running, the bit $\overline{PD}$ in the STATUS register is cleared, the $\overline{TO}$ bit is set, and the oscillator driver is turned off. The I/O ports maintain the status they had, before the SLEEP command was executed – driving logic high or low, or high impedance.

For lowest current consumption in this mode, all I/O pins should be either at VDD, or Vss, with no external circuitry drawing current from the I/O pin. I/O pins that are in the High z mode (unconnected or unused) should be pulled high or low externally to avoid switching currents caused by floating inputs. The RTCC input should also be at V_{DD} or V_{SS} for lowest current consumption.

Wake Up

The device can wake up from SLEEP through one of the following events:

◆ External reset input on $\overline{MCLR}$ pin

◆ Watchdog Timer time-out reset (if WDT enabled)

◆ Interrupt from INT pin, RB port change or data EEPROM write completion

The first event will cause a device reset proper. The two latter events are considered a continuation of program execution. The $\overline{TO}$ and $\overline{PD}$ bits in the STATUS register can be used to determine the cause of device reset $\overline{PD}$ bit, which is set on power-up is cleared when SLEEP is invoked. $\overline{TO}$ bit is cleared if WDT time-out occurred and caused wake-up.

When the SLEEP instruction is being executed, the next instruction is pre-fetched. For the device to wake-up through an interrupt event, the corresponding interrupt enable bit must be set (enabled). Wake-up is regardless of the state of the GIE bit. If the GIE bit is clear (disabled), the device continues execution at the instruction after the SLEEP instruction. If the GIE bit is set (enabled), the device executes the instruction after the SLEEP instruction and the branches to the interrupt address (0004h). In cases where the execution of the instruction following SLEEP is not desirable, the user should have a NOP after the SLEEP instruction to cause a delay. The WDT is cleared when the device wakes-up from sleep, regardless of the source of wake-up.

Configuration Fuses

The PIC16C84 has five configuration fuses which are EEPROM bits. These fuses can be programmed (reads '0') or left unprogrammed (reads '1') to select various device configurations – they are mapped in program memory at location 2007h. This is beyond the user program memory space. In fact, it belongs to the special test configuration memory space (2000h to 3FFFh). By executing a special configuration mode, these locations can be accessed during programming. Figure 5 shows the various fuse options.

	Clock Speed Configuration	Power consumption – assumes no I/O	Clocking Methods
LP	0 to 200kHz	Low: Approx 90mA	Crystal resonator and External clock
XT	100kHz to 4MHz	Medium: 110 to 150mA	Crystal resonator, Ceramic resonator and External Clock
HS	4MHz to 10MHz	High: 150 to 170mA	Crystal resonator, Ceramic resonator and External Clock
RC	0 to 10MHz	Variable – dependent on clocking speed	External resistor/capacitor combination

Table 5. Clock performance and current performance versus current consumption.

Oscillator Type	Resonator Frequency (MHz)	Capacitor Range C1 and C2 (pF)
XT	455	150-330
	2	20-330
	4	20-330
HS	10	20-200

Table 6. Capacitor and selection for ceramic resonators.

Oscillator Type	Frequency	C1 (pF)	C2 (pF)
LP	32kHz	30	30-50
	100kHz	15	15
	200kHz	0-15	0-15
XT	100kHz	15-30	200-300
	200kHz	15-30	100-200
	455kHz	15-30	15-100
	1MHz	15-30	15-30
	2MHz	15	15
	4MHz	15	15
HS	4MHz	15	15
	10MHz	15	15

Table 7. Capacitor selection for crystal oscillators.

Locations

The PIC16C84 has four ID locations (2000h to 2003h) mapped in the test program memory for storing code revision number, manufacturing information or other useful information. As with the configuration word, these locations are readable and writable through a programmer. They are not accessible during normal code execution.

If the chip is code protected, it is recommended that the user uses only the lower seven bits of the ID locations and programs the higher seven bits as '0'. This way, the ID locations will be readable even after code protection.

Code Protection

The code in the program memory can be protected by blowing the code protect fuse (CP). When code protected, the contents of the program memory cannot be read out in a way that the program code can be reconstructed. In addition, all memory locations are protected against re-programming. The code protected data EEPROM can be read and updated by the CPU in normal operation. All EEPROM data memory locations cannot be programmed nor can they be read out in normal operation.

Once code protected, the CP fuse can be erased only through a chip erase. A chip erase will erase EEPROM program and data memory before erasing the code protect fuse.

Next Month

Next month, we'll look at how the PIC family of microprocessors interfaces to the outside world, before we start building code for the PIC16C84. 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.

Reader Opportunity

We are hoping to complete the series by examining a number of case studies, to show how users have built applications using the PIC microprocessor. If you think you've designed a PIC based system that you think readers might like to hear about, please write to Stephen Waddington, *Electronics and Beyond*, Maplin Electronics PLC, Maplin House, 274-288 London Road, Hadleigh, Benfleet, Essex SS7 2DE or e-mail swaddington@cix.compulink.co.uk. We'll give Maplin gift vouchers to the designer of any PIC-based system featured.

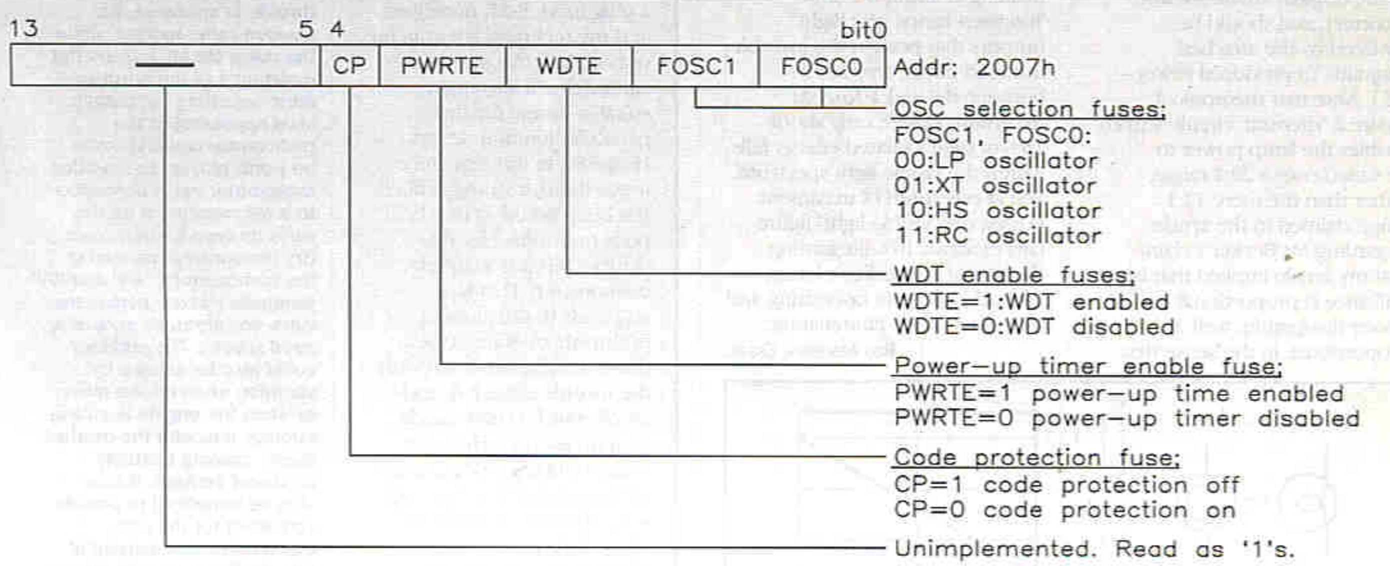


Figure 5. Configuration fuses.

AIR YOUR VIEWS

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

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

Bright to Reply

Dear Editor,

I was most interested to read D. Becker's letter in Issue 107, pointing out some errors in my 'Lamp/LED Brightness Control Circuits' feature in Issue 104. In the feature, I claimed that the hot-to-cold resistance ratio of the average filament bulb is typically 4:1, but as Mr Becker points out, this is a considerable underestimate, and the true ratio is typically about 12:1. Consequently, Figures 1 & 3 of the original article are also incorrect, and should be replaced by the attached diagrams (reproduced below – Ed.). Note that the original Figure 2 'rheostat' circuit actually enables the lamp power to be varied over a 20:1 range, rather than the mere 12:1 range claimed in the article. Regarding Mr Becker's claim that my article implied that lamp brilliance is proportional to power dissipation, well, it *is* proportional, in the sense that the lamp gets brighter when the power is increased and vice-versa, but the relationship is quite obviously not a linear one, and I never claimed that it was. Tungsten filament lamps are very crude devices, with power-to-light energy conversion efficiencies of only a fraction of 1%, and most of their radiated output is in the infra-red, rather than the visible, range. The human eye, for example, responds to light wavelengths in the 0·4 to 0·7μm range, with its sensitivity peaking at about 0·54μm. Tungsten lamps give 'light' outputs that peak in the invisible infra-red range, typically at between 0·8 and 1·1μm. At maximum power, only about 25% of their radiated energy falls within the visible light spectrum, and at one tenth of maximum power, the 'visible light' figure falls to about 10%. Regarding the rest of Mr Becker's letter, I found it all quite fascinating and – to use a pun – illuminating.

Ray Marston, Essex.

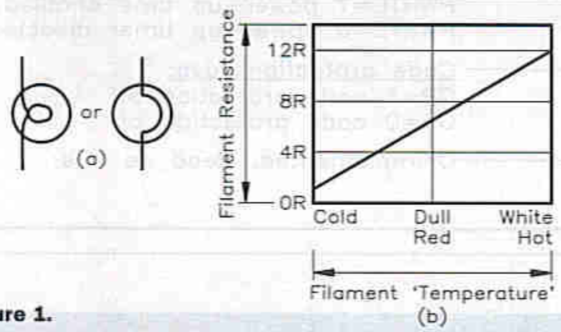


Figure 1.

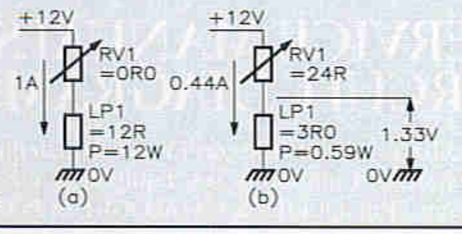


Figure 3.

In this issue, P. J. D'Alquen of Pickering, North Yorkshire wins the Star Letter Award of a Maplin £5 Gift Voucher for the following REValations.

£5 MAPLIN GIFT VOUCHER

Star Letter

Dear Sir,

We had a strange problem with the Digital Tachometer project featured in Issue 90. Our apprentice said that she would like to fit one to the van, so I ordered a kit for her to build. She duly built it and did a very good and professional job including a nice plasticard box for it to sit in. It set up beautifully on the bench, displaying 15 for a 50Hz 12V AC input. However, when fitted to the vehicle, it displayed 00 and nothing else. The van is a Ford Escort 1·6 with electronic breakerless ignition. After modifying the input circuitry with the help of Maplin's technical advisors, we got it running but it was hopelessly inaccurate. It seemed to dislike the RF bursts which occurred when a plug fired. Both ourselves and the technical advisors ran out of ideas. We eventually agreed that it was not a suitable design for that particular ignition design. However, in the year since it was fitted, a strange effect has been noted. It may be a poor revcounter for this vehicle, but it is a superb econometer! That is, it responds to the amount of throttle opening. Going down a slope at 60mph with the throttle closed, it reads 29-20, which is very nearly spot on for revs. However, when climbing a slope at the same speed, if you open up to full throttle, it reads 49-52 and can be brought back to 29-30 by just closing the throttle. The relationship between open and closed throttle appears to be linear above 2,000rpm in any gear. With closed throttle at all speeds, the reading agrees fairly closely with the correct revs. How this is occurring beats me. Is it the fact that the voltage necessary to fire a plug depends on the dynamic compression ratio, which is, of course, affected by throttle opening? Ideas please, somebody.

A curious phenomenon for a Digital Tachometer to exhibit, but at least the readings it shows provide information of some value, particularly if it helps save fuel! To give credit to the circuit design, your particular example is the only one that has caused any (reported) problems among the many kits that have been sold. Therefore, it would seem that the problem lies with either the way the project has been built/installed, or a peculiar feature of the van's ignition/electrical system. The strange response to throttle opening could be down to something simpler than you suggest. It is possible that the earthing strap which normally connects between the engine block and the body is not making good contact, with the result that the earthing is instead occurring via the throttle cable (in addition to other engine-to-body attachments, perhaps). Thus, when the throttle is operated, the bowden cable moving within the outer sheath causes the resistance of the earth to alter, upsetting the voltage level appearing at the tachometer input. It could be worth moving the existing tachometer earth connection to a different point on the van's bodywork/wiring loom (try temporarily connecting the tachometer's '+V' and '0V' terminals directly across the van's battery to be sure of a good supply). The problem could also be caused by vibration when on the move, or when the engine is pulling strongly (i.e. with the throttle open), causing unstable electrical contact. It may also be beneficial to provide screening for the unit, e.g. a metal box instead of the plasticard one, to prevent stray electrical signals from affecting the circuit. Alternatively, screening could be added to the inside of the existing plasticard box, using conductive paint (FY72P), nickel screening spray (DM10L) or aluminium tape (KW30H) – taking care to avoid short circuits. Without knowing the exact output signals of the vehicle's ignition system in response to throttle opening, it is impossible to be more specific about why the tachometer should be behaving in this way.

On a Lighter Note

Dear Sir,

Further to D. Becker's letter in Issue 107 about the hot-to-cold resistance ratio (= $^{R_H}/_{R_C}$) of filament lamps, this is simply determined by the temperature coefficient of resistance of tungsten, the standard filament material. If the filament working temperature is known, $^{R_H}/_{R_C}$ can be calculated. It is normally at least 10:1 for adequate visible light output. In low voltage bulbs, the internal connecting wire resistance can increase the RC value sufficiently to reduce the $^{R_H}/_{R_C}$ ratio somewhat below the true figure for the filament alone. The $^{R_H}/_{R_C}$ ratio is further increased by an improvement such as a halogen atmosphere, which raises luminous efficiency by allowing a higher filament temperature without reducing life expectancy.

R. Simpson, Potters Bar, Herts.

Thank you for this information. However, attempting to measure the working temperature of a lamp filament could prove to be easier said than done!

Scope for Improvement?

Dear Sir,

Referring to the circuit diagram of the Remote Control for Lights transmitter (Issue 107, page 39), it is stated that 'D9 protects the circuit if the battery is connected incorrectly.' Well, yes, it does. But unless you are quick to notice the error and disconnect the battery, you will have a very hot diode and a very flat alkaline battery. The orthodox protection is preferable. In the same issue, I greatly enjoyed Greg Grant's article on the Early Oscilloscopes. Obviously, no article can cover all early types, but I think the Cossor Double-beam 'scope of the 1930s is worth mentioning. The 'dual beam' facility was achieved not by chop-or-alternate switching circuits, but by (literally) splitting the beam in two, with a separate electrostatic deflector plate for each half of the beam.

Ron Cook, Frome, Somerset.

The usual method of reverse polarity protection, that of wiring a diode in series with the supply rail, can be inconvenient on some circuits due to the 0·7V or so voltage drop across the diode. This is particularly important on battery powered circuits (such as remote control transmitters), where as long a battery life as possible is desirable; the 0·7V difference 'gained' by instead wiring the diode in reverse bias across the supply rails could be equivalent to a few more weeks/months before a battery change is necessary (0·7V being almost 8% of 9V). In any case, if the supply polarity is clearly indicated (as with the PP3 battery clip used in the transmitter), the chances of the battery being connected the wrong way round for long are, shall we say, remote!

Return to Format

Dear Sir,

Many thanks for returning to your original style of format for the 96/97 Catalogue. The 95/96 version was exasperating, to say the least. How about a project for an LCD frequency counter? This could be based upon your 12·5mm LCD DPM module (or similar), with perhaps five measurement ranges, covering 0Hz to 19·999MHz and with input sensitivity of 200mV or less. If the (9V) supply's negative rail is at common earth level, the DPM could be incorporated into portable equipment. Ray Marston's article 'How to Use LCD Digital Panel Meters' (Part 4, Issue 79, Figure 58) is exactly what I have in mind (in kit form). I have built the Ultrasonic Detector and at present, have it combined with a self-made analogue frequency meter, but would prefer an LCD readout.

F. Wilson, Scarborough, North Yorkshire.

We are pleased that you like the revised style of the latest MPS Catalogue, and thank you for the project suggestion – which is now in the hands of the development laboratory engineers.

Readers Letters

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

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.

November 1996

1 to 3 November. Acorn World Computer Show, Olympia, London. Tel: (01295) 788386.

6 to 9 November. Apple Expo, Olympia, London. Tel: (0171) 388 2430.

