THE MAPLIN MAGAZINE

ELECTRONICS

and Beyond

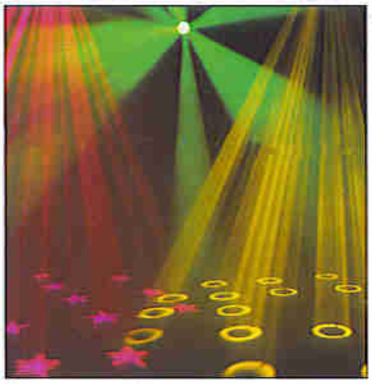
9 771363 638087 06

JUNE 1997 NO. 114 £2.25

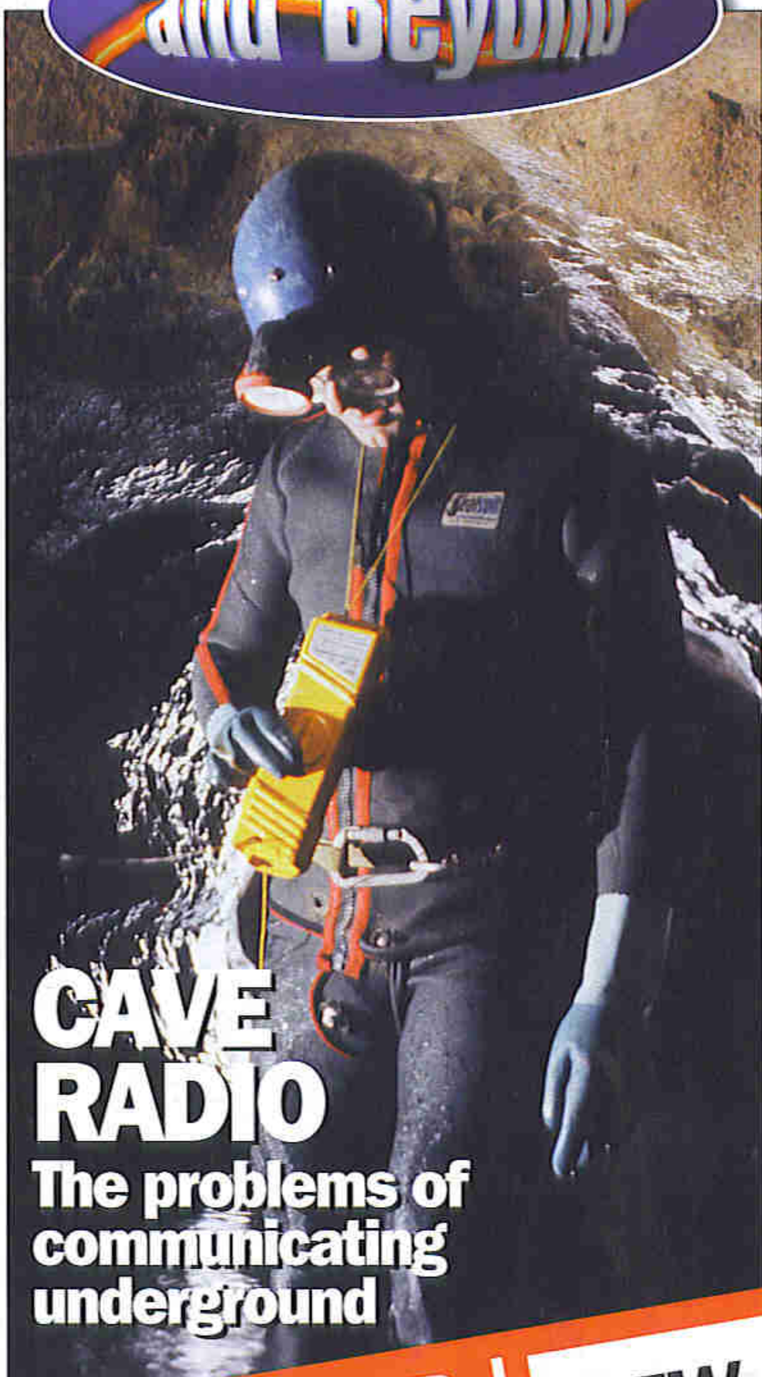
Best Value Electronics Monthly

http://www.maplin.co.uk

A History of Disco Lighting



High Tech at the Post Office



CAVE RADIO

The problems of communicating underground

Towards the Millennium

A look at Time

Seeing in the Dark with Night Vision

PROJECTS FOR YOU TO MAKE

Audio Lead Checker

Slow Scan TV Project

Wah Wah Pedal

NEW MONDO MAPLIN SUPERSTORE opening in Thurrock

ENTER OUR CROSSWORD COMPETITION AND WIN £25!

Britain's most widely circulated magazine for electronics!

THE MAPLIN MAGAZINE
ELECTRONICS and Beyond
June 1997 Vol. 16 No. 114

Projects

Features

Regulars

Editorial
Editor Paul Freeman-Sear BSc (Hons)
Technical Author Maurice Hunt BSc (Hons)
Editorial Assistant Lynda Hardy
News Editor Stephen Waddington BEng (Hons)
Technical Illustrator Paul Evans

Production
Design Layout Artist Karen Harris
Photography Librarian Tracy Swann
Published by Maplin Electronics plc., P.O. Box 777, Rayleigh, Essex, SS6 8LU.
Tel: (01702) 554155.
Fax: (01702) 554001.
Lithographic Reproduction by Planagraphic Studios, 18 Sirdar Road, Brook Road Ind. Estate, Rayleigh, Essex SS6 7UY.
Printed by St Ives (Andover) Ltd., West Portway, Andover SP10 3SF.

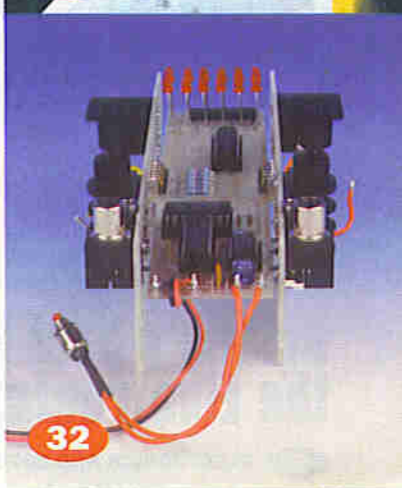
Management
Manager Paul Freeman-Sear BSc (Hons)
Marketing Services Manager Steve Drake

Subscriptions
Maureen Harvey
Tel: (01702) 554155 Ext. 311.

Advertising
Advertisement Manager Paul Freeman-Sear
Tel: (01702) 554155 Ext. 288.
Fax: (01702) 556987.

UK Newstrade Distribution
Seymour, Windsor House, 1270 London Road, Norbury, London SW16 4DH.
Tel: +44 (0)181 679 1899.
Fax: +44 (0)181 679 8907.

ABC CONSUMER PRESS
Member of the Audit Bureau of Circulations.



ELECTRONICS and Beyond

As most of you know the great countdown to the end of the millennium has begun – and that's official. An atomic clock has started the process and time zero will be at midnight December 31st 1999.

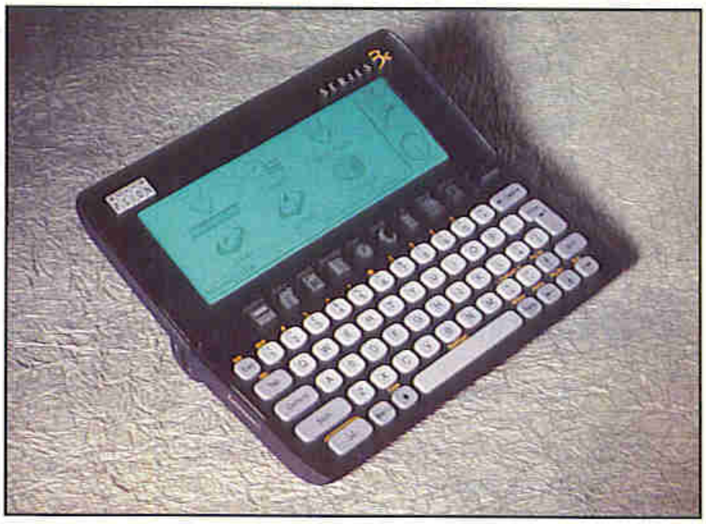
Time, as most of us will say, 'is never on our side'. I don't think I'm the only one that seems to feel the length of the day seems to get shorter and shorter as I get older. Maybe our internal biological clocks do run faster as we all get older! And why is it that hour-or-so in the early morning before going to work seems disproportionately faster to any other hour within the rest of the day? Be that as it may, I hope you enjoy reading the article on Time by Douglas Clarkson to see how far we have come in measuring time accurately.

Finally, it also makes us realise how artificial the year 2000 AD really is and in fact should we not be thinking of re-basing our year count from when time, as we know it, scientifically started at the beginning of the universe, at the time of the 'big bang'. Then everybody will be talking about the 'big time' – in powers of ten!

Paul Freeman-Sear, Publishing Manager

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT



Wideband Transistors Optimise Performance at Low Power

Psion has launched a new model Series 3c with a backlit screen. The backlighting feature may be switched on or off with a key press when needed, with the option of auto-switch off. The Series 3c 2M-byte with backlit screen has a recommended selling price of £399.95.

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

Contact: Psion, Tel: (0990) 143050.

IBM Doubles Storage Data Speeds

IBM has developed a prototype semiconductor chip – the SSA 160 – that takes Serial Storage Architecture (SSA) to a new level of performance. SSA 160 doubles link speeds that result in throughput increases from 8M-byte per second to 160M-byte per second.

IBM expects to ship SSA 160 products next year. Other companies will have access to IBM's SSA 160 technology to design and develop additional serial storage solutions to the SSA industry standard.

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

Contact: IBM, Tel: (0990) 426 426.

Philips Fab Operational in 98 Days

Philips Semiconductors has formally opened MOS4YOU (Yield Output Utilisation), its latest fab in Nijmegen, The Netherlands. From the arrival of the first piece of equipment to first wafers out took only 98 days, which Philips believes is a world record.

The opening ceremony was performed by His Royal Highness, de Prins van Oranje-Nassau. The $600,000 fab brings to five the number of wafer fabs in Philips' Nijmegen complex, making it Europe's largest semiconductor plant. For further details, check: **http://www.semiconductors.philips.com.**

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

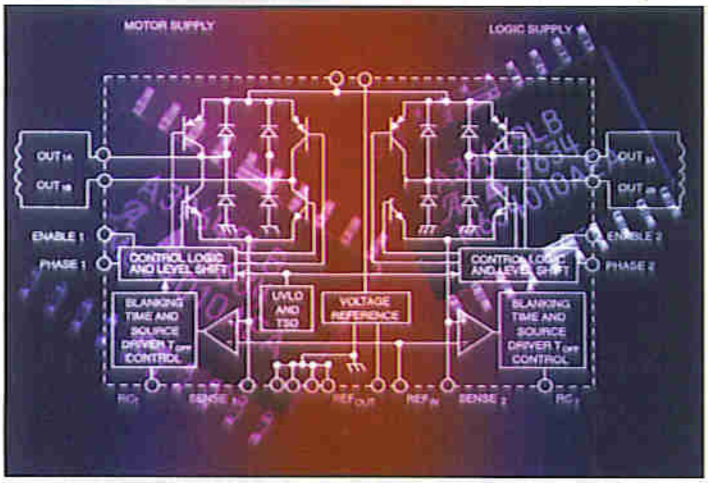
Advanced Logic Probe Simplifies Troubleshooting

For engineers who like a logic probe for its precise probing and quick circuit checks, but are frustrated by its performance limitations, there is now an instrument that takes logic-probe capabilities to a new level of performance. The HP LogicDart from Hewlett-Packard is an advanced logic probe which is designed to give engineers a head start on troubleshooting fine pitch circuitry. The unit incorporates a 100MSa/s timing analyser, a logic monitor, a DC voltmeter and a continuity tester.
For further details, check: **http://www.hp.com/go/tmdir.**
Contact: Hewlett-Packard, Tel: (01344) 366666.

Internet Content to GSM Phone

Motorola's European Cellular Subscriber Group and Unwired Planet (UP) will work together to incorporate Unwired Planet's UP.Browser client applications on Motorola's GSM smart phone. This solution will provide network operators and service providers with the compelling application of efficiently and economically delivering Internet-based content to wireless communications devices such as cellular smart phones and alphanumeric pagers.

For further details, check: **http://www.uplanet.com** or **http://www.mot.com.**
Contact: Unwired Planet, Tel: +1 415 596 5200; or Motorola, Tel: (01256) 790173.



Dual Full Bridge Motor Drive

The A3964SLB from Allegro MicroSystems is a dual bridge motor driver IC which provides pulse-width-modulated (PWM) current control of bipolar stepper motors.

The new device is capable of continuous output currents of up to ±800mA and has an operating voltage rating of up to 30V.

Contact: Allegro MicroSystems, Tel: (01932) 253355.

Ericsson Alliance Develops Integrated Portable GSM/PC Solutions

Ericsson has announced an alliance with Compaq, to develop portable PC GSM solutions that will enable mobile business users to seamlessly connect to the Internet or corporate Intranet, send faxes and e-mail and exchange documents. The first product resulting from the alliance will be available from the end of the year.

For further details, check: **http://www.ericsson.se.**
Contact: Ericsson, Tel: +46 70 590 9900.

Panasonic Strides into LCD Market

With the LCD monitor market still in its infancy, Panasonic has made its presence felt with the launch of a high-resolution flat screen display based on a 14in. TFT active matrix LCD panel. The PanaFlat LC40, costing a mere £2,950, is aimed at computer users that need the ultimate in monitor performance without sacrificing desk space.
For further details, check: **http://www.panasonic.co.uk.**
Contact: Panasonic, Tel: (01344) 853157.

NEWS BYTES

Microsoft Teams Up with Intel and Cisco

Microsoft, Intel and Cisco Systems have announced they will be working together to promote the development of multimedia applications, providing technical assistance to software developers and network operators. The three companies hope to set industry standards for multimedia products.

Don Listwin, senior vice-president of market development at Cisco Systems, told Electronics and Beyond, "This alliance signals that the networked computing age will be more about industry cooperation than industry fragmentation".

For further details, check: http://www.microsoft.com, http://www.intel.com or http://www.cisco.com.

Contact: Microsoft, Tel: (0345) 002000; Intel, Tel: (01793) 403000; or Cisco, Tel: (0181) 756 8000.

Intel Sues Rival Chip Makers

Intel has filed a legal suit against Advanced Micro Devices (AMD) and Cyrix, accusing the companies of infringing in the MMX trademark Intel says it has established for its multimedia-enhanced Pentium chip.

The suit alleges that AMD and Cyrix have designed and begun implementing strategies to improperly leverage Intel's enormous investment in the MMX trademark which could result in confusion in the minds of consumers as they make buying decisions. The suit seeks preliminary and permanent injunctive relief, along with unspecified damages and fees.

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

Contact: Intel, Tel: (01793) 403000.

BT Announces National and International ATM Service

BT has announced it is taking orders for CellStream, its national ATM service. The service is aimed at organisations with large and varied communications requirements between remote sites. It provides organisations with a flexible and cost-effective telecommunications backbone network for voice, video and data applications. In conjunction with MCI's HyperStream ATM service, BT's CellStream will also provide international connectivity to the US via Concert, their joint venture global services company.

For further details, check: http://www.bt.co.uk.
Contact: BT, Tel: (0800) 800152.

NEWS BYTES

City & Guilds Revises Radio Amateurs Exam

City & Guilds is proposing to simplify the format of the Radio Amateurs' Examination from May 1998. Following a request from the Radio Society of Great Britain (RSGB), it has been agreed that the revision will start in May 1998.

Currently, the examination is taken in two parts at a cost of £19.40 per paper. From May 1998, the two papers will be amalgamated into one paper of 80 multiple choice questions. The cost of the revised examinations will be reduced to £26.

Contact: City & Guilds, Tel: (0171) 294 2468.

PC Price Cuts

The price of notebook and portable PCs is sliding dramatically, to the extent that there will soon be little difference between the price of mobile and desktop computing.

Compaq the Presario 1060 by 10%. The notebook, which incorporates a 120MHz Pentium processor, 16M-byte EDO memory, 128-bit graphics, 1·0G-byte hard drive, and 11·3in. STN display, is now priced at £1,799, which is a saving of £200 on the original price of £1,999.

Meanwhile, Viglen has launched a new entry level notebook with a price tag from £1,380. The Dossier CL range comprises models based on Intel's 120MHz or 133MHz Pentium processors and all have PCI local bus architecture. Measuring 299 × 545 × 232mm and weighing 3·6kg, all models feature as standard a 10·4in. dual-scan colour screen, giving a 640 × 480 resolution and built-in multimedia stereo sound speakers and microphone.

For further details, check: `http://www.compaq.com` or `http://www.viglen.co.uk`.

Contact: Compaq, Tel: (0181) 332 3000; or Viglen, Tel: (0181) 758 7000.

PowerPC Chips Beat Intel at Speed

The PowerPC alliance between IBM, Apple and Motorola has inched ahead of Intel's next microprocessor generation with its G3 family chip, code-named Arthur, which is slightly faster and cheaper to manufacture than Intel's Pentium II chip – code-named Klamath – due out in the second quarter of this year.

The fact that the PowerPC chips generate much less heat than the Pentium chips will make them ideal for laptops, a market that will be critical for Apple in the next couple of years.

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

Contact: Intel: (01793) 403000.

Battery Breakthrough

Philips has developed a range of PowerLife batteries based on expanded graphite technology, which it claims last twice as long as conventional alkaline cells in power demanding circumstances such as in portable CD players and radios.

Batteries work by converting chemical energy into electrical energy. PowerLife's enhanced performance is due to high-grade graphite which means lower internal resistance to electrical currents and allows them to pass through the battery more efficiently, leading to less loss of energy.

Smaller particles of graphite mean that more manganese dioxide – the active material – can be contained in the battery, providing higher capacity. This lower resistance combined with increased battery capacity results in longer life.

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

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

VLSI FireGard Cryptography Chip Targets Cable Modem

VLSI has launched what it claims to be the first chip to provide a complete cryptography on a single piece of silicon, in the form of FireGard. It meets the requirements of the just announced Multimedia Cable Network System (MCNS) reference design. MCNS is a joint effort of seven leading cable service providers to provide new generations of cable-based information services.

The new VLSI chip, the FireGard security processor, will provide data cryptography and key exchange services at 27 to 38 million bits per second – up to 500 times faster than current generation telephone line-based modems.

The chip will incorporate the company's DES/triple DES encryption engine and RSA key exchange/authentication circuitry with an ARM RISC processor core and a MCNS-compliant bus interface block. Other circuit elements include blocks for power management, assurance logic, interrupt control, clock, system memory interface, on-chip SRAM, on-chip code ROM and the company's proprietary vROM secure read-only memory.

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

Contact: VLSI, Tel: (01908) 667595.

3Com Acquires US Robotics

In the largest ever deal in the networking business, 3Com has acquired modem-maker US Robotics for $6.6 billion, creating a combined company with $5 billion in annual revenues and more than 12,000 employees. 3Com's move will make it one of the two top competitors in the networking business, the other being Cisco Systems.

3Com, a market leader in LAN equipment, provides Ethernet adapter cards, hubs, switches and remote-access products. USR is a manufacturer of modem products, remote-access servers, enterprise communication systems and telephony products.

The transaction is expected to close by summer 1997 and is subject to approvals by federal regulators and the vendors' shareholders. 3Com, with revenue of approximately $2.8 billion, will take a quarterly charge when the deal is completed. USR has annual revenue of approximately $2.26 billion.

For further details, check: `http://www.3com.com` or `http://www.usr.co.uk`.

Contact: 3Com, Tel: (01628) 897000; or US Robotics, Tel: (0118) 922 8200.

IBM, Oracle, Sun and Netscape Collaborate on Network Computing Standards

IBM, Oracle, Sun and Netscape have joined forces to work together on open standards for network computing, demonstrating cooperation among industry leaders. The widespread adoption of these standards will allow corporate customers to conduct electronic business without having to worry about the underlying technologies.

As corporations extend their businesses from the enterprise to the Internet, they require industrial strength reliability, functionality and interoperability – a software infrastructure that is the equivalent of a dial tone for the Web. This unprecedented collaboration, which is open to broad industry participation, will join common interfaces, protocols, and procedures that will allow diverse software components to connect from clients to servers, through corporate intranets and extranets and the public Internet.

Building on the Object Management Group's CORBA and Internet Inter-ORB Protocol (IIOP) standards – the glue that enables software from different vendors to work together seamlessly – the planned levels of integration will allow the companies' software to work together as if it were created with the same development tools, in the same language, with the same runtime, on the same system.

Interoperability will enable software developers to build new applications by mixing and matching components created from a variety of application development tools, technologies and platforms, including IBM's VisualAge, Oracle's Network Computing Architecture (NCA), Sun's Internet Workshop, WebServer and Solaris products, and Netscape ONE (Open Network Environment).

For further details, check: `http://www.software.ibm.com`; `http://www.oracle.com`, `http://www.sun.com` or `http://www.netscape.com`.

Contact: IBM, Tel: (0990) 426 426; Oracle, Tel: (0990) 332200; Sun, Tel: (01276) 20444; or Netscape, Tel: + 33 1 41 97 55 44.

Time MEASUREMENT

by Douglas Clarkson

Time has increasingly become a key aspect of our modern times. Without a world-wide appreciation of its every passing instant, and the relativities of time in zones around the world, our modern society could not function. Also, as the link of telecommunications and computers increasingly integrates the world, so too, there are more clocks to synchronise.

A study of time measurement, however, reveals a vast history of human endeavour and application and encompasses understanding of physical science at many levels ranging from celestial mechanics, quantum physics and general relativity. The accurate measurement of time has been a lifelong dedication for a great many individuals and consequently, the amount of material that is touched upon in such a study is considerable. This is almost impossible to summarise in one article.

In the modern era, the importance of accurate time keeping was initially brought about by the requirements for navigation at sea – in particular, to know the longitude. The striving for an accurate time keeper or chronometer on board ships at sea was borne out of the need to navigate successfully around the world. At stake was the expansion of the British Colonies, the establishment of trade and being victorious in conflicts with rival maritime nations. Thus, the keeping of accurate time was not just a convenience to ensure that all guests arrived at a dinner party on time. The floors of the oceans are littered with wrecks of vessels whose navigators could not determine longitude accurately. In this regard, the keeping of time was relative to the solar day. It would be a great error, however, to consider that time was not important to much more distant cultures – far from it.

Ancient Keepers of Time

While the Greeks reflected an advanced knowledge of astronomy and geometry that gradually slipped from western culture, this appreciation of many of the subtler aspects of astronomy had certainly been a core of knowledge of even earlier cultures.

The builders of Stonehenge and Avebury in England, Callanish in the Outer Hebrides, the Ring of Brodgar in Orkney – not to mention the extensive systems of Carnac in Brittany, all reflect an understanding of the passage of the Earth around the sun and of the moon around the Earth. Linked also with this was consideration of various principal stars including Canopus, Capella and Sirius. Thus, using the features of the Earth (distant mountains, etc.), in association with man-made stone rings, avenues and ellipses, quite ancient societies were able to measure time, not in terms of seconds in a day, but in terms of days within a year for the solar calender and days within the 18·61 year cycle of the moon's orbit round the Earth. The moon has quite a complex orbit round the Earth, since not only is the orbit inclined to the ecliptic by about 5°, but the moon's orbit has an eccentricity of 0·0549.

There was also an appreciation in the Ancient World of the precession of the equinoxes, as in the cycle of around 25,920 years for the pole star to wander in a complete circle through the signs of the zodiac. The key point in this cycle is the point of the sky to which the Earth points at sunrise on the spring or vernal equinox. Recent speculation related to appreciations of the origins of the Sphinx in Egypt in the book *Keeper of Genesis* by Robert Bauval and Graham Hancock has provoked widespread interest. While conventional archaeologists point to the evidence of water-related erosion of the monument, it is quite revealing to determine that the giant lion-like edifice would have been looking directly on the horizon at the rising of the constellation of Leo in the year around 10500 BC – in fact, the date of claimed completion of the monument by these authors. This is, of course, the stuff that nightmares are made of for Egyptologists, who prefer to move the period of the building of the Sphinx to more like 2500 BC.

It is interesting to note that, according to Diodorus Siculus, book V of the first century BC:

'The disposition of the stars as well as their movements have always been the subject of careful observation among the Egyptians . . . they have preserved to this day, records concerning each of these stars over an incredible number of years, this study having been zealously preserved among them from ancient times.'

That point in time when records first began to be made is now being placed earlier and earlier by such new theories. Numerous cultures around the world shared this preoccupation with clocks in the sky. The book *In search of ancient astronomies,* edited by E. C. Krupp, provides a scholarly and well researched work on this topic.

There is no doubt, however, that the Egyptian civilisations have attracted the lion's share of archaeological interest. An interesting account of time keeping and in particular, calenders in the Mayan culture of South America, is given by Adrian G. Gilbert and Maurice M. Cotterell in the *Mayan Prophecies.*

Thus, in the past, the preoccupation with time was with how the Earth would interact with the cosmos – what external factors by way of alignments, oppositions, conjugations, etc. were or would be present with the inherent belief that such influences would influence the destiny of human affairs.

In the modern context, the preoccupation with time is with the 'instant' – the here and now. It turns out, however, that time is now one of those physical quantities that can be measured with excellent accuracy. An increasing number of physical parameters are being defined in

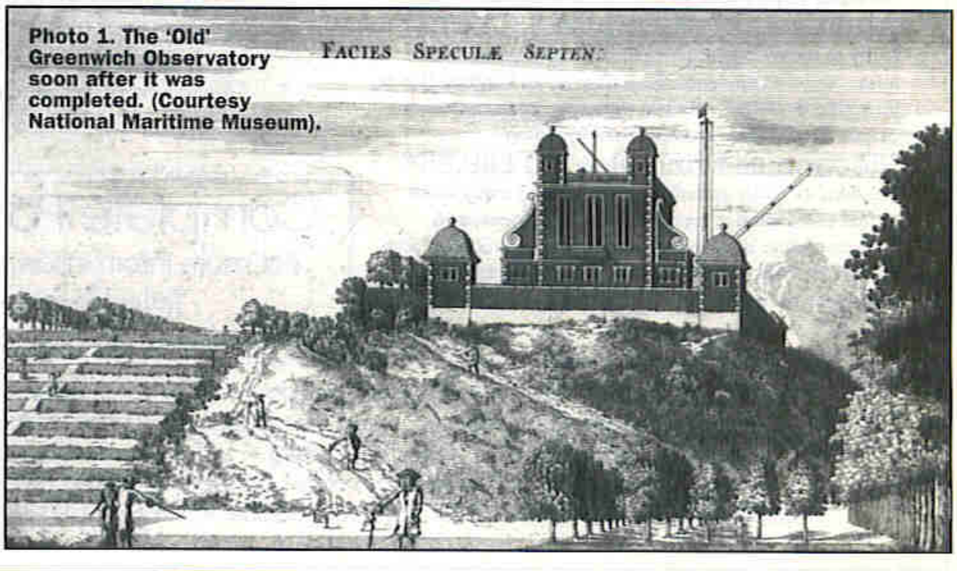


Photo 1. The 'Old' Greenwich Observatory soon after it was completed. (Courtesy National Maritime Museum).

terms of time as the defining standard. In fact, the history of the derivation of time as we know it is a fascinating tale. So much of what we take for granted in the way time is displayed and its value distributed has taken place only in the last 150 years.

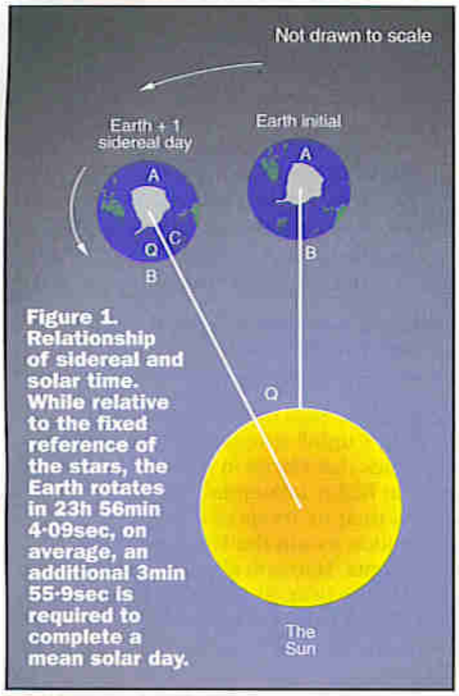


Figure 1. Relationship of sidereal and solar time. While relative to the fixed reference of the stars, the Earth rotates in 23h 56min 4·09sec, on average, an additional 3min 55·9sec is required to complete a mean solar day.

Solar and Sidearal Time

In the concept of sidereal time and solar time, sidereal time is that time referenced to the rotation of the Earth against the fixed background of the stars. Solar time relates to the apparent time interval of a day – e.g., the time between successive points in time when the sun is highest in the sky.

In Figure 1, the Earth is shown as revolving on its axis and with also moving to its present position one sidereal day later. Relative to Sidereal Time, one revolution of the Earth will translate point B to B. To complete a solar day, an extra time interval is required to bring the sun directly overhead at C – i.e., to complete a solar day. This additional time interval is, on average, 3 minutes and 56 seconds.

In Figure 1, the average angle, Q, is given by 360/365·25, being the total number of degrees in one revolution round the sun divided by the number of days of the year cycle.

$$\textit{Solar Day} = \textit{Sidereal Day} + \textit{Sidereal Day} \times \frac{Q}{360}$$

$$\textit{Solar Day} = \textit{Sidereal Day}\left(1 + \frac{1}{365{\cdot}25}\right)$$

$$\textit{Solar Day} - \textit{Sidereal Day} = \frac{\textit{Sidereal Day}}{365{\cdot}25}$$

= 3 minutes, 55·9 seconds.

Between successive days, the transit time of a star to a point on the horizon is 23 hours, 56 minutes and 4·09 seconds (1990 data) and the mean solar day is, therefore, very close to 24 hours. This was one way for clock makers to test out the accuracy of their earthly mechanical clocks where they did not have available a highly accurate mechanical timepiece.

Thus, solar time is not just influenced by the rate of rotation of the Earth on its own axis – it is modified by the angular velocity of the orbit of the Earth round the sun.

The eccentricity of the orbit is 0·017, meaning that ratio of minor to major axis of the ellipse. While the mean distance to the sun is $1{\cdot}496 \times 10^8$km, the length of the solar day is not constant for the Earth in orbit round the sun. The variability of difference between solar day and a sidereal day ranges from 3 minutes, 35 seconds to 4 minutes, 26 seconds.

When the Earth is further away from the sun, the sidereal day is closer to the solar day and when the Earth is closer to the sun, it is moving faster and so the solar day is longer. The Earth is, in fact, at aphelion (furthest distance) at around 3rd July and at perihelion (closest distance) at around January 4th. The main effect of this is to make successive solar days – e.g., timed noon to noon on successive days of variable length. What is relevant in this regard, however, is the concept of the mean solar day – the average length of the day during the year.