9 to 10 November. Radio Rally, Llandudno, North Wales. Tel: (01707) 659015.

11 November. System Approach to Manufacturing, IEE, Savoy Place, London. Tel: (0171) 344 5427.

11 November. Sounds of Yesteryear, Stratford-upon-Avon & District Radio Society, Tiddington, Stratford-upon-Avon. Tel: (01789) 773286.

18 November. System Approach to Manufacturing, IEE, Savoy Place, London. Tel: (0171) 344 5427.

25 November. Night on Air, Stratford-upon-Avon & District Radio Society, Tiddington, Stratford-upon-Avon, Tel: (01789) 773286.

26 November. Manufacture – Save Time, Save Money, IEE, Savoy Place, London. Tel: (0171) 344 5427.

December 1996

3 to 4 December. DSP UK – Digital Signal Processing Exhibition, Ramada Hotel, London. Tel: (0181) 547 3947.

3 to 5 December. International Online Information Exhibition, Ramada Hotel, London. Tel: (01865) 730275.

7 December. RSGB Annual Meeting, London. Tel: (01707) 659015.

8 December. SDX Cluster Support Group Electronics & Computer Rally, Maryhill Community Centre Halls, Maryhill Road, Glasgow. Tel: (0141) 638 7670.

9 December. Quiz, Stratford-upon-Avon & District Radio Society, Tiddington, Stratford-upon-Avon, Tel: (01789) 773286.

25 December. Christmas Greetings on Air, Stratford-upon-Avon & District Radio Society, Tiddington, Stratford-upon-Avon, Tel: (01789) 773286.

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. 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.

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.

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

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?

NetWorld+Interop Paris Winners

From over 250 exhibitor entries, Checkpoint Software Technologies led the NetWorld+Interop Paris *best of show* awards unveiled on October 9, as the overall Grand Winner for its Firewall-1 v.3.0.

The judging panel of nine Data Communications editors also chose six networking winners from different technology categories and one Best European Product winner. Data Communications selected these products based on their innovation in the networking and distributed computing industries.

Checkpoint Software's Firewall-1 v.3.0 was chosen as the Grand Winner for its wealth of new features, such as controlling access, content, and connections from a single platform. Besides offering strong security and wire-speed performance, Firewall-1 now delivers integrated virus checking, Java security, URL screening, and load balancing.

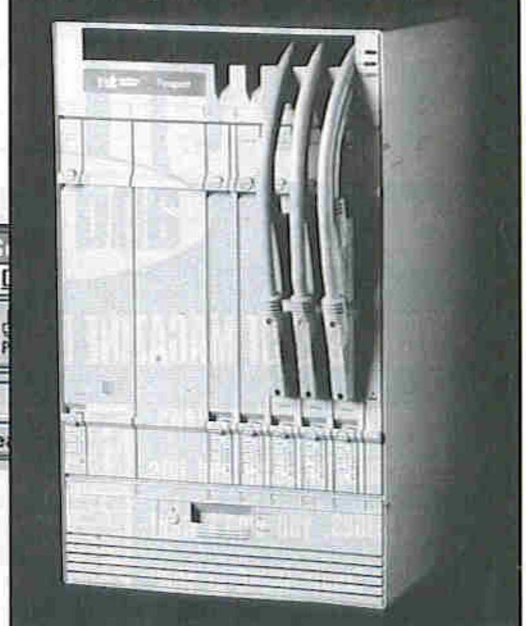
France Telecom received the Best European Product award for its Global Intranet Solutions, a world-wide IP network of services that includes Messaging, groupware, and directory and Web-hosting services.

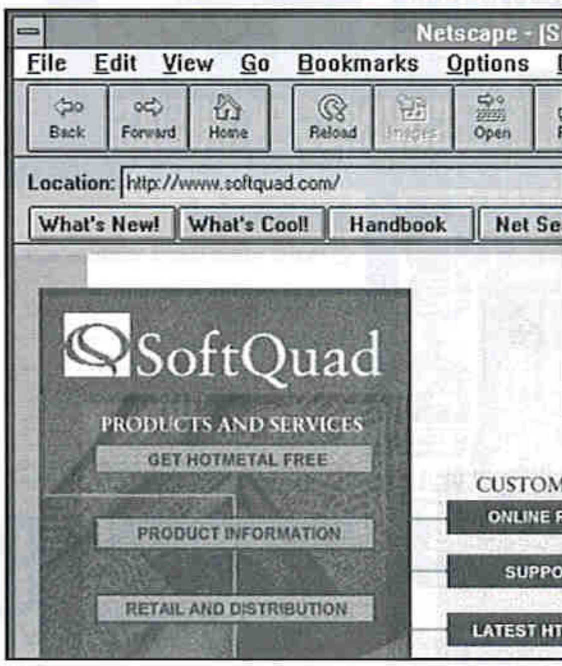
The six *best of show* winners in each category were:

- Best Internet/Intranet Product or Service: Firewall-1 v3.0 from Checkpoint. This category included Web servers and browsers, Internet access services, Internet-specific security, and connectivity products and services.
- Best Internetworking Product: IBM's Multiprotocol Switched Services Server. This category included LAN and campus switches, hubs, routers, and other connectivity devices, as well as remote access and branch-office networking equipment.
- Best Network or Systems Management or Network Analysis Product: Infovistas' Infovista. This category included systems and utilities for managing network devices and applications software, and network analysers and applications.
- Best Networking Software Product: Forum Mail from Telis/Worldtalk. This category included network services software (directory, print, and fax communications) and network applications (databases, Messaging, and groupware).
- Best Telecommunications Product or Service: Northern Telecom's Voice Switching over ATM. This category included public and private wide-area services and equipment, value-added services, and wireless data networks.
- Best LAN Product: Fluke's One Touch. This category included servers, NICs, storage, cabling, and printers.

We reckon the hottest product at Networld+Interop was SoftQuad's HoTMetaL PRO HTML authoring tools. The new version raises the bar on HTML publishing by incorporating many new features and enhancements geared to providing users with a very powerful and easy-to-use environment for creating and editing documents for delivery on corporate Intranets or the Internet.

HoTMetaL PRO 3.0 is focused on usability, while providing Web authors with a publishing tool that incorporates the most recent and exciting advancements in HTML (3.2). It enables users to import documents regardless of their origin, and to visually piece them together in Web pages using any of the new HTML features, like tables and frames, very quickly.


Passport ATM Enterprise switch from Nortel Magellan.



Young Amateur of the Year Announced

This year's winner of the RSGB Young Amateur of the Year award is 14-year old Christopher Davies, M0AAU, from Shrewsbury in Shropshire. The runner-up is Benjamin Clarkson, G7WHO, also 14 years old, from Reading in Berkshire.

The two boys received their prizes from the Radiocommunications Agency (RA), RSGB, and industry, at a special ceremony on 6 October at the RSGB HF and IOTA Convention at the ICL Beaumont Conference Centre in Old Windsor. The prizes were presented by Roger Louth on behalf of the RA; RSGB President Peter Sheppard, G4EJP; Peter Simpson of Wray Castle; Dennis Goodwin of Icom (UK); and Tom Crosbie of Lowe Electronics.

Contact: RGSB, Tel: (01707) 659015.

Left to right: Peter Sheppard (G4EJP), President of RSGB; Young Amateur of the Year 1996 Christopher Davies (M0AAU); Runner-up Benjamin Clarkson (G7WHO); and Roger Louth of the RA.

Techniques of Today's Movie Magic

Movie Magic with Digital Imaging Technology was the topic chosen for the National Lecture of The Institution of Electronics and Electrical Incorporated Engineers (IEEIE) given on October 21, by Peter Owen, director of Quantel.

With the movie world celebrating one hundred years of cinema, the technical and creative developments made during that time have been amazing. During the lecture, Peter Owen gave an insight into the advances of film making, from the early trick effects, such as shooting against false backgrounds and painting on images, through to the elaborate methods in current use and the development of television and the digital video recorder.

Contact: IEEIE, Tel: (0171) 836 3357.

Adam James, Young Engineer for Britain 1996.

Adam Braced for Engineering Success

A revolutionary method of treating serious wrist injuries, which could make plaster casts obsolete, has earned an 18 year-old Welsh student the coveted title of 'Young Engineer for Britain 1996'.

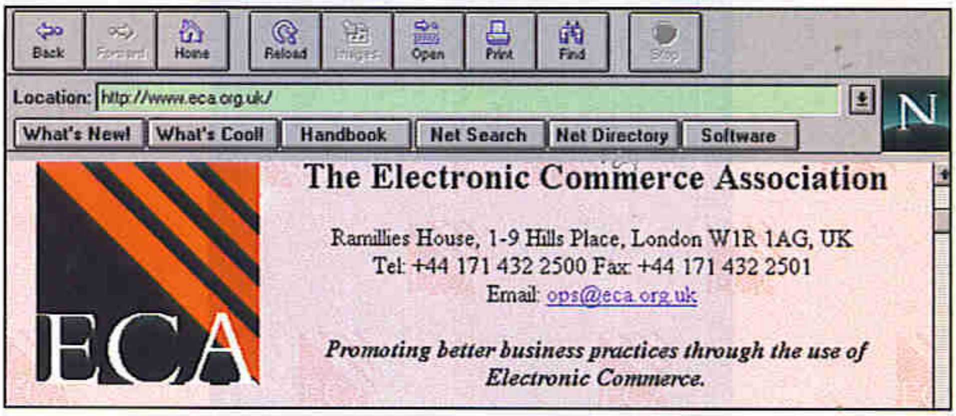
Adam James, of Y Pant Comprehensive, Pontyclun, Mid Glamorgan was announced winner of the annual competition at an awards ceremony at London's Heathrow Airport in late September.

Adam's innovative wrist brace is a fluid-lined plastic sleeve which, in addition to being more convenient to wear than the traditional plaster cast, is more effective in the repair of fractures. He developed the brace, which is currently undergoing a 12 month programme of medical trials, after a friend suffered a second fracture when his wrist was already in plaster.

Success in the competition wins Adam a cash prize of £1,000, a trip on Concorde and a £1,500 award for his school to buy engineering equipment.

Contact: Young Engineers for Britain, Tel: (0171) 240 7891.

Inaugural Forum for Business on the Internet



The first forum for business users of the Internet has been set up by the Electronic Commerce Association (ECA). The newly created 'Business on the Internet' Interest Section will operate as a permanent forum for the exchange of ideas, information and experience, as well as providing advice and guidance. It was set up in response to ECA members keen to explore and exploit the business potential of the Internet, but also anxious to understand the pitfalls and drawbacks.

ECA Chief Executive, Dr Roger Till, welcomed the launch of the new group, saying, "The unprecedented explosion of interest in this aspect of the Information Superhighway underlines the need to develop best business practice principles for the Internet and the Web – in much the same way as we have been doing for other aspects of electronic commerce, like electronic data interchange (EDI). There is also a clear need for a source of sane and sensible advice on the whole subject, something we are well placed to provide."

The Business on the Internet Interest Section's terms of reference include developing best business practice, contributing to developments, representing UK users, providing advice and working with service providers to meet the business community's needs.

Initially, the group will focus on concerns such as security, intellectual property rights, and best business practice on the Internet. In a parallel move, Internet Service Providers (ISPs) are being invited to join the ECA Suppliers Section.

The new Business on the Internet group joins existing ECA Interest Sections and Advisory Groups which focus on Accountancy, Communications & Software, Finance, Healthcare, Interactive EDI, Legal, Logistics & Transport, Public Sector, Security and, more recently, groups representing SME (Small & Medium Enterprises) and Suppliers.

Dr Roger Till summed up saying, "We are delighted with the response so far, and are keen to encourage many other organisations to join us to ensure that the UK business community takes full advantage of this exciting new medium."

For further details, check: **http://www.eca.org.uk**.

Contact: ECA, Tel: (0171) 432 2500.

WHAT'S IN A NAME

PART 1

A Great Atmosphere!

by Greg Grant

What's in a name? Frequently, a great deal, sometimes, nothing at all. Our profession – communications engineering – is littered with a wide variety of names, many of which are used daily, without any idea as to why they are so prevalent.

In this occasional series, we look at some of the more – and less – familiar names, uncovering some interesting facts, not a few false trails and many a contradiction along the way.

Two layers of it in fact, the combination described by a single word first used in this context by a radar pioneer. All neat, well defined, sorted, if you will. Yet, it didn't begin that way: a great deal of work and not a few names went into the final picture that is Figure 1.

On December 12th, 1901, Marconi broadcast the letter 'S' from his radio installation at Poldhu, Cornwall to a similar setup he had built at the appropriately named Signal Hill, Newfoundland. When, four days later, he informed the world's media of this feat, he was treated with considerable scepticism by both the national press and the technical journals of the day. The latter thought that he'd challenged the fundamental laws of electromagnetic waves. There was, nevertheless, the niggling question of how radio waves had managed to bridge 3,000-odd miles of ocean.

By the following year, a tentative answer was put forward by two scientists; firstly, the British physicist-mathematician, Oliver Heaviside, secondly, Harvard's Professor of Electrical Engineering, Arthur Kennelly. They suggested that Marconi's signals had been reflected back to earth by a conducting layer in the upper atmosphere. Kennelly put forward his ideas in the journal *Electrical World*, Heaviside in the latest edition of the *Encyclopaedia Britannica*.

Neither man offered any deeply scientific explanation for what they'd proposed, although Heaviside had been one of the earliest researchers into Skin Effect, providing a great deal of the subject's terminology and mathematics, among which was the expression Radio Frequency resistance. Kennelly, however, did attempt to calculate the proposed layer's height, reckoning it to be some 50 miles above the Earth's surface, working on the assumption that low pressure would aid conductivity.

Here, at least, was an explanation of sorts for what Marconi had claimed and, equally importantly, it could be given a name swiftly becoming the Kennelly-Heaviside or Heaviside-Kennelly Layer, depending on which side of the Atlantic you were discussing, disputing or lecturing on the subject!

A decade later, Dr. William Eccles – the first half of the Eccles-Jordan partnership – suggested that what was doing the reflecting was ions in the upper atmosphere and in 1913, the second attempt to measure the layer was made.

Using the San Francisco Federal Telegraph Company's Arc transmitter, Lee de Forest, inventor of the Triode valve, and Leonard F. Fuller made an interesting discovery. Signals could fade at one frequency whilst increasing at a frequency close to it. This was because the Arc transmitter was keyed by moving the frequency slightly from its working frequency so that it could oscillate continuously. The pair thought that the direct wave – the ground wave as it would later be termed – could be alternatively moving in and out of phase with the sky wave.

de Forest aired his views in the 'Proceedings of the Institute of Radio Engineers', noting that if the proposed layer was halfway between his transmitting and receiving locations, it was some 62 miles above the Earth. Fuller, who continued the research until late in the following year, published a more detailed account of the experiments in the 'Transactions of the American Institute of Electrical Engineers'.

Amateurs too, were interested in the possibility of long distance communication and, in fact, were the earliest users of the High Frequency (HF) band, the Short Wave region of the spectrum. In the American radio amateurs' journal *QST Magazine* of May 1924, Dr. A. Hoyt Taylor of the United States Naval Research Laboratory, at once a physicist and amateur radio enthusiast, wrote that there was probably a complete reflection of radio waves from an upper, possibly ionised, layer of the atmosphere.

Eleven months later, another amateur, John Reinartz, put forward the idea that the reflection or refraction in the Kennelly-Heaviside layer was a function of frequency. He carried out a number of tests on 20m and 60m, noticing that his signals, in contrast to those of longer wavelengths, became weaker after sunset. They were still, however, received at a considerable distance.

Having travelled a short distance, the ground wave appeared to fade totally but, after a 'dead' area, re-appeared once more. Reinartz's observations were confirmed by Hoyt Taylor, who termed the 'dead' area the 'Miss' or 'Skip' distance, the latter name being that by which it is still known.

Another amateur who did much early work on the characteristics of radio wave propagation

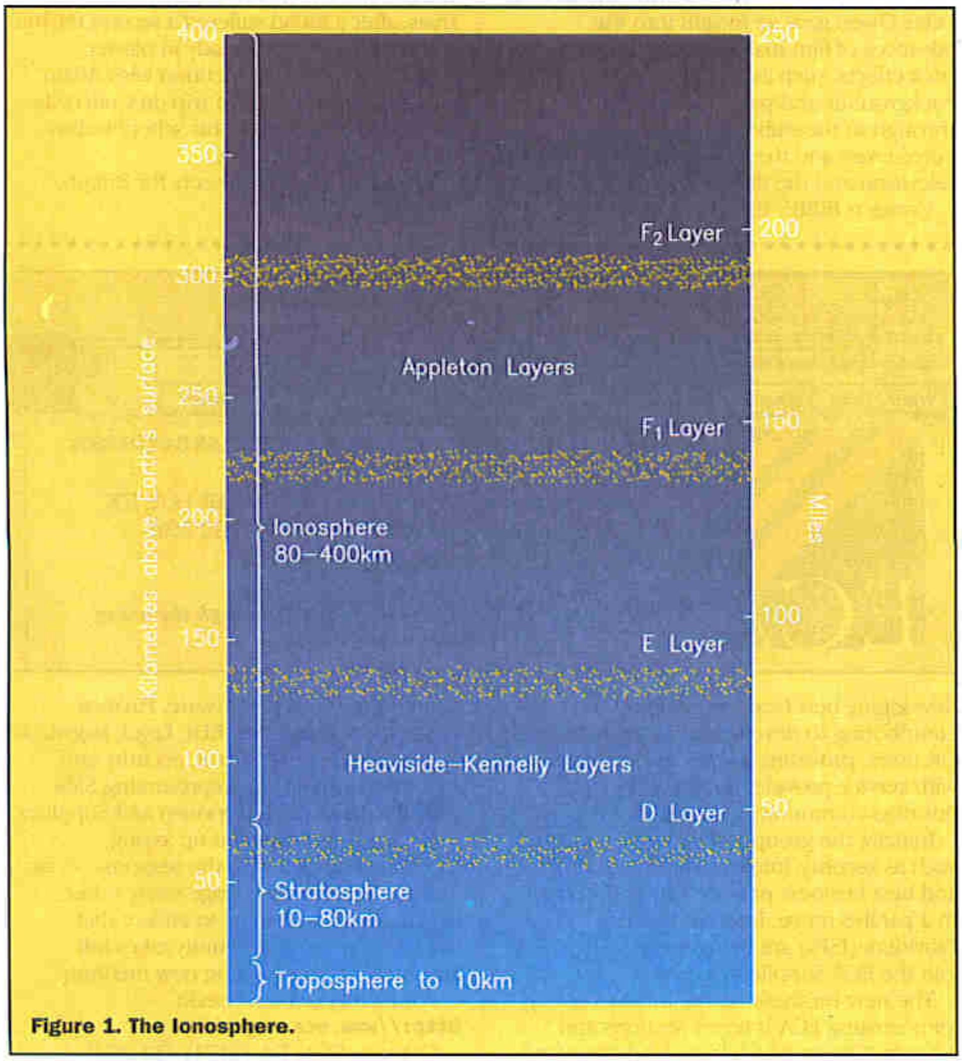


Figure 1. The Ionosphere.

was K. M. Jansky Jnr., who suggested that the distance a radio wave travelled along the ground was also a function of frequency. He was also of the opinion that the higher the frequency, the greater the ground attenuation.

Despite these little-recognised efforts, the Kennelly-Heaviside layer was still regarded as a single entity which, as we shall see, was only partly true. Shortly, scientists on both sides of the Atlantic began a concerted effort to understand the upper atmosphere. As a result, names would change, designatory letters would come in, and the results would indicate several other ways in which radio waves could be generally beneficial.

In 1924, Hoyt Taylor and his Navy Research Laboratory colleague, E. O. Hulburt, began the task of analysing a large body of data on successful shortwave radio communication. Their intention was to describe the reflective layer's world-wide characteristics.

Across the Atlantic, the British physicist, Edward Appleton, began a now-classic series of experiments in which he had the British Broadcasting Corporation's (BBC) Bournemouth transmitter vary its frequency, whilst the received signal strength was monitored and recorded at Cambridge. The test arrangement is shown in Figure 2.

He thought that, for wavelengths of 300 to 500m, there could be a point some 100 miles from the transmitter at which the ground and sky waves would be of similar strength and so create considerable interference. He confirmed this theory on the nights of the 11th December 1924 and the 17th February 1925, the interference caused by the different paths enabling him to measure the height of the layer as 80 to 90km above the Earth. This compared favourably with de Forest's 62 miles.

At dawn, Appleton discovered that the Heaviside-Kennelly layer broke down. However, there appeared to be signal reflections from another layer higher up, at around 220km. This was the first of his discoveries, which he designated the E Layer. Shortly afterwards, he discovered a second, even higher, layer which he termed the F Layer. When, finally, he discovered yet another layer, this time lower down, he allocated it the letter D.

He did this, he said, because there would still be enough letters left for other researchers, should they discover further conducting regions or layers. Although the area he discovered would come to be known as the Appleton Layer, his colleague, Robert Watson-Watt, later to become one of the British radar pioneers, thought that the whole reflecting region should be given a distinct designation and proposed the term Ionosphere, which was soon accepted internationally.

Although these regions are termed layers, they overlap, forming a continuous, if non-uniform, region of around four levels of maximum intensity. The lower regions, the Heaviside-Kennelly layers, are the result of molecular ionisation: the Appleton layers of atomic ionisation.

Figure 3 illustrates the daily and seasonal conditions of the various reflecting layers.

The D layer is located between 55 and 95km above the Earth and its ionisation is maximum when the sun is overhead. It tends to impede shortwave signals, through absorbing some of their incident power.

The most stable of the ionised regions is the E layer. Its maximum density increases from zero just before dawn to its greatest value at noon. It then begins to decrease, reaching zero again shortly after sunset. Its height varies between 110 and 120km.

The F layer is the most important, reflecting radio signals up to 50MHz. Its regular night time height is 300km, a figure which falls to 200km during the day, when the region breaks up into the F1 and F2 layers. The former acts like the D and E layers, with maximum density at noon. The latter continues to exist around the clock, making long distance communications possible.

The study of the upper atmosphere was really begun by Appleton who, between 1927 and 1932, developed his magneto-ionic theory of the ionosphere. The practical result of this was ionospheric prediction, enabling radio engineers to forecast, several months ahead, the most useful frequencies for long distance, day and night communication.

As Appleton settled down to write up his results, two American physicists, Merle Tuve and Gregory Breit, used a different technique to demonstrate that the atmospheric layers existed and what their respective heights were by transmitting pulses directly upwards. Using the Naval Research Laboratory's transmitter on a wavelength of 71·3m, transmitting pulses of $^{1}/_{1000}$th of a second's duration, they estimated the height of the ionosphere to be between 50 and 130 miles.

To begin with, they received three, sometimes more, echoes, the first from the direct wave between transmitter and receiver, the second from a conducting region some 60 miles up and finally, from another even higher region. Tuve and Breit then varied the transmitted pulse's frequency and found that there was always an upper frequency at which no signal was reflected. The pair termed this the Critical Frequency, an expression still with us today.

The Appleton and Tuve-Breit experiments were repeated around the world and it soon became evident that this Critical Frequency varied according to the time of day, the seasons and the geographical location. Increasingly too, engineers discovered that the conducting layers were considerably influenced by solar activity generally, particularly the 11 year Sunspot Cycle. Indeed, the early research on this subject was another of Appleton's originations. These experiments were the earliest examples of what the British would later term RADio Location And Ranging which, in the hands of the Americans, would become the acronym RADAR, a subject I'll discuss further in Part 10.

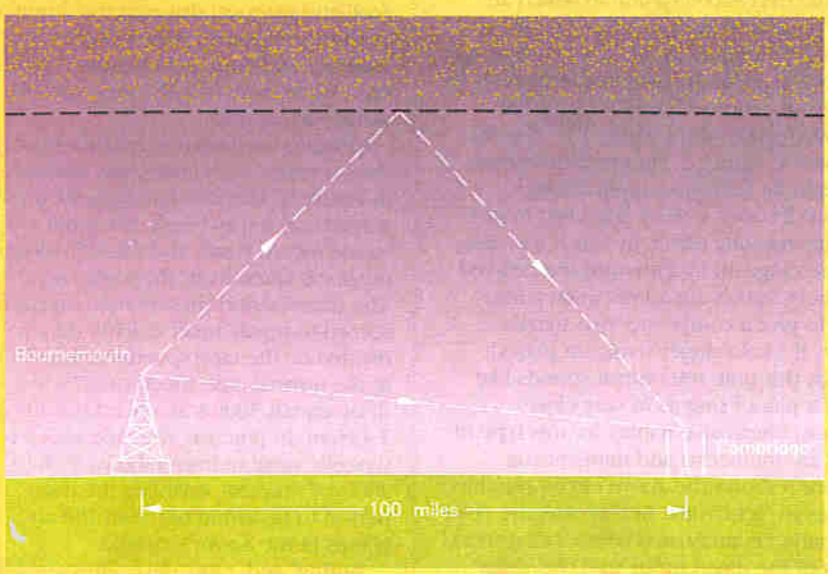


Figure 2. The Appleton experiment of 1924.

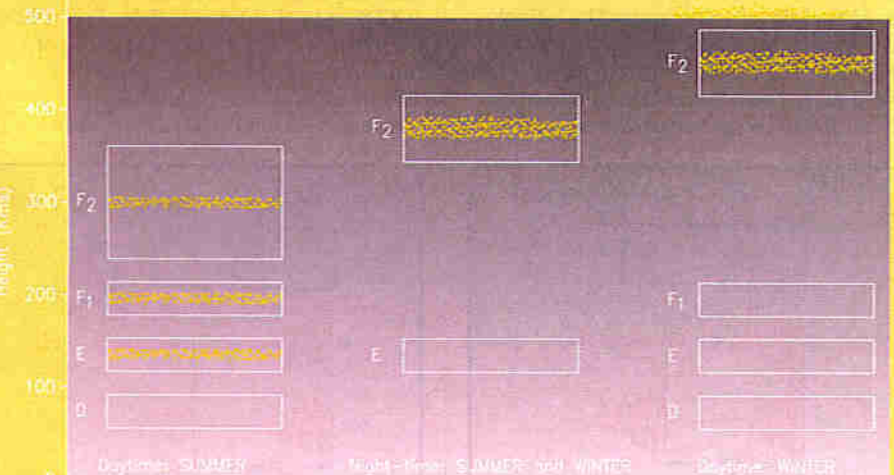


Figure 3. The daily and seasonal conditions of the Ionospheric Layers.

Audio Delay-line SYSTEMS AND CIRCUITS

PART 1

by Ray Marston

Ray Marston explains audio delay-line principles in this opening episode of a new 4-part series.

Solid state audio-frequency delay lines are widely used in modern music and audio systems. They can be used to produce popular sound effects such as echo, reverb, chorus or phasing in music and karaoke systems, rare effects such as ambience synthesis or pseudo 'room expansion' in expensive Hi-Fi systems, or to give predictive/anticipatory effects such as automatic pre-switching in cassette tape recorders. Also, they can be used for click/scratch elimination in record (disc) players, or to enhance message intelligibility in multi-output public address systems by inserting correctly balanced acoustic delays between individual loudspeakers, etc.

Modern solid-state audio delay-line systems can be built in either analogue or digital form. In the former case, they are built around one or more dedicated analogue delay-line ICs, and in the latter case, are usually built around collections of ICs such as D-to-A and A-to-D converters, RAMs, and a variety of less exotic digital ICs. In both cases, the delay-line systems are driven via 'clock' waveform generators, and the delay period is controlled by the clock frequency. This new 4-part series explains the operating principles of both systems, and shows how dedicated analogue and digital delay-line ICs can be used in practical delay-line systems.

Audio Delay-line Basics

An audio delay-line is a unit in which an audio (usually speech or music) signal is applied to the line's input, and an identical copy of the signal appears at the line's output but is time-delayed by a pre-set amount (usually in the range 1 to 500ms), as shown in Figure 1. Figures 2 to 4 show some simple delay-line applications.

Figure 2 shows a delay line used to give a double-tracking effect, in which the delay is in the range 10 to 25ms and the delayed and direct signals are added in an audio mixer to give a composite 'two signals' output. If a solo singer's voice is played through this unit, the output sounds like that of a pair of singers in very close harmony. Alternative names for this type of circuit are mini-echo and mini-chorus.

Figure 3 shows the above circuit modified to act as an 'echo' unit. In this case, the delay line's output is attenuated before being added to that of the direct input, and the 'delay' time is in the range 10 to 250ms. At sea level, at a temperature of 20°C, sound travels through the air at a speed of 0·343m/ms. Thus, if this unit gives a delay of (for example) 20ms, its output will sound like the original signal accompanied by a single echo that has bounced off a surface that is 3·43m from the original sound source. Note that this circuit produces only a single echo, but that the echo volume is variable.

Figure 4 shows the above circuit modified to act as an echo/reverb unit that produces multiple echoes (reverberation). This circuit uses two mixers, one ahead of the delay line and the other at the output. Part of the delay output is fed back to the input mixer, so that the circuit gives echoes of echoes of echoes, etc. The reverb time is defined as the time takes for the repeating echoes to fall by 60dB relative to the original input signal, and depends on the delay time and the overall attenuation of the feedback signals. Echo delay time, echo volume and reverb time are all independently variable.

Prior to the end of the 1960s, circuits of the above types were usually built around electromechanical devices such as coil-spring delay lines or continuous-loop tape recorders. Coil-spring units rely on the fact that acoustic vibrations travel quite efficiently along steel wire that is under tension, and that considerable lengths of such wire can be housed in a relatively small area by winding it in the shape of a coil-spring. A 100-turn coil-spring that is 5cm in diameter and 25cm in length may, for example, contain about 15·5m of steel wire, and an acoustic signal takes about 45ms to travel such a length. Practical coil-spring delay lines have an electromagnetic (coil-and-magnet) driver at the 'input' end of the spring, and a magnetoelectric (magnet-and-coil) pickup at the 'output' end. Figure 5 shows the basic way of using such a unit.

Continuous-loop tape recorder delay lines operate in the basic way illustrated in Figure 6. The unit has separate erase, record and replay heads; the input is applied to the record head, and the time-delayed output is taken from the replay head. The delay period (in seconds) equals the record-to-replay head spacing (in cm) divided by the tape speed in cm/s. Thus, at the normal tape speed of 4·75cm/s, the delay equals 300ms at a head spacing of 1·425cm. In practice, the tape speed is typically variable from (about) 50% to 200% of nominal, enabling the delay period to be varied between 150 and 600ms in the above example.

'Spring' and 'tape' delay lines are delicate devices with very limited delay-period range control. In the early 1970s, both types of device were made obsolete by the arrival of a new type of integrated circuit that is variously known as a charge-coupled device (CCD) or bucket brigade delay line (BBD). In essence, these ICs house a chain of hundreds of IGFET-plus-capacitor sample-and-hold analogue storage elements that act like charge-storage

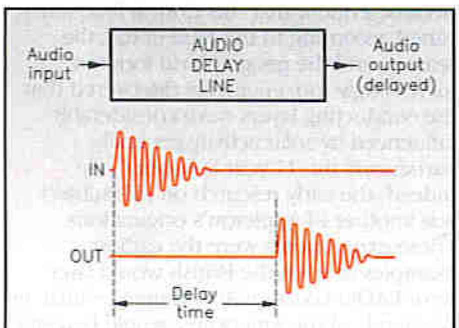


Figure 1. Basic audio delay line system.

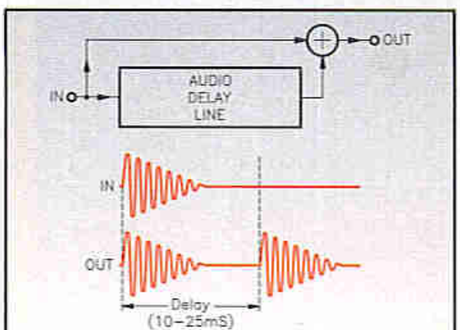


Figure 2. Basic double-tracking circuit.

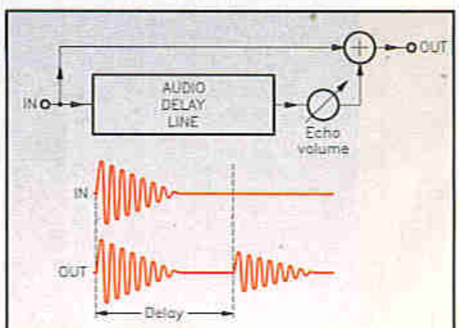


Figure 3. Basic 'echo' unit.