This effect is indicated in Figure 2, where the so-called Equation of Time relates how local solar time as indicated on a sun dial is fast or slow relative to a mean time, where days are defined to be of equal length. Thus, the correction varies from +16 minutes fast to 14 minutes slow during the year. For many types of activity, however, this degree of accuracy – when the sun was available – was quite adequate. For scientific and subsequently commercial practice, it was very unsatisfactory. The transits of the stars provided a more accurate clock in the sky.

A Non-Constant Earth

Everyone is familiar with the demonstration of the spinning ice skater, who with arms outstretched, spins at one speed and then with arms drawn in, spins at a faster speed – a demonstration of the conservation of angular momentum. The Earth can also be considered to possess a finite amount of rotational energy. Every kg of mass at the equator has a rotational kinetic energy of around 100,000J.

Changes in density of material deep within the crust of the Earth or changes in distribution of dense and light air masses on the Earth's surface can cause detectable fluctuations in the speed of the Earth's rotation as its rotational inertia fluctuates.

In addition to the seasonal fluctuations and also unpredictable wobbles, the dissipation of energy through tidal cycles is causing the speed of rotation of the Earth to slow down, so that days are – ever so slowly – getting longer. In a few million years, there could be exactly 365 days in the year instead of the current 365·25, although it is difficult to project present observations into the far future.

These two effects are in a way complications, which have added complexity to the measurement of time. While the effect of the non-constant length of the solar day due to orbital velocity variation round the sun was known to the ancient Greeks, the effect of variation in speed of rotation of the Earth was only measurable with more accurate clocks from around 1920 onwards.

Ancient Clocks

The Moons of Jupiter and Pendulums

The ancient Egyptians around 700 BC used so called shadow clocks to tell the time. These consisted essentially of a raised rectangular block on top of which a horizontal rod was mounted. The day was marked into a mid day shadow line and five distinct hours that would apply to both morning and afternoon. In use the device was laid flat on the ground and pointed in the direction of the sun.

The Clepsydra or 'water thief' clock was used by the ancient Greeks and Egyptians – being essentially a vessel initially filled with water and which emptied in a set time. Presumably there would have been a slave whose duty it would have been to refill it and keep a tally of the refills during the day.

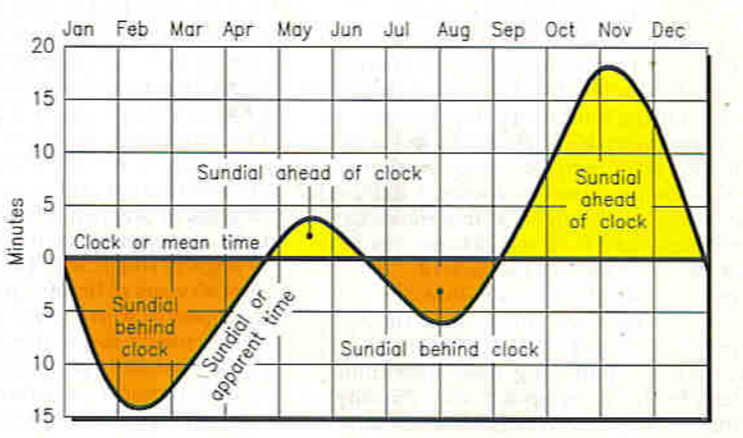
The ancient Chinese water clock consisted of a series of around six vertically mounted vessels which slowly drained into each other. Water was initially added at the top and the time noted for the level in the lowest collecting vessel to change by set amounts.

Sand clocks were later developed in Europe, typically in units of 15, 30, 45 and 60 minutes. In the reign of King Alfred, time at court was kept using candle clocks marked in hour extents. For most of the population, however, activity was essentially regulated by the sun. It was only around 1335 onwards that there are reports of mechanical clocks with these being developed initially in Italy.

The Greenwich Connection

The Greenwich Old Observatory has played a pivotal part in the determination of time for the whole world. This role relates both to the measurement of time in terms of high accuracy from timekeeping and also to

Figure 2. The Equation of Time of the difference of apparent solar time from mean solar time.



setting Greenwich as the zero meridian of longitude. In our current modern age when the importance of our maritime role is significantly reduced, the legacy of setting the standards for time serves as a major memorial of the age when Britannia did rule the waves.

In one sense, the origin of the Observatory at Greenwich is quite clear. King Charles II signed a royal warrant for its establishment on the 4th March 1675. The actual set of events that led to this result, however, are rather more obscure, and involve the king's mistress, Louise de Kerouallé and a Frenchman, St. Pierre, who proposed a method of lunar measurements and predictions to calculate longitude. The observatory was basically initiated in order to establish a core of observational data that could lead to the successful implementation of such a scheme. It is perhaps no coincidence that some years previously, Louis XIV had established in 1666, the French Academie Royale des Sciences, principally to solve the problem of longitude through astronomical observation.

Photo 2. Illustration of John Flamsteed, the first Astronomer Royal. (Courtesy National Maritime Museum).

The Royal Observatory at Greenwich was designed by Sir Christopher Wren and with observations beginning by John Flamsteed – the first Astronomer Royal – in around October 1676. Flamsteed's star catalogue, which had taken around 40 years to compile, was published posthumously in 1725. Photo 1 shows the Old Greenwich Observatory soon after it was completed and Photo 2 depicts John Flamsteed.

Two so-called 'great clocks' were ordered to be made for the observatory by Thomas Tompion, a leading London clockmaker, and were set going satisfactorily together on 24th September 1676. These clocks had a 13ft. long pendulum for a 2 second period, used a new pin-wheel escapement and used very heavy weights in order that the clock would only have to be wound once per year. This was really the first instance of determination of Mean Solar Time at Greenwich. Flamsteed in fact used the transit of the bright star Sirius as a time reference for monitoring Mean Solar Time as kept by the 'great clocks'. The reliability of these clocks was around seven seconds per day. Flamsteed's work was indeed an uphill struggle, based on the meagre allowance he had been allocated to undertake his work.

One of the key parameters measured was the time at which the sun was highest overhead – at noon. From 1676 to 1725, the method used was that of Double Altitude or Equal Altitude, when the time that the sun attained a fixed altitude a set time before noon was compared with a corresponding set time after noon. The time of apparent noon (by sun's position) was then calculated. Applying the correction of the Equation of Time then gave the Mean Solar Time.

The invention of the transit instrument by Ole Romer led to the introduction of such an instrument by Edmond Halley in 1721 at Greenwich. This telescope device had essentially only one degree of freedom, with the axis of telescope in east west direction fixed. This was in time replaced by Airy's transit circle in 1851, and which continued to be used until 1927.

John 'Longitude' Harrison

The loss of five warships off the Scilly Isles on the foggy night of October 22nd 1707 with the loss of 2,000 troops focused attention on the need to improve navigation methods. This resulted in the passing of the Longitude Act of 1714, which offered a prize of £20,000 for solving the problem of finding longitude at sea. In this method, there were two main rivals – that of astronomy and that of accurate time keeping. As time progressed and mechanical invention developed, so did the science of astronomy.

Significant progress towards the development of an accurate chronometer for sea navigation was to come not from the more famous clock makers of London such as Thomas Tompion and George Graham, but rather, from a certain John Harrison from Barrow-on-Humber in Linconshire. Having been apprenticed as a carpenter, John Harrison soon migrated to making clocks. Not apparently having received formal training in such a craft, Harrison revisited many of the problems of accurate time keeping and came up with highly original and advanced solutions. He found it possible to use special types of self-lubricating wood for key elements of his clock movements, which allowed clocks to operate without lubrication. Also, in the design of pendulum clocks, Harrison combined brass and steel in pendulums to ensure that the pendulum had a length essentially independent of temperature. Also, he developed the 'going ratchet' to keep the clock ticking while it was being wound.

Harrison visited London in 1730 and was well received by Astronomer Royal, Halley and George Graham a famous London watchmaker – giving encouragement in the quest for the development of an accurate timepiece to win the coveted Longitude Prize established by Act of Parliament.

In order to win the prize, however, Harrison had to evolve completely new designs. At sea, pendulums had a nasty habit of stopping due to the violent motion of ships in rough seas. He would spend the next 40 years of his life both perfecting the mechanisms with the aim of claiming in full the payments assigned by the Longitude Act. Dava Sobel's book gives a good account of this innovative period of timepiece design. It is a fascinating story.

Table 1 gives a summary of the main events in the saga of John 'Longitude' Harrison's uphill struggle. One of the major difficulties that Harrison was to experience was that highly influential astronomers wanted their methods of astronomical observation to win the Longitude Prize. By all accounts, Harrison should have been awarded the prize in 1762, but he was to have to wait until 1773 following intervention by the King, until some redress was made.

Date	Event
1730	Received in London
1735	Completes H1 clock
1736	Successful trials onboard HMS Centurion
1741	H2 presented to Board of Longitude
1757	H3 essentially complete
1759	H4 completed
1761	Sea trial of H4 on HMS Depford
1762	H4 accuracy verified but not credited
1765	Parliament changes rules of Longitude Act
1766	H1, H2, H3 and H4 removed to Greenwich
1770	H5 completed
1772	Captain Cook uses K1 copy of H4
1773	Belated payment of L8750 to Harrison
1775	Captain Cook vindicates K1 accuracy
1776	Death of John Harrison

Table 1. Key events in saga of John 'Longitude' Harrison.

The accuracy of H4, had been verified in 1762 as losing only five seconds after 81 days at sea. H4 was a very exceptional watch – a miraculous watch in some respects. Lesser watches were subsequently made as official copies but they omitted various key features of the original mechanism design.

John Harrison's timepieces not only improved the accuracy of clocks and watches in general, it allowed safer navigation of the sea with all the implications for trade and establishment of colonies overseas.

The London watchmaker, Lacrum Kendell, was given H4 to copy, making the famous timepiece K1 and later, a less accurate K2. K1 was used with great success on Captain Cook's second voyage, from which he returned in 1775. K2 was used by the mutineers on board HMS Bounty to find Pitcairn Island. During this period of horological history, necessity was very much the mother of invention.

Before long, chronometers of acceptable quality were widely available. It was common, however, for reliance not to be placed on a single timepiece. Thus, when HMS Beagle set out in 1831 with Charles Darwin on board, a total of 22 chronometers were in use.

The End of Local Solar Time

In the early 1800s, while there were a great many clocks in the land, it was the custom for them to show local solar time. Thus, clocks in Norwich could be 6 minutes ahead of Greenwich and clocks in Plymouth, 16 minutes behind. This caused the greatest problem for the operation of Railway Timetables. It was however, not until 1840 that the Great Western Railway established Greenwich Mean Time at all of its stations. Gradually, over a period of ten years, other railway companies also began to use Greenwich time.

With the implementation of telegraph lines, Greenwich from around 1850 onwards began to act as the source of time synchronisation signals across the UK. The adoption of Greenwich Mean Time (GMT), however, was more progressive than universal, with some 98% of public clocks in Great Britain being set to GMT by 1855. It was not until 1880 that GMT became the legal time also for commerce and industry in Britain.

Towards Global Time Standards

It was one thing for one country to adopt a national time standard – quite another for there to be global agreement regarding time. It was only at the International Meridian Conference in Washington DC in 1884 that a consensus was adopted for the definition of the length of the day, viz: 'That the universal day is to be mean solar day; is to begin for all the world at the moment of mean midnight of the initial meridian, coinciding with the beginning of the civil day and date of that meridian; and to be counted from zero up to twenty-four hours'.

This conference also accepted 'the adoption of the meridian passing through the centre of the transit instrument at the Observatory at Greenwich as the initial meridian for longitude'.

Up until this point in time, there were at least eleven other contenders for other points of origin for the meridian – with Paris the main rival. It was the fact, however, that some 72% of global shipping were using maps with the Greenwich meridian for navigation that led to the choice of Greenwich as the prime meridian.

This subsequently allowed the formalisation of time zones around the world, with generally zones of one hour corresponding to 15° of longitude. Since then in many respects, time has seen some subtle refinements but no major re-definitions.

The New Time Machines

The accuracy of clocks used for astronomical purposes and time reference improved during the 19th century. In 1870, the Dent number 1906 of Airy kept time to an accuracy of 0·1 seconds per day. Around the turn of the century, significantly more accurate clocks produced by Sigmund Riefler of Munich became available. In the 1920s, so-called free pendulum clocks produced by W. H. Shortt in the UK became available with an accuracy of 10 seconds per year. In the free pendulum clock, the time is maintained by a free pendulum in an evacuated chamber and synchronised to time with a slave pendulum in a normal atmosphere.

The development of quartz as a resonator material provided a superior means of measuring time compared with mechanical clocks. Quartz, however, was sensitive to environmental conditions of temperature and vibration. Also, quartz crystal underwent a gradual ageing process which gradually altered its resonant frequency with time. Initially, resonant frequencies around 100kHz were used at Greenwich between 1939 and 1964, though subsequently higher frequencies were used. Typical accuracies of high precision quartz clocks was of the order of 0·1ms per day.

For the modern wristwatch, the accuracy of quartz to a few seconds per week is entirely adequate. Photo 3 shows the component parts of the Seiko Kinetic movement with quartz oscillator.

Atomic Clocks

It seems that although time is being measured with ever increasing accuracy, there is always the perception that even greater accuracy is required. The advent of quartz clocks in the 1940s provided an accuracy of around 0·1ms per day. This was not, however, of sufficient resolution to investigate specific tests relating to relativity. Some pioneering work was undertaken with atomic beam resonance at Columbia University in the 1930s. The first atomic clock to be used in earnest was one at NPL in 1955 and developed by John VL Parry. In 1967, the second was defined as 9,192,631,770 periods of the resonance of Cs 133 atom. The Q of such a resonator, the ratio of the frequency divided by the line's frequency spread, is of the order of 100 million. For such clocks, the reproducibilities are of the order of 1 in 10^{14}.

The atomic beam frequency standard is indicated in Figure 3. A source of atoms is obtained by heating Caesium atoms by a filament lamp. Atoms of appropriate energy state selected by magnet A pass into a resonant microwave cavity where their energy is changed to a second level and with magnet B deflecting these to a detector. The system incorporates a servo mechanism to optimise the current of Caesium atoms detected and hence to resonant frequency of the microwave cavity.

Recently, atomic hydrogen masers have been developed, which allow improved performance at a lower frequency of around 1,420MHz. Initial problems with the poorer stability of the resonant cavity have been overcome to make atomic hydrogen masers the atomic clock of choice for several national laboratories, including that of the NPL in the UK. The Q of such a resonator is of the order of 10^{9} and with a frequency stability better than one part in 10^{15}.

Another clock which is commercially available is that of Rubidium 87 at a frequency of 6,836MHz. While such sources are less expensive, their reproducibly is only of the order of one part in 10^{10}.

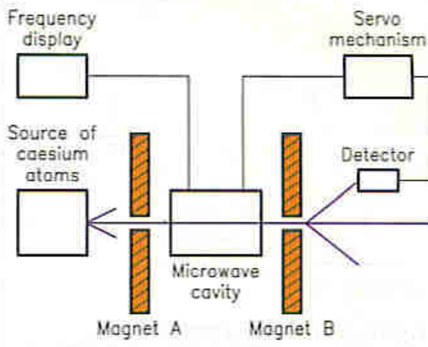


Figure 3. Schematic diagram of Caesium beam atomic clock.

Lonely Cold Ions

Investigations, however, continue in the search for even more accurate methods of measuring time. Trapped atoms suspended in a vacuum and isolated from disturbing influences have been made to resonate with stabilities comparable or equal to that of the hydrogen maser. In the so-called atomic fountain, atoms are nudged into a resonant microwave cavity by a series of laser beams so that the atoms suffer no spectral broadening through collisions with containment walls. A resonant Q of such systems of 1013 has been observed in work at NIST in the USA. The problem with such systems, however, is that they have not been operated over extended periods. Perhaps, however, this technology will provide a natural end point for the accuracy of time measurement.

Recent work at the NPL has reported on using trapped Ytterbium ions cooled to within 0·5mK as a means of obtaining an ultra-stable 467nm clock transition. While the best Caesium clocks give a stability of 3 parts in 10^{13} per day, this ion trap technique could provide an additional factor of a thousand in line stability. Figure 4 summarises the details of the sequence of ions cooling, energy absorption and recycling of ion energy system.

Initially, the Ytterbium ion is in a reference state. The ion is irradiated by a laser beam at around 369nm, just below an absorption transition of the ion. If the ion moves toward the photons, the doppler effect increases the energy of the photon and the ion absorbs it – absorbing momentum and in effect slowing it down. This continues until the ion is more or less stopped. If another laser is tuned around·

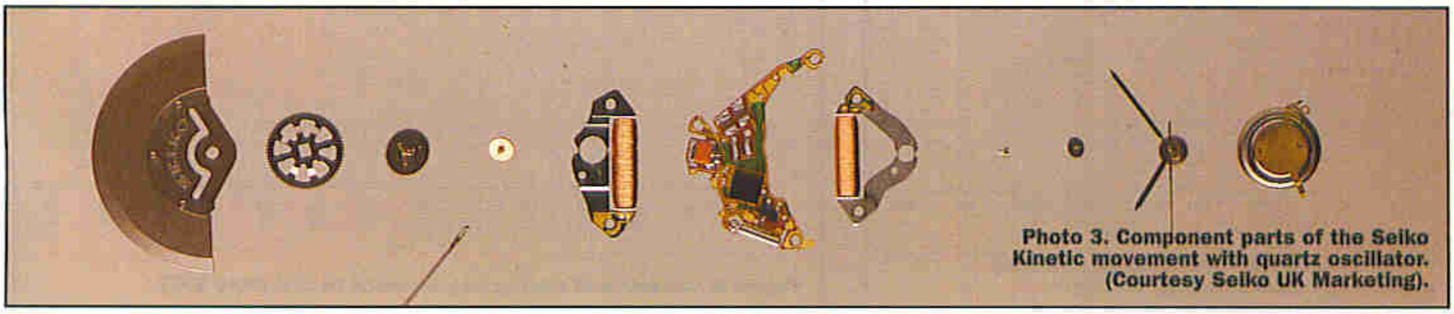


Photo 3. Component parts of the Seiko Kinetic movement with quartz oscillator. (Courtesy Seiko UK Marketing).

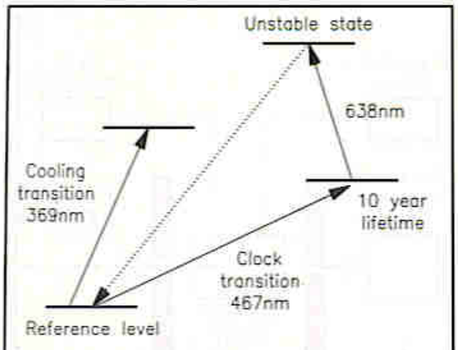


Figure 4. The ultra-stable 467nm absorption is achieved by cooling the ion to close to absolute zero. The ion is 'recycled' by raising it to a higher level which in turn decays rapidly to the reference level.

Date	Event
1884	Greenwich Mean Time adopted as Universal Time (UT)
1952	Ephemeris Time (ET) introduced
1956	UT0, UT1, UT2 defined as sub-divisions of UT
1956	Ephemeris Second defined
Jan 1, 1958	TA1 (Atomic Time) commences
1967	Second defined in terms of Cs periods of radiation
Jan 1, 1972	Coordinated Universal Time (UTC) established

Table 2. Key events in determining time standards.

467nm, the ion absorbs this energy and the ion remains in a higher stable state. It would probably remain in this state for 10 years through natural lifetime processes. A laser at 638nm, however, is used to raise the energy to a higher state which rapidly decays to the starting level. The uncertainty in the frequency of the 467nm transition is only 0·5nHz which in turn provides an uncertainty of 1 in 1018. This is typically better by a factor of 10 million compared to state-of-the-art stabilised He-Ne reference lasers. Such a technique could well be the basis for future design of atomic clocks for resonance at the ultra-stable transition wavelength. Figure 5 summarises the increasing accuracy of achieved by clocks through history.

Towards Universal Time

There is a perception that there can only be one time for everybody. Allowing for time zones, then the minutes and seconds tick all over the world the same (except in time zones with 0·5 hour divisions). Current time is described as Coordinated Universal Time (UTC). There have been various key initiatives, however, in establishing UTC.

While time as Universal Time had been defined as established by Greenwich Mean Time in 1884, the advent of radio which allowed time signals to be sent rapidly round the world revealed that various stations could be several seconds adrift. It was the French who, in 1912, established the Bureau International de l'Heure (BIH) to co-ordinate accuracy in time keeping. This group did not formally function until around 1920.

From more accurate measurements of the Earth's rotation using more accurate clocks, it became apparent that the value of the mean solar day was changing very slowly. It became desirable to use instead the year as the measure of time scales. Even though the year is slowly decreasing by about 0·5 seconds per century, this would provide a more stable reference. Thus, in 1952, the so-called Ephemeris second was defined as the fraction 1/315,569,25·9747 of the tropical year for 1900 January 0d 12h ephemeris time.

While this provided a more stable basis for time measurement, and the second had been defined in terms of a time period that had occurred and, therefore, had a finite value, the problem of lack of accessibility remained. No one could produce, for example, a traceable pulse of signal exactly one second long.

The adoption of the atomic clock standard was to solve this with the formal adoption of the atomic second in 1967. Prior to this, the atomic clock had started ticking on January 1st 1958 and defined within TA1 (Atomic Time). The UTo (Earth time) was gradually losing seconds by this time. On January 1st 1972, a new time, Coordinated Universal Time (UTC), was defined as 10 seconds slow on TA1 (Atomic Time). The BIH in Paris currently coordinates the world 'mean' atomic clocks based on the time held by around 200 high precision atomic clocks. Thus, time as we know it is still subject to the vagaries of statistics. Table 2 summarises the main sequence of events in establishing time standards.

The point about the scales of time is that absolute accuracy is required for astronomy and modern communications technology. At the same time, it is required that the noon 'pip' of UT1 (close equivalent of Greenwich Mean Time) occurs within 0·9 seconds of noon according to the average transit of the sun. At present, leap seconds are being added at the rate of typically one per year – reflecting the fact that compared to the Ephemeris day of 1900 – the mean solar day of that year, the Earth is now rotating more slowly. The formal year as we know it is only reducing by around 0·5 seconds per century. Figure 6 indicates how leap seconds have been added to the UTC since 1972. Planned leap seconds are notified well in advance by the BIH in Paris.

Awareness in Time: The Türler Cosmic Clock

While time is something that is being charted with increasing accuracy, the awareness of where we are in time – its expression, as it were, of its passing is still subject to human inventiveness. The Türler Swiss watch company, founded in 1883, has

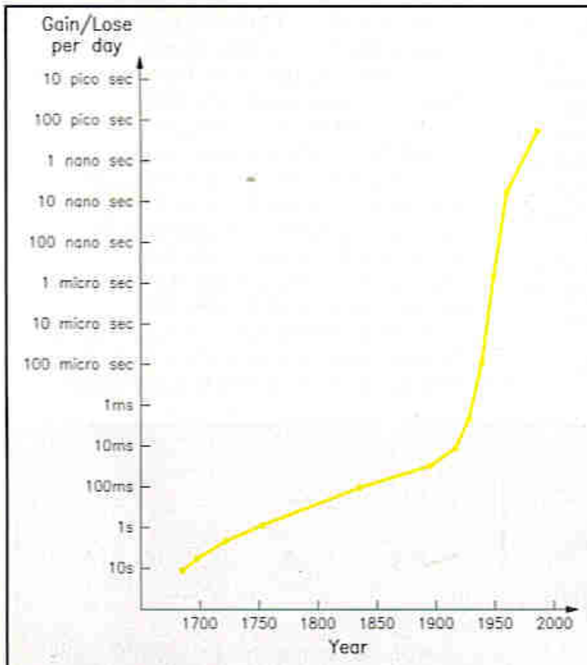


Figure 5. Sequence of increasing accuracy achieved by clocks through history.

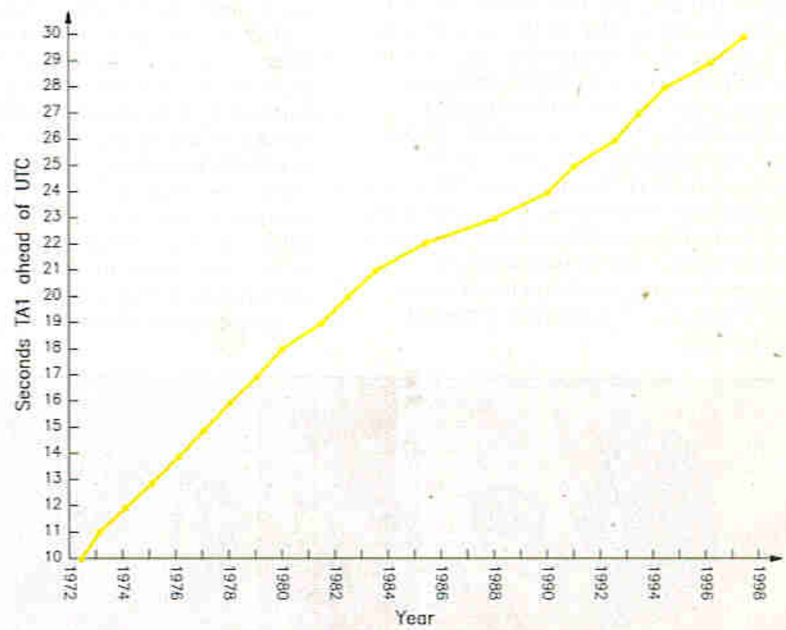


Figure 6. Incidence of adding leap seconds to UTC since 1972.

Photo 4. Main details of the Türler Clock of the Cosmos. (Courtesy Türler Uhren & Jewelen 1883).

always maintained a high standard of quality in watch design and manufacture. It was fascination with the aura surrounding time that inspired the present head of the company, Franz Türler, to create a clock 'of unique perfection' – and 'a work of art, timeless and of lasting value'.

To turn these aspirations into reality was to take nine years of planning and development. The end result is the Türler Clock – a model of the cosmos. This clock, whose main details are shown in Photo 4, combines in a way all the previous clocks that man has tried to build to describe sidereal time, solar time, rotation of the moon and the Platonic year of 25,794 years as the Earth completes one cycle of precession about its axis. The four components of the clock comprise the Globe, the Perpetual Calendar, the Planetarium, the Tellurion and the Horizon.

The Globe, shown in more detail in Photo 5, provides a snapshot of the relative rotation of the Earth, moon, sun and stars as perceived from an outside observer gazing in from the solar system. The Perpetual Calendar provides the time in hours and minutes and with four smaller inner dials indicating the day of the week, the day number in month, the month and the year in decade century and millennium. Full corrections are implemented for leap days on 29th February and with dropping leap day every 100 years and adding it again every 400 years, in accordance with full Gregorian calender.

The Planetarium encompasses the nine planets of the solar system, from Mercury with an orbit of 87 days, to that of Pluto of 247 years. It provides, therefore, a mechanical view of cosmic reality.

The Tellurion indicates with reference to a model globe of the Earth, the positions of the sun and moon and on the outer rim, the position of the sun in terms of the ecliptic, zodiac and month is displayed.

The Horizon is a novel representation of the paths of the sun and the moon, as visible at the location of the clock on the physical horizon. Events are indicated in terms of a 24-hour clock showing local mean solar time.

The Swiss Watch Industry

After suffering the destabilisation of the era of the dollar quartz watch, the Swiss watch industry, emphasising its skills in craftsmanship and quality, is still a major industry. In 1994, for example, exports totalled some SF 8 billion. While companies like Swatch have tried to recapture the mass production market, a core of companies in the famous Joux Valley, including Audemans Piguet, Blancpain, Jaeger-LeCoultre, Daniel Roth, Nouvelle Lemania, Dubois-Depraz and Fila, maintain the highest standards of quality and tradition. The focus of economic activity to high value products tends, therefore, to produce an economy which is inherently stronger. The Gross Domestic Product of Switzerland per person at around $35,000 is over twice that of the UK.

The NPL Time Services

MSF 60kHz Time and Date Code (Rugby clock)

This radio transmission is the principal means of communicating time within the UK, and broadcasts effectively UTC Coordinated Universal Time, which is always within one second of Greenwich Mean Time. With a transmitter power of 27kW, the signal can also be received widely in western and northern Europe. The carrier frequency is maintained at 60kHz within one part in 10^{12}.

Data from the clock is presented second-by-second with identification of details of seconds within minutes. The modulation used is simple on/off modulation. Figure 7 indicates the normal appearance of the identification of the second 00 – effectively a minute marker and appearance of subsequent seconds. The modulation is typically switched off for an interval of 500ms. In addition, however, other modulated information can fill this slot – presumably, test data of some kind. In each of the following seconds, the first 100ms is always OFF and with the next two intervals of modulation of 100ms, either ON or OFF, thus assigning values to bits A and B

Photo 5. Detail of the Globe of the Türler Clock. (Courtesy Türler Uhren & Jewelen 1883).

within the specific second. Data is primarily contained with bits 17A to 51A of the time signal within each second. Thus, from switch on, as it were, the clock needs a complete minute to recover all the data from the transmission regarding time, date, etc. Thereafter, the signal is principally updating the second details of the time. Table 3 indicates the year coding utilised and Table 4, the month, day in month and day of week.

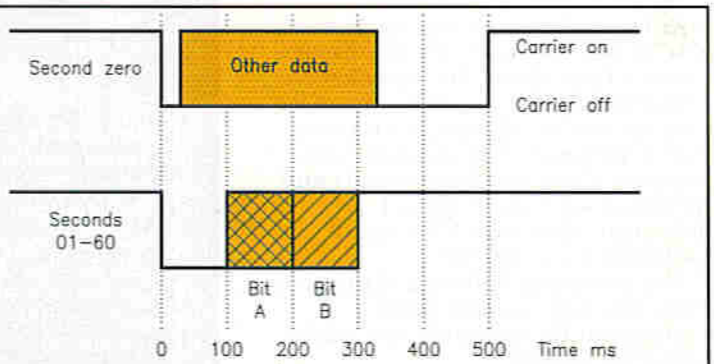
Last but not least, the time in hours and minutes is given by details as presented in Table 5.

Bits 9B to 16B are used to indicate the difference between UTC and UT1 (closely equivalent to GMT) to the nearest 100ms in range +800ms to -800ms.

NPL Truetime

NPL Truetime is a recently introduced time service that allows computer clocks to be set within one fiftieth of a second by direct telephone connection to the national time scale maintained by NPL. This time reference at NPL is itself based on an atomic clock which is itself maintained within one millionth of a second of Coordinated Universal Time (UTC). Data is currently set using V22 1,200-baud standard with eight data bits, no parity and one stop bits. Data is sent in strings of characters which are numbered 01, 02, ...77. More complete details are included in NPL information sheet reference CETM h 099. Table 6 summarises key parameters communicated by NPL Truetime.

Figure 7. Waveform of Rugby clock signals in the first and subsequent seconds.