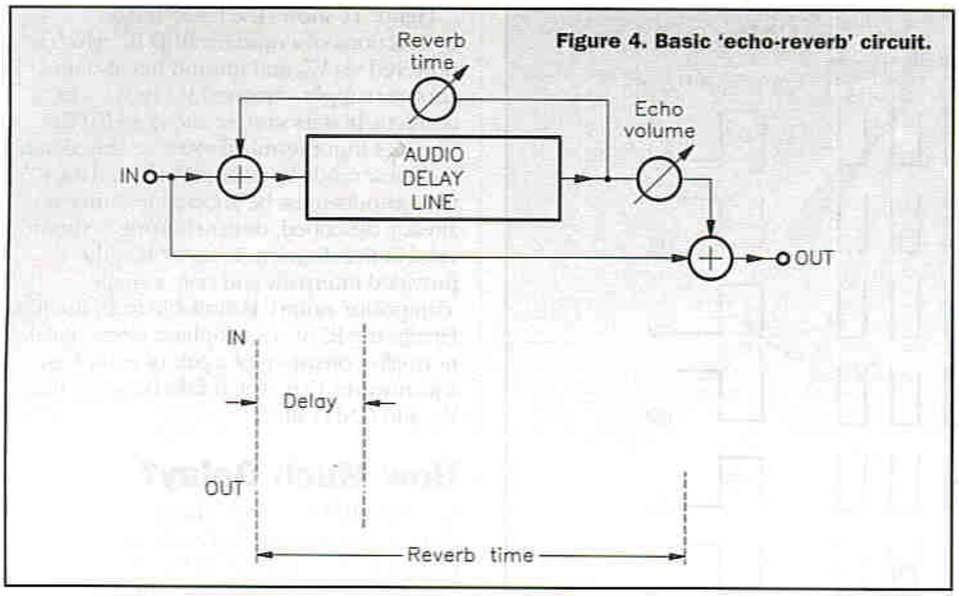


Figure 4. Basic 'echo-reverb' circuit.

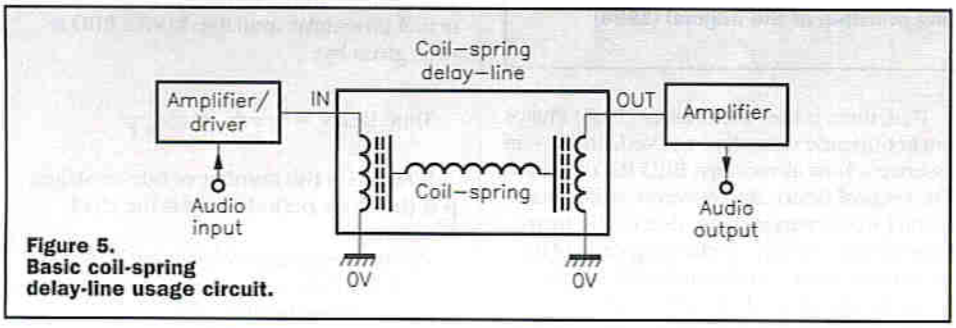


Figure 5. Basic coil-spring delay-line usage circuit.

'buckets' (hence the bucket brigade title) which are interconnected via IGFET electronic switches that are clocked via an external 2-phase generator so that the IC acts like an analogue shift register. Analogue samples of the input signals are clocked in at the front of the bucket chain, and are clocked out in reconstructed time-delayed form at the chain's end. The IC's delay time is proportional to its number of 'bucket' stages and to its clock-frequency period, and can easily be varied (via the clock generator) over a very wide range. Such devices are thus robust and versatile and require very little external support circuitry, other than a clock generator and a couple of simple active filters.

BBD Principles

The first primitive BBD IC was developed by Philips Laboratory in 1968, and in use was connected into the basic circuit shown in Figure 7. Here, the audio input signal is AC-coupled to the IC's IN terminal, which is biased into its linear operating range via voltage divider R1 & R2. The IC's bucket stages are clocked by a pair of antiphase squarewave inputs at a frequency that is high relative to that of the audio input signal. The IC has two outputs (OUT A and OUT B), and these are effectively shorted together to generate the final reconstructed and delayed audio output.

The basic operating principle of this type of BBD can be understood with the help of Figure 8, which depicts the first six stages of the IC as individual 'buckets', shown operating through the first six half-cycles of the clock phase-1 waveform (notated +1 to –3 in the diagram). Switch S1 represents an IGFET switch that is connected between the IC's IN terminal and the first bucket stage. The IC's basic action is such that S1 is open and all odd-numbered buckets transfer their charges into the even-numbered buckets to their right when the phase-1 waveform is high (+), and S1 is closed and all even-numbered buckets transfer their charges into the odd-numbered buckets to their right when the phase-1 waveform is low (–).

Thus, in the first (+1) clock period, S1 is open and all buckets are empty, but in the second (–1) period S1 is closed and the 'A' input is connected to the 1ST sample-and-hold bucket stage. In the +2 period, S1 opens again and charge 'A' is moved into bucket 2, leaving bucket 1 empty. In the –2 period, S1 is closed and charge 'B' is loaded into bucket 1, and simultaneously, charge 'A' is transferred into bucket 3. This basic process repeats on each successive clock cycle, with all bucket charges shifting one step to the right on each half-cycle, and with a fresh input sample being loaded into bucket 1 each time S1 closes.

Note in Figure 8, that each charge steps two places to the right in each complete clock cycle, and that there is always an empty bucket between each charge-carrying pair of buckets. Consequently, the output waveform from the final bucket stage is too rough to be of direct value, and to overcome this problem, the IC incorporates voltage-follower buffers on the final two bucket stages, making both of these outputs externally accessible, as shown in Figure 9(a). This enables a useful 'composite' output waveform to be obtained by shorting the two outputs together (either directly or via a balance pot) as shown in Figure 9(b), thus effectively adding the two outputs together and generating a gap-free 'composite' output, as shown in Figure 9(c). This final output is thus a quantized but time-delayed replica of the original input signal.

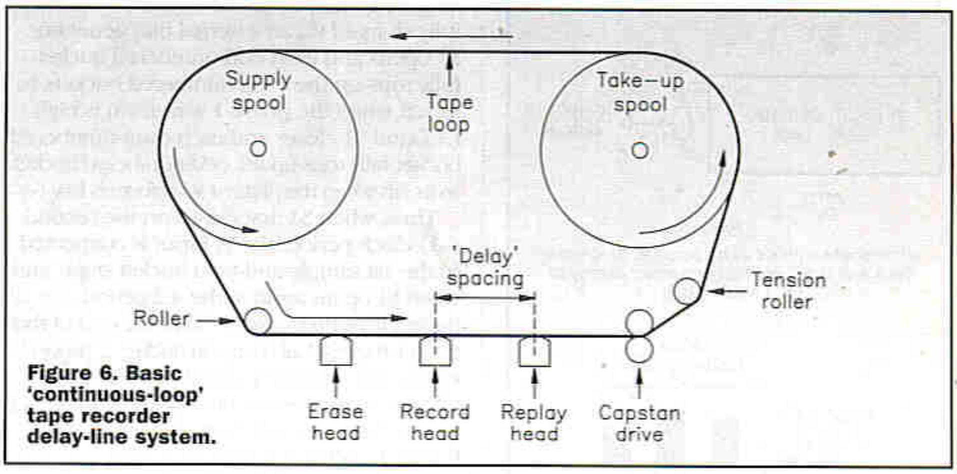


Figure 6. Basic 'continuous-loop' tape recorder delay-line system.

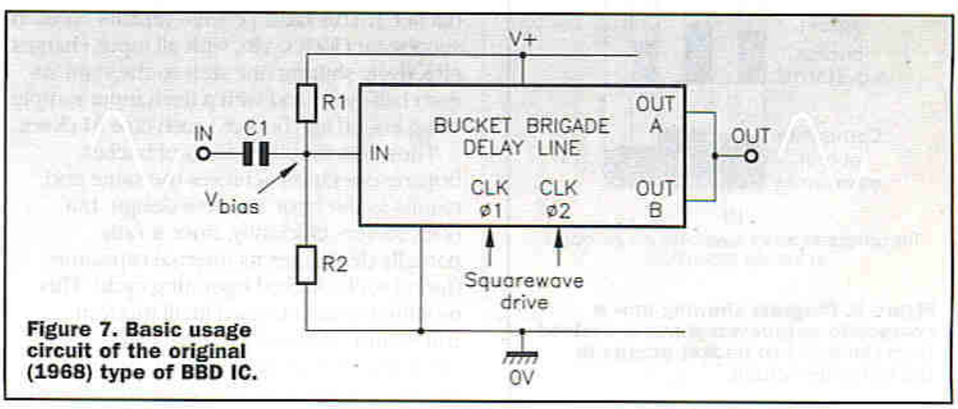


Figure 7. Basic usage circuit of the original (1968) type of BBD IC.

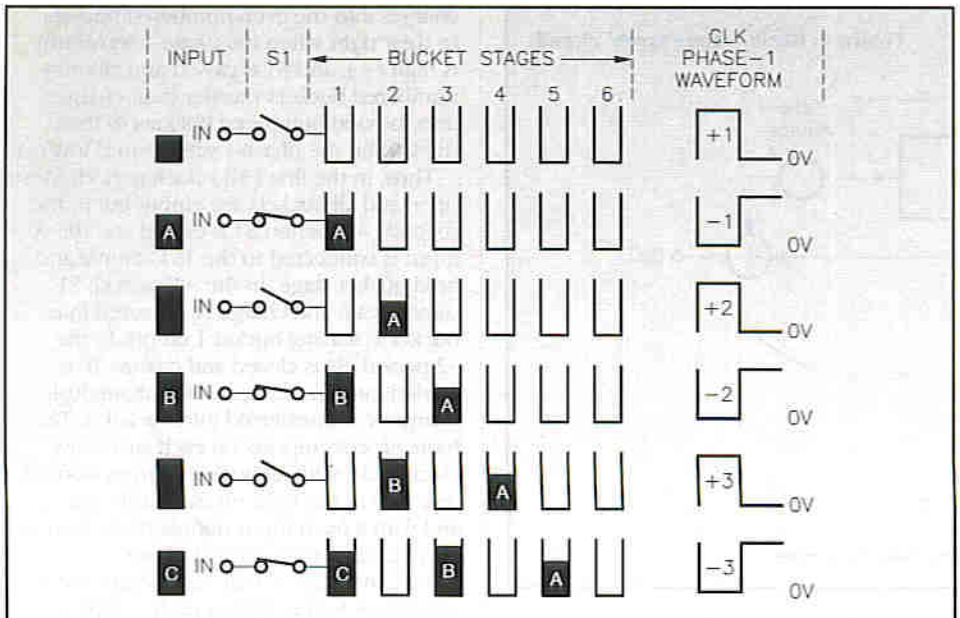
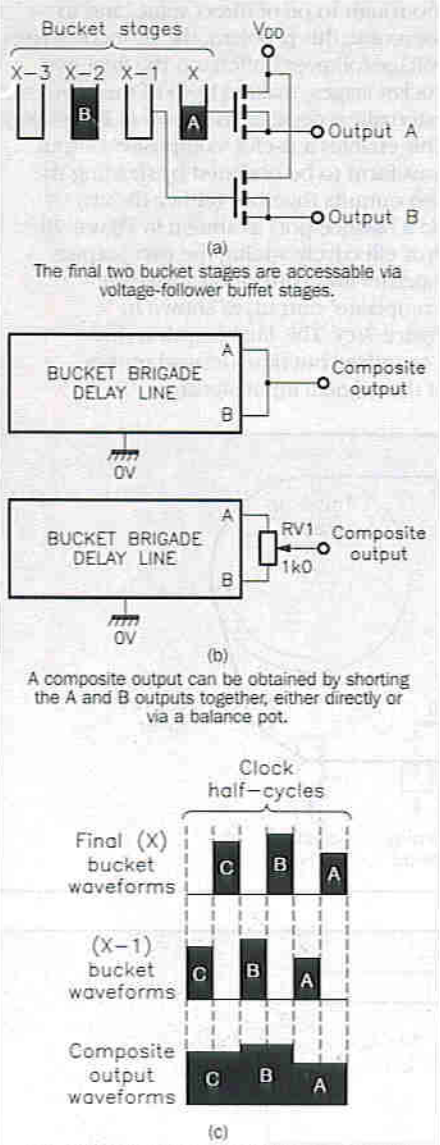


Figure 8. Diagram illustrating the basic operating principle of the original (1968) type of bucket-brigade delay line.



(a) The final two bucket stages are accessable via voltage-follower buffet stages.

(b) A composite output can be obtained by shorting the A and B outputs together, either directly or via a balance pot.

(c) The composite output waveforms are generated in the way shown here.

Figure 9. Diagram showing how a composite output waveform is derived from the last two bucket stages in the delay-line chain.

That, then, is how the original (1968) Philips bucket-brigade delay line worked, and is – in essence – how all modern BBD ICs operate. The original device did, however, suffer from several major weaknesses, due to the near-impossibility of fully discharging each of its several-hundred 'sample-and-hold' storage capacitors at the end of each transfer cycle, and this caused the IC to give poor transfer efficiency and to offer a very poor dynamic operating range (typically less than 60dB). Throughout the early 1970s, companies such as Philips, Bell, and Reticon devoted much effort to improving the basic design, and this resulted in the modified concept illustrated in Figure 10.

The major feature of the Figure 10 bucket brigade system is that all 'buckets' start off fully charged via an external bias generator. S1 opens and each odd-numbered bucket fully tops-up the even-numbered buckets to its left when the phase-1 waveform is high (+), and S1 closes and each even-numbered bucket fully tops-up the odd-numbered bucket to its left when the phase-1 waveform is low (–).

Thus, when S1 first closes on the second (–1) clock period, the 'A' input is connected to the 1st sample-and-hold bucket stage, and when S1 opens again in the +2 period, the '2' bucket tops-up bucket 1, so at the end of this period, the residual charge in bucket '2' precisely equals the original 'A' charge, i.e., charge 'A' is effectively transferred into bucket 2. In the –2 period, S1 closes and charge 'B' is loaded into bucket 1, and simultaneously bucket 3 tops-up bucket 2, effectively transferring charge 'A' into bucket 3. This basic process repeats on each successive clock cycle, with all input charges effectively shifting one step to the right on each half-cycle, and with a fresh input sample being loaded into bucket 1 each time S1 closes.

Thus, this modified form of bucket-brigade operation achieves the same end results as the basic Figure 8 design, but does so very efficiently, since it only partially discharges its internal capacitors during each clocked operating cycle. This modified system is used in all modern BBDs, and offers very high transfer efficiency and has an excellent dynamic operating range (usually better than 80dB).

Figure 11 shows the basic 'usage' connections of a modern BBD IC, which is powered via V_{DD} and ground but also uses another supply – notated V_{BB} or V_{GG} – to correctly bias its sample-and-hold IGFETS. The IC's input terminal must be biased into the linear mode by voltage Vbias, and the IC's two outputs must be shorted together as already described; direct-shorting is shown used in the diagram. In some ICs, this is provided internally and only a single 'composite' output is available from the IC. Finally, the IC needs a 2-phase clock signal, normally consisting of a pair of anti-phase squarewaves that switch fully between the V_{DD} and GND values.

How Much Delay?

Each of a BBD's bucket charges are shifted through two bucket stages during each complete clock cycle, and the maximum number of samples held by a BBD is equal to half the number of bucket stages. The actual time-delay available from a BBD is thus given by:

$$\text{Time Delay} = \frac{S \times p}{2} \text{ or } \frac{S}{2 \times f}$$

Where S is the number of bucket stages, p is the clock period, and f is the clock frequency.

Practical analogue delay line ICs usually have 512, 1,024, 1,536, 3,328 or 4,096 stages. Thus, a 1,024-stage line using a 10kHz (100μs) clock gives a delay of 51·2ms. A 4,096-stage line gives a 204·8ms delay at the same clock frequency. In practice, the maximum useful signal frequency of a delay line is equal to one third of the clock frequency, so a delay line clocked at 10kHz actually has a useful bandwidth of only 3·3kHz.

Figure 12 shows the block diagram of a practical BBD analogue delay line system. The input signal is fed to the BBD line via a low-pass filter with a cut-off frequency that is one third (or less) of the clock value, and is vital to overcome 'aliasing' or inter-modulation problems. The BBD's output is passed through a second low-pass filter, which also has a cut-off frequency one third (or less) of that of the clock. This serves the dual purposes of rejecting clock breakthrough signals and integrating the delay line output pulses, so that the final output signal is a faithful (but time-delayed) copy of the original.

A closer look at practical 'clock' and filter circuits is taken in the second part of this series. In the meantime, it is wise to look at some more popular delay-line applications, and in order to fully understand these, it is necessary to first briefly study the subject known as psycho-acoustics.

Psycho-acoustics

Many of the special effects obtainable with delay lines rely on the human brain's idiosyncratic behaviour when interpreting sounds. Basically, the brain does not always perceive sounds as they truly are, but simply 'interprets' them so that they conform to a preconceived pattern; it can easily be fooled into misinterpreting the nature of sound. The study of this particular subject is known as psycho-acoustics. Here are some relevant psycho-acoustic 'laws' that are worth knowing:

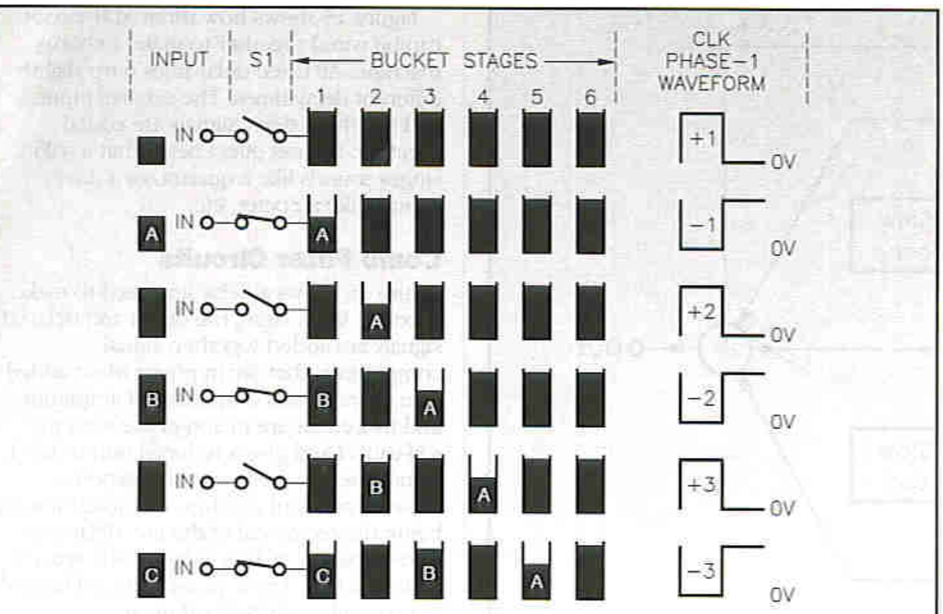


Figure 10. Diagram illustrating the basic operating principle of the modern type of bucket-brigade delay line.

For example, if echo times are 50ms but reverb time is 2s, the brain may interpret the environment as being a 17m (56ft.) cave or similar hard-faced structure, but if the reverb time is only 150ms, it may interpret the environment as being a 17m wide softly furnished room. Delay lines can thus be used to trick the brain into drawing false conclusions concerning its environment, as in ambience synthesizers or acoustic 'room expanders'.

(6). The brain is very sensitive to brief transient increases in volume, such as caused by clicks and scratches on records (discs), but is blind to transient drops in volume. Delay lines can be used to take advantage of this effect in record players, where they can be used (on conjunction with other circuitry) to effectively predict the arrival of a noisy click or scratch and replace it with an 'unseen' neutral or negative transient.

(1). If a human's ears receive two sounds that are identical in form but are time-displaced by less than 10ms, the brain integrates them and perceives them as a single (undisplaced) sound.

(2). If a human's ears receive two sounds that are identical in form but are time-displaced by 10-50ms, the brain perceives them as two independent sounds but integrates their information content into a single easily recognisable pattern, with no loss of information fidelity.

(3). If a human's ears receive two signals that are identical in form but time-displaced by greater than 50ms, the brain perceives them as two independent sounds but may not be able to integrate them into a recognisable pattern.

(4). If a human's ears receive two sounds that are identical in basic form but not in magnitude, and which are time-displaced by more than 10ms, the brain interprets them as two sound sources (primary and secondary) and draws conclusions concerning (a) the location of the primary sound source and (b) the relative distances apart of the two sources.

Regarding 'location' identification, the brain identifies the first perceived signal as the prime sound source, even if its magnitude is substantially lower than that of the second perceived signal (this is known as the Hass effect). Delay lines can thus be used to trick the brain into wrongly identifying the location of a sound source.

Regarding 'distance' identification, the brain correlates distance and time-delay in terms of approximately 0·34m (13·4in.) per millisecond of delay. Delay lines can thus be used to trick the brain about 'distance' information.

(5). The brain uses echo and reverberation (repeating echoes of diminishing amplitude) information to construct an image of environmental conditions.

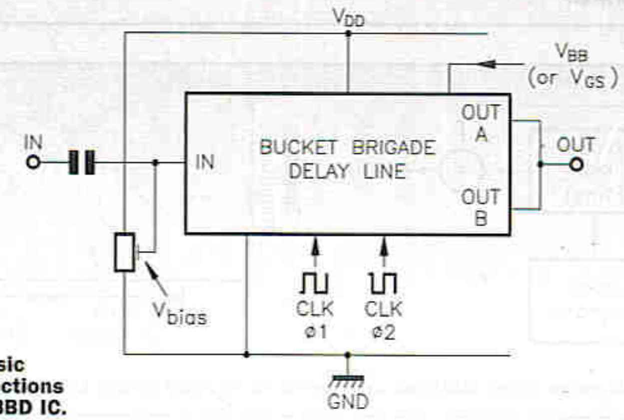


Figure 11. Basic 'usage' connections of a modern BBD IC.

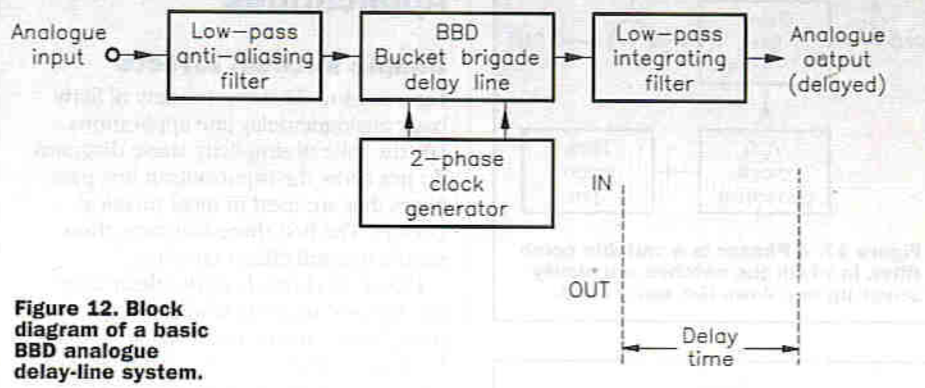


Figure 12. Block diagram of a basic BBD analogue delay-line system.

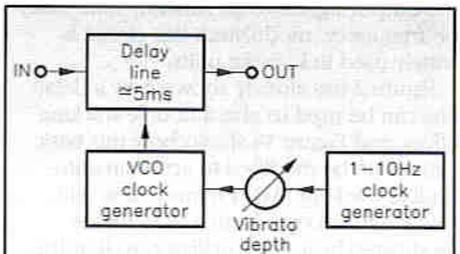


Figure 13. True vibrato circuit, which applies slow frequency modulation to all input signals.

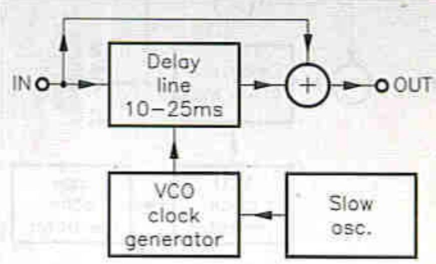


Figure 14. Auto-double-tracking (ADT) or mini-chorus circuit.

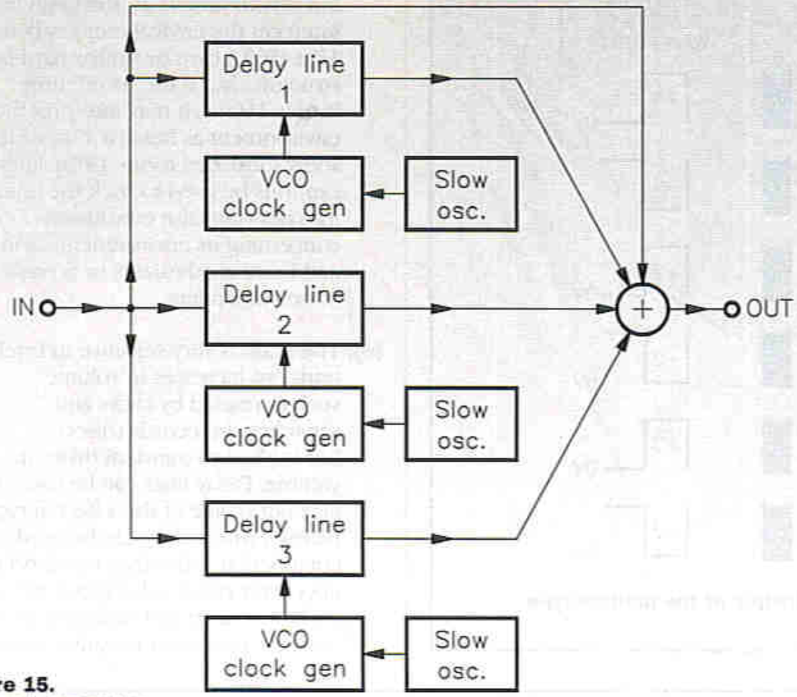


Figure 15. 'Chorus' generator.

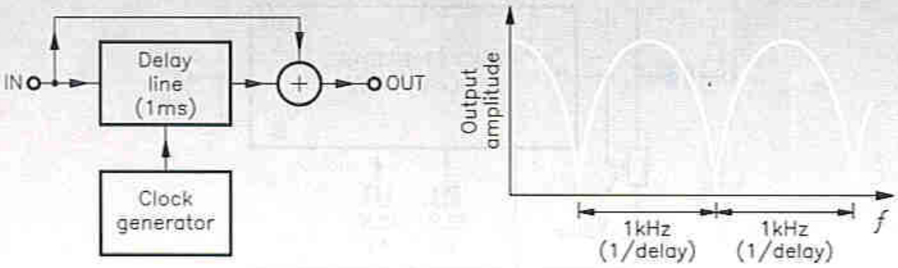


Figure 16. CCD comb filter. Notches are about 20 to 30dB deep, 1kHz apart.

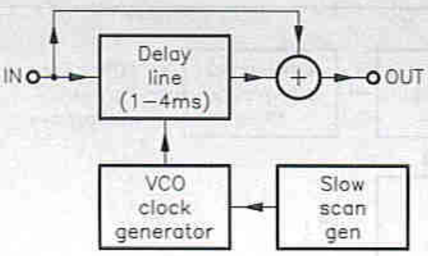


Figure 17. A Phaser is a variable comb filter, in which the notches are slowly swept up and down the audio band.

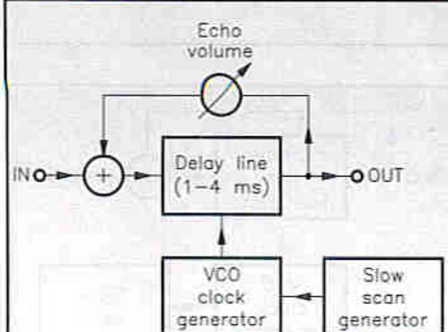


Figure 18. A flanger is a phaser with accentuated and variable notch depth.

Practical Delay Line Applications

Simple Musical Effects

Figures 13 to 22 show a variety of fairly basic analogue delay line applications. For the sake of simplicity, these diagrams do not show the input/output low-pass filters that are used in most practical circuits. The first three diagrams show simple musical effects circuits.

Figure 13 shows how the delay line can be used to apply vibrato (frequency modulation) to any input signal. The low-frequency sinewave generator modulates the voltage-controlled oscillator (VCO) clock generator frequency and thus causes the output signals to be similarly time-delay or 'frequency' modulated; this circuit is widely used in karaoke units.

Figure 2 has already shown how a delay line can be used to give a double-tracking effect, and Figure 14 shows how this basic circuit can be modified to act as an auto-double-tracking (ADT) mini-chorus unit. Clock signals come from a VCO that is modulated by a slow oscillator, so that the delay times slowly vary. The effect is that, when a solo singer's voice is played through the unit, the output sounds like a pair of singers in loose or natural harmony.

Figure 15 shows how three ADT circuits can be wired together to make a chorus machine. All three delay lines have slightly different delay times. The original input and the three delay signals are added together, the net effect being that a solo singer sounds like a quartet, or a duet sounds like an octet, etc.

Comb Filter Circuits

Figure 16 shows a delay line used to make a 'comb' filter. Here, the direct and delayed signals are added together; signal components that are in-phase when added give an increased output signal amplitude, and those that are in anti-phase tend to self-cancel and give a reduced output level. Consequently, the frequency response shows a series of notches, the notch spacing being the reciprocal of the line delay time (1kHz spacing at 1ms delay, 250Hz spacing at 4ms delay). These phase-induced notches are typically only 20-30dB deep.

The two most popular musical applications of the comb filter are in phasers and flangers. In the phaser (Figure 17), the notches are simply swept slowly up and down the audio band via a slow-scan oscillator, introducing a pleasant acoustic effect on music signals.

The Figure 18 flanger circuit differs from the phaser in that the mixer is placed ahead of the delay line and part of the delayed signal is fed back to one input of the mixer, so that in-phase signals add together regeneratively. Amplitudes of the peaks depend on the degree of feedback, and can be made very steep. These phase-induced peaks introduce very powerful acoustic effects as they are swept up and down through music signals via the slow-scan oscillator.

Echo/Reverb Circuits

Basic echo and reverb circuits have already been shown in Figures 3 and 4, and Figure 19 shows how several reverb circuits can be coupled together to make an ambience synthesizer or acoustic room expander. Here, the outputs of a conventional stereo Hi-Fi system are summed to give a mono image and the resulting signal is then passed to a pair of semi-independent reverb units (which produce repeating echoes but not the original signal). The reverb outputs are then summed and passed to a mono PA system and speaker, which is usually placed behind the listener. The system effectively synthesises the echo and reverb characteristics of a chamber of any desired size, so that the listener can be given the impression of sitting in a cathedral, concert hall, or small club house, etc., while in fact sitting in his own living room. Such units produce very impressive results.

There are lots of possible variations on the basic Figure 19 circuit. In some cases, the mono signal is derived by differencing (rather than summing) the stereo signals, thereby cancelling centre-stage signals and overcoming a rather disconcerting 'announcer-in-a-cave' effect that occurs in 'summing' systems. The number of delay (reverb) stages may vary from one in the cheapest units to four in the more expensive.

Predictive Switching Circuits

Delay lines are particularly useful in helping to solve predictive or anticipatory switching problems, in which a switching action is required to occur slightly before some random event occurs. Suppose, for example, that you need to make recordings of random or intermittent sounds (thunder, speech, etc.). To have the recorder running continuously would be inefficient and expensive, and it would not be practical to simply try activating the recorder automatically via a sound switch, because part of the sound will already have occurred by the time the recorder turns on.

Figure 20 shows the solution to this problem. The sound input activates a sound switch, which (because of mechanical inertia) turns the recorder's motor on within 20ms or so. In the meantime, the sound travels through the 50ms delay line towards the recorder's audio input terminal, so that the recorder has already been turned on for 30ms by the time the first part of the sound reaches it. When the original sound ceases, the sound switch turns off, but the switch extender maintains the motor drive for another 100ms or so, enabling the entire 'delayed' signal to be recorded.

Figure 21 shows how predictive switching techniques can also be used to help eliminate the sounds of clicks and scratches from a record player. Such sounds can easily be detected by using stereo phase-comparison methods.

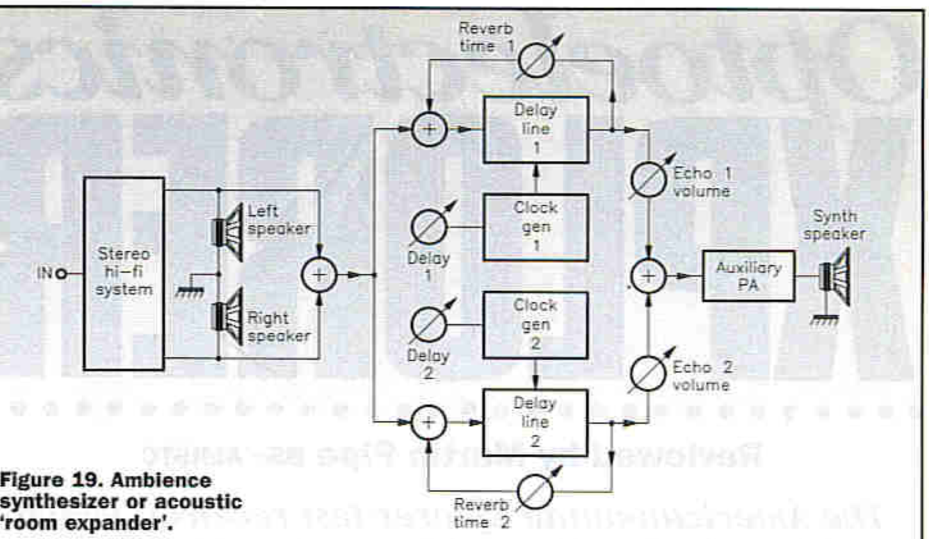


Figure 19. Ambience synthesizer or acoustic 'room expander'.