Code	Function
17A	Year × 80
18A	Year × 40
19A	Year × 20
20A	Year × 10
21A	Year × 8
22A	Year × 4
23A	Year × 2
24A	Year × 1

Table 3. Year value decoding.

Code	Function
25A	Month × 10
26A	Month × 8
27A	Month × 4
28A	Month × 2
29A	Month × 1
30A	Day of Month × 20
31A	Day of Month × 10
32A	Day of Month × 8
33A	Day of month × 4
34A	Day of month × 2
35A	Day of month × 1
36A	Day of week × 4
37A	Day of week × 2
38A	Day of week × 1

Table 4. Month, day of month, day of week decoding (0 = Sunday).

Code	Function
39A	Hour × 20
40A	Hour × 10
41A	Hour × 8
42A	Hour × 4
43A	Hour × 2
44A	Hour × 1
45A	Minute × 40
46A	Minute × 20
47A	Minute × 10
48A	Minute × 8
49A	Minute × 4
50A	Minute × 2
51A	Minute × 1

Table 5. Month, day of month, day of week decoding.

Parameter	Details
Date	YYYY-MM-DD format
Time	hh:mm:ss format
local time	e.g., UTC+0 during GMT and UTC+1 during BST
day of week	Monday = 1 – 7 = Sunday
Week of year	week 01 contains first Thursday of year
DUT1	difference in 0·1 sec UT1 and UTC
LEAP SECONDS	announcement of pending leap seconds
Julian Date	Modified Julian Date – day value

Table 6. Key parameters communicated by NPL Truetime from 0891 number.

More complete details are given in NPL data sheet CETM h098. The number of NPL Truetime is (0891) 516 333 and can only be dialled from inside the UK. NPL Truetime provides direct traceability to the National Time Standard. There are a range of clocks that detect Rugby time. One interesting system provided by Timenet Ltd. serves as an add-in card to a PC to enable on line time keeping to be achieved.

Interconnected Units

The definition of the metre is related to 1/299,792,458 part of a second and the volt is defined in terms of the characteristic frequency associated with a voltage that appears across a Josephson junction in a superconducting circuit. Thus, improving the accuracy of time allows more accurate measurement of a range of related physical parameters.

Relativistic Effects

Just as it required clocks of improved accuracy to detect the variations in the rate of rotation of the Earth, so too, it required the development of clocks like the atomic clock to detect relativistic effects. One such effect relates to the relationship between the frequency of a photon of energy and the gravitational field in which it is emitted. If, at the surface of the Earth, a photon of light is emitted with a frequency *fo*, then at a height one metre higher, the frequency will be higher by one part in 10^{16}. This is part of the general effect of gravity lowering the energy of a quantum state. Thus, there is implied in this effect, the reference height at which standard measurements are made for the world's set of atomic clocks. This effect is a necessary correction to apply for atomic clocks held onboard Global Positioning Satellites in geostationary orbits round the world.

Also, there is an effect in respect of the non-uniformity of the velocity of the Earth round the sun – the very variation in orbital speed that resulted in the Equation of Days which corrected mean time against apparent solar time. This, coupled with the variation in sun's gravitational potential, makes TA1 run faster by about 6·6 parts in 10^{10} at aphelion around July 3rd compared to that at perihelion – around January 4th. The effect of this in a whole year is around 3·3ms. These relativistic effects probably are detectable and have to be corrected for in GPS technology.

Greenwich Meridian 2000

In the words of the 1884 International Meridian Conference, the universal day 'is to begin for all the world at the moment of mean midnight of the initial meridian'. This is taken as meaning that the prime Meridian at Greenwich is the point from which the new millennium will begin.

The 1000 Day Countdown to the new millennium began on Friday 4 th of April 1997 as indicated by unveiling of the Accurist Millennium Countdown Clock at Greenwich.

Summary

In the efforts of the individuals to investigate and measure time can be traced also the rise of the once supreme maritime nation of Great Britain. The confusion over the relevance of Greenwich in terms of the celebration of the Millennium is no more than an indication of the ignorance of the greatness of past days. Can you think what the French would do in terms of Millennium celebrations if the zero of longitude ran through Paris?

Also, in response to the age old question, 'What time is it?' – as after-dinner conversation, the reply could very well be long in the extreme.

References

Longitude: the true story of a lone genius who solved the greatest scientific problem of his time,
Dava Sobel, Fourth Estate, London, 1996.

Greenwich Time and the discovery of the longitude,
Derek Howse, Oxford University Press, 1980.

Accurate measurement of time,
W. M. Itano and N. F. Ramsey, Scientific American, July 1993, 46-53.

Sun dials: Their theory and construction,
A. E. Waugh, Dover Publications, New York, 1973.

MSF 60kHz Time and Date Code (Rugby Clock),
published by NPL, reference CETM h 099.

The Leap Second,
published by NPL, reference CETM h 101.

In search of ancient astronomies,
edited by E. C. Krupp, Chatto and Windus, 1979.

Keeper of Genesis,
Robert Bauval and Graham Hancock, Mandarin, 1996.

The Mayan Prophecies,
Adrian G. Gilbert and Maurice M. Cotterell, Element, 1995.

Swiss Quality Timing,
Spring 1996, SQP SA Elena Cicurel (Türler Clock).

Cold-ion optical clock is the future of calibration,
Oliver Graydon, Opto and Laser Europe, March 1997, 30-31.

Points of Contact

National Physical Laboratory (NPL),
Electromagnetic and Time Metrology,
Teddington, Middlesex,
United Kingdom TW11 OLW.
Tel: (0181) 977 3222,
Fax: (0181) 943 6458.

National Maritime Museum,
Picture Library,
Greenwich, London, SE10 9NF.
Tel: (0181) 312 6631.

Timenet Ltd.,
PO Box 35, Washington NE 38 7YZ.
Tel: (0191) 417 8288,
Fax: (0191) 419 3893.

Türler Uhren & Jewelen 1883,
Paradeplatz, CH-8001 Zurich, Switzerland.
Tel: (00411) 221 3838,
Fax: (00411) 221 1472.

Naval Observatory,
Washington DC.
Tel: (001) 202 762 1401
(time signal speaking clock).

The Antiquarian Horological Society,
'New House', High Street, Ticehurst,
East Sussex, TN5 7AL.
tel 01580 200155

The Worshipful Company of Clockmakers,
Room 66-67, Albert Building,
49 Queen Victoria Street,
London, EC4N 4SE.
tel 0171 606 3030

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.

May 1997

2 to 4 May. Internet Live, Earls Court, London. Tel: (0181) 948 1666.

12 May. Visit to the Technical Operations Centre, BBC Transmissions, Warwick, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon.
Tel: (01789) 740073.

13 to 14 May. Property Computer Show North, Royal Armouries, Leeds.
Tel: (01273) 857800.

13 to 15 May. Technology Transfer Exhibition, NEC, Birmingham.
Tel: (0181) 302 8585.

20 to 22 May. Internet World, Olympia, London. Tel: (01865) 388000.

26 May. Discussion Night, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

June 1997

June 1997. Barnsley & District Amateur Radio Club coach trip to Friedrichshafen Hamfest, staying near island of Lindau for 6 nights. Further information from Ernie G4LUE, 8 Hild Avenue, Cudworth, Barnsley, South Yorkshire S72 8RN.
Tel: (01226) 716339,
Mobile (0836) 748958.

2 to 5 June. CIRED – 14th International Electricity Distribution Conference and Exhibition, ICC, Birmingham.
Tel: (0171) 344 5478.

3 to 6 June. UKCMG Annual Conference and Exhibition, Riviera Centre, Torquay.
Tel: (01635) 32338.

9 June. Two Metre Direction Finding Competition, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

18 to 19 June. Government Computing and Information Management, Royal Horticultural Halls, London.
Tel: (0171) 587 1551.

18 to 19 Nov. Workplace '97, Olympia, London. Tel: (0181) 910 7910.

23 June. Technology Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon.
Tel: (01789) 740073.

24 to 26 June. Database Expo, NEC Birmingham. Tel: (0181) 742 2828.

24 to 26 June. Networks '97, NEC Birmingham. Tel: (0181) 742 2828.

24 to 26 June. Software Development '97, NEC Birmingham.
Tel: (0181) 742 2828.

24 to 26 June. Systems '97, NEC Birmingham. Tel: (0181) 742 2828.

29 June. Radio Rally, Longleat, Wiltshire.
Tel: (01707) 659015.

June 1997

7 July. Seventh International Conference on HF Radio Systems and Techniques, IEE, East Midlands Conference Centre, Nottingham. Tel: (0171) 344 5469.

11 July. Fifth International Conference on Holographic Systems, Components and Applications, University of Bath, Tel: (0171) 344 5467.

14 July. Summer Social Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

28 July. Construction Competition, Stratford-upon-Avon and 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 3, Rayleigh, Essex SS6 8LU or e-mail to swaddington@cix.compulink.co.uk.

What's On?

TriMedia Takes Best Multimedia Hardware Award at CeBIT

Philips Semiconductors' TriMedia TM-1000 media processor collected the 'Best Multimedia Hardware Award' at the CeBIT best of show awards in Hannover, Germany, during March. The TM-1000 media processor brings broadcast quality video, multi-channel audio and photo realistic interactive graphics to the PC.

For further details, check: **http://www.semiconductors.philips.com.**
Contact: Philips, Tel: +31 40 272 20 91.

Intel Outlines How to Make Money and Save Money During Internet World Keynote

Making money and saving money on the Internet using the Connected PC was the theme of Intel's keynote address at Internet World, US, in March. In his presentation, Frank Gill, executive vice-president and general manager of the Internet and Communications Group at Intel, explored the opportunities for business to both make money and save money by addressing new capabilities, new markets and new customers using the Connected PC and the Internet.

During his presentation before several thousand Internet World attendees, Gill stated that the growth of the Internet has been responsible for revitalising the PC industry. The Connected PC offers business the opportunity to take advantage of these changes in order to deliver innovative marketing and service programs, but he warned that there is no 'easy' money.

Gill demonstrated how emerging Internet technologies, including many developed by Intel, are enabling business to create new opportunities on the Internet. Inside the corporate world, increased efficiency via training and network management tools were explored. Outside the corporate world, creative new marketing programs and products for financial institutions and the music industry were highlighted.

"The Gold Rush to the Internet is over. The time is ripe now for getting down to business. Using connected PCs combined with the Internet, businesses can now add value in significant ways to offer customers new products and new services. They can reach down the wire and impact their clients quickly and directly", said Gill. "We are only at the beginning of the development of these new business approaches where both the customer and business will benefit."

In conjunction with Internet television company, JamTV, Gill demonstrated the ability of a fast growing company to use innovative business models to reach new customers and new markets in the exploding music entertainment industry. The JamTV demo utilised hybrid application technology to deliver personal, interactive computing to customers. A demonstration with Wells Fargo Bank illustrated the possibilities of a well established industry leader to offer new banking services and products using Internet telephony and streaming video technologies.

For further details, check: **http://www.intel.com.**
Contact: Intel: (01793) 403000.

RSGB Claims Low Frequency Records

Two members of the Radio Society of Great Britain (RSGB) have walked into the record books by setting three new records: the first two-way contact on the UK 73kHz band; the first portable operation on the band; and the lowest frequency on which an amateur radio contact has ever taken place anywhere in the world.

Mike Dennison G3XDV and Peter Dodd G3LDO made the historic contact over a 175m path. Dennison's transmitter ran 20W input from his home station in Welwyn Garden City, Hertfordshire. The antenna was a 300ft. loop, loaded with a series tuned 5·5mH coil.

Dodd, who claims the first portable operation, ran some 7W input into a 50ft. dipole, centre-loaded with approximately 3mH of inductance, parallel-tuned with a vacuum capacitor.

Since the distance involved was less than one twentieth of a wavelength, and the portable antenna so small, there seems to be plenty of opportunity for the record to be broken in the near future.

For further details, check: **http://www.rsgb.org.**
Contact: RSGB, Tel: (01707) 659015.

Skin Cell Experiments Could Plug Surgical Gaps

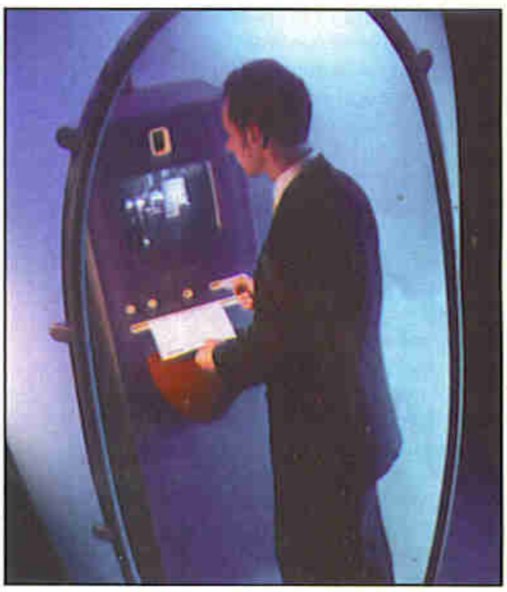
Methods of growing human skin on polymer films was just one of the papers presented at the Institute of Physics Annual Congress in Leeds from 24 to 27 March.

The skin cell experiments are being conducted by the Institute of Science and Technology at Loughborough University. The idea is that if an individual's skin cells could be grown quickly and easily in this way, it would become possible to supply surgeons with pieces of skins that could be used for grafts or with clumps of cells that could be used to plug small gaps where tumours had been removed.

Dr Robert Bradley and research student, Clare Tremlett, told the Institute of Physics Annual Conference in Leeds how they are currently attempting to identify polymer surfaces that have the right shape, chemistry and energy to encourage skin cells to attach themselves and multiply rapidly.

Environments that discourage cell growth are also of considerable interest. Surfaces that are bio-incompatible with human cells would be very valuable for cardiovascular applications, for example, where surgeons do not want cells to grow on a catheter or other piece of equipment inserted in the body.

For further details, check: **http://www.iop.org.**
Contact: Institute of Physics, Tel: (0171) 470 4800.



Cave RADIO

PART 1

Communication

by Mike Bedford

If you've ever been on a tourist trip inside a show cave, you'll probably recall a time when the guide asked everyone to stand still while he turned the lights out. For many people, this would have been the first time they'd ever experienced total darkness and it would have been just that – not a glimmer of light would have penetrated the depths.

And it wouldn't have been only light which was excluded from the world above. You wouldn't have heard any audible sounds from the surface and if you'd taken a VHF radio with you, you'd have found that all the familiar stations would have been absent.

For a tourist on a trip of Wookey Hole, this total isolation only adds to the fascination of the subterranean realm. But it's a different story entirely for members of the cave rescue organisations who are called out in the event of potholing accidents. Here, a means of communication with the surface can sometimes mean the difference between life and death for a casualty. If your only experience of the world of limestone caverns is as a tourist, you may not realise that it can take many hours or even days to reach the extremities of the world's larger caves. Now, imagine that rescuers have found an injured caver on the far side of a collapse which they don't have the necessary equipment to remove. Sending someone back to the surface may take many hours, by which time, the casualty may have died of exposure. But if you can get word to the surface immediately, there may just be a chance of reaching him in time.

In this article, we're going to be investigating how electronics can offer a solution to cave communication. Specifically, we'll look at low frequency induction, earth-current communication, single-wire telephones, and guide-wire communication. But communication is only one application of electronics to caving. Whereas the idea of potholers packing electronic equipment together with their ropes, ladders and lamps may seem an odd one to come to terms with – cavers are now using electronics to assist them in photographing, surveying, conserving, studying and documenting caves. This article on cave communication forms the first in a three-part series on cave electronics, and in the remaining two parts, we'll put many of these other applications under the spotlight.

Ordinary Radio Won't Work . . .

If you drive through a long road tunnel, or even under a motorway bridge, you'll sometimes find that the car radio will fade out. The simple explanation for this is that radio waves are attenuated by conductive media such as concrete or rock. In fact, the amount of attenuation depends on the conductivity of the medium and the frequency of the radio waves. The fact that the attenuation increases with the conductivity of the medium will come as no surprise. However, what far fewer people appreciate is that the attenuation also increases with the frequency. In other words, lower frequencies will penetrate the ground more easily. Exactly how low a frequency you need depends on the

Field testing of commercial single-wire telephone equipment developed for mine rescue purposes.

conductivity and the depth you need to penetrate. Caves occur in limestone, are rarely more than a few hundred metres deep, and to penetrate this, frequencies up to around 180kHz have been found to be useful. So, we're talking of the frequencies just below the longwave broadcast band. The areas of particular interest are officially called the VLF (Very Low Frequency) band which covers 3-30kHz and the LF (Low Frequency) band which covers 30-300kHz. The VF (Voice Frequency) band, which covers from 300Hz to 3kHz, has also been used for non-speech communication and for radio-location, as we'll see later in the series.

All this looks quite plausible until we start to consider the wavelengths at these frequencies. A frequency of 100kHz corresponds to a wavelength of 3km and down at 300Hz, the wavelength is 1,000km. In order to be efficient, radio antennas need to be a reasonable proportion of a wavelength long, so at these frequencies, we'd be talking in terms of some rather serious antennas. This has been a major problem for the UK's radio amateurs using the new 73kHz band and explains why, so far, the longest distance communication achieved is no more than about 5 miles. But if the antennas pose a problem to radio amateurs for aboveground use, the situation is far worse in the confines of tiny cave passages. Here, anything much larger than a whip antenna would be totally impractical, yet this would be grossly inefficient for radiating at LF or VLF.

. . . But Induction Will

So far, we've been thinking in terms of conventional radio. Radio involves a transfer of electromagnetic energy through free space by a process called *radiation* and is the process which dominates at a distance of a few wavelengths from any radio antenna. This is referred to as the *far field*. However, when we look much closer to the antenna, we find something quite different. In the so-called *near field*, we find independent magnetic waves and electric waves referred to as the *induction field* and the *electrostatic field* respectively. The induction field can be generated quite efficiently by feeding an electrical signal into a multi-turn loop. Since this can be far smaller than a wavelength, this looks promising as a means of cave communication. However, unlike the far field which decays with the square of distance, the induction field obeys an inverse cube relationship. In other words, it drops off very quickly as you move away from the antenna as the phrase 'near field' would suggest. However, this is not an insurmountable problem for cave communication, since it is frequently adequate to be able to communicate from the cave to the closest point on the surface. And as we've already seen, caves are rarely more than a couple of hundred metres deep.

So, cave radio employs the principle of low frequency induction. Strictly speaking, the word 'radio' is not appropriate since no radiation is involved, but 'cave radio' is, nevertheless, a convenient term and is in widespread use. The transmitter feeds a signal into a loop and thereby sets up a

Evaluation of a flexible antenna wound inside a bicycle inner-tube.

magnetic field. At the receiver, an electrical signal is induced in a similar loop by the transmitted magnetic field. So, we can view an induction communication system as being similar in operation to that of a transformer, albeit one with a particularly large separation between its primary and secondary windings. Despite the fact that real radio employs radiation whereas cave radio works by induction, the design of the transceivers are very similar.

A small hand-held cave radio called the Molefone was first developed about 15 years ago by Bob Mackin of Lancaster University and is used extensively by cave rescue groups. More recent designs tend to use the same principles – namely around 10-40W of SSB on around 80-120kHz – but make use of more modern techniques and components. However, although the transceivers will be comparatively familiar to any radio engineers, the loop antennas are peculiar to cave radio and their design poses a major challenge.

The amount of signal generated by an induction loop antenna depends on its magnetic moment which, in turn, depends on the electrical current, the number of turns, and its cross-sectional area. Loops are normally tuned to resonance at the operating frequency in order to overcome the inductance and hence maximise the transmitted current. So, designing a loop antenna involves balancing a number of factors. So long as the transmitter's PA remains constant, the thickness of the wire would have to be increased to increase the electrical current. This increases the weight of the antenna which is another factor which has to be taken into account – portable equipment needs to be light. In fact, when you consider the fact that the induction field decays with the cube of distance, it is clear that eight times the weight of copper is needed to double the range.

Increasing the number of turns also increases the weight, but this is only part of the story.

Increasing the number of turns without also increasing the wire gauge will increase the resistance and thereby decrease the current. The other factor which affects the magnetic moment is the loop's cross-sectional area. In fact, for a given weight of wire, the most efficient transmitting antenna turns out to be a large single-turn loop. However, we now come up against another constraint – small multi-turn loops are far more practical than large single-turn loops in caves. And if this isn't enough balls to keep in the air at once, we also have to throw in the question of the Q-factor. If this is too high, the antenna won't have sufficient bandwidth for speech communication and we could run into the problem of the tuning drifting when the loop is subjected to temperature variations.

Cave Proofing

Designing a cave radio and its associated loop antenna poses quite a technical challenge, even if it only has to work in the laboratory. But, of course, this is not the environment in which cave radios are used and the real cave environment is far more hostile to potentially delicate electronic equipment. If I were to build a cave radio for my own use, I'd carry it in a padded waterproof box and handle it with kid gloves when I opened the box to use the radio. As such, there's a good chance that it would survive, after all, I've been using a 35mm SLR camera underground for a number of years without mishap.

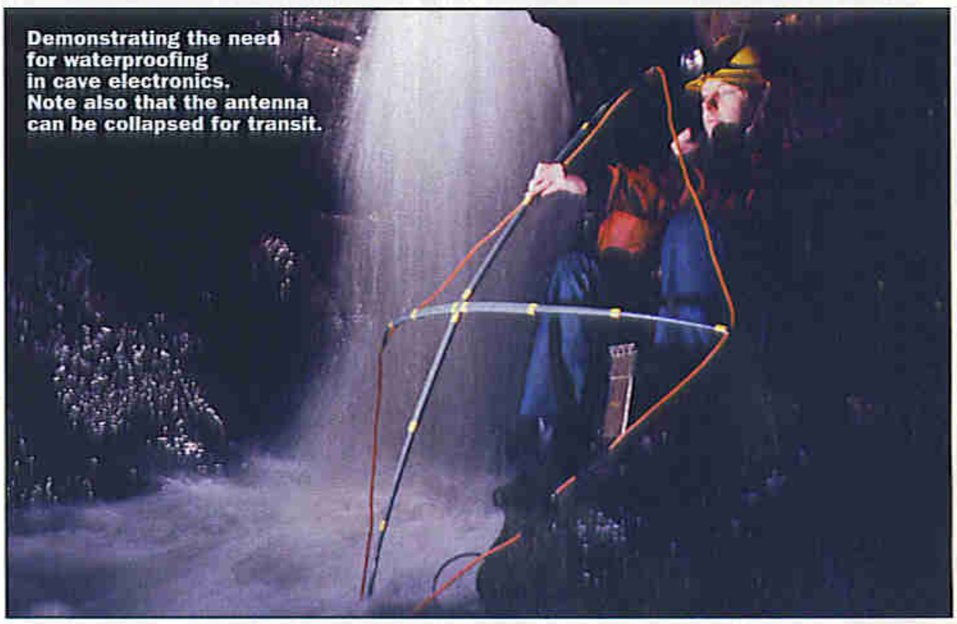
However, being realistic, I know that it is not reasonable to expect that cave rescuers would treat a radio with the same sort of respect. And even if they did, with the utmost care, accidents do still happen. Although I've been lucky with my camera, I know many other people who've had some expensive losses. So, cave radios must be cave proofed. This means that they need to withstand mud and water and they also need to be sufficiently robust to survive being dropped a couple of metres or knocked against a rock face.

Closely related are issues of ergonomics – cave radios need to be small and light. This is probably more of a problem in the design of the loop antenna than of the transceiver itself. Although induction allows the use of an antenna which is far smaller than a wavelength, a loop diameter of one metre still tends to be needed. Certainly, we might expect that improved transmitter and receiver designs may allow this to be reduced, but it's probably still going to be of such dimensions that it'll be cumbersome to carry in cramped cave passages. So, a major requirement is for a loop that can be folded up for transit, yet be rapidly deployed for use.

Earth Current Communication

If you're a regular reader of electronics magazines, there's a good chance that you've read articles on earth current communication. Except for use on the front-line during the First World War, there have been few serious applications, but it tends to remain popular amongst electronics hobbyists due to its novelty value and the fact that a licence is not required. Here's how it works. Take a microphone and audio amplifier as the transmitter but instead of connecting the output to a loudspeaker, attach it to a pair of copper rods driven into the ground a few metres apart. Take another audio amplifier and a loudspeaker as the receiver and here, connect a similar pair of earth rods to its input. Although you'll suffer significantly from 50Hz mains hum interference, you'll find that this setup can be used successfully over a distance of a few hundred metres.

Most earth current experimenters have restricted themselves to working above ground, but if you put an earth current transmitter on the surface and take an earth current receiver into a cave immediately below, you'll find that the earth currents also penetrate the ground to some considerable depth. Despite the possible difficulty of knocking earth rods into the solid rock floor found in many cave passages, and despite the perennial problem with mains interference, this sort of system has been used as a cheap and


Demonstrating the need for waterproofing in cave electronics. Note also that the antenna can be collapsed for transit.

Setting up a surface earth-current station.

cheerful method of cave communication. Of course, it's comparatively easy to get rid of the mains interference and this will have a very significant impact on the range. Rather than use a baseband (i.e., audio) transmitter and receiver, use an RF system. For reasons we saw when we looked at induction radio, the frequency will need to be in the VLF or LF bands, so we'd end up with transceivers virtually identical to those used as induction cave radios. Only the antennas would be different – we'd have earth rods instead of loops.

However, when we investigate further, we find that RF earth current systems and induction cave radios have even more in common. So long as they're on the same frequency, you'll find that you can receive the signal generated by a surface earth current transmitter using an induction radio with a loop antenna in the cave. Similarly, you'll find that a signal transmitted underground using an induction loop can be received on the surface using an earth current receiver. What this means, of course, is that an earth current generates an induction field in the ground and that an induction field generates an earth current. Effectively, the section of earth below the ground rods is being made to act as a huge induction loop antenna. The obvious advantage of this sort of hybrid system is that the problem of using ground rods in caves is eliminated, yet the advantage of having a very efficient antenna (i.e., the earth rods) on the surface is realised.

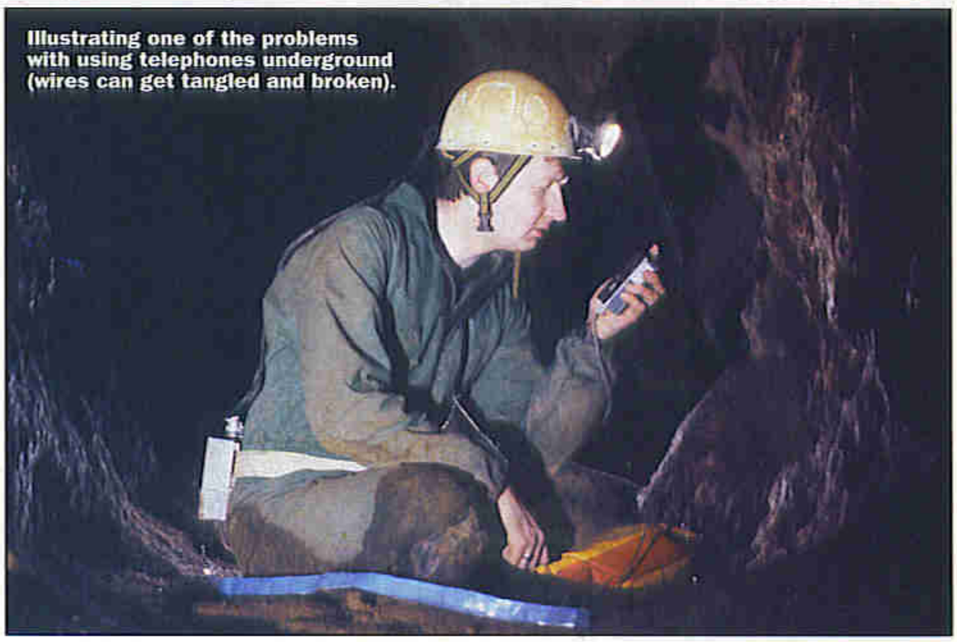
Single-wire Telephones

With the current generation of cave radios, effective communication can only be achieved at the maximum design depth if the surface party is directly above the underground party. So, cave rescue organisations make a point of knowing the surface locations which correspond to underground landmarks and are therefore able to arrange to contact the rescuers when they arrive at these particular points. Of course, this only applies to caves which have been well surveyed. But what about a rescue in a newly discovered cave? In this case, using cave radios may be a very hit-and-miss affair, and rescuers often fall back on telephones. OK, this may not sound particularly high-tech compared to induction radio and earth current communication, and there's the undoubted drawback of having to lay the line, but even here, new developments are being made.

The vast majority of telephones used for cave communication are single-wire telephones. Here, a single conductor is used to connect the two sets, the earth making up the return path. Otherwise known as the earth-return telephone for obvious reasons, the main advantage compared to a two-wire telephone is that the bulk and weight of the wire is cut by half. This is a major consideration if you're laying the line through hundreds of metres of tortuous crawling passages. Traditionally, single-wire telephones have a metal case so that the return earth path is made through the operator's body. The normal stance is with the free hand making a firm contact with the floor or the cave wall. However, more recent developments have changed all that and, in the process, brought other advantages. Single-wire telephones featuring a very high impedance input are much more tolerant of poor earthing, thereby making them more suitable for use by non-trained operators. They've been shown to work even if the user is wearing dry rubber boots and doesn't touch the wall, in fact, they've even been shown to work if the operator leaps into the air. OK, the need to communicate whilst falling down a pitch is, perhaps, low down on the list of priorities, but it does lead to an interesting and useful conclusion. The return path was obviously being made via the small capacitance between the operator and the ground. Let's take a look at why this is useful.

A single-wire telephone system lends itself to use by more than two parties. However, there are practical difficulties. If there are just two parties, then it is reasonable to assume that each will have a telephone attached to the end of the line. However, a third party would need to connect somewhere in the middle of the line. With a conventional single-wire telephone, this means stripping the wire. And if that stripped section of wire is subsequently allowed to trail in a pool of water, the signal will leak to ground and communication be lost. However, if a capacitive link to earth provides a viable alternative to a conductive link, then perhaps the same applies to the connection to the line. If users can tap into

John Hey, G3 TDZ, testing his LF induction radio in Jug Holes, Derbyshire.



Illustrating one of the problems with using telephones underground (wires can get tangled and broken).

Laying of the wire can be a time-consuming task.

the line capacitively, then it would no longer be necessary to strip the wire. Cave communication experimenters have recently conducted successful trials using high impedance single-wire telephones and capacitive couplers.

However, the single-wire telephone technique need not be limited to baseband with its inevitable mains interference problems. An RF carrier-based single-wire telephone has a number of advantages, indeed, a system operating at about 30kHz is currently under development for use in mine rescues. Additional benefits over the audio approach include the ease of capacitive coupling to the line, and the fact that capacitive repairs to broken lines can be made simply by 'tying together' the broken ends.

Other Methods

Induction radio, earth current communication and single-wire telephony are not the only possible methods of cave communication, indeed, many other techniques have been attempted and at least one other method is regularly used by cavers.