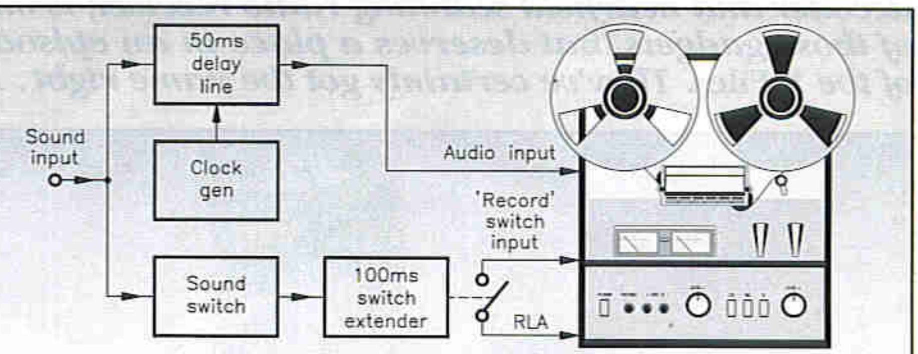


Figure 20. Automatic tape recorder with predictive switching.

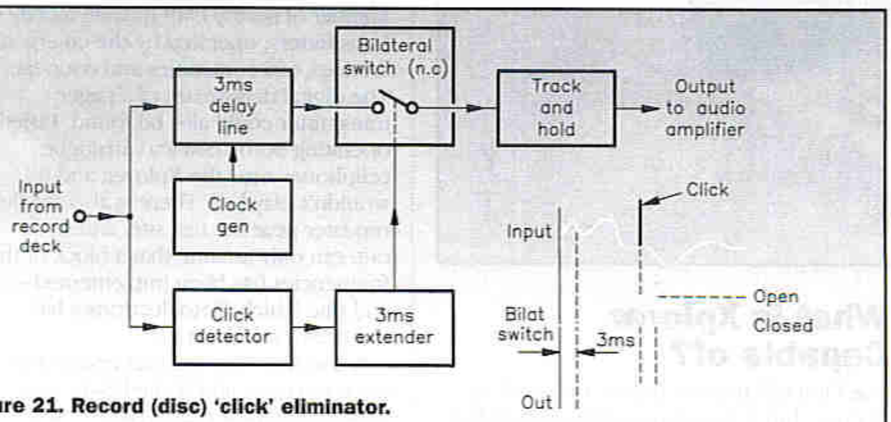


Figure 21. Record (disc) 'click' eliminator.

In the diagram, the record (disc) signals are fed to the audio amplifier via a 3ms delay line, a bilateral switch, and a track-and-hold circuit. Normally, the bilateral switch is closed, and the signal reaching the audio amplifier is a delayed but otherwise unmodified replica of the disc signal. When a click or scratch occurs on the record, the detector/expander circuit opens the bilateral switch for a minimum of 3ms, briefly blanking the audio feed to the amplifier. Because of the presence of the delay line, the blanking period effectively straddles the 'click' period, enabling its sound effects to be completely eliminated from the system (see 'Psycho Acoustics').

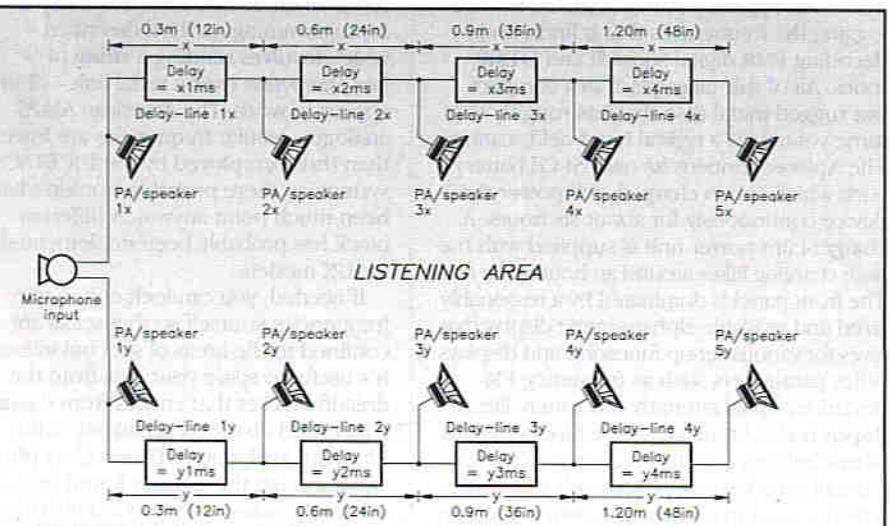


Figure 22. Public address speech-delay equalisation system.

Delay Equalisation

One of the most important applications of delay line techniques is in sound-delay equalisation of public address systems in theatres and at open-air venues such as air shows, etc.

Sound travels through air at a rate of about 0·34m/ms. In simple multiple-speaker public address systems, in which all loudspeakers are fed with the same signal at the same moment, this factor inevitably creates multiple sound delays which can make voice signals unintelligible to the listener. This problem can be eliminated by delaying the signal feed to successive speakers (which are each driven by their own PA units) by progressive amounts (by 1ms per 0·34m of spacing from the original sound source), as shown in Figure 22. Ideally, the speakers should be spaced at 6m intervals; the spacing intervals should not exceed 60m.

Part two of this series will look at practical BBD delay line ICs and applications.

Optoelectronics XPLORER

Reviewed by Martin Pipe BSc AMISTC

The American-made Xplorer test receiver, which combines the functions of frequency recorder, tone decoder and nearfield scanning radio receiver, is one of those gadgets that deserves a place in an episode of the X Files. They've certainly got the name right . . .

Everybody's heard of radio scanners – wideband radio receivers that 'scan' across a range of frequency channels until a signal is received. The coverage provided by some scanners ranges from hundreds of kHz to a couple of GHz. The fact that many scanners cover the analogue cellphone frequencies is responsible for the scanner's notoriety – unscrupulous tabloid journalists have been known to chance upon private conversations of interest to them. Such activity is illegal, but it certainly caught the imagination of the public.

Eavesdropping on cellular conversations is difficult, but the publicity generated has made the more secure digital cellphone systems popular – generally, GSM (Global System for Mobile communications) for business, and PCN (Personal Communications Network; One2One, Orange) for consumers. Scanners have hit the headlines more recently – a TV news report stated that it is possible to use them to receive signals from pager transmitters. A PC is used to decode the unscrambled digital data (which conforms to a late 70s format known as POCSAG). The software, together with simple circuit diagrams for the interface, is readily available over the Internet.

What is Xplorer Capable of?

The Optoelectronics Xplorer isn't really a scanner, but it does have some scanner-type functions. But it's capable of far more than a scanner. Special features available include logging the frequencies that it finds, and decoding PMR digital squelch and DTMF tones. All of this takes place in a compact but rugged metal case that has roughly the same volume as a typical hand-held scanner. The Xplorer contains its own Ni-Cd battery pack which, when charged, will power the device continuously for about six hours. A charger-cum-power unit is supplied with the unit; charging takes around an hour and a half. The front panel is dominated by a reasonably sized and readable alphanumeric display that gives for various set-up functions, and displays other parameters such as frequency, FM deviation, signal strength and battery life. A display backlight can be selected for occasions where lighting conditions are poor. There is a membrane keypad underneath the display, which is used in conjunction with a knob on the top of the unit to configure the unit and select operating modes. Also on the front panel is a tiny yet remarkably clear speaker for the demodulated audio. On top is a tape output (3·5mm) motor control jack (for the unattended audio recording of 'found' signals; normally open relay outputs, 2·5mm jack) and a 50Ω BNC aerial input. A telescopic aerial is supplied, but there is no reason why the Xplorer could not be attached to an external aerial – or indeed, a wideband low-noise aerial pre-amplifier.

Scanners, overall, have quite sensitive front ends – 0·25μV for a signal-to-noise ratio of 10dB – when you consider that they have to be tuned over a wide range. The Xplorer's breed of 'nearfield' receiver, however, is a different kettle of fish. Sensitivity is not of particular importance, since the device is only being used to capture exceptionally strong radio signals, or those in the immediate vicinity. Nearfield radios are commonly used in the checking of radio equipment, and the hunting of illegal transmitters and 'bugs' (one can just imagine Fox Mulder waving the Xplorer, aerial extended, around his flat!). The Xplorer, for example, only has a sensitivity of 100μV, which makes it somewhat useless as a scanner. Scanning-type capabilities are offered, though – in 'sweep' mode, the Xplorer will tune across the band and lock into any signals that it receives.

Frequency Coverage

Xplorer has a coverage range of 30MHz to 2GHz, which closely matches that of decent scanners. Despite the 100μV sensitivity, Xplorer could detect the signals from a number of nearby PMR (private mobile radio) transmitters, operated by the emergency services, taxi companies and couriers. The digital datastream of a pager transmitter could also be found. I tried operating both GSM and analogue cellphones near the Xplorer, and it wouldn't play ball. There is also a cellular repeater near the test site, and so one can only assume that a block of these frequencies has been implemented – and one which Optoelectronics has not drawn attention to.

A check on the Internet reveals this to be the case, and some US-derived newsgroup messages explain how it can be overcome using a PC and terminal emulation software. Sadly, the reprogramming method described – which involves sending a string of hex characters over a serial link – didn't appear to work. The American AMPS analogue cellular frequencies are lower than those employed by the UK ETACS system, so there probably wouldn't have been much point anyway. A different block has probably been implemented for UK models.

If needed, you can lock out certain frequencies yourself so that seeks are confined to the areas of spectral interest. It's useful to spare your ears from the dreadful racket that ensues from digital pagers and distorted broadcast radio. I have an analogue (CT0) cordless phone, and although the Xplorer found one of the frequencies used (around 49MHz), it wouldn't demodulate the audio during a conversation.

This is interesting, since narrowband FM is used. Narrowband FM (100kHz or less) transmissions are the only ones that the Xplorer's audio side will handle. It will handle wideband FM, such as broadcast VHF transmissions, but the sound quality is extremely distorted. Interestingly enough, BBC Radio 2 was, for some reason, intercepted quite powerfully at 1,243MHz; the distortion that accompanied the signal indicated that it was a wideband broadcast. All other radio equipment in the vicinity was turned off. There was a momentary glitch in Xplorer's frequency display.

Compare this restriction with scanners, most of which offer compatibility with three modulation systems – AM (for broadcast, civil aircraft, etc.), FM wide (FMW, for broadcast) and FM narrow (FMN, for PMR, military, broadcast 'backchat', cellular, pager, etc.). Some of the pricier scanners, such as the Yupiteru MVT7100 and AOR AR8000 (both available from Maplin), also include a SSB detector for working with amateur radio transmissions and the like. The Xplorer is in no way a scanner, and Optoelectronics will assume that those who enjoy the hobby of (clandestine?) radio listening will already have something a bit more suited to the task.

Fast Frequency Sweeping

It may not be a scanner, but there is one task in which Xplorer out-scans these conventional units. Frequency sweeps are blisteringly fast, and knock most scanners into a cocked hat. It was not uncommon for the Xplorer to be monitoring something around 70MHz, before leaping to a signal around 165MHz, and thence to 450MHz, within a couple of seconds. Remember that it scans across the entire band, and not just a selection of pre-stored channels. It could take tens of minutes to tune a scanner into an unknown frequency. Optoelectronics claim that the Xplorer will sweep from 30MHz to 2GHz in less than a second – this is quite amazing.

The device is thus an ideal partner for a scanner – it's just a shame that it sells for twice as much as most of the high-performance scanners now available, putting out of the reach of most enthusiasts. According to Optoelectronics, the fast sweeps are possible because the Xplorer's RF circuitry takes a rather different approach to that of conventional (read regular superhet) radio receivers and scanners. The Xplorer is based around a unique frequency conversion system that employs multiple swept harmonic local oscillator frequencies.

A little segment on the right of the display shows roughly where the current signal is in relation to the Xplorer's complete tuning range. In addition to the 'sweep' mode, there is a manual tuning function (VFO). Manual tuning offers two steps – coarse and fine. There was a slight bug here – if you advanced the tuning knob too quickly, the Xplorer would actually tune backwards! All tuning is done via a knob (which is coupled to a shaft encoder, rather than a potentiometer), as is volume, squelch and various mode selection functions.

The Xplorer's nearfield radio receiver is married to a frequency recorder – in other words, it will accurately display, and store in non-volatile memory, the frequency of any signal that it receives as it sweeps the band. Most of the electronics is needed by the nearfield receiver, and so it makes sense to add the feature. Needless to say, the Xplorer can also be used as a conventional frequency counter, albeit one that doesn't require a direct connection to the equipment being tested.

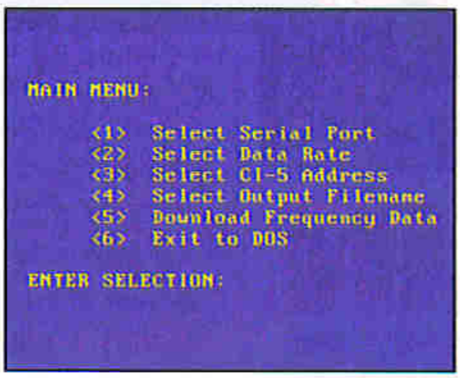
Deviation Display

The Xplorer will also give a display of deviation (in kHz), assuming that the signal is the FM type with which it can cope. The signal strength meter, when selected, is a joy to behold, and is far superior to those fitted to scanners. It's a bargraph that has 50 segments, and a decent dynamic range. When you're trying to track down a radio source, a proper signal strength meter is critical. Unfortunately, if you want deviation and/or deviation logged, you have to do it manually, presumably due to memory limitations. Interestingly, it is possible to log the date and time at which a particular signal was caught – there's an in-built clock/calendar.

Optoelectronics has, for some time, been famous for a recording device known as the Scout. The Scout, which took frequency counters a stage further, doesn't have any audio demodulating capability and so a scanner would be used to make sense of signals that the Scout detects over its 10MHz to 1·4GHz range. A serial port is provided to interface the Scout to certain types of scanner. As the Scout picks up new frequencies, it instructs the scanner to tune to those frequencies – Optoelectronics calls this 'reaction tune'. Scanners from Icom, AOR and Tandy (models from the latter have to be modified) are compatible with this. It is also possible to download a list of the Scout's 400 most-recent frequency 'sniffs' to a PC for analysis.

Linking Xplorer to a PC

Xplorer, like Scout, has a serial port – this takes the form of a 8-pin mini-DIN connector – and is supplied with a lead that terminates in a PC-standard 9-way D-type socket. It was through this serial port that we attempted to reprogram the device so that its sweeps included cellular. In the Xplorer's box is a couple of PC software disks. On the first, you'll find an extremely basic program that exports a list of scanned frequencies (up to 500) to your PC, in the form of a text file. There are also



programs of relevance to owners of other Optoelectronics products, such as the Scout. A Windows-based Radio Manager program wasn't of much use, since it wasn't written with Xplorer in mind. The same is true of the second disk, which contained the demo version of another scanner control tool, ScannerWear. Perhaps Optoelectronics has only included them because the likely Xplorer customer is likely to already own a scanner. Such people will be disappointed to learn that the Xplorer doesn't offer the Scout's 'reaction tune' facility.

The serial port can also be used to connect a NMEA-0183 compliant GPS receiver. Two of the pins of the serial port carry the NMEA data, and a suitable lead is made up to interconnect the two. With a GPS receiver hooked up in this way, the Xplorer will log not only frequency, but the geographical position (longitude, latitude, altitude) at which logging occurred. This will be very useful when tracking down unauthorised transmitters. If a directional aerial is used, the Xplorer can be used for accurate triangulation – the data from the GPS receiver could be used to accurately place your position on a map. One things for sure – don't let radio amateurs use them during 2m DF hunts, or all the fun will disappear!

The third function of the Xplorer is that of a decoder. It will decode DTMF (Dual-Tone Multi-Frequency) tones, which are usually to facilitate dialling on telephone systems. When the DTMF option is selected, the number will appear on the display. This facility could theoretically be used to log numbers being dialled on mobile and cordless phones, which is perhaps worrying. It does have a legitimate use in the faultfinding and testing of such systems. Xplorer will also decode DCS and CTCSS data, which is commonly found on PMR networks. In this case, the tone-burst frequencies used are displayed.

DCS (Digitally Controlled Squelch) is used to restrict access to repeaters, and in situations where two or more groups of radio users are using the same frequency, but don't want to hear each other's communications. CTCSS (Continuous Tone-Controlled Signalling System) is another system of ensuring that only defined closed groups can communicate with each other on busy PMR channels. DTMF, DCS and CTCSS data, like signal strength and deviation measurements, must be manually captured into memory.

Summary

Overall, the Xplorer proved to be a useful and versatile gadget. With it, I was able to determine that a neighbour had a cordless phone that operated on an frequency extremely close to mine, thus explaining the interference I periodically experience during conversations! It also enabled the modulation of a 2m amateur radio transceiver to be checked, albeit only in FM mode. Finally, I got somebody to hide an FM bug, and the Xplorer was used to find it without too much trouble.