Before induction radio became a reality, tests with transmitting sound waves through the rock were conducted by mining companies. Although a degree of success in sending and receiving signals by the use of small explosive charges was demonstrated, a high rate of data transfer was clearly not achievable. Most other methods rely on radio communication, albeit using more conventional frequencies than those used for through-rock induction. Even though VHF and UHF radio is particularly inappropriate for penetrating the rock between a cave and the surface, there has been some experimentation with firing signals along the cave passages.

The major problem, of course, is that cave passages are highly convoluted so communication much beyond line-of-sight would have to rely on some sort of reflection or wave-guide effect. So far, little success has been achieved, although the higher frequencies appear to be the most effective. Somewhat more successful, however, is the use of conventional HF, VHF or UHF radios in conjunction with a guide-wire – a wire laid along the cave passage. In a way, this is similar to the single-wire telephone approach, especially if we're comparing with those telephones which use an RF carrier. Certainly, the same drawbacks

Single-wire telephones can sometimes provide a solution where induction radio can't. Here, a capacitive coupler (foreground in blue) is being tested.

Firing VHF and UHF signals along passages has not been particularly effective, even with high gain antennas.

Main caving areas within the UK.

apply, primarily that of having to lay and maintain the line. However, at the higher RF frequencies which tend to be used for guide-wire communication (the 27MHz Citizen's Band is a common choice), the basic mechanism is quite different – radiation rather than conduction is predominant – and a far looser coupling to the line is required. In practice, effective communication can be achieved over many hundreds of metres using unmodified CB rigs by simply holding their whip antennas close to the line.

A World of Darkness

It's a reasonable assumption that most readers won't know a great deal about the world beneath their feet. So, to put this series into context and, perhaps, to explain why cavers find this world of darkness so fascinating, here's a bit of background information. The map shows that the main caving areas in the UK are Ireland – the British areas most frequented by potholers are the Yorkshire Dales, the Derbyshire Peak District, South Wales and the Mendip Hills. What drives many potholers is the hope of finding a new cave, of going where no man has gone before. To other cavers, the challenge is one of pitting themselves against nature – many of the more difficult caves require a high degree of skill, stamina and endurance. For yet others, the fascination is simply one of experiencing this harsh yet beautiful world of stalactites, stalagmites, underground rivers and waterfalls, of fossils and of strange rock formations. Finally, there are those whose interest is in some specialist discipline, perhaps in researching cave hydrology, biology or archaeology, perhaps perfecting cave photography, or perhaps developing electronic equipment for use by the caving community.

May people ask "which is the UK's longest cave?", "which is the deepest?", or "which has the largest chamber?", but the figures are in a constant state of flux since cavers are always pushing back the boundaries. One of the most recently discovered caves in the UK is Ogof Draenen in South Wales. So far, 58.3km of passages have been discovered, many of them boasting lavish decorations, and new passages are being found at the rate of 2km per month. But pride of place for the longest cave in the UK still goes to the Lancaster Hole/Ease Gill System in the Yorkshire Dales, with over 70km of known passages and many different entrances.

With a guide-wire, small hand-held amateur or CB rigs can be quite effective.

Caves like those mentioned above are a far cry from the sanitised environment of the show cave with its electric lights, hand-rails and concrete paths. If you want an introduction to a 'real' cave, to see nature in the raw, then Gaping Gill, also in the Yorkshire Dales, could provide you with that opportunity. Twice a year, local caving clubs set up a motor-driven winch to lower members of the public into its depths. This cave is also one of superlatives. Your trip into Gaping Gill will be via a 385-foot vertical shaft from the surface, and you'll land in the UK's largest cave chamber – supposedly large enough to house York Minster – into which Britain's tallest single-drop waterfall lands.

Caution

My aim in writing this article is to communicate some of my fascination of caving, and in particular, my fascination with the challenges of cave communication. My hope is that some of you will decide to experiment in this field and perhaps help to develop improved cave radios. You could even help save lives as a result of your work.

However, don't forget that caves are potentially dangerous places – if it wasn't for this fact, then there would be no need for cave rescue groups and no need for cave communication. I don't say this to frighten you off, and most of the risks can be virtually eliminated if you take care. But if you're not an experienced caver, you certainly shouldn't go underground unescorted. By all means, start experimenting and carry out tests above ground, but when the time comes for the acid test, find some experienced cavers to show you the ropes. Ideally, make contact with CREG (see Further Information) and perhaps attend one of their field meetings. CREG members will share your interest in electronics, whereas members of your local caving club probably won't have the slightest inclination to help you test a cave radio.

Further Information

If the idea of cave electronics appeals to you, a good first step would be to make contact with the Cave Radio & Electronics Group (CREG) of the British Cave Research Association (BCRA). CREG is the world's most active group dedicated to the development of electronic equipment for caving, with around 200 people subscribing to its publications. The quarterly *CREG Journal* contains a broad mix of practical and theoretic articles and will keep you up to date on what's happening in this fascinating field. And if you're just starting out in cave electronics, there's a wealth of background information to be found in back issues of the *CREG Journal*. For details and an application form, send an SAE to: Bill Purvis, 35 Chapel Road, Penketh, Warrington, WA5 2NG. You may also like to take a look at the CREG Web site at **http://www.sat.dundee.ac.uk/~arb/creg.**

Jimi Hendrix at the Isle of Wight Festival 1970. ©1994 The Hulton Deutsch Collection.

Psychedelic WAH WAH PEDAL

Design by Nigel Skeels
Text by Nigel Skeels and Robin Hall

This extremely popular project, originally published in the October 1994 issue of* Electronics the Maplin Magazine, *has recently been updated. Details of the changes are included in this article so as to allow existing projects to be modified and brought up to date.

EMC Compliance

The changes to this project form part of the overall programme of EMC compliance for project kits that Maplin has been working on since 1995 [perhaps the subject of another article? – Ed.]. Maplin is proud of its range of project kits and takes its responsibility for ensuring EMC compliance seriously.

The changes that have been made to the Pschedelic Wah Wah Pedal do not alter how it works or its performance in use, but simply ensure that the changing requirements of the EMC directive continue to be met. In particular, with the changes implemented, the unit can now withstand an electrostatic discharge of at least 8kV as defined in EN 50082-1. In reality this means that in normal use it is very difficult to cause damage to the unit through a build up of static electricity on a user's body. A discharge of static electricity could easily be applied to the 'dry/effect' selector switch or the PCB mounting bolt just by picking the unit up. If this discharge was of sufficient magnitude and was not otherwise harmlessly diverted to circuit 0V, damage to the electronics might otherwise be caused rendering the unit inoperable – not what you want just before a gig!

The Changes

To provide a path to circuit 0V for static discharges, the PCB mounting bolt, potentiometer (RV4) and the 'dry/effect' switch SW1 must be connected to the chassis pin on the PCB in addition to the previous metal base-plate connection. To facilitate this, a longer PCB mounting bolt (M4 x 20mm [JY17T] instead of M4 x 16mm), two extra shake-proof washers (M4 [BF43W]) and an additional solder tag (M4 [LR63T]) are now supplied in the latest kits produced. The changes are illustrated in the exploded assembly diagram, Figure 4, and the wiring diagram, Figure 5 – these figures supersede those published in the original magazine article and in Issue 2 instructions supplied in previous kits produced. These modifications can readily be carried out on existing units – many constructors will already have the necessary items in their 'spares' box.

If you have any queries relating to this modification, please contact Maplin Technical Sales (see page 79 for contact details).

For the uninitiated, the sound effect of a Wah Wah pedal is synonymous with many recordings of bands of the seventies. For an example listen to 'Voodoo Chile' by Jimi Hendrix, the track opens with a prime bit of wailing. The Wah Wah acts as a kind of tone boost control, and moving the pedal adjusts the frequency point at which the boost occurs.

FEATURES

- Powered from 9V PP3 battery or regulated power supply
- Regulated reference to prevent low battery voltage drift
- Built-in compander to minimise noise
- Traditional Wah Wah sound (without the crackle)
- Rich warm harmonic content
- Minimal adjustment
- IC design, no laborious coils to wind
- Adjustable resonance and range
- Economically priced with unbelievable performance

PROJECT RATING 2

SPECIFICATION

Power supply:	+9V DC
Current consumption:	14·7mA
Maximum boost @ 1kHz:	20dB
Minimum frequency:	90Hz
Maximum frequency:	20kHz

Rhythm or lead guitar usually play through the device. When playing rhythm, the pedal is moved in time with the 'strum', and when playing lead, extra expressive abilities become available enabling almost 'infinite sustain' without screaming feedback.

Circuit Description

The block diagram of the Psychedelic Wah Wah Pedal is given in Figure 1, this as well as the circuit diagram in Figure 2, will help illustrate how the circuit operates. The input to the Psychedelic Wah Wah is fed to the input stage of IC1 an LF351 op amp. This is a low-noise J-FET device and is used to buffer the input signal, thus preventing the rest of the circuit loading the input. There is no gain in this part of the circuit as seen by the direct link between the inverting input and the output.

The next stage in the circuit is IC2 an NE571. This is set up to compress the signal by the ratio of 2 to 1 before it is fed into IC3 the LM13700 dual transconductance amplifier. This is where the magic takes place, and is used here to provide two voltage-controlled tunable peaks in the audio band. This is achieved by placing both parts of the LM13700 in series with each other. The voltage change is obtained by using a 100k linear pot; the wiper of this pot is then connected to both of the amplifier bias inputs via R19 and R25. These two resistors could be of the same value thus causing both of the peaks to be on top of each other, but this is not what we are after, as the overall peak would be too narrow and not give us that characteristic Wah Wah sound that is so desirable. With this in mind, the peaks are slightly separated thus widening the overall peak and is performed by having different values for R19 and R25.

The diode bias inputs are tied to the supply rail via resistors R17 and R20 both 15k, these help to linearise the input stage of the amplifier. Capacitors C15 and C16 also set the frequency at which the gain occurs.

The gain of the first part of the LM13700 is adjusted by varying RV1, this is known as the resonance control, by increasing this, the effect is more pronounced. The overall gain of IC3 is determined by R15.

The final stage in the circuit is to expand the signal back to its original form, IC2 is again used for this operation. The idea of compression and expansion is to prevent any noise from being amplified in the system. R6 sets the output impedance of the unit and C6 is to ensure HF stability.

PCB Construction

Construction of the Psychedelic Wah Wah is fairly straightforward, refer to the Parts List and to Figure 3 for the PCB legend and track. The sequence in which the components are placed is not critical. However, the following instruction will be of use in constructing the project. If you are new to project building please refer to the Constructors' Guide (XL79L) which is included with the kit.

Fit the smaller components first, such as the resistors and diode, noting correct polarity for the diode. Next fit the wire links which are made from wire offcuts from the resistors. Fit the capacitors next, making sure that the electrolytic capacitors and the tantalum capacitor are fitted the correct way round. Next fit the PCB pins into the relevant holes. Identify the horizontal resistor presets, fit and solder. Next, install the regulator RG1, making sure that its outline conforms to the package outline on the legend. Fit the IC sockets, correctly orientating them on the board noting that the notch at one end matches that on the legend.

Next fit the power socket SK1, and the two jack sockets

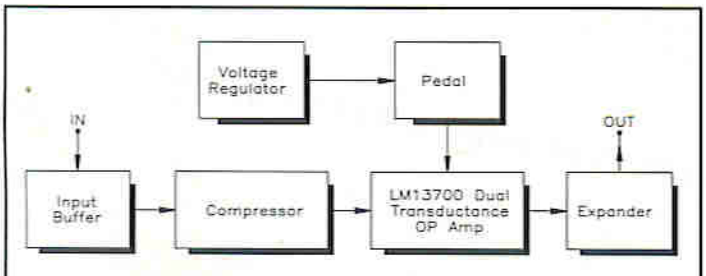


Figure 1. Block diagram of the Psychedelic Wah Wah Pedal.

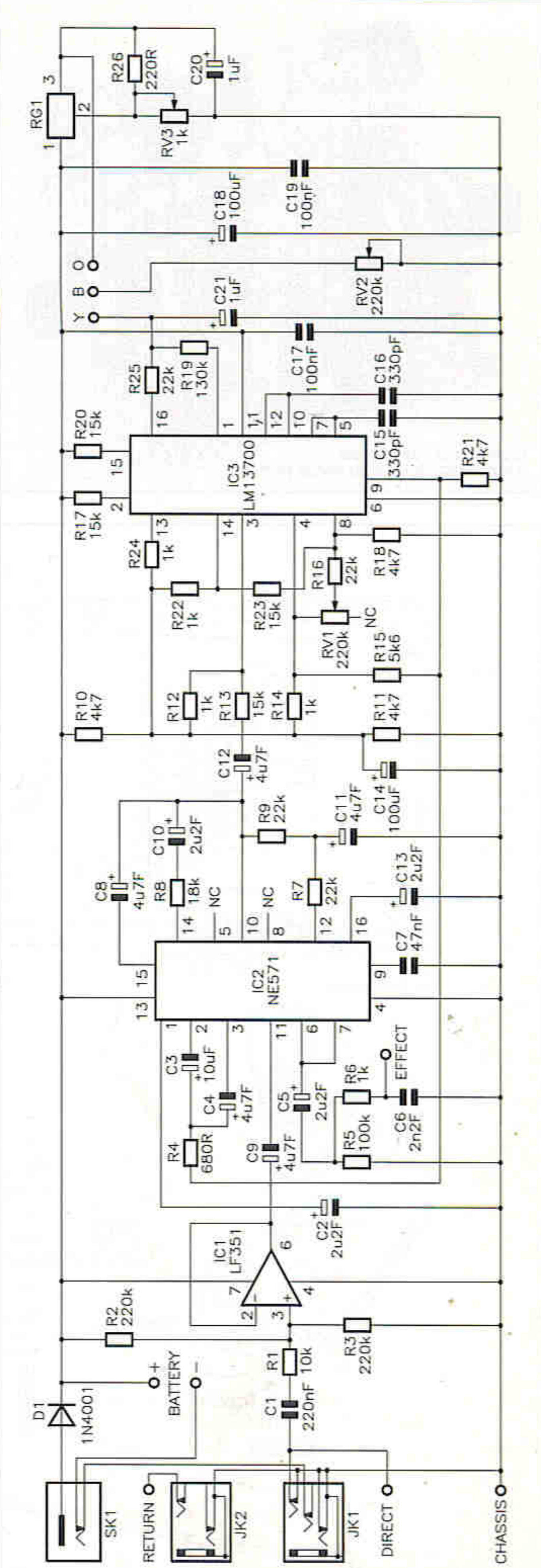
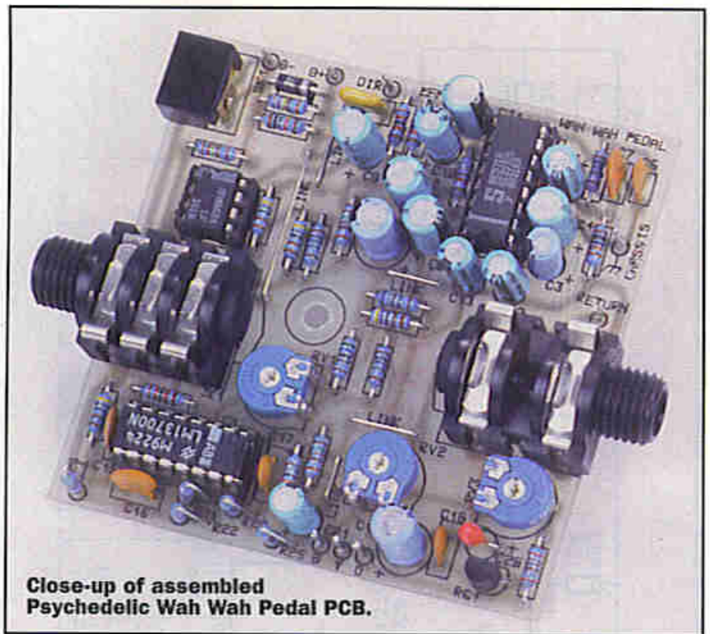


Figure 2. Circuit diagram of the Psychedelic Wah Wah Pedal.



Close-up of assembled Psychedelic Wah Wah Pedal PCB.

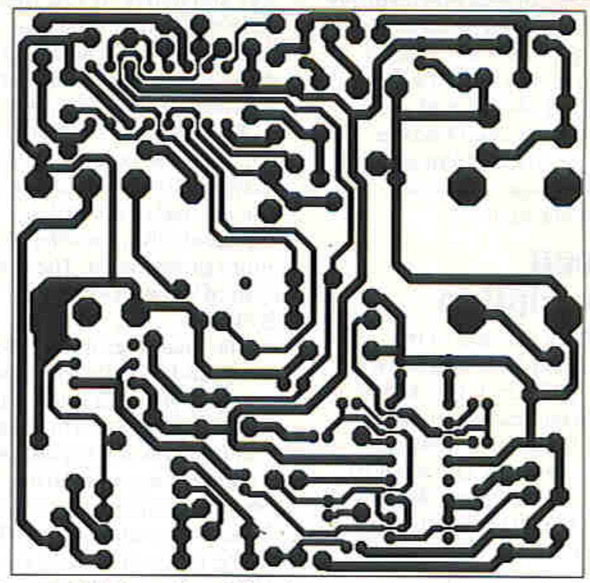


Figure 3. PCB legend and track.

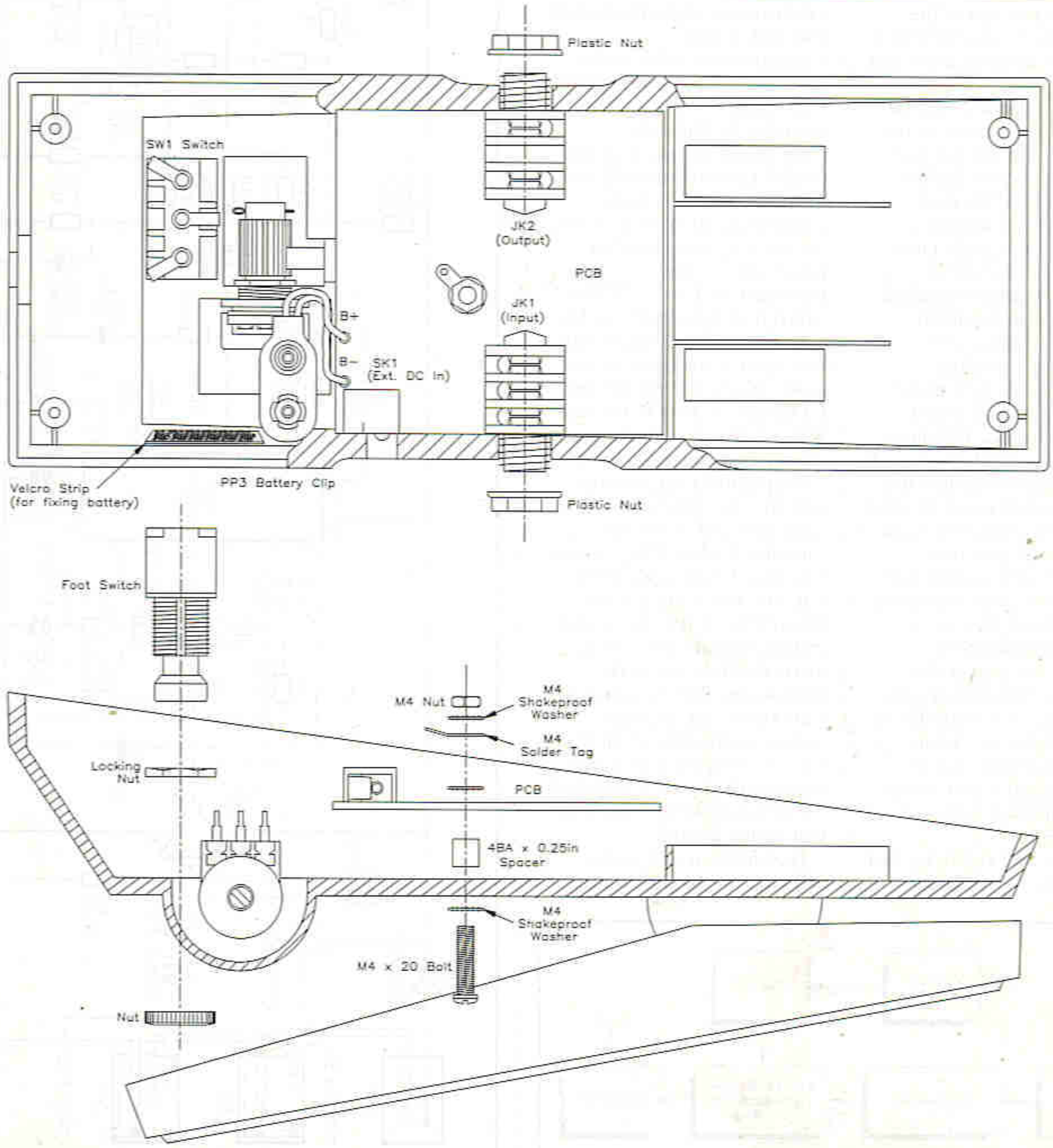


Figure 4. Exploded assembly of the Psychedelic Wah Wah Pedal.

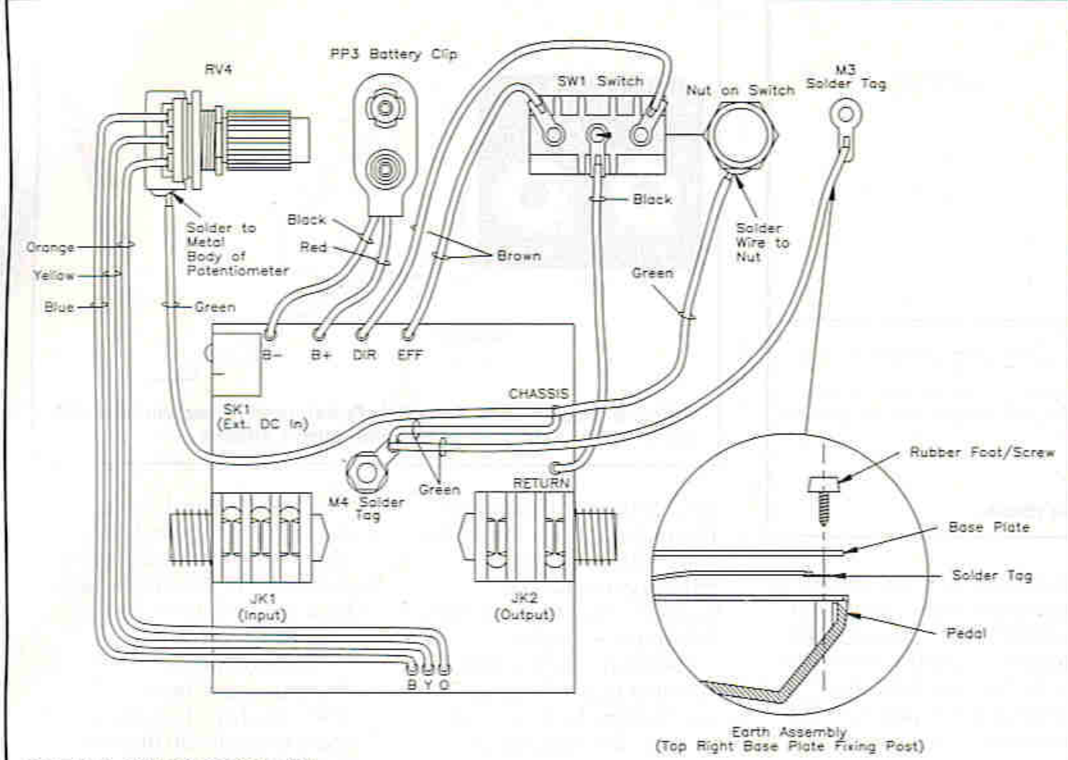


Figure 5. Wiring diagram for Psychedelic Wah Wah Pedal.

JK1 and JK2. Identify and fit the ICs into the correct DIL sockets, correctly orientating them so that the notch on the ICs matches those on the sockets.

Finally attach the battery clip making sure that the leads are correctly positioned.

Once the PCB construction is complete, check over your work to ensure that all components have been correctly fitted and that there are no short circuits caused by solder bridges or splashes. Finally, clean all the flux off the PCB using a suitable PCB cleaning solution.

Pedal Modification

There are a number of modifications required to be made to the foot pedal box, refer to Figure 4 in the original article or instruction leaflet for box drilling and modifications.

Remove the existing cable clamp and screw. Cut a hole for the foot switch, and if necessary remove any plastic obstruction (where the original cable clamp was located). Drill a hole for the output socket, and also cut a slot for the input socket, the reason for the slot will become apparent when the PCB is fitted. Next drill a hole for the power socket. Remove the variable resistor from the pedal (it may be helpful to loosen the white plastic runner). Carefully take the split pin from the end of the shaft and remove the cog and the washer. Next place the cog and washer onto the 100k linear potentiometer supplied in the kit. Figure 5a in the original article or instruction leaflet shows an exploded assembly view of the potentiometer. Using the holes on the cog, drill through the shaft of the potentiometer and place the split pin through the hole, next bend the split pin in order to secure the cog to the shaft. Now put the finished potentiometer back into the pedal and tighten up the lock nut.

Before mounting the PCB in position, cover the white runner screw, with the strip provided on the main base panel label (KP70M), cut the strip off and stick over the screw, thus preventing contact with the PCB and possibly shorting out.

Next mount the PCB into the case, refer to Figure 4 which shows an exploded assembly view. Fit one end of the PCB with the jack socket into the hole on the side and then slide the other end into the slot provided. Mount the PCB onto the spacer, fit a shakeproof washer and bolt in position. Discard the washer from the footswitch, and mount the switch in position, adjusting it so that it will only come into contact at the very end of pedal travel (in order to switch it on or off).

Referring to Figure 5 the wiring diagram, connect up the potentiometer, the switch and the 0V bonding wires. Lastly, attach one part of a pair of Velcro pads to the battery and the other part inside the box, this is in order to secure the battery in position.

Test and Set up

Well now that it is built, now comes the nerve racking moment of truth, adjust the presets as near to those in Figure 6 as possible, plug in a guitar and give it a go (see Figure 8). Make sure that the unit is switched to effect and not to bypass. If it does not work check for misplaced components, dry solder joints, and solder bridges between tracks.

To set the correct range of the unit the pedal must be pushed forward to the end of its travel (just before the switching point). In this position the higher frequencies are amplified, so now (first checking that your guitar is in tune!) play the highest note. Whilst letting the note sound adjust preset RV3 (the high and low frequency presets are shown in Figure 6) it is correct when you hear the note at its loudest point (just like tuning in a radio). It may help you to hear the effect by turning the resonance to full, this is when RV1 is turned fully clockwise.To set up the lower frequencies, move the pedal to its lowest point and play the lowest note (usually the open E string), with this note sounding adjust RV2, you will have to decide if you want it to boom out (ideal for Reggae music, special effects and feedback) or to be more conventional to have a more subtle bottom end. Note, when adjusting RV2 the sound may disappear, the level that you are looking for is just before this point.

Before proceeding recheck your adjustments and realign if necessary. A typical frequency response graph is given in Figure 7.

The last setting to adjust is the resonance, you can turn it down now unless of course you want loads of lovely feedback. This setting is again a matter of personal preference, for subtle effects turn RV1 anticlockwise, for feedback turn clockwise.

To complete the project, fit the baseplate panel label, this is

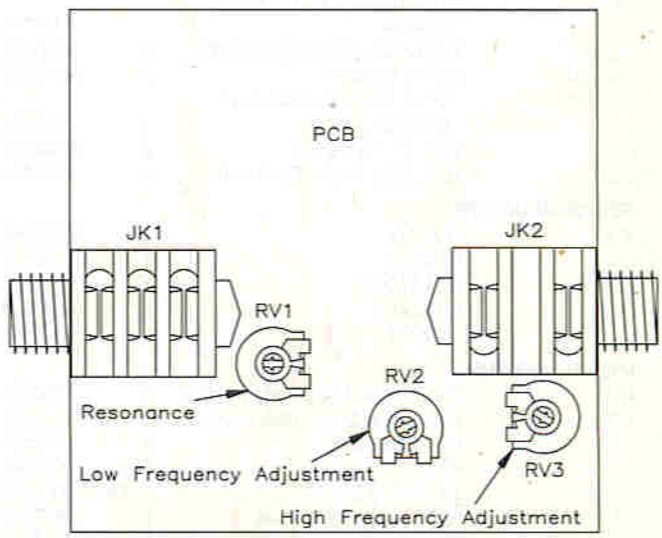


Figure 6. The resonance, low and high frequency presets on the PCB.

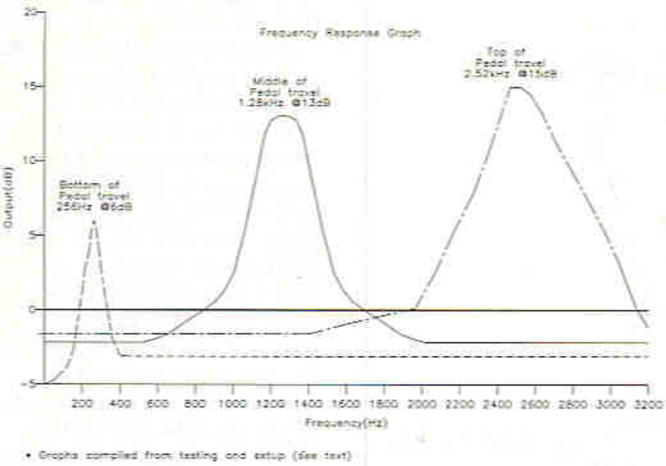


Figure 7. Typical frequency response graph.

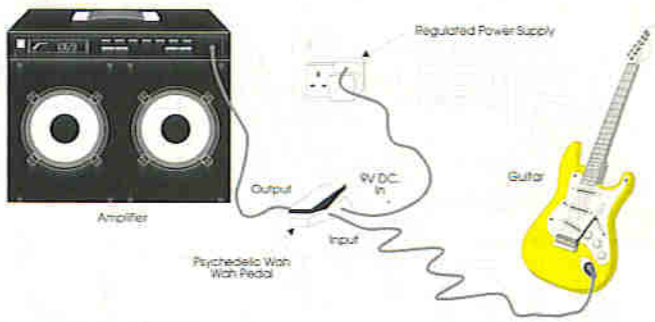


Figure 8. Psychedelic Wah Wah Pedal used in conjunction with guitar and amplifier plus optional power supply.

supplied in the kit and available separately (KP70M). Peel the backing paper off the label and stick in position on the baseplate.

Operation

Figure 8 shows how the Psychedelic Wah Wah is used in conjunction with a guitar and amplifier (plus optional power supply if required). To operate the device once it has been set up, insert a jack plug into JK1 from a guitar or some other suitable electric instrument. The plug connects the 0V rail to the battery as well as providing a signal path. Connect a lead from the Wah Wah to the amplifier.

The main switch is then operated by pushing the foot-pedal as far forward as possible, this determines whether the signal passes through without modification (no effect) or with effect. Once switched on, moving the pedal back and forth provides the Wah Wah effect.

So all you need now, are the flared trousers, psychedelic shirt, afro hair style, and granny specs to complete the image.