It is expensive, but the Xplorer combines several functions – frequency counter/recorder, wideband nearfield radio receiver/scanner, deviation meter and tone decoder. At least some functions will be of interest to those with scanners, but it remains to be seen whether they are prepared to pay £899 for it. It's worth pointing out that in its country of origin, the Xplorer sells for £899, so if you're after one and are going on holiday to the US (or know somebody who is), it may be worth sourcing one from there directly. The power supply/charger (mode UVAC2) runs on any voltage between 100V an 240V AC, so there's no need to buy another power supply.

Many thanks to Waters and Stanton Electronics for the loan of the review sample.

Internet Sources

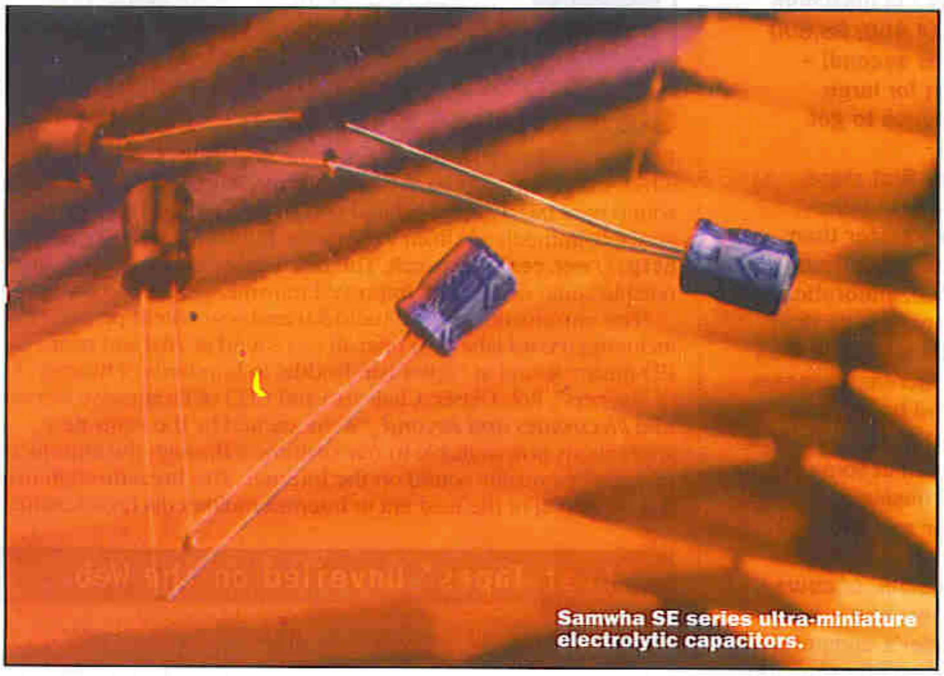
Optoelectronics' Web site: http://www.optoelectronics.com. It's not particularly well-designed, though you're advised to turn off the images on your browser, or you'll be downloading for ages!

SPECIFICATION

Price:	£899
Frequency coverage:	30MHz to 2GHz
Modulation:	Narrow FM (NFM)
Sensitivity:	100µV (@500MHz)
Audio Frequency Response:	50 to 3,000Hz
Auto Sweep Time:	<1 second (lockouts turned off)
Signal decoding:	52 CTCSS tones, 106 DCS codes, 31 DTMF digits
CTCSS acquisition time:	600ms
DCS acquisition time:	350ms
DTMF digit rate:	10 digits/second
Deviation measurement:	0 to 10kHz, 0·1kHz resolution, ±0·5kHz accuracy 10kHz to 100kHz, 1kHz resolution, ±5kHz accuracy
Frequency measurement:	100Hz resolution, ±500Hz accuracy
Aerial Input:	50Ω, −59dBm @ 100MHz, −25dBm @ 1GHz
Outputs:	Internal speaker, audio headphone jack, tape control jack, 8-pin mini-DIN serial interface connector
Controls:	Multifunction rotary encoder with push button; skip, hold, function, F1, F2, and power membrane keypad switches
Indicators:	LEDs: Lock, charge
Signal strength:	50 segment bargraph, relative reading, uncalibrated.
Display:	2 Line × 16 character LCD panel with switchable EL backlight
Power:	Battery: Internal Ni-Cd pack, 8·6V 900mA
Charge/Operate:	Universal AC input, 12V regulated 2A maximum output
Rapid Charging:	Less than one hour with reverse slope, timeout, temperature, and voltage-sensing charge-end determination
Serial Data:	CI-V compliant with both TTL and RS232C interface protocol, NMEA-0183 interface

Capacitors from SAMWHA ELECTRONICS

by Keith Rolfe



Samwha SE series ultra-miniature electrolytic capacitors.

For general use, Samwha's range of low cost electrolytics are ideal substitutes for tantalums, having a lower profile, costing half the price or less, but being footprint compatible. The ultra-miniature SE series has a standard height of only 5mm and an operating temperature range of –40°C to +85°C. Available in values from 0·1 to 100·F, they all have a maximum leakage current of 0·01CV or 4μA, whichever is greater. The 0·1μF 63V electrolytic capacitor, measuring 4mm(dia.) × 5mm has a dissipation factor of less than 0·09 and maximum permissible ripple current of 4·1mA rms at 85°C and 120Hz. The SG standard series offers electrolytics for general purposes in a range from 0·47 to 4,700μF, with voltages from 6·3 to 100V and a load life rating of 2,000h at 85°C.

The HC series provides a versatile choice of compact, snap-in radial aluminium capacitors for higher capacitance values with a 2,000h load life rating at 85°C. Covering a voltage range from 16 to 450V, they are available in values from 4,700 to 22,000μF for the lower working voltages, and from 47 to 330μF at the high voltage end of the range. Recently introduced is a new range of low profile can-type electrolytics offering long life and stability for values from 2,200μF at 63V to 10,000μF at 63V. The 2,200μF has a diameter of 25·4mm and a length of 30mm.

The Samwha Electric Company Limited is a major world player in the manufacture of quality electrolytic and plastic film capacitors. Based in South Korea, it has a production capability of 330 million pieces per month between its two factories. In addition, it has a factory in China producing capacitors for their domestic market. It supplies major clients throughout the world, such as Samsung, LG, Daewoo, Nokia, Blaupunkt, Bang and Olufsen and Kodak.

Electrolytic capacitor manufacture goes back to 1965, though Samwha itself started trading in 1956. Nichicon, a manufacturer of high quality capacitors in Japan, took a share in the company in 1973, and now a holds a 22% stake in the company. In 1986, the Samwha Electric Company Limited was quoted on the Korea Stock Exchange. The second factory and a design laboratory, at Chong Ju in S. Korea, were opened in 1989 to increase the production capacity. This now stands at 2,700 million electrolytics and 600 million plastic film per month between the two. The manufacture of both types was introduced into Tianjin in China in 1993. The Korean factories are certified to ISO 9000. Employees currently total around 1,200.

Other companies within the Samwha Group in Korea produce power and ceramic capacitors and automated production machines for film and ceramic capacitors, ferrite cores, transformers and coils.

The main line Samwha products fall into the following categories:

Aluminium electrolytics:
- ultra-miniature for general use
- switching power supply use
- wide temperature range
- photo-flash use
- large capacitance

They also manufacture plastic film capacitors of the following types:
- P.E.T.
- polypropylene
- metallised polypropylene
- P.E.T. and polypropylene
- box-type polyester

The automated manufacturing process for a typical aluminium electrolytic can be broken down into a number of separate stages.

The aluminium foil, and the separating medium which will eventually become the dielectric, are cut into the relevant sizes: two strips of each are required. The two aluminium foil pieces are each stitched to a lead wire to provide connection to the outside circuit.

The four interleaved strips of aluminium (+), separator, aluminium (–), and separator are now wound into a compact 'swiss roll' and the end taped. Under vacuum conditions, the whole assembly is dipped in the requisite electrolyte to impregnate the separator, and thus prepare the dielectric.

The capacitor is ready for placement in its surrounding aluminium can. The top seal is put in place and the whole unit placed inside its can and carefully sealed. It is sleeved in plastic and labelled.

The final important step involves connecting a DC supply at the capacitor's working voltage and its high temperature state. This generates the final chemical state of the dielectric, 'stabilising' the capacitor ready for operational use.

Inspections take place during the whole production cycle and at the final stage, before the products are eventually prepared to meet customer specifications and shipped to them.

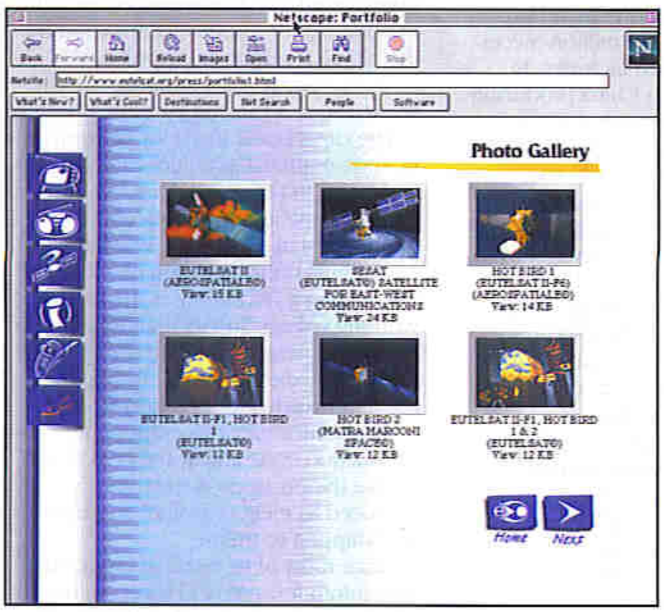
Since most of its material input, such as aluminium foil and lead wire, are produced by other companies within the group, Samwha has almost total control over quality of their finished products. ELECTRONICS

The Maplin MPS Catalogue contains full details of Samwha's electronics capacitors, which are now available to all of our customers, with quantity discount prices.

Most readers of these pages will know the main frustration of surfing the Internet – the time it takes for the data you want to be 'downloaded' to your computer screen. Generally, this is a product of the telephone network connecting your computer to the Internet itself. Your simple request to the server on the other side of the world takes just a second or so to get through, the requested data (being very much larger) takes an irritating length of time to get back. Even if the link to the Internet over the local line between you and your Internet service provider gives you its full maximum of data flow (depending on your modem: 14,400, 28,800 or, with the latest modems, 33,600 bits per second) – which few do consistently – the time taken for large files or multimedia-rich World Wide Web pages to get to you can still be quite a while.

With this in mind, Eutelsat has taken the first steps in using satellite television to provide fast data links (400K-bits per second – some twelve times faster than the fastest current land-line modem technology allows, and still many times higher than ISDN links). Theoretically, this speed can be maintained far more consistently than land-line modems too, so the overall speed increase is likely to feel rather more than the twelve times increase appears on paper. The new DirecPC service provided by Hughes Olivetti Telecom via the Eutelsat II-F3 satellite was launched on 24 October, and we hope to review a system at some point.

Initially the DirecPC service is aimed at business users but is to be launched as a consumer service sometime next year. A two-way link between satellite and a satellite dish on your roof is not feasible, of course, so information flow at this high speed is only one-way – from the satellite to your dish. Data the user's computer generates (the usual Internet ftp, http and so on requests) together with outgoing e-mail will all travel by more conventional modem or ISDN means, back to the Internet service provider's server.



Turnpike 3

Version 3 of Turnpike is out and about. It's the preferred method of accessing the Internet via Demon if you have a PC, and is worth upgrading to if you have an earlier version (free for upgraders) and still worth buying if you don't. Turnpike 3 allows multiple users (up to 99) from a single Demon account, and has many improvements over earlier versions.

Stereo Sound Over 28.8

Progressive Networks, has released the RealAudio System 3.0, which delivers stereo sound over 28.8 modems and near CD-quality sound over ISDN and LAN bandwidths. RealAudio 3.0 beta is available immediately from Progressive Networks' Web site at `http://www.realaudio.com`. The new release also features more reliable audio delivery via improved transmission protocols.

"The introduction of RealAudio 3.0 enables content providers, including record labels, to offer stereo sound at 28.8 and near CD-quality sound at higher bandwidths to hundreds of thousands of listeners", Rob Glaser, Chairman and CEO of Progressive Networks told *Electronics and Beyond*. "We're excited by the many new applications now available to our customers through the introduction of broadcast-quality sound on the Internet. This breakthrough marks the beginning of the next era in Internet multimedia broadcasting".

'Ghost Tapes' Unveiled on the Web

Internet users can now hear the controversial Norfolk 'ghost tapes' by downloading them from Eastern Counties Network Web site at `http://www.ecn.co.uk`.

The tapes give the public a chance to hear the unexplained tapping, bumps and echoes which paranormal researchers recorded at a secret location in Norfolk.

A spokesperson for the Anglia Society for Paranormal Research told *Electronics and Beyond*, "The building concerned was locked and the windows sealed. The investigating team were all outside the building and we can guarantee that there was no person within ten yards of the building when we heard the noises".

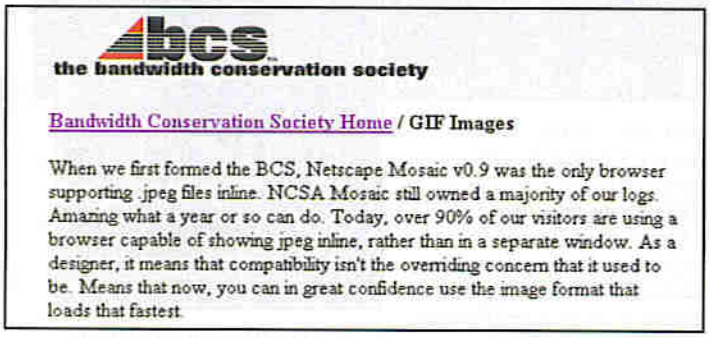
News of the tapes was first published in the Norwich Evening News last week and they were made available on the Eastern Counties Network Website shortly afterwards. Access to the tapes is free and each of the three recordings should take about one minute to download, after which, it can be replayed on the user's own computer.

Bandwidth Conservation

The US-based Bandwidth Conservation Society (BCS) has published a guide at **http://www.infohiway.com/faster/index.html** to producing graphical based Web pages that are bandwidth-efficient and can consequently be loaded quickly.

According to the guide, most GIF files on the Web use an 8-bit pallette. This means that there are 256 available colours in any given picture or graphic. However, in most cases, the palette can be reduced, which reduces the file size of the GIF, while retaining acceptable image quality. For instance, a 6-bit GIF only uses 64 colours but can reduce the file size by over 25%.

The guide also suggest that the size of graphics can be reduced by altering the balance between colour, brightness and contrast. Minor changes here can effect reductions of up to 50%.



AT&T Defects from Netscape Browser to Microsoft

Hot news from across the pond. In what some consider yet another blow to Netscape, AT&T has announced it would make Microsoft's Internet Explorer the default browser for its WorldNet service.

WorldNet, which currently claims 425,000 US subscribers, will make Microsoft Internet Explorer 3.0 the default browser for Microsoft Windows '95 customers immediately. Microsoft claims a version of IE 3.0 for Windows 3.1 and Mac will be in beta shortly. Once this is released, Internet Explorer 3.0 will be the default browser for all versions of the WorldNet service.

In return, WorldNet will come bundled with future versions of the Windows '95 operating system and will get an icon in the Internet services folder on the desktop.

AT&T like AOL and CompuServe before them, clearly see the opportunity to be bundled with Windows '95. Could this be the death of Netscape?

CD Quality Audio over the Web

Hayes is the first UK modem manufacturer to launch a range of 33.6k-bps internal modems. Supporting 33,600bps for data transmission and 14,400bps fax transmission, Hayes Accura 336 internal fax modem with Voice is priced £199, including VAT.

The Hayes Accura 336 internal fax modem with voice is a plug and play modem featuring full voice functionality, including full duplex speaker phone, digital voice messaging, and automatic paging, bringing professional office messaging capability to home users.

Meanwhile, rival modem manufacturer, US Robotics, has unveiled a new technology that increases the top speed of a standard modem for transferring data from 28.8 or 33.6k-bps to 56k-bps. This is equivalent to many Integrated Services Digital Network (ISDN) connections, but without the need for expensive new central office equipment required by other high-speed technologies.

NETCOM is the first Internet Service Provider to strike a deal with US Robotics to enable users to exploit US Robotics x2 technology, which will provide Internet and on-line connections at speeds nearly twice as fast as those currently available over standard telephone lines.

For further details, check: **http://www.usrobotics.com** or **http://www.netcom.net.uk**.

Contact: Hayes, Tel: (01252) 775577.