PSYCHEDELIC WAH WAH PEDAL PARTS LIST

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

R1	10k	1	(M10K)
R2,3	220k	2	(M220K)
R4	680Ω	1	(M680R)
R5	100k	1	(M100K)
R6,12,14,22,24	1k	5	(M1K)
R7,9,16,25	22k	4	(M22K)
R8	18k	1	(M18K)
R10,11,18,21	4k7	4	(M4K7)
R13,17,20,23	15k	4	(M15K)
R15	5k6	1	(M5K6)
R19	130k	1	(M130K)
R26	220Ω	1	(M220R)
RV1,2	220k Enclosed Preset	2	(UH07H)
RV3	1k Horizontal Enclosed Preset	1	(UH00A)
RV4	100k Linear Potentiometer	1	(FW05F)

CAPACITORS

C1	220nF Monolithic Ceramic	1	(RA50E)
C2,5,10,13	2μ2F 100V Radial Electrolytic	4	(FF02C)
C3	10μF 50V Radial Electrolytic	1	(FF04E)
C4,8,9,11,12	4μ7F 63V Radial Electrolytic	5	(FF03D)
C6	2n2F Ceramic	1	(WX72P)
C7	47nF 16V Miniature Disc Ceramic	1	(YR74R)
C14,18	100μF 25V Radial Electrolytic	2	(FF11M)
C15,16	330pF Ceramic	2	(WX62S)
C17,19	100nF 16V Miniature Disc Ceramic	2	(YR75S)
C20	1μF 35V Tantalum	1	(WW60Q)
C21	1μF 100V Radial Electrolytic	1	(FF01B)

SEMICONDUCTORS

IC1	LF351N	1	(WQ30H)
IC2	NE571N	1	(YY87U)
IC3	LM13700N	1	(YH64U)
RG1	LM317LZ	1	(RA87U)
D1	1N4001	1	(QL73Q)

MISCELLANEOUS

JK1	Stereo PCB 1/4in. Jack Socket	1	(FJ05F)
JK2	Mono PCB 1/4in. Jack Socket	1	(FJ00A)
	Foot Pedal Box	1	(XY28F)
	PP3 Clip	1	(HF28F)
	1in. Velcro Strip	1 Pair	(FE45Y)*
	PCB Mtg Power Socket	1	(RK37S)
	8-pin DIL IC Socket	1	(BL17T)
	16-pin DIL IC Socket	2	(BL19V)
	3A Hook-up Wire Black	20cm	(FA26D)*
	3A Hook-up Wire Blue	20cm	(FA27E)*
	3A Hook-up Wire Yellow	20cm	(FA36P)*
	3A Hook-up Wire Orange	20cm	(FA31J)*
	3A Hook-up Wire Green	50cm	(FA29G)*
	3A Hook-up Wire Brown	20cm	(FA28F)*
	Single-ended PCB Pin 1mm (0·04in.)	10	(FL24B)*
	Press Switch SPDT	1	(FH92A)
	M3 Solder Tag	1	(LR64U)*
	M4 Solder Tag	1	(LR63T)*
	M4 3 20mm Steel Bolt	1	(JY17T)*
	M4 Shakeproof Washer	3	(BF43W)*
	M4 Steel Nut	1	(JD60Q)*
	4BA 3 1/4in. Spacer	1	(FW31J)*
	PCB	1	(GH88V)
	Base Panel Label	1	(KP70M)
	Instruction Leaflet	1	(XU89W)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

Regulated Mains Adapter	1	(YB23A)
9V PP3 Battery	1	(JY49D)
Double Screened Straight Jack Lead	1	(YZ30H)
Neon Lead Green	1	(CC36P)
Neon Lead Pink	1	(CC37S)
Neon Lead Orange	1	(CC38R)
Guitar Lead	1	(CC39N)

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

The above items (excluding Optional) are available as a kit. Order As LT43W (Psychedelic Wah Wah Pedal) Price £39.99

Please Note: Items in the Parts List marked with a * are supplied in 'package' quantities (e.g., packet, strip, reel, etc.), see current Maplin Catalogue for full ordering information.

The following new item (which is included in the kit) is also available separately.
Psychedelic Wah Wah Pedal PCB **Order As GH88V**
Psychedelic Wah Wah Pedal Base Plate Panel
Order As KP70M

High Tech COUNTER-OFFENSIVE BY THE POST OFFICE

by Alan Simpson

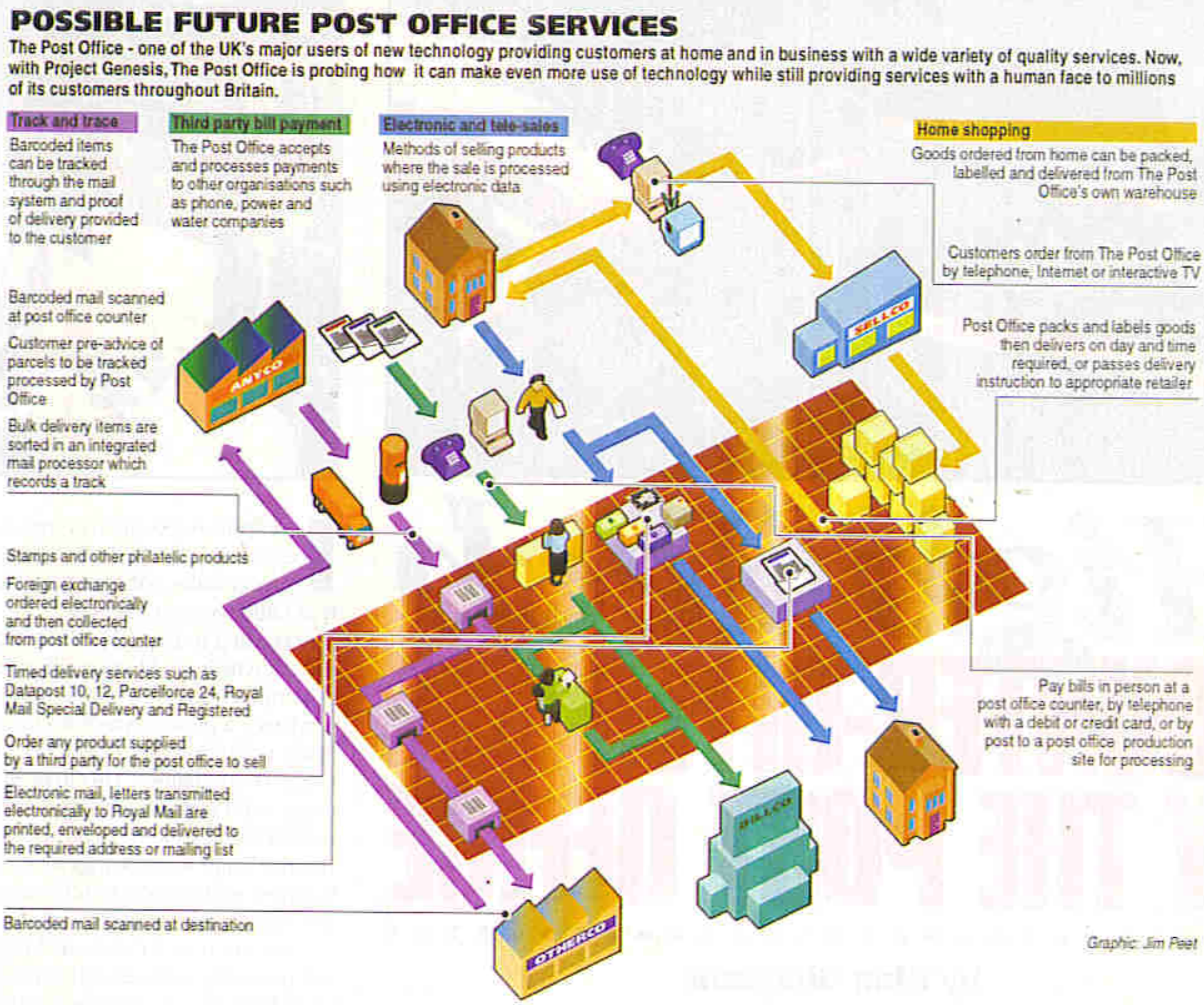
The visible face of the Post Office may well be the postman plodding his round with sack attached. But behind the scenes, high technology moves are being planned which will not only speed up traditional services but will offer facilities more in keeping with Cape Canaveral than with Mount Pleasant.

If our future postman comes to resemble a Winged Mercury, the responsibility will clearly be the new Post Office project, Genesis.

According to the Post Office, Genesis is a project which could open the gateway to offering exciting new technology-based services – a project which is currently being masterminded by the P.O. and some major IT companies. This in itself is a major achievement, with no less than 22 world class technology companies casting rivalries aside to work together to create a business information systems model for the Post Office of the day after tomorrow.

"Our aim is to embrace technology while still providing services with a human face to millions of our customers throughout Britain", says P.O. chief executive, John Roberts. "This will be the biggest single systems integration of company information and systems any business in Europe has ever undertaken."

"Nobody in British Industry has tackled culture change by bringing so many suppliers together to collaborate on something like this. For our more sophisticated customers, we will be looking at ways for them to be more interactive with the Post Office in their homes. We want to make technology the future life blood of the Post Office."



Possible Future Post Office Services.

Opportunity – and Challenge

No one doubts that the Post Office has many technological opportunities ready to be examined. With e-mail and fax (not to mention the burgeoning private courier services) carving a niche in the traditional P.O. business, the P.O. might well be considered negligent if they were not conducting a far-reaching review of services for the future. New technologies must help drive existing procedures enabling, for instance, a guaranteed first thing next morning delivery for leading UK business centres and also help create opportunities for a rapid response service in a variety of applications:

- Interactive access to many Post Office services through domestic TV sets, telephones, PCs and the Internet.
- New electronically-based products and services, rapidly tailor-made to individual customer requirements and including ordering of goods, distribution of computer-generated letters and messages, and payment of all kinds of bills.
- State-of-the-art retail kiosks and cash acceptance systems.
- Much more sophisticated track and trace systems for letters and parcels with customer access.

No More Postman Pat – Now it's High Tech Euro Postman

As Dr Duncan Hine, director of technology at the Post Office who is heading the Project Genesis states: "A fully integrated business system gives the Post Office the potential to become the most powerful 'virtual' company in Europe – a complex set of networks putting enormous computing and communications capability at the fingertips of the 190,000 staff in the Post Office Group. We are blazing a trail that will enable us rapidly to put into place some of the biggest, futuristic concepts in the history of The Post Office."

Willesden distribution centre.

Railnet.

Parcelforce delivery.

For the Record

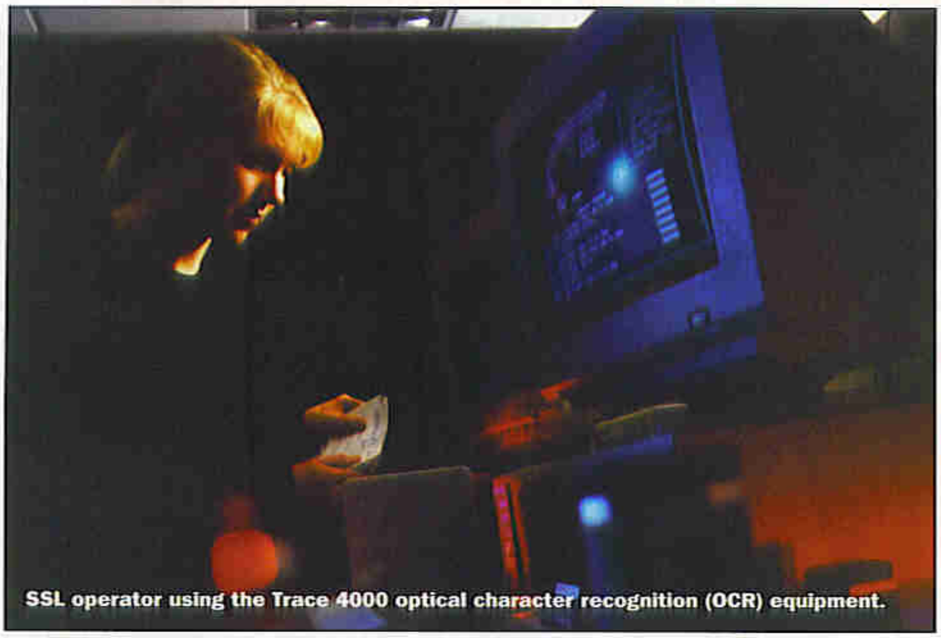
The Post Office has an annual turnover of £6,200 million and unlike most postal authorities which need state support, actually contributes funds to the government. In fact, the Post Office boasts that it has contributed an incredible £1,600 million to government funds since 1981. Good for the government maybe, but less good for users having to pay regularly increased prices. Despite the quantities involved, The Royal Mail delivers 92·3% of First Class letters on the day after posting.

When it comes to productivity, the P.O. also has an excellent record – nearly five times more than the average productivity gain in service industries in the past ten year period. Much of this gain has been achieved thanks to the installation of OCR (Optical Character Recognition) equipment in sorting offices. These have the ability to read typed or printed addresses at a rate of up to 35,000 letters an hour. State-of-the-art machinery then sorts mail up to 20 times faster and more accurately than by hand. Royal Mail handles some 70 million items of mail a day and prides itself on delivering to the door of all the UK's 26 million addresses at a uniform price nationwide. There are also some 112,000 red posting boxes dotted around the Kingdom, served by a vehicle fleet of nearly 30,000.

But as far as the P.O. is concerned, there is little time to be complacent. Already, a rival service is operating an early evening collection for a guaranteed delivery before 9am the next morning.

In addition to Royal Mail, the P.O. Group includes Parcelforce, the UK's leading carrier operator, which handles around 400,000 parcels a day with a network which certainly reaches where other networks fail to reach – 239 countries and 99·6% of the world's population. Bar coding technology is used extensively, allowing a powerful parcels tracking system across Europe. There is also Post Office Counters – the somewhat odd name given to the retailing network. Europe's largest retail chain, serves 28 million customers each week from almost 20,000 post offices with some 170 different services. The division is currently engaged in a massive automation programme with the aim of computer terminals being installed at every post office in the network over the next few years. Meanwhile, Subscription Services, whose main service is collecting the TV licence fee, also provides customer management services such as telemarketing.

Franchise counter.



SSL operator using the Trace 4000 optical character recognition (OCR) equipment.

The Project

Essentially, Project Genesis is the blueprint for a model Post Office Corporation, and is probably the most ambitious project ever undertaken by the Group in its 350 year history. It aims to integrate the dozens of applications which run on its computing systems so that its £200 million a year investment in information technology can be used to greatest effect. The benefits of integration are believed by the P.O. to be enormous. It would create a huge portfolio of products and services available from all the Group units, to which customers would have immediate access from workplace or home, just at the touch of a button.

Recently, a Genesis model was set up to demonstrate the scope, power and versatility of the design concept. This took the form of a representative set of transactions involving either placing orders for products and fulfilling those orders or obtaining a service. There were four main transactions:

1. Electronic and tele-sales showed various methods of selling a product where the sale is processed using electronic data. Electronic Mail, a hybrid service in which messages or letters are transmitted with a mailing list electronically to Royal Mail, printed and enveloped at a production site and delivered. Foreign exchange, enabling customers to order and pay for foreign currency electronically, subsequently collecting it at a post office counter. CD sales, represent any product supplied by a third party for the P.O. to sell, warehouse and distribute.

2. Third Party Bill Payment demonstrated how the P.O. accepts and processes payments on behalf of other organisations such as BT, gas, electricity and water users, would have 3 different methods of payment: at a local post office; by telephone via a Post Office call centre; or payment by post to a P.O. production site for processing.

3. Track and Trace is designed to keep close tabs on items going through the P.O. system. This can be achieved by having the item bar-coded at a collection post office or within a bulk delivery system, where an integrated mail processor records a track and handles details for invoicing.

4. Home Shopping makes use of a Net station accessing the Internet or from interactive TV.

The Partnership

The key companies involved in the Post Office Genesis partnership include Alcatel – who are responsible for demonstrating the automated capture by OCR/MTT transports for a major billing operation. BT have the role of providing call centre and PABX systems. The whole project leans heavily on telephones and computers providing screen-based telephony.

Bull Information Systems is the systems integrator for the overall Genesis project. The company has integrated the entire Genesis model at a local centre. In particular, Bull has designed and built the value-added processor, the hub of the data exchange, the track and trace database, the data warehouse and specialist interfaces.

Compaq Computer are providing the desktop solution on which much of the development work is centred. Hewlett Packard are principally involved in the installation of UNIX systems and printers, the shaping of electronic commerce and web servers. The role of IBM was to show how Internet and Intranet applications can be supported and integrated into the central system.

Masterminding all the elements of the database was Oracle. The company provided data warehousing for an Executive Information System, Electronic Commerce through interactive TV and mobile agents for remote wireless capability.

Overall, the Post Office sees several major benefits flowing from the implementation of Project Genesis. These include a practical proof of concept – showing how disparate hardware and software components from over 20 different suppliers can be brought together to provide a comprehensive Information Systems platform for the business. Then, there is the ability to formulate an understanding of the cost implications of implementing the Strategy, and the changes that will need to take place in the organisation to deliver it. Together with the value of establishing common customer records, common systems and a cohesive technical platform across the Post Office.

However, The Post Office is not just sitting back and waiting for Operation Genesis to become operational. The organisation is already deploying a new core large scale network built around ATM. Described as being probably the largest deployment of ATM in the UK, the system will provide integrated voice and data services between 22 regional communications centres and 180 mail and parcels sorting offices at a budgeted cost of £4 million. This joint network development is being part-funded by Alcatel Data Networks who are supplying the necessary IGX switch. The Group is also making use of BT's Advanced Linkline call-handling system, which enables Royal Mail's 52 million customers to call a single enquiry number to check destination postcodes – so helping on-time delivery, particularly over peak periods like Easter and Christmas.

Certainly, it looks like The Post Office is determined not to miss the high tech post.

Dr. Duncan Hine, Post Office Director of Technology, behind the scenes at Project Genesis – The Post Office's vision of the 21st century.

PROJECT

AUDIO LEAD CHECKER

PROJECT RATING 3

Kit Available
Order as LU26D Price £19.99

Design and Text by Tony Bricknell

Open any gigging musicians cable-box and you're bound to find a handful of 'questionable' leads – do they or don't they work? Or are they just wired incorrectly?

FEATURES
- Easy to build
- No setting-up required
- Easily and clearly identifies interconnections on most types of audio cable

APPLICATIONS
- PA/Sound engineers
- Gigging bands
- No home or professional studio is complete without one!

The problem is, there are only so many types of connectors, but an almost infinite number of ways to interconnect them! Are those balanced XLR-to-unbalanced jack cables wired correctly? Or are those suspect 5-pin DIN-to-DIN MIDI cables wired 'straight', 'mirrored', or do they just have a broken connection in the cable?

So, much time is spent rummaging through boxes of cables, trying each one out until a working lead is finally found. But what happens once the gig has finished? The lead is thrown back into the box with all its friends, returning you to square one!

Those of us with the time have probably developed labelling techniques that allow us to instantly recognise each type of cable. However, what happens when the label falls or wears off?

Well, help is at hand! The compact and rugged audio lead tester described here has been designed to show interconnections on the majority of audio leads used at anything from a home hi-fi set-up through to live venues. With pairs of phono, 3·5mm & 6·35mm (¼in.) jack, XLR and 5-pin DIN connectors, the wiring of almost any cable can be clearly and easily seen.

Working by sending a signal out on each pin of a connector, routing it through the cable-under-test, and returning it to the unit, the cable interconnections are clearly displayed on two rows of LEDs – one showing the 'sent' pin, and the other the 'return' pin.

Circuit Description

Reference to the block diagram shown in Figure 1 and the circuit diagram of Figure 2 will assist with the understanding of the following description of how the circuit works.

The entire circuit is powered from a 9V PP3 battery, with C1 and C2 providing, respectively, low- and high-frequency de-coupling of the supply rail.

IC2, a tried-and-tested 555 multi-vibrator, is configured as an equal mark-space ratio astable oscillator with an output frequency, set by R7 and C3, of approximately 1Hz. This circuit configuration was chosen in preference to the more common 'two resistors and capacitor' astable oscillator for no other reason than it saves on components!

For those who are interested in the calculations; Capacitor C3 charges *and* discharges from/to the output of the 555, pin 3, through R7. This makes the charge and discharge periods exactly the same, $t_{charge/discharge} = 0{\cdot}693 \times C3 \times R7$. The total period of oscillation is therefore twice this, $t_{period} = 1{\cdot}386 \times C3 \times R7$. Using the component values chosen, $t_{period} = 1{\cdot}386 \times 0{\cdot}0000047 \times 120000 = 0{\cdot}78$ seconds, resulting in an operating frequency of $f = 1/t_{period} = 1{\cdot}3$Hz.

The clock output of IC2 is fed into IC1, a decade counter. On each clock pulse the active output is moved along one step

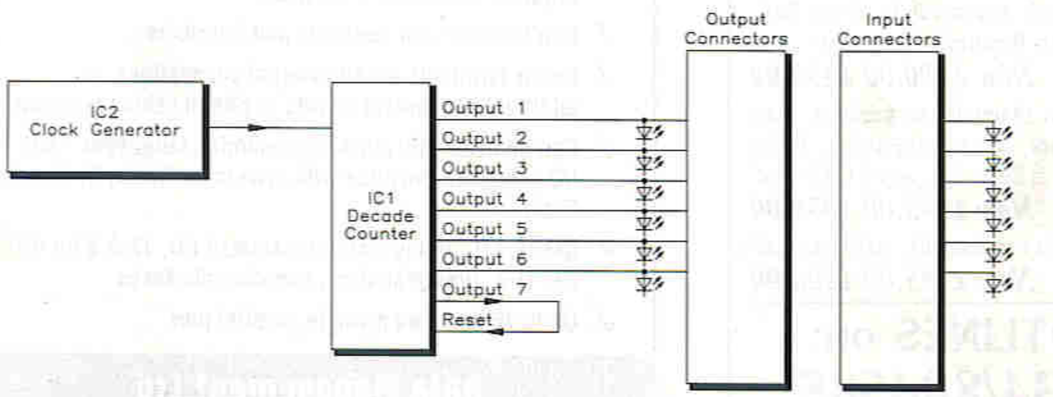
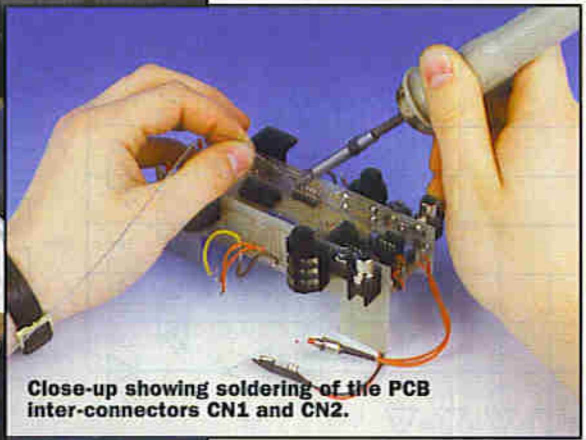


Figure 1. Block diagram.



Close-up showing soldering of the PCB inter-connectors CN1 and CN2.

– Output 1 to Output 2, Output 2 to Output 3, etc. However, as Output 7 is linked directly to the RESET input of IC1, when the active output is moved from Output 6 to Output 7, IC1 resets and starts the cycle once again. In addition, the active output of IC1 at power up cannot be guaranteed but, by tying Output 7 to RESET, it can be ensured that wherever IC1 powers up, it will always (eventually) issue itself a RESET.

Outputs 1 to 6 of IC1 are connected to IC3, a Darlington Array. This drives the six LEDs used to indicate which output is active. The outputs of IC1 are also connected, each through a diode and current limit resistor, to the connectors on the right-hand side of the unit – labelled 'OUT'. To minimise both the number of LEDs and the complexity of the project, all input and all output connectors are wired in *parallel*, see Figure 3. So, for example, when Output 5 of IC1 is active, a signal is sent to pin 4 of the 5-pin DIN connector, pin 3 of the XLR connector, *and* the ring of the jack connectors (both 3·5mm and 6·35mm).

The lead under test is plugged between a suitable 'OUT' connector and 'IN' connector. As each of IC1's outputs become active, a signal is sent to the 'OUT' connector, through the cable, and back to the 'IN' connector. Each pin of the 'IN' connectors is wired identically to the 'OUT' connectors, with the return signals being buffered by IC4 (a slightly different variant of the Darlington Array, IC3), before being displayed on LEDs LD7 to LD12. Therefore, plugging in a direct pin-to-pin 5-pin DIN lead will result in LD6 & LD12 illuminating, then LD5 & LD11, LD4 & LD10, LD3 & LD9, LD2 & LD8, and finally LD1 & LD8 before starting all over again at LD6 & LD12.

PCB Construction

The Audio Lead Checker is easy to construct and requires no special tools, setting up or adjustment. The circuit is constructed on a three-part high quality fibreglass PCB which has a printed legend to facilitate component positioning. If you are new to project building, refer to the Constructors' Guide included with the kit for further information on component identification and soldering techniques.

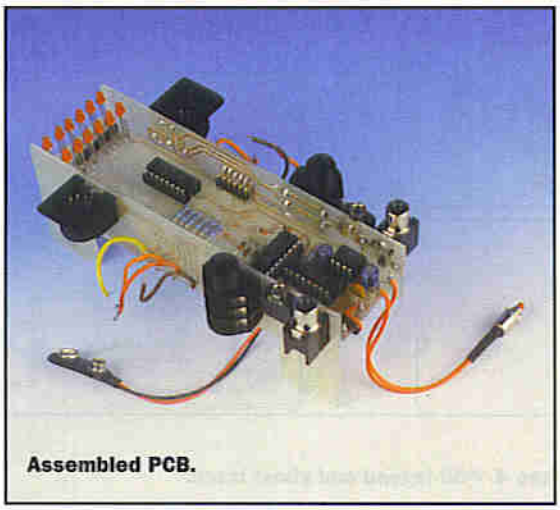
First start by breaking the PCB into its three parts, and sand- or file-flat the snap-off tags; This is especially important along the top edge of the 'Transmit PCB'. Insert and solder the components onto the PCB referring to Figure 4. Start by inserting the twelve PCB pins, and press them into position using a hot soldering iron. When the pins are heated in this way very little pressure is required to push them in place. Once the pins are in position they can be soldered. Now fit the resistors, diodes, capacitors, seven wire links (made from off-cut resistor/diode legs), IC sockets (taking care to match the notch in the end of the socket with the block on the legend), and SIL resistor (matching the pin 1 designator to the outline on the legend). Now fit and solder sockets SK1 to SK8, ensuring that each one is pushed *fully* home before soldering. All component leads should be kept as short as possible and the height of the components above the component side of the PCB must be kept to an absolute minimum to avoid problems when housing the project.

You may now fit the LEDs at a height of 17mm above the PCB (from PCB to top of LED, 12·5mm from PCB to bottom of LED), see Figure 5. The best way to do this is to cut a thin strip of card 12·5mm wide and place it between the legs of the LEDs and the PCB whilst they are soldered in place. Note that the cathode wire, which is the shorter of the two, must correspond with the 'flat' side of the LED symbol printed on the PCB legend Take care not to overheat the LEDs as they can be very easily damaged. Once the LEDs are fitted, and after taking suitable anti-static precautions, the IC's can be inserted into their holders.

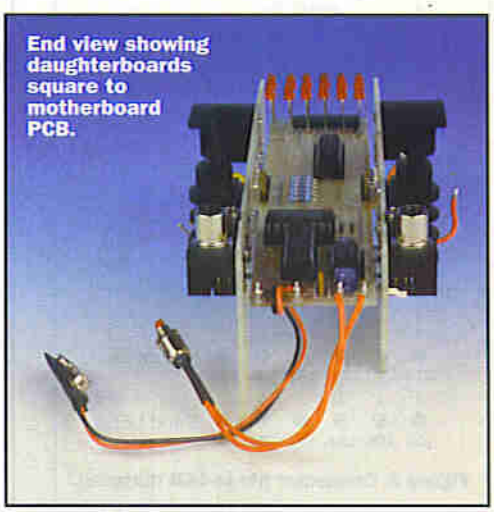
Break off two six-pin sections of right-angled pin-strip and solder them to the 'main' PCB in positions CN1a and CN2a, as shown in Figure 6. Next, align each side PCB at 90° to the main PCB before soldering it in place. (It may be easier to stand the PCBs up on their end for this.) Initially only solder the first and last pins then, after ensuring that the PCBs meet at 90°, solder the remaining pins.

Now thread the PP3 battery clip through the strain-relief hole, and solder it to the PCB pins marked BATT+ and BATT-. Cut the supplied red wire into three equal lengths, using two of the lengths to connect the power switch to the PCB (don't forget to insulate the wires at the switch end with heat-shrink sleeving), see Figure 7.

Now check your work very carefully, ensuring that all solder joints are sound. It is also important that there are no trimmed component leads standing proud by more than 1mm (this is very important of the right-angled connectors CN1 and CN2).



Assembled PCB.



End view showing daughterboards square to motherboard PCB.

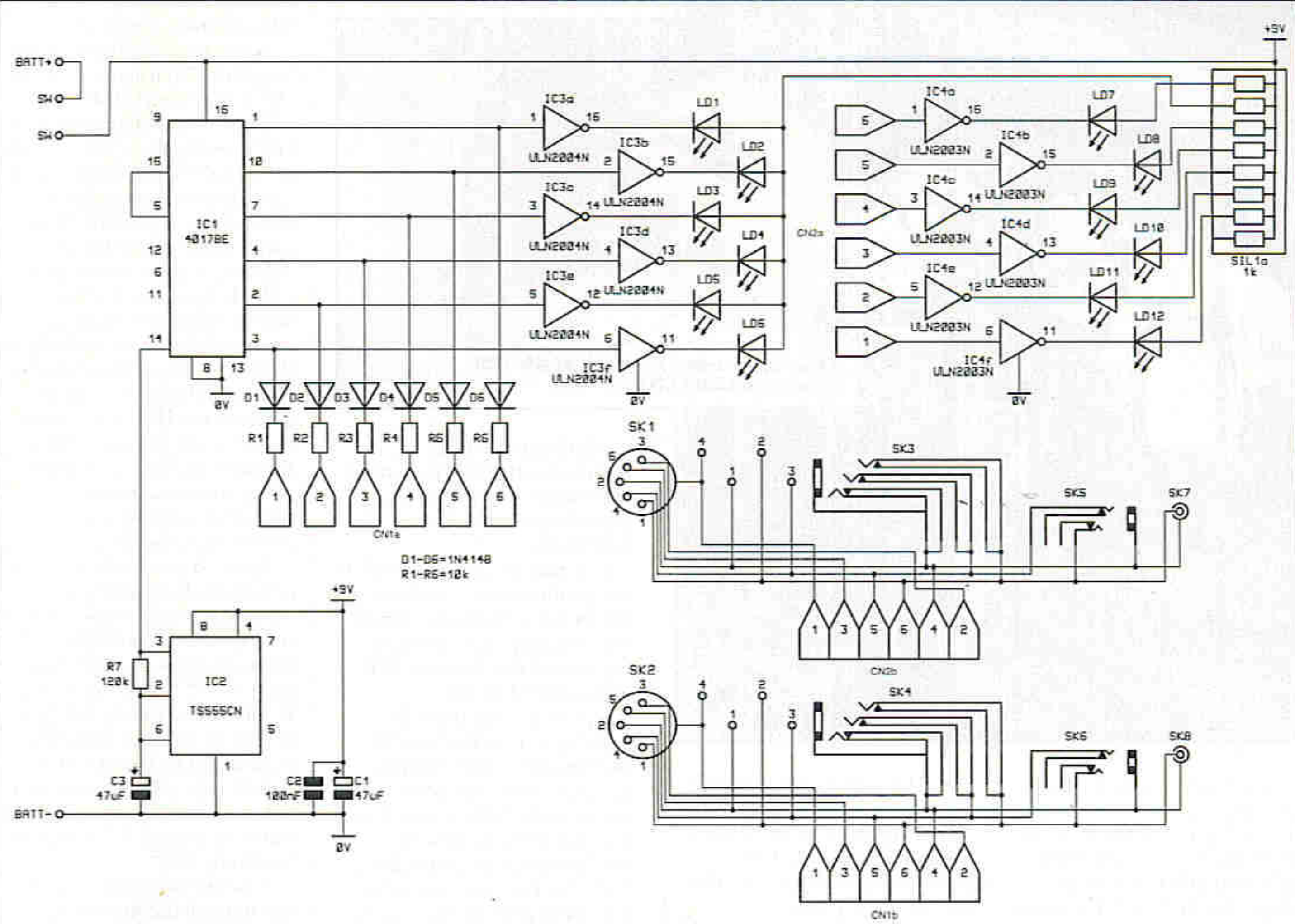


Figure 2. Circuit diagram.

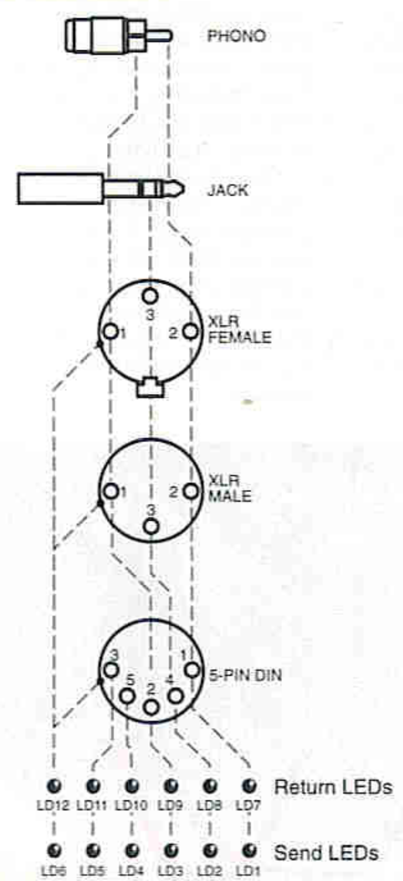


Figure 3. Connector pin-to-LED mapping.

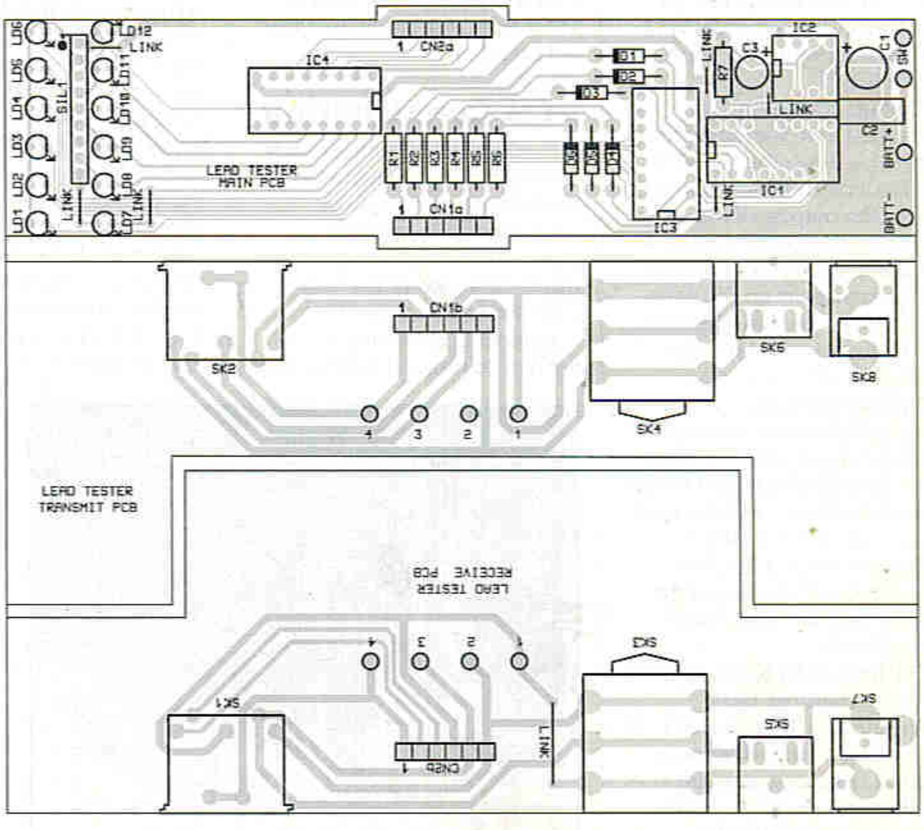


Figure 4. PCB legend and ghost track.

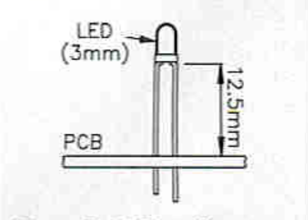
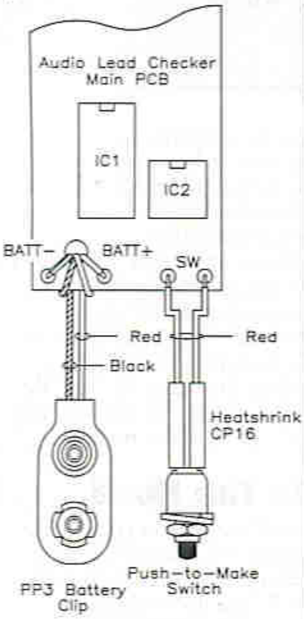


Figure 5. Setting the LED heights.

Figure 7. Wiring the PP3 battery clip and push-switch.



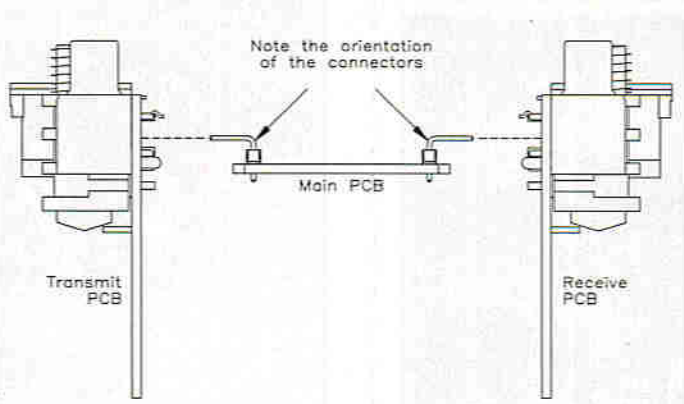


Figure 6. Exploded PCB assembly.

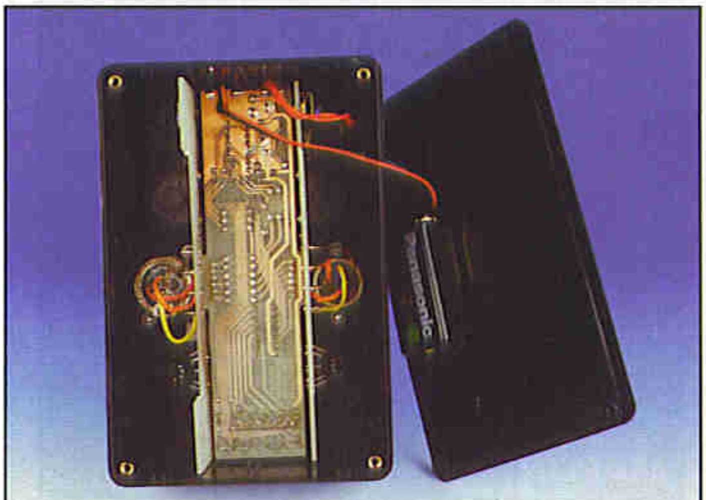
Boxing and Final Assembly

The remaining wire should be cut into equal length strips so that you have two lengths of each colour. Using the following colour convention, solder each wire to the solder tags/buckets on the rear of the XLR connectors: Pin 1 – Brown, Pin 2 – Red, Pin 3 – Orange, Case/Chassis – Yellow.

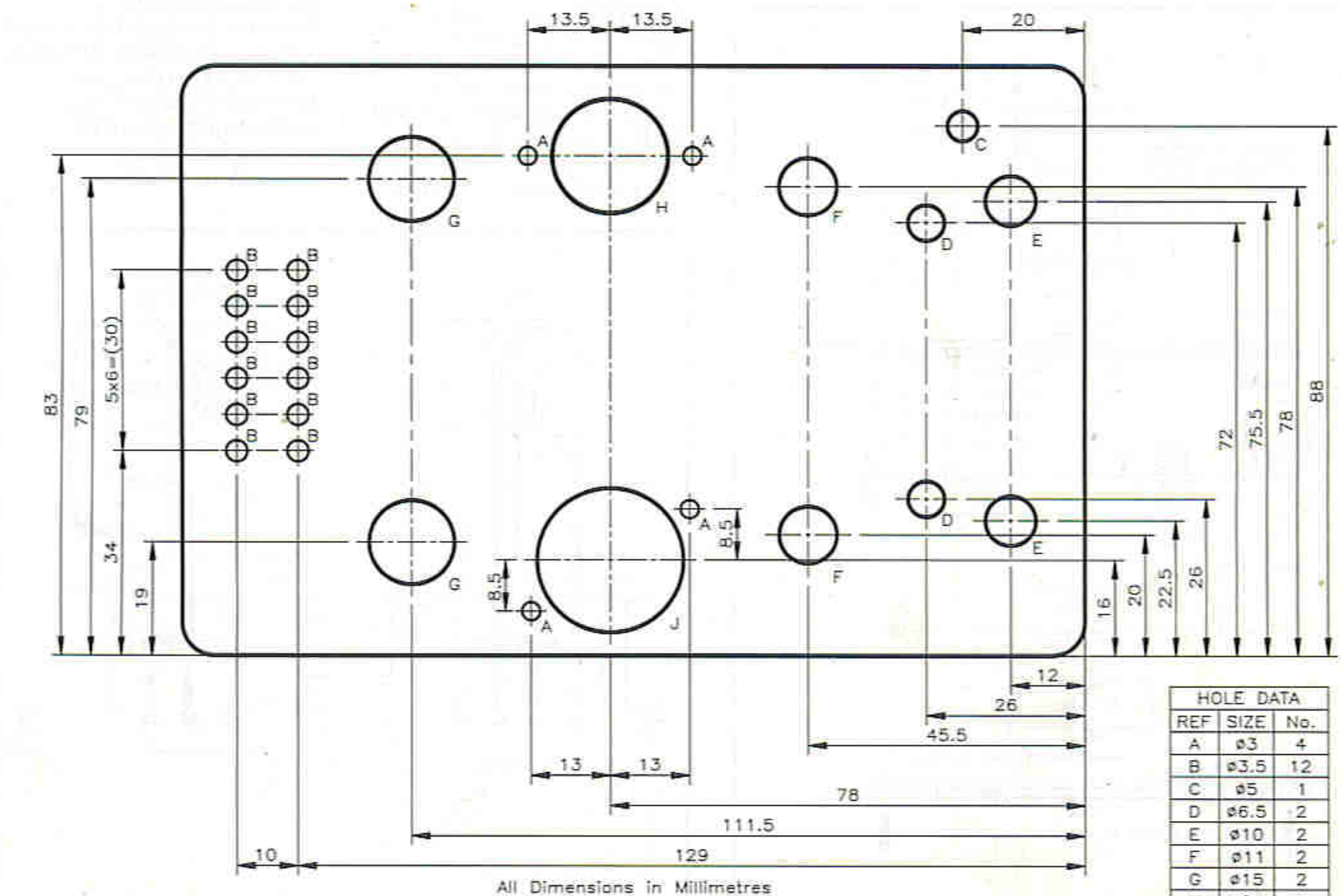
A black plastic ABS box with self-adhesive label is supplied to house the PCB assembly. However, the tray of the box must be drilled in accordance with Figure 8. It may be

A Testing Time

It is now best to carry out the basic tests on the unit before it is housed, as this will make it easier to identify and rectify any faults. The first test is for any short circuits. Using a multimeter on the ohms range and applying the test probes either way around to the PP3 battery connector, you should read open circuit ($>20M\Omega$). With the positive probe connected to BATT+ and the negative probe to BATT-, pressing the power button should yield a resistance of $>1k\Omega$. If your readings disagree greatly with these, then carefully check your work for misplaced components and bad solder joints.



PCB positioned in box prior to base lid fitment.



HOLE DATA		
REF	SIZE	No.
A	ø3	4
B	ø3.5	12
C	ø5	1
D	ø6.5	2
E	ø10	2
F	ø11	2
G	ø15	2
H	ø20	1
J	ø24	1

Figure 8. Box drilling.

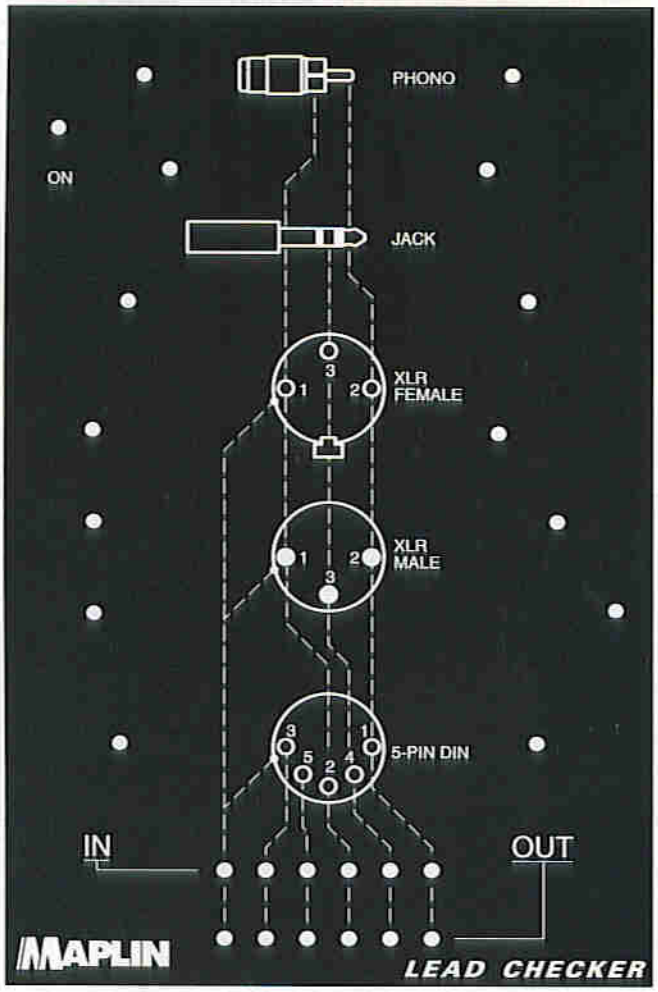
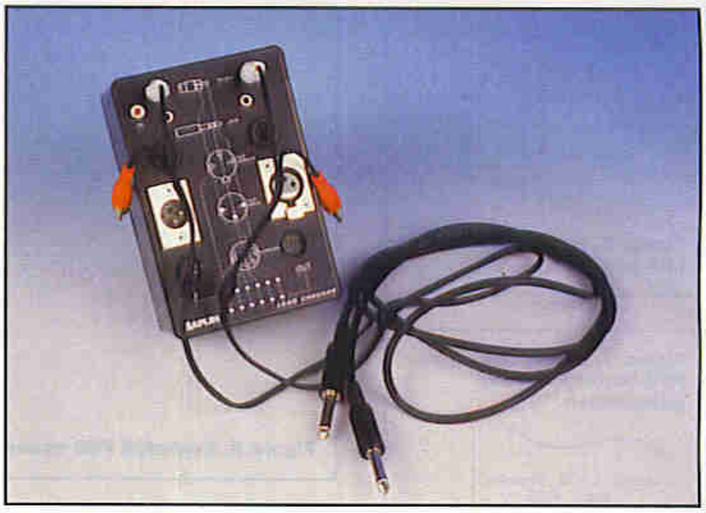


Figure 9. Audio Lead Checker label. (reduced to 90%).



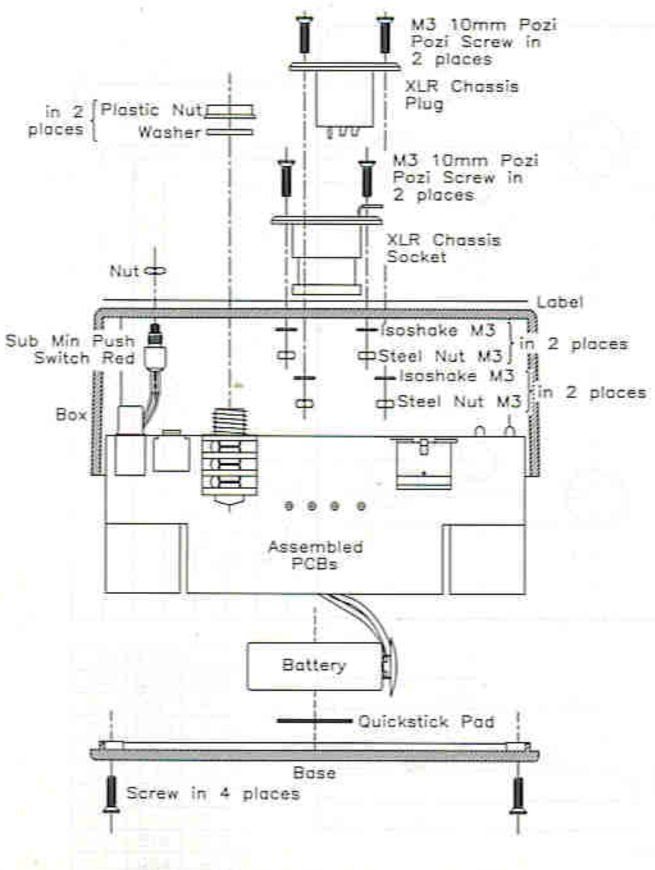


Figure 10. Exploded assembly.

necessary to use small hole punches for the ø20mm and ø24mm hole. Once these two large holes have been made, the XLR connectors can be dropped in place, enabling the positions of their fixing screws to be easily marked and drilled.

Having drilled the box, chamfered the holes to remove any burrs and removed all traces of swarf, apply the self-adhesive label, see Figure 9. The label is pre-punched and will ensure the final appearance is professional even if the holes are slightly irregular.

Using M3 hardware, fit the XLR connectors in place, followed by the push-switch. Now wire the XLR connectors to pins 1 to 4 on the Transmit and Receive PCB's, as shown in Figure 10 and Figure 11. Carefully ease the PCB into the box and fix in place with the 6·35mm Jack socket 'nuts' (omit the fibre washers). Using the supplied 'Quickstick Pad', a PP3 battery (not supplied) should now be affixed to the lid of the box – take care to ensure the battery will not foul the PCB when the box halves are brought together.

If you experience difficulty in placing the PCB in the box, check carefully for tightly trimmed component leads on connectors CN1, CN2, and sockets SK1, SK2, SK7 and SK8.

This completes the assembly and testing of the project.

On The Road

Use of the project couldn't be simpler – connect your 'cable-under-test' between a suitable 'OUT' and 'IN' connector, depress the 'ON' button and read out the connections on the two rows of LED's.

Note that the 5-pin DIN sockets will also accept 3-pin DIN plugs, and that mono jack plugs can be tested in the stereo jack sockets – just remember that the 'ring' and 'sleeve' connections will be connected.

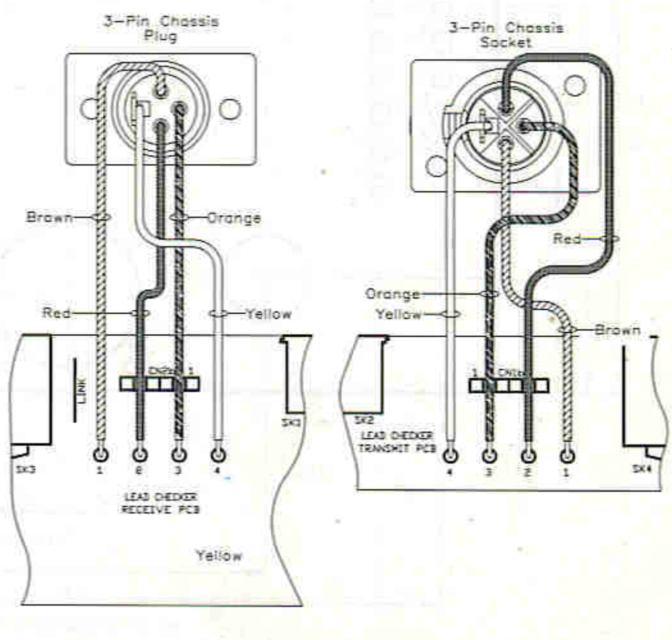


Figure 11. Wiring the XLR connectors.

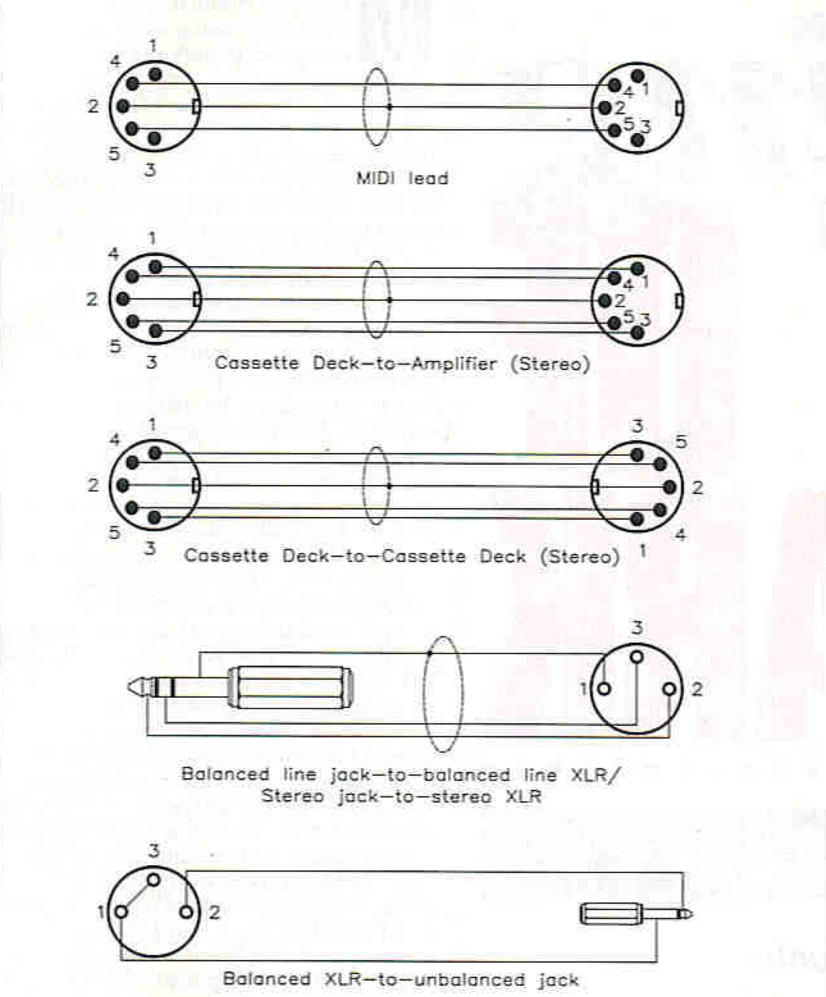


Figure 12. Wiring of common audio leads.

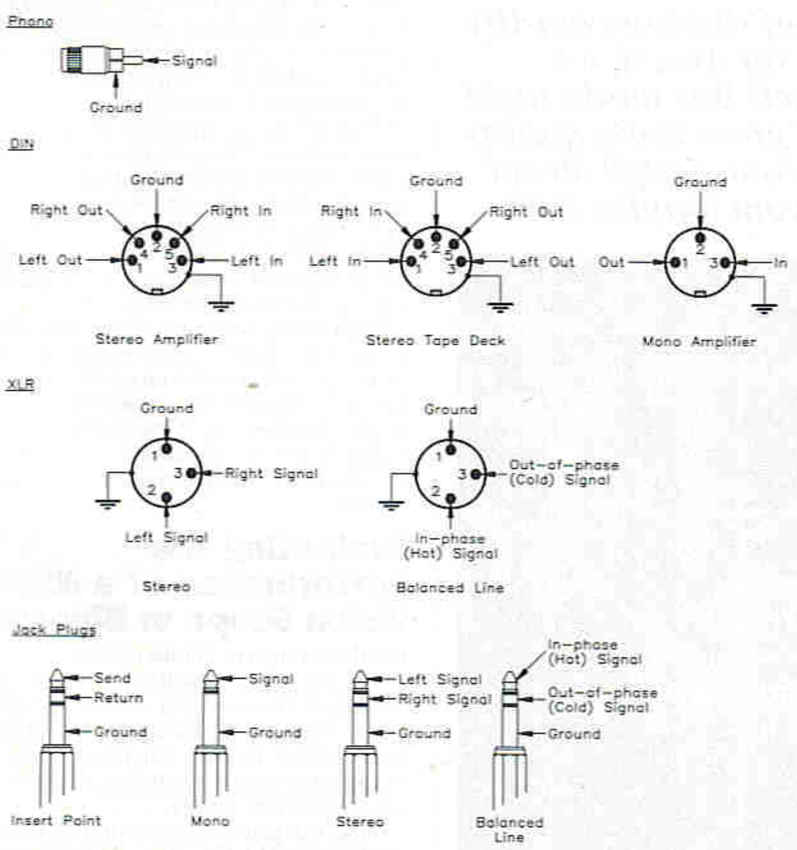


Figure 13. Pin configuration of common audio connectors.

PROJECT PARTS LIST

RESISTORS All 0·6W 1% Metal film (Unless specified)			
R1-6	Min Res 10k	6	(M10K)
R7	Min Res 120k	1	(M120K)
SIL1	SIL Resistor 1k	1	(RA27E)
CAPACITORS			
C1	GenElect 47uF 16V	1	(AU01B)
C2	Minidisc 0.1uF 16V	1	(YR75S)
C3	GenElect 4.7uF 50V	1	(AU05F)
SEMICONDUCTORS			
IC1	HCF4017BEY	1	(QX09K)
IC2	TS555CN	1	(RA76H)
IC3	ULN 2004 A	1	(AD94C)
IC4	ULN 2003 A	1	(AD93B)
LD1-12	Mini LED Red	12	(WL32K)
D1-6	1N4148	6	(QL80B)
MISCELLANEOUS			
	16-pin IC Socket	3	(BL19V)
	8-pin IC Socket	1	(BL17T)
	PP3 Battery Clip	1	(HF28F)
	Box MB5	1	(YN40T)
SK1,2	PC DIN Skt 5-pin A	2	(YX91Y)
SK3,4	Stereo PCB 1/4in Skt	2	(FJ05F)
SK5,6	PCB 3.5 Sto Sw Skt	2	(JM20W)
SK7,8	PCB Phono Skt	2	(HF99H)
PL1,2	Pin Strip 1x36 RA	0·5	(JW60Q)
	XLR Chassis Socket	1	(BW90X)
	XLR Chassis Plug	1	(BW92A)
	Pin 2145	10 Pins	(FL24B) ★
	M3 10mm Pozi Screw	4	(LR57M) ★
	Steel Nut M3	4	(JD61R) ★
	Isoshake M3	4	(BF44X) ★
	7/0.2 Wire 10M Brown	10cm	(BL02C) ★
	7/0.2 Wire 10M Red	30cm	(BL07H) ★
	7/0.2 Wire 10M Orange	10cm	(BL05F) ★
	7/0.2 Wire 10M Yellow	10cm	(BL10L) ★
	Heatshrink CP16	10cm	(BF86T) ★
	Quickstick Pads	1	(HB22Y) ★
	Sub Min Push Switch Red	1	(JM47B)
	Audio Lead Check PCB	1	(GJ65V)
	Audio Lead Check Label	1	(KV20W)
	Audio Lead Check Leaflet	1	(XZ20W)
	Constructors Guide	1	(XH79L)

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

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately. Order as LU26D (Simple Audio Lead Checker) Price £19.99

Please Note: Items in the Parts List marked with a ★ are supplied in 'package' quantities (e.g., packet, strip, reel, etc.), see current Maplin Catalogue for full ordering information.

The following new items (which are included in the kit) are also available separately.

Audio Lead Checker PCB **Order As GJ65V Price £6.99**
Audio Lead Checker Label
Order As KV20W Price £6.99

Making LIGHT OF THE DARK

Night Vision Scopes

by Moonlight Products

Until recently, night vision scopes, or image intensifiers, were available solely to the military. Any that were available on the consumer market were either extremely expensive, of dubious quality and reliability, or both. Now an American distributor called Moonlight Products has made night vision scopes more affordable and given them quality assurance. They are available from a high street Maplin Store or by mail order from Maplin MPS.

Moonlight Products, was set up in 1992 after having developed from a computer peripherals company (Pacific Data Products). Moonlight were originally looking for innovative computer products to market. What they found was a huge potential market for budget night vision equipment. The removal of the Iron Curtain meant that large quantities of night vision products were available from Russia – at a fraction of the cost of any that could be produced in the West.

Moonlight reasoned that with tough quality controls, something seriously lacking in stock Russian equipment, excellent marketing support (quality information sheets, instructions and packaging) and a top grade dealer/customer support infrastructure, then night vision could become a mass appeal consumer proposition.

The result is a company who, every year, have posted multi-million dollar sales, the turnover increasing by over 40% annually.

During 1996, a European HQ was established in the UK to handle the company's distribution in Europe, Africa and the Middle East. At the end of the year, a Hong Kong office was set up, handling Asian distribution, confirming Moonlight as the largest worldwide supplier of affordable, branded consumer night vision systems.

Why choose a Moonlight scope? Quality, competitive pricing and peace of mind. With sales growth as it stands, the company is set to be around for a long time; you will get clear, understandable instructions in multiple languages; and, should something go wrong, there is a 1 Year Exchange warranty and a UK-based technical/service support centre to help resolve the problem.