Netscape Fights Back

Netscape's newest version of its Navigator browser, scheduled for test release sometime this month, will enable collaboration among groups without the need for groupware software such as Lotus Notes. It will also make it possible for users to create multimedia e-mail messages and their own Web pages. The strategy is to continue persuading people to install Netscape's browser and to buy Netscape server software.

According to a September 1996 report from Zona Research, Netscape currently enjoys a dominant position for Web server software on the Windows NT platform, with 74% of those surveyed. Additionally, the survey found that on the UNIX platform Netscape holds an even greater percentage, with approximately 84% of all participants surveyed using Netscape Web server software. Overall, Netscape's nearest competitors among those surveyed are Microsoft, with 11% market share, and public domain servers with 7%.

IBM Joins Forces with Yahoo! in Europe

IBM Joins Forces with Yahoo! In Europe IBM has teamed up with Yahoo!, the Internet online guide, for the launch of European versions of the Yahoo! service. Yahoo! UK, at **http://www.yahoo.co.uk**, provides access to the most comprehensive guide to the UK web sites currently available as well as the complete database of world-wide listings people have come to expect from Yahoo! This will be followed in October by local language sites for France and Germany.

@Internet

Sun on the Net

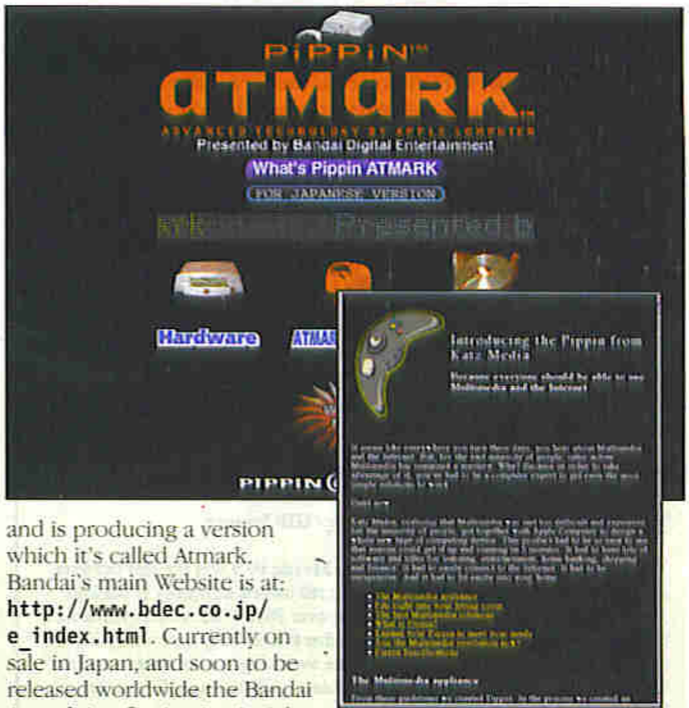
British Telecom and News International are creating a new joint venture which aims to bring Internet services to the masses. Codenamed Springboard currently, launch is scheduled in January. Content for the service is likely to be culled from the wide range of publications in the News International camp, and titles such as *The Times*, *The Sun*, and *The News of the World* are possible candidates.

In effect, all the new service seems to offer is a convenient way to access the Internet, with a front-end graphical suite which points you to relevant parts of the newspapers which are pertinent to your own requirements, while British Telecom simply provides the means of connecting you to the Internet in the first place. British Telecom will still continue to provide its BTInternet service.

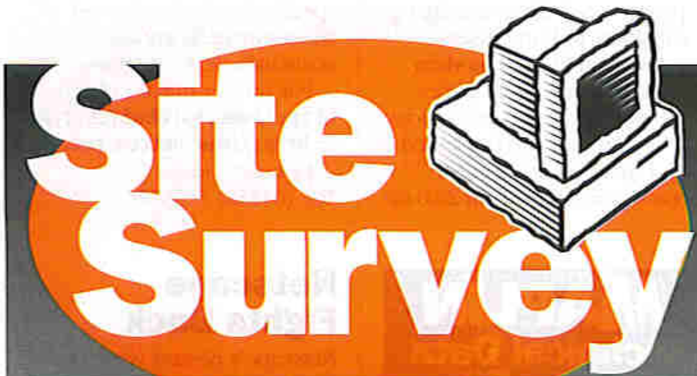
On the Bandwagon

Everyone (including *Electronics and Beyond*) is constantly talking about the Network Computer (NC). Everyone has got an opinion about it, and is prepared to voice it. But getting real information about it (you know, the nitty gritty stuff, like what does it do?, what games can it play?, how do I get one?) and its many derivatives isn't quite as easy. So it's worth going straight to the source to find out what's happening. One of the big players in the technology is Apple, which has produced and marketed a cut-down Macintosh computer variant under the Pippin trademark, which it has licensed out to third-party manufacturers to make and sell.

Bandai (yes, the Bandai of Power Rangers fame) has taken up the Pippin mantle and is producing a version which it's called Atmark. Bandai's main Website is at: **http://www.bdec.co.jp/e_index.html**. Currently on sale in Japan, and soon to be released worldwide the Bandai Atmark is a fascinating insight into the future of home and personal computing.



Meanwhile, in Europe, the marketing is in another company's domain. Katz Media (at: **http://www.Katz.no/main-app.htm**) has the Pippin license and is busily getting together its own variant which is due for release shortly.



The month's destinations

If you want something on the World Wide Web and don't know where it is, there are always search engines to help you. Trouble is, apart from the obvious few (Yahoo, Lycos, AltaVista and so on) going to the right search engine to get the exact specialist information about which particular search engine you want the exact specialist knowledge from almost seems to require a search engine in its own right. Try the Netlinks site at: **http://www.netlinks.net/Netlinks/NEWBIE/NEWBIE3.HTML** to get a hot-linked list of just about every search engine in the public domain.

Finding out about UK Internet service providers is a bit like searching for a needle in a haystack. There are hundreds of them (well, seems like it, anyway) and getting their details and finding out which one is best for you isn't the easiest job in the world. Internet UK has an index of Internet service providers at: **http://www.limitless.co.uk/inetuk/providers.html** where you can locate details of them all. It's worth checking out the Internet UK main site too, at: **http://www.limitless.co.uk/inetuk/** where you will get links to loads of other relevant information. Trouble is, of course, you need to be on the Internet to get the information in the first place, and if you are looking for your first Internet service provider you probably haven't got Internet access. Talk about the chicken and the egg…

Above: The Newbie search engine guide.

Right: Internet UK's index of internet service providers.

Below: Internet UK main site.

ELECTRONICS and Beyond

next issue

Don't miss another great assortment of entertaining and easy-to-make projects and essential electronics information aimed at the novice constructor in another of our special educational supplements.

Educational Mini Circuits

FREE SUPPLEMENT INSIDE

Metal Detector

Find your pot of gold using this compact hand-held unit capable of indicating the presence of ferrous and non-ferrous metal objects.

Multifunction Car Courtesy Light

An add-on delay unit designed to get the most out of your vehicle's interior lighting, featuring automatic and manual control and adjustable delay.

Remote Control Extender

This useful project extends the operating range of your video and satellite system remote controls so they'll operate the equipment from other rooms of the house.

PLUS Air Traffic Control by Alan Simpson reports on modern Civil Aviation Authority (CAA) standards and equipment employed at airports.

Development of the Electron Microscope by Greg Grant describes the accidental invention of this astoundingly powerful form of microscope.

Intelligent Systems from Frank Booty takes a look at neural networks, fuzzy logic and forms of artificial intelligence.

Life and Times of Tesla by Douglas Clarkson finds out about the Croatian-born American scientist whose name is given to the unit of magnetic flux density.

Greg Grant's series What's in a Name? chronicles how the terms Baud and Erlang came into use, and how their values are calculated.

Part 2 of Audio Delay Line Systems by Ray Marston looks at the crop of Delay Line ICs available and how to use them effectively in circuits.

The penultimate instalment of PIC Programming by Stephen Waddington demonstrates how to interface PIC microcontrollers to the outside world.

Surface Mount Technology – Today and Tomorrow from Ian Davidson picks and places present and future developments in component miniaturisation.

Issue 110 on sale Friday 3rd January

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

This month, I will continue with what Keith Brindley started in last month's issue, namely the 'Year 2000' problem. It has even been given its own web site information-point, **http://www.y2k.com**, complete with fancy logo (but then again, even the Eurofighter death-machine has one of those . . .). The Year 2000 problem will affect pretty much all computers and software created from the sixties to the present day. Yes, it will amaze you to learn that programs, the core code of which was written in the 1960s for such venerable mainframe platforms as the IBM 360, are still being used today. You'll find these ancient programs buried in applications that range from airline ticket booking to finance.

But the problem could affect computers designed several IT generations later – even the personal computers that you and I rely on. Amazingly, the software industry has remained somewhat blasé about the whole thing – perhaps in the interests of built-in obsolescence and the opportunity to sell new products. One industry insider told me that in many cases, there was a 'deliberate choice' not to fix the problem, even in comparatively recent software releases. The IT industry has known about it all for some time. The whole thing's a bit of a PR disaster for them, and with little over three years to go, there's a lot of head-scratching going on in all circles.

According to Gartner Group, "90% of the applications will be affected by the Year 2000 problem, and systems will crash if the century problem is not corrected before 1999". If this worst-case scenario occurs, there is a fair chance that parts of our society could grind to a stop, seconds into the new millennium. After all, computers now play a greater part in our lives than ever before.

So, what exactly is the Year 2000 problem? It stems back decades, to the days when computers were treated like the queen bee in an air-conditioned hive, attended to by hordes of white coated workers. In those days, it was decided that the date code for a filename or a data field should be in the form dd/mm/yy. But what happens when the date digits exceed '99'? Some software will go back to '00', which could hold problems if a computer holds data more than 100 years old (insurance policies relating to a man born in 1899 and historical census data, for example).

Why was a two-digit year code introduced in the first place? With hindsight, it seems a little short-sighted, but those 1960s programmers didn't think that their toilings would still be in use thirty years thereafter. At the time, they had two main issues to contend with. Firstly, data was entered by teams of teletype or card-punch operators, and if they didn't have to put the '19' in front of a year, then two fewer keypresses were needed, and productivity was increased.

Secondly, in the 1960s, data storage was expensive – in 1968, an IBM 2314 hard disk unit with a now-laughable 13M-byte capacity would set you back £70,000. The use of two, instead of four digits, saved memory and disk capacity – two bytes in each case. If there are over a million records, then those two bytes soon add up. Processing information has become automated and data storage costs have dramatically fallen since the 1960s, but the computer industry has not acted on the date code issue until comparatively recently.

There is another problem – which could creep in a year sooner in 1999. In some 1980s instances, it was common practice to use the date 9/9/99 for files that were intended to be permanent (i.e., have no expiry date). Come the 9th September 1999, and havoc could be wreaked. Other companies, such as finance houses, could also face headaches in 1999 – some of their systems are designed to look a year ahead. It would appear that companies have got a lot of work to do, rewriting application software, programming languages and in some cases, entire chunks of operating system.

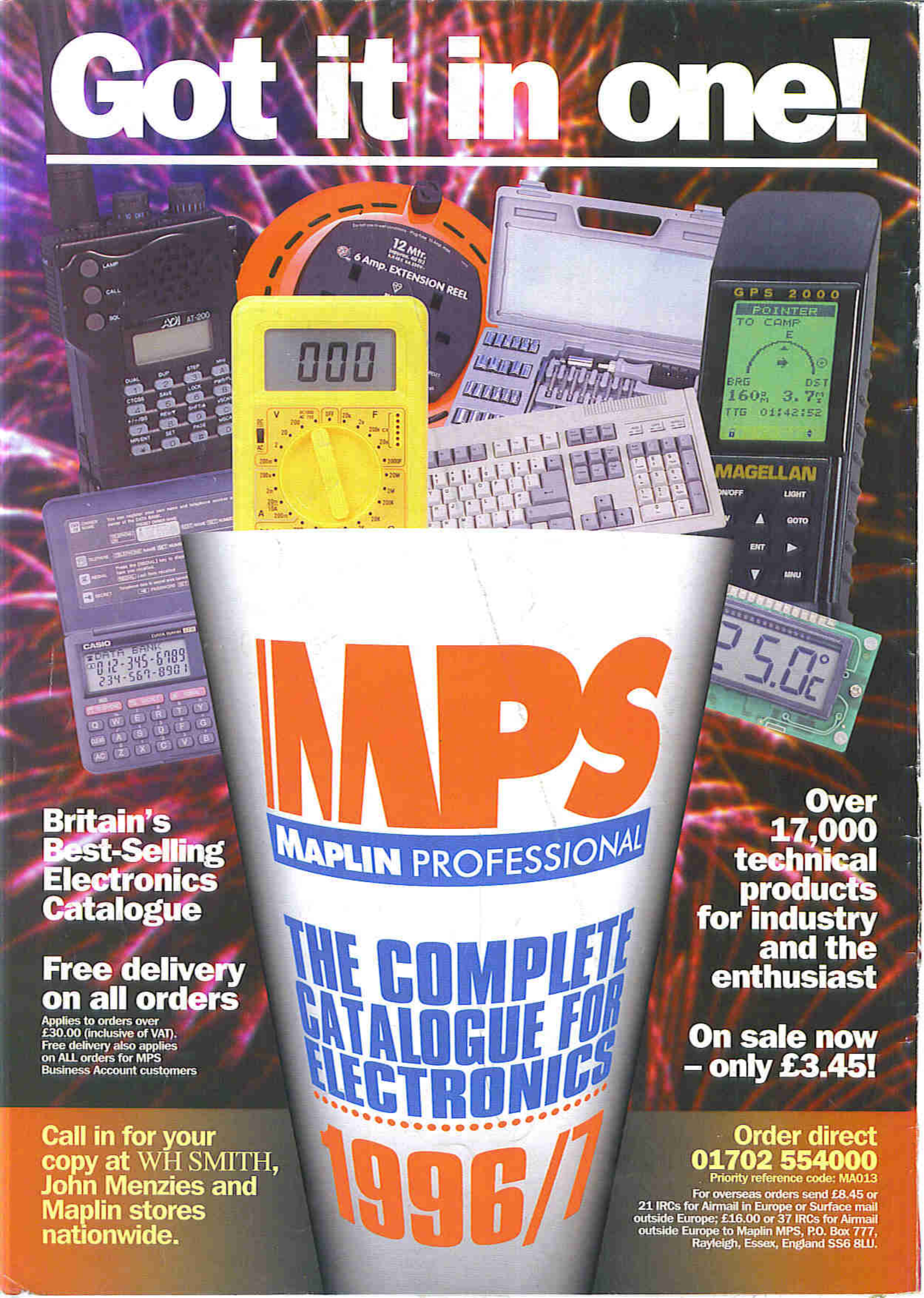
Some industries will use the problem as an excuse to ditch obsolete mainframe-based architectures for good, and set up information systems based around more modern thinking. Chances are, programmers will become as valuable a commodity as they were around the time of the 'Big Bang' in 1986. As far as modifying the data goes, there are answers to the donkey-work. Some companies, such as BMC, have developed 'intelligent agents' which add the extra two bytes to each date code that it finds on a system.

It is claimed that older PCs also suffer from the Year 2000 problem, since the clock/calendar facilities of their BIOS chips use the 2-digit year (dd/mm/yy) format. They will get the wrong day for January 1st 2000, and all subsequent dates, because they assume that all dates are 20th century. Older BIOS calendars will return January 1st 2000 as a Monday (the correct day for New Years Day, 1900). Unfortunately, it is wrong – January 1st 2000 will, in fact, be a Saturday. Recent computers won't suffer from the problem, and new BIOS chips can be bought for older motherboards. A Pentium 133-based machine equipped with Windows '95 appeared to be totally Year 2000 compliant – entering 01/01/2000 returned the correct day.

Interestingly, an elderly (1989) Elonex 386 laptop, equipped with DOS 6.2, seemed to work with 4-digit year codes – although the BIOS is an older type, entering a 'DOS date' of 01/01/2000 also returned the correct day. It would appear that later versions of Windows and DOS have some kind of BIOS fix. A 1989 Mac II running System 7.1 also appears to be immune to the problem – one can assume that later Macs are also unaffected. You have to ask yourself, though, how many of those older machines (e.g., 286 and 386 PCs) will still be in use come 2000. Sometimes, though, these obsolete computers find themselves being used for other background applications – such as printer servers and voice messaging systems. You have been warned.

Applications are a different matter, however – a sizeable number of applications have been written to work with the two-digit year code and will revert to (19)00 and all such dates when the new millennium is reached. Microsoft has issued memorandums to all software developers to make them aware, so that fixes can be implemented. It looks like, come late 1999 (or sooner), Internet FTP sites will be awash with software upgrades for older products – assuming, of course, that they are still supported.

E-mail your comments or suggestions to Martin Pipe at whatnet@cix.compulink.co.uk.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