How Night Vision Works

Night Vision scopes and binoculars are electro-optical devices that amplify existing light, allowing you to see in conditions too dark for the naked eye. Any available light (photons) is collected by the objective lens and focused on the image intensifier. Inside the intensifier, a photocathode is 'excited' by the light and converts the photon energy into electrons. These electrons accelerate across an electrostatic field inside the intensifier and strike a phosphor screen (like a green monochrome TV screen) which emits an image that you can see. It is the acceleration of electrons which provides gain and enhances the image.

Night Vision systems improve your ability to see in low-light conditions, but they cannot provide a useful image in complete darkness – there is no available light to amplify. To allow use in these conditions, an accessory infrared illuminator is required, the intensifier being sensitive to Infra Red sources.

Evaluating the Performance of a Night Vision Scope or Binocular

The darker the conditions and the more distant the subject, the tougher the job gets for a Night Vision system. If the user needs to see fine details in the image, the job gets even tougher. Probably the three most important criteria when testing are: gain, range and image quality.

Ultra-high gain systems with long range capability and highly resolved images are impressive, but they come with huge price tags. Luckily, more affordable Night Vision scopes and binoculars will allow you to see

Moonlight 1400 Select™ night vision scope.

Moonlight Mini™ night vision scope.

the subjects that interest you most: nocturnal wildlife, boats, buoys or berthings, or maybe the source of that strange noise behind the garage.

Unfortunately, it is difficult to choose a Night Vision system by simply reading technical specifications. Performance specs are tough for most of us to understand and even tougher to relate to real-world field use. To properly compare two or more Night Vision systems using technical specs, you must understand: gain, resolution, spectral response, distortion, optical speed and more. In addition, comparison of specifications is only valid if test instrumentation and methodology are consistent and reliable. That is unlikely, considering the number of sources for Night Vision equipment around the world. Consequently, the published specifications for any Night Vision product tell you little about how it compares to the competition. More importantly, specifications won't tell you how the product might fill each of your specific needs.

The most valid way to evaluate a Night Vision device is to try it under real-world conditions. If this is not possible, buy from a dealer who can give you quality advice and possibly a dark room in which to try the product.

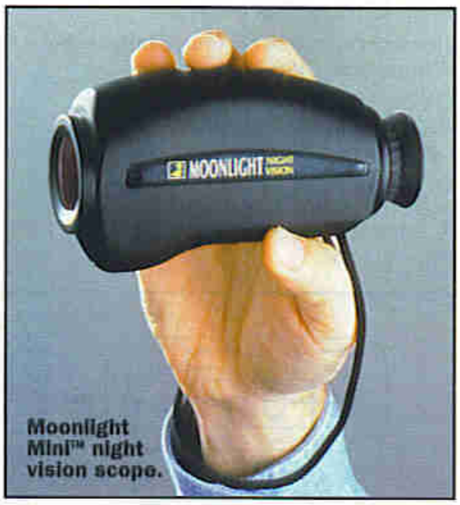
Urban and suburban areas have much more ambient light than rural areas, so your needs may be satisfied with a fairly inexpensive device. In moorland/fenland or forest, a more sophisticated device might be called for, especially if greater range is needed on moonless nights. If you intend to use the device in total darkness, such as in a cave or sealed building, range is not an issue, but you will need an infrared illuminator.

As mentioned above, gain, range and image quality are tied together to define the overall performance of a Night Vision device. Here's how they contribute to the utility of a scope or binocular:

- Gain – Can you see your subject in real-world darkened conditions? The darker the conditions, the harder it is for the system to render a clear image with reasonable contrast. Additional gain is required as conditions grow darker and for longer range. Further, the longer lenses needed to magnify distant subjects typically transfer light less efficiently than shorter lenses and require even higher gain.

More gain is not automatically a good thing. Populated areas always have an atmospheric glow. Most people don't realise how bright their neighbourhoods are until they use a Night Vision scope at home. A high-gain device might be suitable in remote areas on overcast nights, but it's a poor choice for use in urban or suburban conditions where it can easily be overloaded by artificial light sources. Even in isolated locations without man-made light, a high-quality, but affordable (£300) Moonlight monocular will provide impressive imaging with a half-moon and clear skies.

- Range – Can you see your subject 200 feet away? Effective range is a balanced function of the system's gain, resolution, image magnification and the amount of ambient light available. While a powerful lens will provide more image magnification, it will also reduce the amount of available light captured. The best effective range with most intensifiers is achieved with a high-speed lens that has minimal magnification (<5×). Higher levels of ambient light dramatically increase any device's range capability. Just as more gain is required for longer range in darker conditions, less gain is required as conditions grow brighter. While long-range capability will certainly benefit a wilderness search and rescue operation, most consumers don't need that level of performance. Most applications are satisfied with systems offering image magnification of 1× to 3×.
- Image Quality – High resolution, high contrast with limited distortion and noise contribute to a premium Night Vision image. The phosphor display renders a green monochrome image (the human eye is particularly sensitive to green contrasts) which is typically sharpest in the centre and fuzzier toward the edges.



Moonlight Mini™ night vision scope.

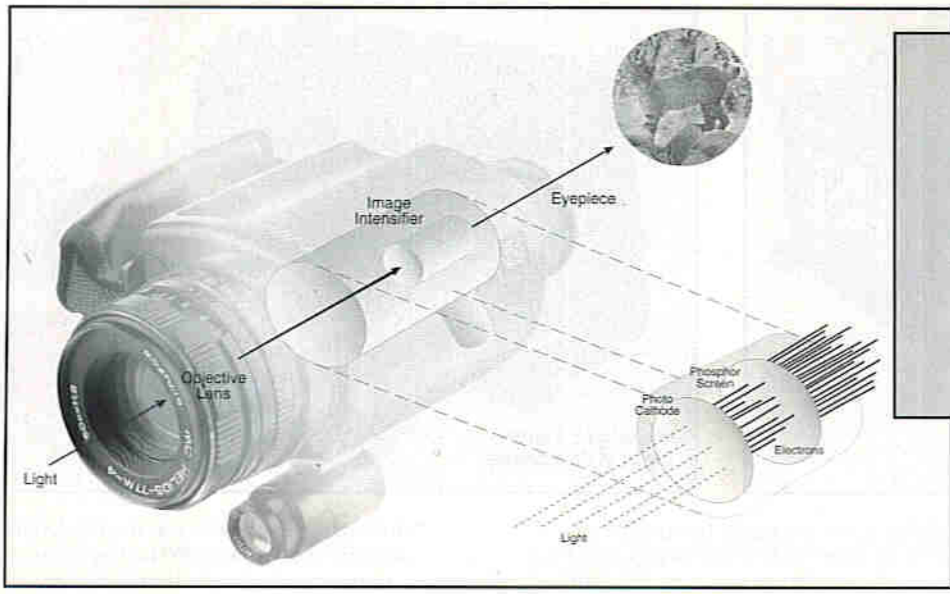
With higher resolution, you might identify someone you know at 200 feet as opposed to simply recognising a human figure. Superior contrast allows you to see dark subjects against darker backgrounds. Lower distortion renders a flatter, less rounded image with crisper details.

Buying a Night Vision Scope or Binocular

When you shop for a Night Vision scope, ask yourself how it will be used. Choose a device with gain, range and image quality suited to your application. If you plan to use the device outside your home and you live in a populated area, select a scope with moderate gain. Since most neighbourhoods don't offer the opportunity for long range viewing, a short objective lens with minimal magnification is appropriate. If you need to recognise people or read distant licence plates, look for a scope with higher resolving power.

Sportsmen or professionals using Night Vision in wilderness locations may consider more gain and a slightly longer lens for greater range capability. Security guards intending to use Night Vision inside buildings or warehouses will need near-field range capability and an infrared illuminator. Once you consider your performance needs, consider these factors as well:

- Ergonomics – Size, weight and ease of use are important considerations. Lightweight devices are more comfortable during extended viewing. Since you will be using the device in the dark, the switches and controls should be positioned logically and be easy to use.
- Practicality – Is the battery a size and model that is commonly available? This is important, especially if you use your system in the field.
- Reliability – With proper care, modern Night Vision designs are fundamentally trouble-free. However, since the image intensifier will eventually wear out with use, buyers should weigh the risks associated with buying used or 'reconditioned' equipment. Old image intensifiers cannot be restored to new condition and it is impossible to anticipate the life of a used tube. Prior abuse or exposure to bright light may further compromise a tube's performance and life. Moonlight Products supply only new Night Vision systems that incorporate protection circuitry which turns the intensifier down



Moonlight NV-100 CompactTM night vision scope.

or off when exposed to bright light. Moonlight's new intensifier tubes are conservatively rated for 1,000 hours of use under normal conditions. It should be noted, however, that any tube will degrade and eventually fail under repeated and prolonged exposure to bright light.

- Service – Is the product protected by a warranty and is technical service available? Moonlight's Night Vision is covered by a 1 Year Exchange warranty and backed by a technical/service centre ready to help.
- Price – Finally, consider how much you want to spend. Night Vision systems range from £179 to more than £10,000. While a £2,000 Generation II monocular might be technically awesome, in all likelihood, your needs will be satisfied with a quality scope or binocular for under £500.

Moonlight MPN 30KTM night vision binoculars.

Moonlight Products Night Vision Scopes – FAQs

Q. How far can I see at night?
A. The distance you can see is a factor of the magnification of the lens and the amount of available light. Moonlight's NV-100 has a magnification of 2·4· which yields a maximum relative viewing range of 300ft., the Mini (1·7×) 150ft., the 1400 Select (1·7×) 225ft. and the MPN30K Binoculars (2·5×) 350ft.

Q. What if it is totally dark or I am indoors?
A. The NV-100 and the Mini include an infrared illuminator which can be used to see in complete darkness. This illuminator casts a light beam in the infrared spectrum (normally invisible to the human eye) up to 100 ft. (about 40ft. in the Mini), improving the illumination and clarity of the scene being viewed.

Q. What type of batteries does it take and how long will they last?
A. The NV-100 and MPN30K require two standard AA batteries, the Mini two AAAs and the 1400 Select one PP3 (9V). Battery life is approximately 120 hours of normal use or 12 hours of continuous use with quality alkaline batteries.

Q. I can see black spots through my scope. What are they?
A. There are two possible causes of these. The first, dirt or debris on the surface of the lens elements, can usually be cleaned away with a quality lens cleaner. The second cause is cosmetic blemishes within the image intensifier. These are normal artifacts of the manufacturing process and do not affect the performance or reliability of the device.

Q. Why should I buy a pair of Night Vision binoculars? And why are they so much more expensive?
A. Generally, Night Vision binoculars offer higher magnification and light amplification than monocular scopes. The extra cost is due to the fact that they consist of not one, but two, image intensifiers.

Q. What are the uses of night vision products?
A. Night vision products can be used to enhance a range of outdoor activities and hobbies. Some of the most popular uses include:

Wildlife Observation – observe badgers, foxes, deer, owls and other nocturnal wildlife in their natural habitat without disturbing them.

Boating – see at night when berthing or when someone falls overboard.

Home/Professional Security – investigate disturbances without being seen.

Fishing/Hunting, Camping/Caravaning, Walking/Hiking, Livestock Observation/Security.

Q. Are there different levels of night vision technology?
A. Night vision devices are divided into three groups:

Generation I – Uses light amplification as described above. The majority of Moonlight's range are Generation I devices. Prices start around £179.

Generation II – Incorporates a microchannel plate (a cross-section of a fibre optic bundle) to enhance gain by focusing the light on the phosphor screen. The high cost of producing the microchannel plate means that Generation II devices start around £900.

Generation III – Uses a gallium arsenide photocathode. Again, uses a microchannel plate. Generation III is currently restricted to military use. Prices start around £3,500.

Q. What happens if I use the scope in daylight or a bright light shines on the scope at night?
A. Direct exposure to bright light is not recommended as it will decrease the life of the device. However, should a bright light shine directly at the lens of Moonlight's product range, the scope will automatically switch itself off.

X-Files – Weird and Wacky uses for Night Vision

A man living in the remote desert of Arizona uses them to catch scorpions in his bed at night. Apparently, they scatter like cockroaches if you put on the light.

Studying embryos in Emu eggs with the use of an IR illuminator.

Paranormal investigations. In the UK, they are used by the Association for the Scientific Study of Anomalous Phenomena (ASSAP).

UFO spotting. Allows the easy identification and disqualification of aircraft, etc.

Photographic darkrooms use them with IR illuminators to check equipment while films are being processed – normal films are not sensitive to IR light.

Electricity companies can use them to inspect power lines for arcing or sparks.

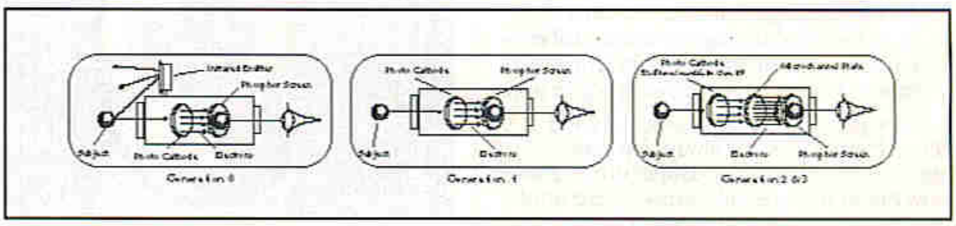
Bat research, especially in caves.

Ranchers in the US observe cows calving at night – apparently, light bothers them.

Night paintballing, skateboarding, mountain biking and orienteering!

Allows sufferers of retinal pigmentosis (causes poor to non-existent night vision) to see at night.

See the range of Night Vision equipment available from Maplin on page 528 of the Maplin MPS Catalogue.



MOONLIGHT PRODUCTS – TOP SELLERS

Moonlight 1400 Select™ Night Vision Scope

- Impressive Night Vision performance at an economical price
- Bright optics with a wide field of view
- Excellent choice for first time buyer

Mini™ Specifications:

Image magnification:	1·7×
Dimensions (l,w,h):	23·1 × 9·9 × 11·9cm
Weight:	1·3lbs. (0·59kg)
Batteries required:	1 × 9V
Field of view:	23° (minimum)
Eyepiece adjustment:	±4 diopters
Relative viewing range:	1ft. (0·35m) to 225ft. (69m)
Objective lens focal length:	58mm
Objective lens aperture:	f 2·0

Moonlight Mini™ Night Vision Scope

- Sleek, miniaturised design – only 5·5" long
- Slips easily into a pocket, briefcase or purse
- Built-in short range IR illuminator for use in total darkness

Mini™ Specifications:

Image magnification:	1·7×
Dimensions (l,w,h):	14 × 4·4 × 7·6cm
Weight:	8·6oz. (0·24kg)
Batteries required:	2 × AAA
Field of view:	37° (minimum)
Eyepiece adjustment:	±5 diopters
Relative viewing range:	8ft. (2·43m) to 150ft. (46m)
Objective lens focal length:	26mm
Objective lens aperture:	f 1·2

Moonlight NV-100 Compact™ Night Vision Scope

- Tremendous Night Vision performance at an economical price
- Optimum blend of light amplification, magnification and compact size
- Includes detachable, zoom IR illuminator for use in total darkness

NV-100 Compact™ Specifications:

Image magnification:	2·4×
Dimensions (l,w,h):	19·3 × 8·9 × 7·1cm
Weight:	1·9lbs. (0·86kg)
Batteries required:	2 × AA
Field of view:	15° (minimum)
Eyepiece adjustment:	±4 diopters
Relative viewing range:	1·1 ft. (33·5cm) to 300ft. (91m)
Objective lens focal length:	58mm
Objective lens aperture:	f 2·0

Moonlight MPN30K™ Night Vision Binoculars

- Bright light amplification
- Quality optics with 2·5× magnification
- Rugged construction for travel and outdoor use

MPN30KTM specifications:

Image magnification:	2·5×
Dimensions (l,w,h):	20·1 × 14 × 9·1cm
Weight:	2·5lbs. (1·1kg)
Batteries required:	2 × AA
Field of view:	15° (minimum)
Eyepiece adjustment:	±5 diopters
Relative viewing range:	15 ft. (4·6m) to 350ft. (107m)
Objective lens focal length:	45mm
Objective lens aperture:	f 1·5

RESEARCH NEWS

by Dr. Chris Lavers

Environmental Monitoring using Infra-red sensing of Crabs

The assessment of toxic trace metals and their effects upon both wildlife and environment is an area of expanding scientific and legal interest. However, it is exceedingly hard to quantify the effects of such pollutants in terms of changes in animal physiological and behavioural patterns. Recent work by Professor Michael Depledge at the Plymouth Environmental Research Centre, University of Plymouth, has been directed towards obtaining a more accurate assessment of the problem. The work of his group has been in the development of potential biological sensors as laboratory screening tools and for actual test-site measurements.

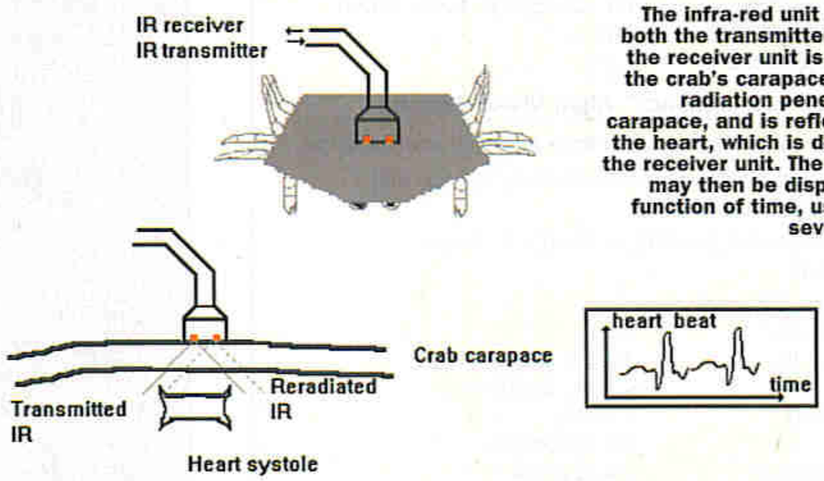
Some of the worst trace metal species involved in pollution are: cadmium, copper, zinc, mercury and arsenic, which may be detected by a variety of methods. Recent technical developments and improvements in both electronics signal processing and instrumentation have led to the acquisition of data from multiple sensors using a wide range of invertebrates. This has lead to a quantifiable 'integrated' animal response. The sorts of processes directly involved include: circulation, osmoregulation, growth and reproduction. The basis of such physiological biomarkers is that if pollution reveals pollution-induced impairment in a significant part of an animal population, it is likely to have direct relevance for the population as a whole.

The most exciting area of this work involves the bonding of a near infra-red transmitter onto a crab carapace near the cardiac region (a transmitter head and a receiver sensor are mounted side by side). The transducer is watertight and weighs about 600mg; it is affixed using a non-toxic adhesive, i.e., Histoacryl Blau, (Braun Melsungen AG., Germany). The state of the heart and its pumping cycle will determine the amount of near infra-red radiation that will be returned to the infra-red sensor.

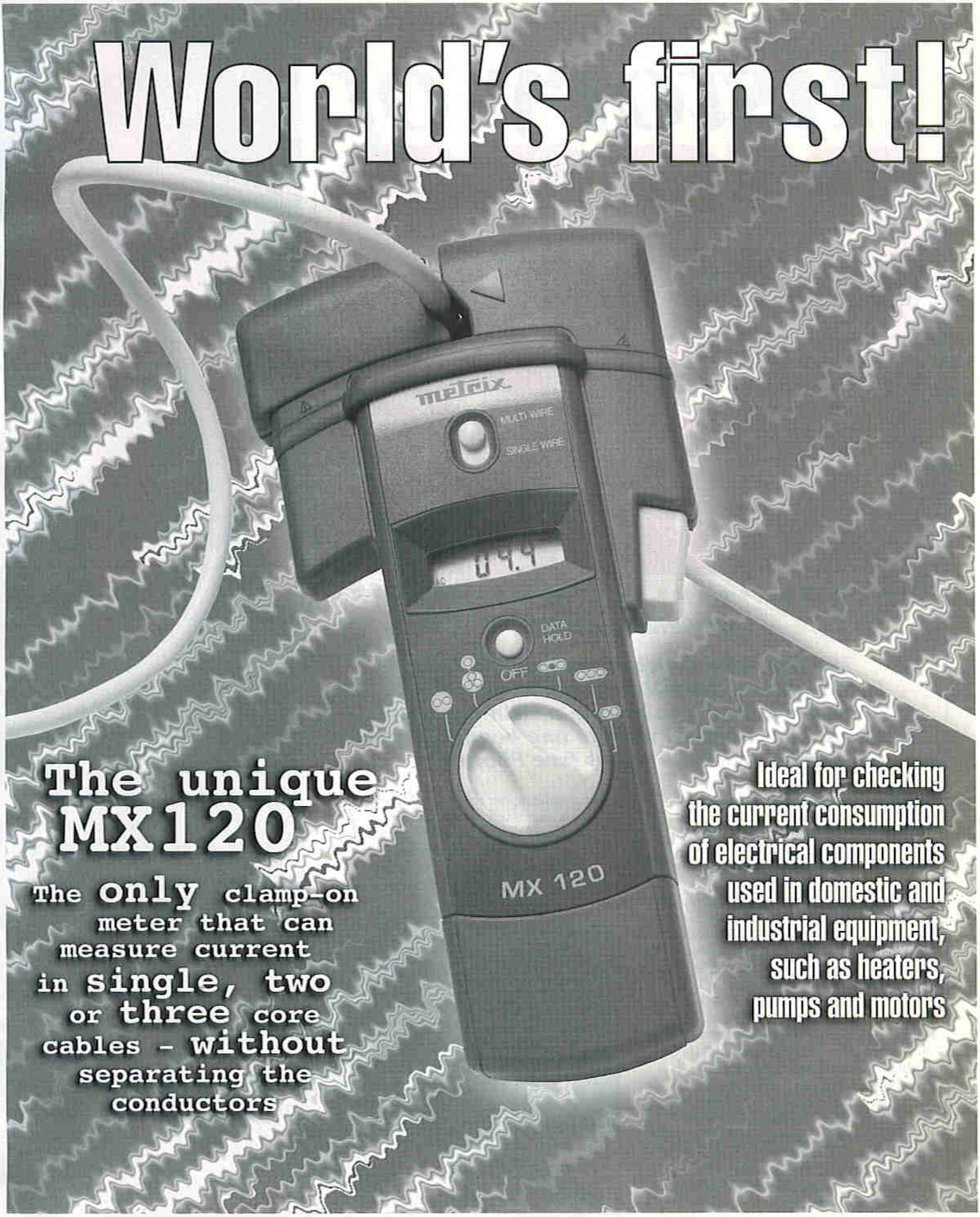
In this way, recordings may be made periodically for durations of several months or even years under a variety of environmental conditions. Up to eight animals may be monitored simultaneously, and basic field work has been conducted in the sub-tropical environment of Hong Kong. In medicine, it has long been recognised that heart rate and cardiac activity patterns are key indicators of the condition of the patient and are included in all general clinical assessments.

Depledge's work has involved computer aided behavioural monitoring, through video camera tracking of animal movements in the test aquarium. Analytical software is then used to determine behavioural parameters such as: distance travelled, average speed, duration of active periods, turning frequency and angle.

The Plymouth system is composed of an IBM compatible computer, and the remaining costs centre around the transducers, transducer/computer interface and computer software which may be purchased for about US $500. Depledge hopes that the system, or an appropriate variant of the system for the task in mind, will become widely adopted. The infra-red sensors will be used to assess the general well-being of animals in both unpolluted control environments, e.g., simple studies of tidal and diurnal rhythms, and also in areas which may suffer from either low level pollution or chronic pollutant toxicity.



The infra-red unit containing both the transmitter head and the receiver unit is bonded to the crab's carapace. Infra-red radiation penetrates the carapace, and is reflected from the heart, which is detected by the receiver unit. The heart rate may then be displaced as a function of time, usually over several hours.


World's first!
metrix
MULTI WIRE
SINGLE WIRE
DATA HOLD
OFF
MX 120
The unique MX120
The only clamp-on meter that can measure current in single, two or three core cables - without separating the conductors
Ideal for checking the current consumption of electrical components used in domestic and industrial equipment, such as heaters, pumps and motors

History of DISCO LIGHTING

by Kevin Hopcroft

The first effects lighting appeared long before discos started. Before the war, it was discovered that if you shine a light on a ball covered with mirrors, you get one beam off every mirror when it rotates (see Photo 1).

My earliest recollection of a mirror ball was in the 1942 film Casablanca, with Humphrey Bogart. So, when discos came along in the late sixties, the mirror ball was the first effect to adopted. Red bulbs provided general lighting, and this gave a warm glow to the room. There would also be a spotlight with a spinning wheel in front of it. A hole in the wheel, provided a strobe effect. Soon after that, an 'Ultra Violet' photographic lamp , which made white things glow in the dark, was quickly transferred into the discos. Then some bright spark found that you could see ladies underwear glowing straight through their clothes. Unfortunately, it also made everybody's teeth glow green as well!

The first real dedicated disco lights were invented in about 1968 when someone decided to control lighting using electronics (Transistors and Thyristors in those days, no silicon chips) – the idea was to flash lamps to different frequencies, originally three channels. Basically, one lamp would flash in time with the bass frequency, one in time with the middle and one in time with the treble. For the first time, sound-to-light had arrived.

Apart from a brief period of popularity for the 'oil wheel', from 1968 to about 1973, sound-to-light was king! It soon progressed from 3-channel to 4-channel, using bass, lower middle, upper middle and treble. However, sound-to-light had a basic problem; whilst the lights were following the music and reacting to different frequencies, the human eye had great difficulty in relating the visual effect to the music. It was just too complex.

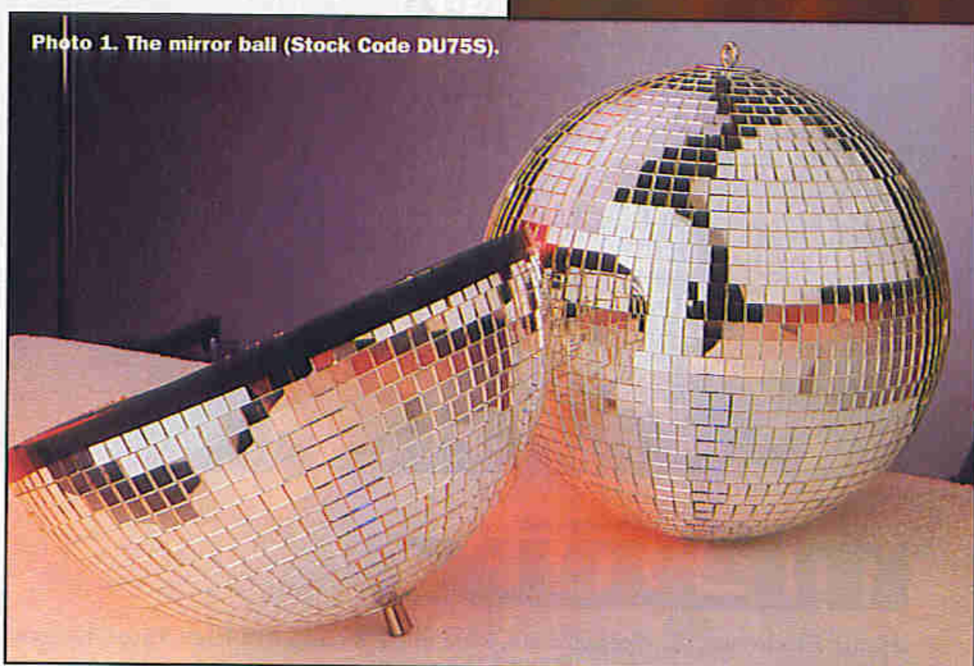


Photo 1. The mirror ball (Stock Code DU75S).

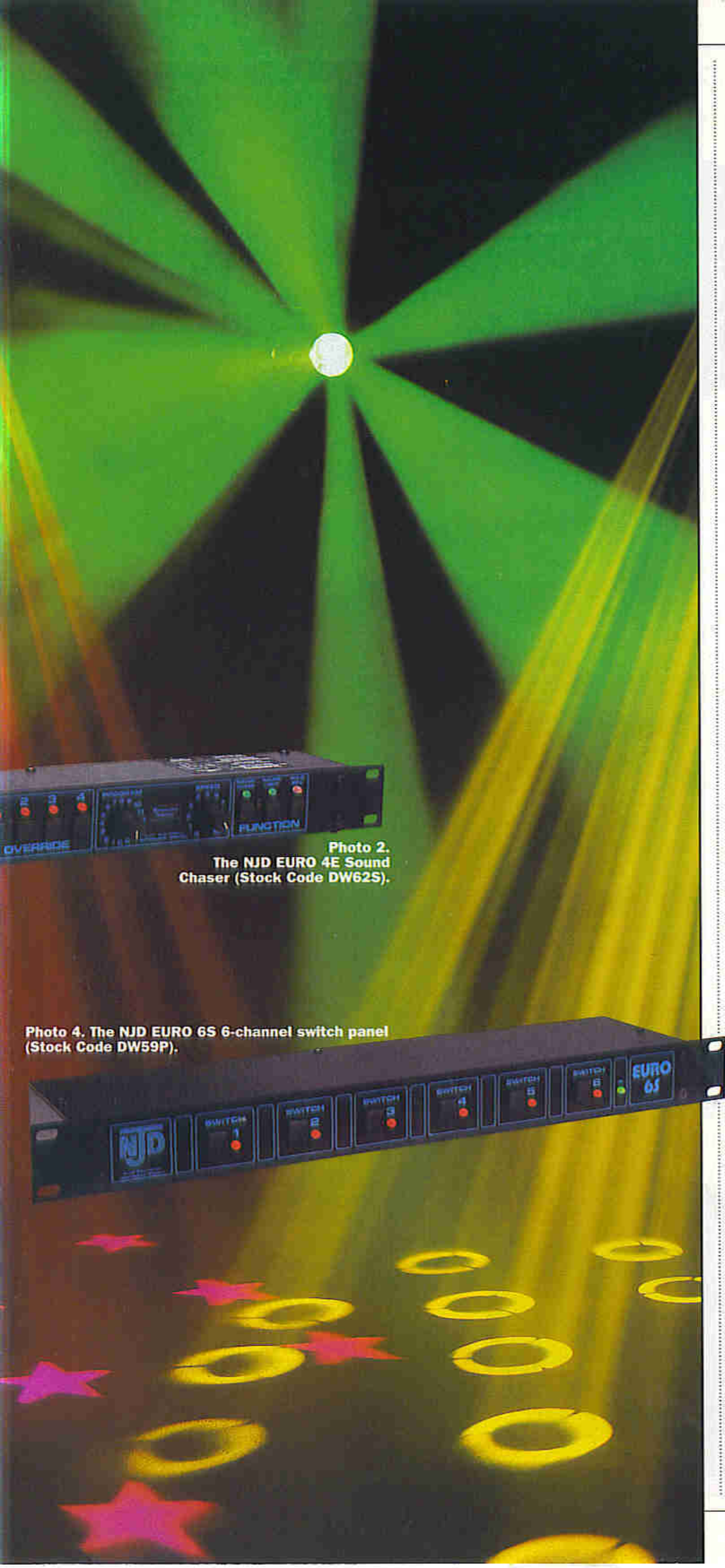


Photo 2. The NJD EURO 4E Sound Chaser (Stock Code DW62S).

Photo 4. The NJD EURO 6S 6-channel switch panel (Stock Code DW59P).

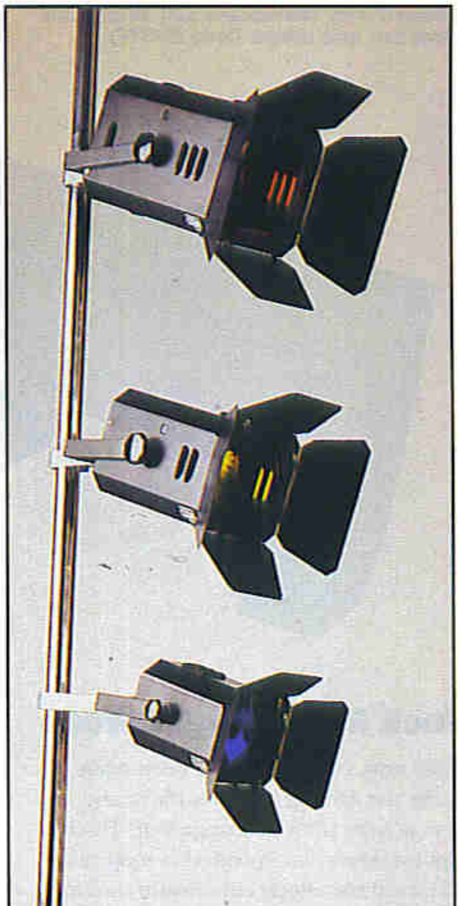


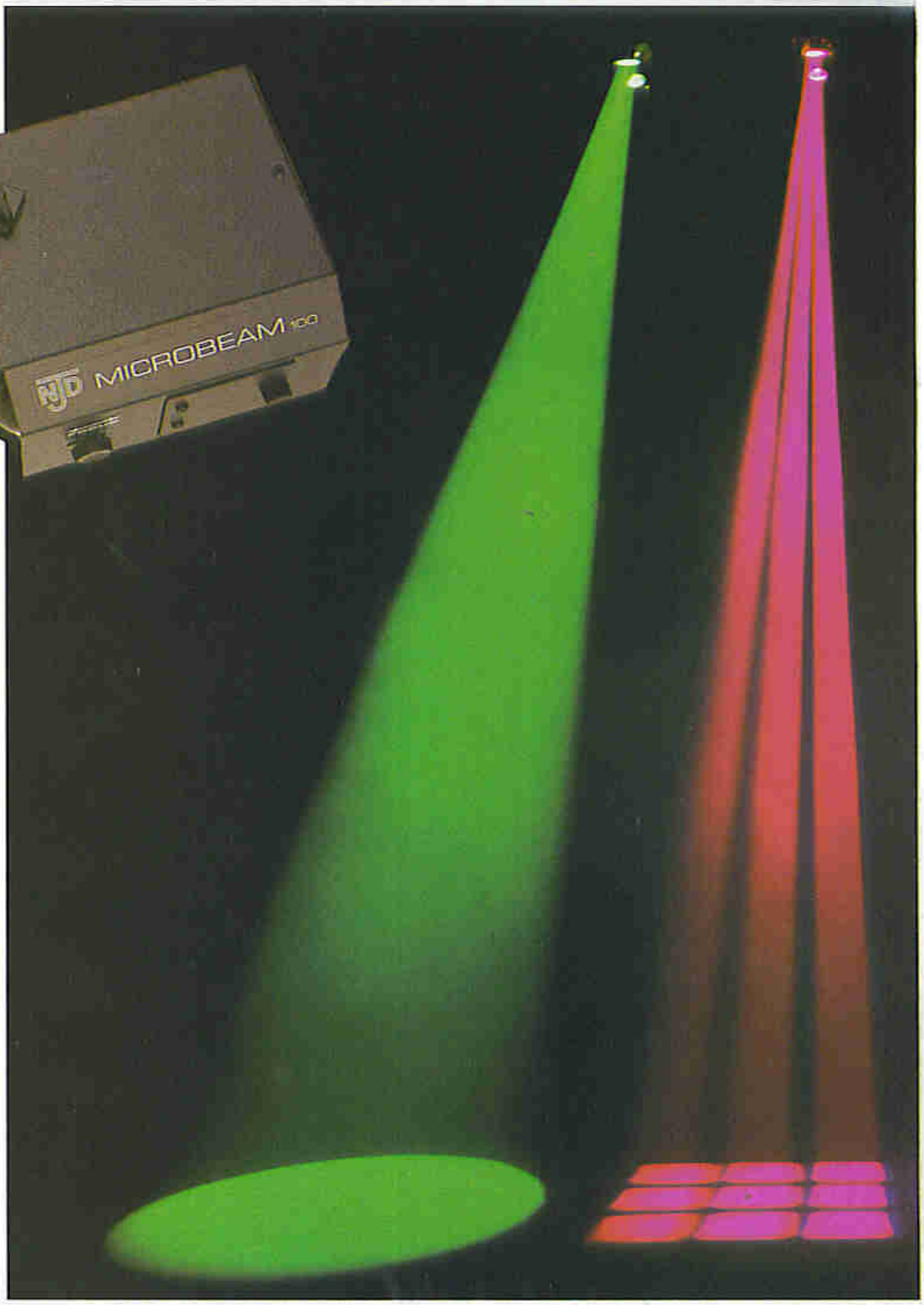
Photo 3. NJD Pin Spot lamps.

Get on Down . . .

In 1973, a new idea was born. Instead of flashing each channel to a different frequency, the new way was to make the lights only react to the bass beat lighting each channel in turn (e.g., first bass beat = light channel one, next bass beat = light channel two, next bass beat = light channel three, next bass beat = light channel four, next bass beat = back to channel one, etc.) This gave an easy and dramatic sound-activated effect that the eye could easily follow, and the Sound Sequencer or Sound Chaser was born. This is still the most popular way of controlling ordinary spot lamps for effects lighting and can be found in the Maplin Catalogue (e.g., EURO 4E – see Photo 2).

The next big change occurred in about 1978, with the arrival of the 'Smoke Machine'. The Smoke Machine brought a whole new dimension to lighting and for the first time, produced 3D effects. Instead of just seeing the lamps flashing, provided you used the right kind of lamp, you could see the whole beam passing through the air. This heralded the reign of the 'PIN SPOT' (PAR36), with a narrow concentrated beam (Stock Code BE28F), as in Photo 3. Ordinary spot lamps (PAR38, R95, etc.) produced only a soft flood and could not give the effect needed in smoke, but the PAR36 Pin Spot was perfect (It's also the right lamp for use with mirror balls). Sound Chasers were used to create stunning effects, sequencing and patterning Pin Spots in smoke.

Photo 6. NJD Microbeam 100 'Intelligent Scanner' unit (Stock Code PD97F).



Jock Makes Light Work

Until now, every effort had been made to make the lighting interpret the sound, but things were afoot to change that! The Pin Spot was now incorporated in motorised effects, these effects either spun the lamps – the Helicopter, or swept them from side-to-side – the Scanner. The job of turning these stunning effects on at the right moment became the job of the DJ, along with playing the records, and in bigger night clubs, they even employed a 'Light Jockey' (new job!). With this came the requirement for more technology; there had to be ways of switching these effects on and off at the right moment whenever the DJ required, without all the clicks and bangs through the sound system that you would get with ordinary light switches, and so the Switch Panel joined the market (See EURO 6S, Photo 4).

The Pin Spot ruled supreme until the early eighties when a new invention hit the market, the Flower Effect. The principle of this was to produce multiple beams, created from a mirror ball, and force them in one direction through a lens. The beams could be individually coloured and made to spin in time with the music. These Flower effects were very expensive at first and only the largest clubs could afford them. These days, technology has progressed so far that they are now small and cheap enough to be afforded by the mobile DJ and are even brighter and more exciting that the originals (See BLITZER, Photo 5).

As you can probably see, Disco Lighting has been a steady progression of modern technology combined with earlier ideas. Incorporated are three earlier principles, Multiple beams of the mirror ball, 3D 'in air' beam projection and sound activation.

Photo 5. The NJD Blitzer Flower Effect generator (Stock Code DW56L).

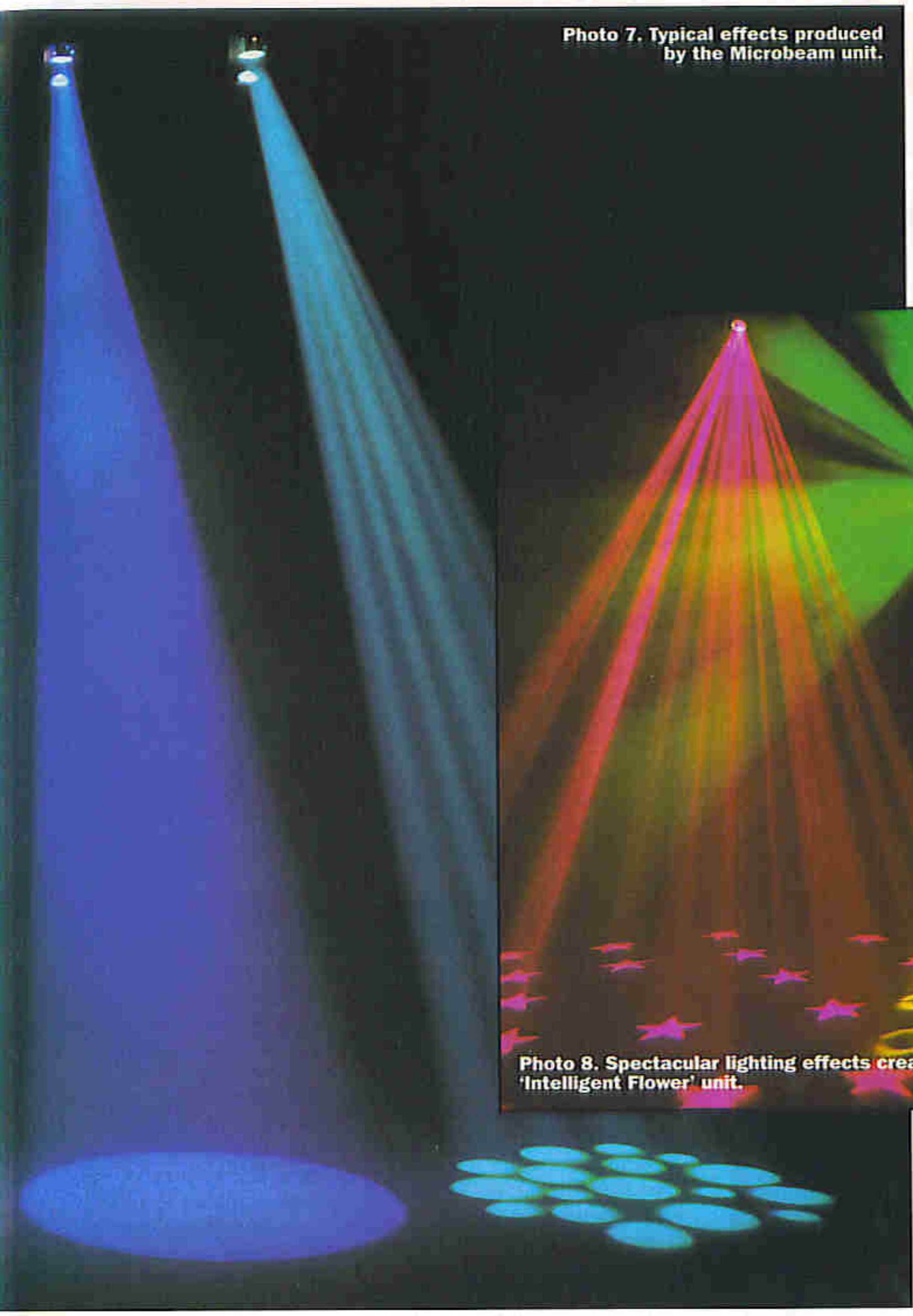


Photo 7. Typical effects produced by the Microbeam unit.

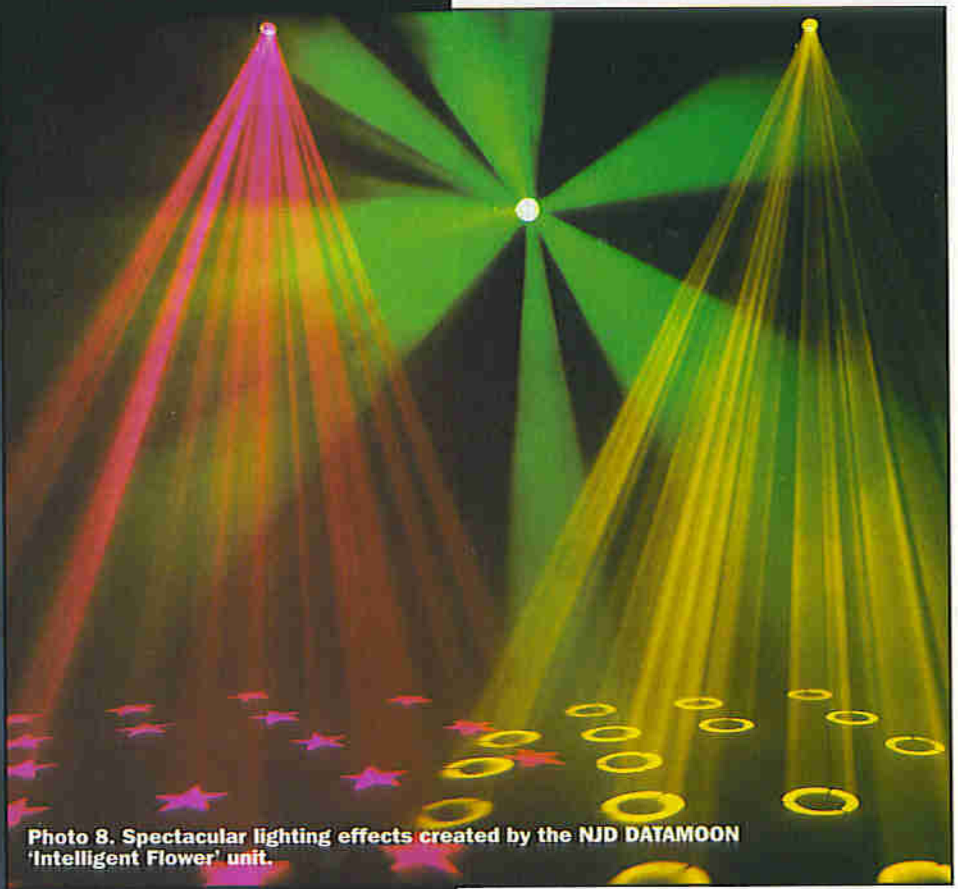


Photo 8. Spectacular lighting effects created by the NJD DATAMOON 'Intelligent Flower' unit.

. . . To the Dance Floor

The next step was the most dramatic and would not have been possible without our friend the Silicon Chip! Until now, the DJ's control was limited to switching effects on and off or choosing the pattern for the Sound Chaser to flash the lamps. At last, the DJ could be given a free reign to let his imagination run riot. In 1990, Intelligent Lighting hit the market.

Intelligent Lighting worked on a new principle: Send a beam through a colour filter and a shape (called a 'GOBO') then project it onto a mirror which was fixed to two motors (one which moved the mirror left and right (X) and one which moved the mirror up and down (Y)) which could be controlled by the DJ. This allowed the DJ to choose the colour and shape of the beam and move the floor projection to anywhere in the room. Originally named the Intelligent Scanner, its name has gradually changed to that of its unintelligent predecessor, 'the Scanner', just to confuse you! (Be careful when buying!) This revolutionary invention was incredibly expensive at first but like all things, has been simplified and miniaturised and is now easily affordable (see MICROBEAM 100, Photo 6, and its effects – Photo 7).

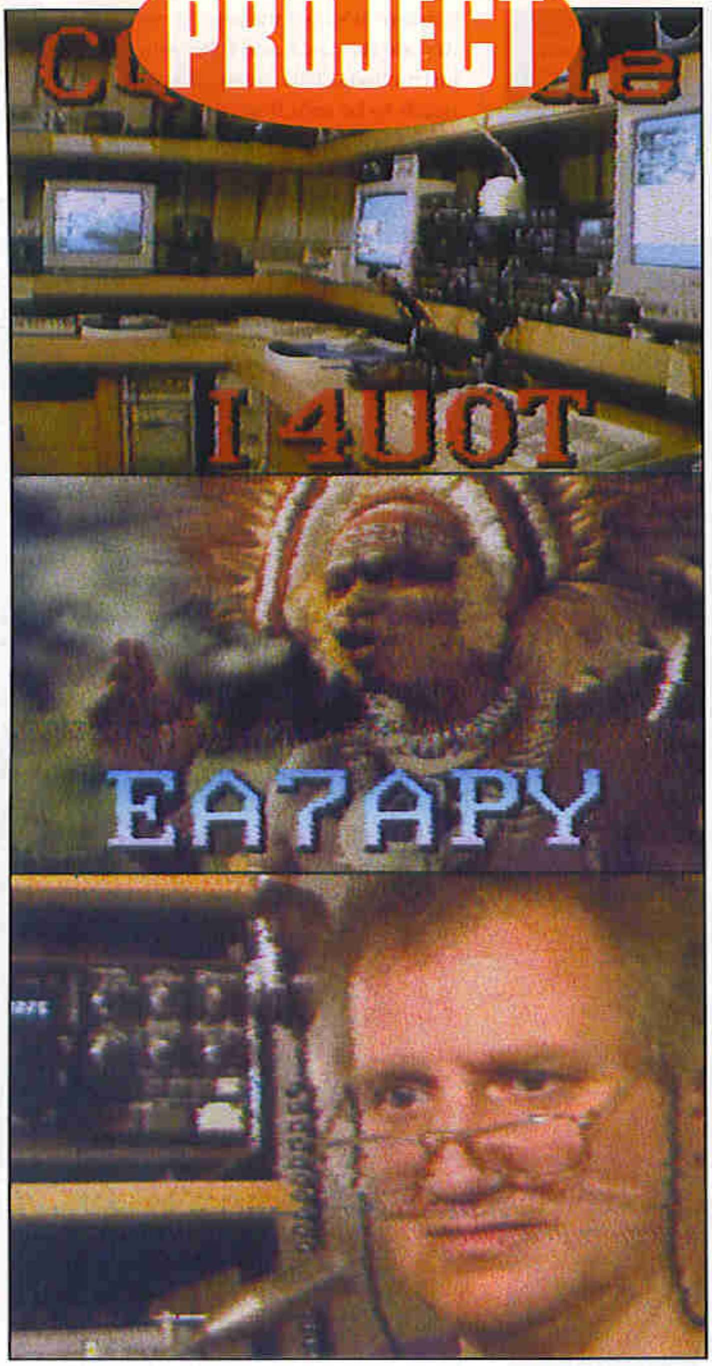
With intelligence came the need to control these new effects, and a whole new system was adopted called DMX. This saved dozens of connecting wires to the lighting effects. Instead of sending a control voltage to the effect, the new system sends digital signals around the circuit, called DMX. Each effect is plugged directly into the mains and contains it's own microprocessor which can decode the DMX and follow the DJ's instructions. This means that only one wire needs to be sent from the DMX controller to the first effect – all subsequent effects are just linked together from the first in a 'Daisy Chain'. The effect, being 'semi-intelligent', knows whether the information it is receiving is for it or is to be passed on to the next effect in the chain, clever eh!

. . . and Boogie!

I suppose the final step in the story was inevitable. In 1994, NJD Electronics of Nottingham, invented the Intelligent Flower. Now instead of projecting one beam, the effect would project 20 beams of a colour and shape of the DJ's choice and move them in time with music. Voted 'The Best Lighting Effect in the World' in 1995, this product is possibly the most stunning disco effect ever produced (see DATAMOON, Photo 8).

Intelligent lighting is now finding its way into 'Live Bands' as the old PAR Cans are replaced with intelligent spotlights, like the CHROMA HX, and this is only the beginning! This is a constantly changing and exciting field as entertainers continuously search for the latest and most stunning effects with which to entertain and amaze people, and I am sure that there are many more new effects just sitting on the drawing board (sorry, CAD screen) as you read this article.

Ask for a demonstration or advice at your nearest Maplin or Mondo store.



Slow Scan TV Decoding

PART 1

Design by Roger Thomas GW8JQW

This article describes a simple PIC-based interface to receive and decode slow scan television (SSTV). The necessary PIC assembler code for a PIC16C84 is given along with information on how to write a program to display the received picture on a PC.

SSTV Background

SSTV is short for 'Slow Scan Television', and is a system used by radio amateurs to transmit static pictures. These pictures can be received using any radio that covers the amateur bands and that can properly demodulate amateur voice transmission. The picture is transmitted using audio frequencies; the audio frequency bandwidth allowed to amateur radio is 300 to 2,300Hz. This restricted bandwidth precludes the possibility of transmitting moving pictures.

SSTV was invented by Copthorne Macdonald while studying part-time at the University of Kentucky, with an authorised test transmission beginning in 1958-9 on the 11 metre amateur band.

The main influence on the technical development of slow scan was the restricted audio bandwidth available and the choice of display technology. Long persistence cathode ray tubes (typically, ex-radar display) were used as they were readily available.

The choice of the timebase for synchronizing pictures was the stable domestic mains power supply. As the equipment was valve based, finding a low voltage mains frequency was not difficult and the 6·3V heater supply was often used.

Mains frequency was divided by an electronic circuit to give the correct timing for the line scan circuit. In Europe, the 50Hz mains frequency was divided by three which defines each picture line as 60ms, and 128 lines per picture. This gives a total picture transmission time of 7·68 seconds for a black and white picture.

In countries with a 60Hz supply, the mains frequency was divided by four to give a slightly longer line length of 67ms, but fewer lines per picture with 120 lines. This gives 8 seconds to transmit a black and white picture.

The picture information lies between 1,500 to 2,300Hz, with black represented by 1,500Hz and white being 2,300Hz, with varying levels of greys between the two frequencies – see Figure 1. To enable picture synchronisation, the frequency used is 1,200Hz, which is blacker than black and thus, not visible. These synchronizing pulses are sent at the beginning of each picture line and last 5ms. A start of picture sync pulse lasts 30ms.

As the highest picture frequency transmitted is 2,300Hz, any harmonics generated from the 1,200Hz sync does not interfere with the picture information and is removed by the transmitter audio filter.

Picture information is encoded using frequency modulation, thus, small variations in amplitude due to propagation conditions do not degrade the picture quality.

Using a long persistence display limited how much could be displayed before the picture faded. If the picture transmit time was any longer than 8 seconds, the top of the image would begin to fade before the scan had reached the bottom. The picture has an aspect ratio of 1:1 (square) since the display tubes were round and a square display was more appropriate.

These displays where only capable of displaying black and white slow scan, in fact, the display itself tended to be made of either blue or green phosphor.

It was common to transmit the same 8 second black and white picture several times to ensure that a complete picture was visible on the display.

Black and white pictures are rarely seen on the bands these days, and then usually to announce the presence of slow scan and during some SSTV contests. Strictly, these black and white transmissions are the only internationally agreed slow scan standard.

During the 1970s,

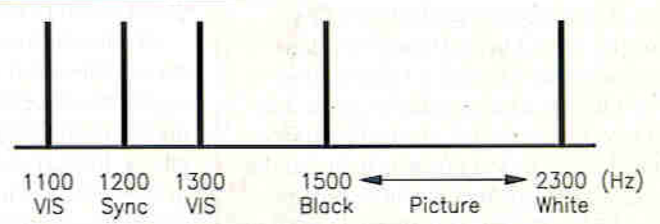


Figure 1. SSTV Audio Frequencies.

commercial equipment was being offered for the first time, the most famous from a company called Robot Research Inc. of San Diego, USA. The first model was the Robot 70 range, using a long persistence cathode display, followed by the Robot 400 which used semiconductor memories (black and white).

It is important to understand some of the history of slow scan because the original technical specification influences virtually all the slow scan TV heard today.

SSTV Colour

With the advent of digital electronics in the 1970s, radio amateurs were no longer tied to the vagaries of the long persistence display.

Digital displays were built using shift registers and then using random access memory (RAM). Improvements in the quality of pictures transmitted were achieved by increasing the number of lines and at the same time, radio amateurs were experimenting with colour transmission.

Colour slow scan can be achieved by increasing the number of display memories to three, with each memory assigned one of the three primary colours (red, green, blue), necessary to display a full colour picture using additive mixing.

When discussing colour in terms of the primary colour, it is correct to refer to the brightness (or luminance) as it has the same meaning as when applied to a black and white picture.

A colour camera was not needed to capture a colour picture. With a black and white camera viewing a caption or photograph, a colour photographic filter (red, green and blue) is placed in front of the camera. The picture is loaded into one of the three memories, as appropriate, and when all three pictures are viewed simultaneously, it will be in colour.

For a colour picture, each of the primary colours (RGB) is transmitted in sequence, although the colour order in which they are transmitted is not important and different modes have the colours in different sequence.

Originally, each frame was transmitted separately but any lines lost caused all the subsequent received lines of the picture to have incorrect registration. It soon became apparent that line sequential colour was better.

Each picture line comprising all three colours is transmitted, without individual sync pulses between each colour. Any line syncs lost would result in only that line missing but this should not affect the rest of the picture.

The Robot 1200C Colour Scan Converter was introduced in the mid 1980s and is microprocessor-based (Intel 8031), considered to be 'state-of-the-art', with ability to capture fast scan pictures and transmit high resolution colour SSTV.

The original Robot colour transmissions (called time multiplexed component colour) used a system that transmitted the luminance (black and white) and the colour signal separately, much like PAL colour television does today. This allowed a black and white Robot to receive a Robot colour picture but only display the black and white part. The original Robot colour format is not heard today.

SSTV Now

In recent years, slow scan television has become more popular due to the increasing use of personal computers in amateur radio and the considerably improved graphics capability.

Dedicated slow scan equipment is capable of 262,144 colours (64 different colours per red, green, blue primary colours), typically with 320 pixels per line by 256 lines. All Windows 95 PC computer graphics cards have better resolution than that required by slow scan and most are capable of 24-bit colour.

These graphics cards can display over 16·77 million different colours (true colour). With these colour graphic cards, the SSTV decoding software does not need to do any colour palette switching.

One criticism of slow scan television is the plethora of different modes and standards. Some are to do with genuine innovation, others are more to do with selling proprietary equipment. However, with software doing the decoding, this is less of a problem as software can decode many variations, but this flexibility can also exasperate the problem.

Over the years, the Robot 1200C internal memory has been increased and the software in the EPROM has been re-written and enhanced by several radio amateurs. The most popular version is written by Martin Emmerson G3OQD and the new modes introduced are named after the originator. Martin mode introduced the concept of only one sync per picture line.

Martin M1
320 pixels per line and 256 lines (114 seconds)

Martin M2
160 pixels per line and 256 lines (58 seconds)

Martin M3
320 pixels per line and 128 lines (58 seconds)

Martin M4
160 pixels per line and 128 lines (29 seconds)

These numbers given are the transmit resolution; on receive, it is possible to display the same line or pixel twice to increase picture size. Thus, mode M4 picture can be received using the display set for M2 but with each line repeated.

In Europe, Martin's mode M1 is the most widely used SSTV mode.

Another version of the EPROM is available from E. T. Murphy GM3SBC, which introduced the 'Scottie' mode, which seems to be more popular in the United States.

There are small technical differences regarding the timing between Martin and Scottie modes but in practice, there is little to choose between the two modes. However, there is a Scottie DX mode which takes around five minutes to transmit a picture but is capable of producing excellent quality pictures. The longer the transmission takes, the less visible is any noise and interference on the received picture.

One mode that is distinct from other modes is called Wraase mode, named after the author, Volker Wraase DL2RZ, and implemented in the Wraase Electronic converter. The colour is transmitted in the more conventional red, green, blue sequence and adopts the established line sequential format.

However, the green line is transmitted at half the rate of the other two colours, in other words, the green line takes twice as long to transmit and equals the combined transmission time of red and blue. The argument is that on a 'natural' picture, such as a face or landscape, the green colour part of the picture holds half the total picture colour information. Thus, improving the quality of green has a significant effect on the quality of the entire picture.

The Robot company ceased production of their slow scan equipment some years ago

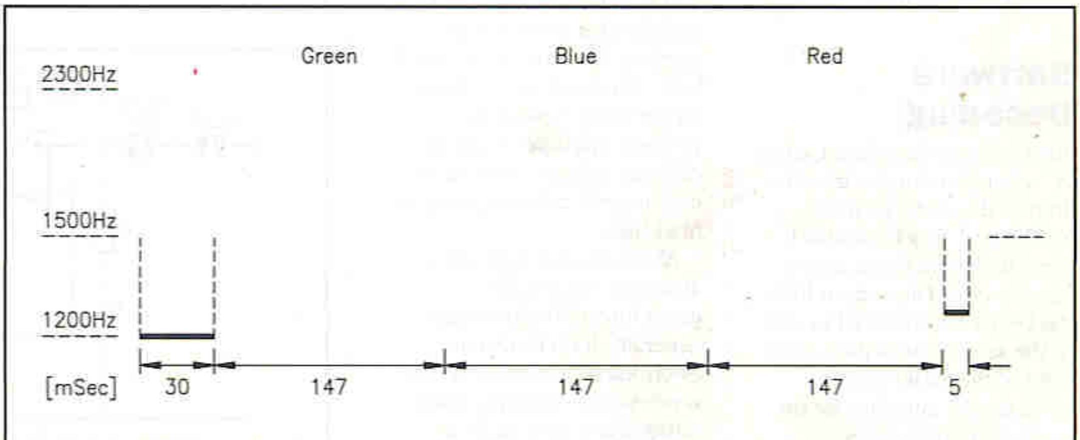


Figure 2. SSTV Test Card.

(1993), due to people using computer software rather than buying expensive dedicated equipment!

Figure 2 depicts what the start of a test card transmitted and first line looks like when transmitted using colour slow scan (Martin mode). A test card is made up of the following colours: white, yellow, cyan, green, magenta, red, blue and black.

VIS Code

Automatic identification of the picture format is accomplished by the decoding of a VIS (Vertical Interval Signalling) code sent at the beginning of the picture. This was introduced by Robot to enable automatic picture format selection between Robots and has been widely adopted by others. Only a few of the possible 128 different combinations were used by Robot.

The VIS format is a 1,200Hz start bit (sync) then 7 data bits plus parity signal, with each bit being 30ms in duration. To confuse the issue, the lower frequency signifies a logic 1 and the higher frequency signifies a logic 0, the inverse of how the picture data is transmitted.

Unfortunately, as this was essentially a proprietary code, little technical information was released and consequently, different programmers have interpreted the same information differently. This has unfortunately led to the same SSTV mode appearing to have different VIS codes, depending on how the programmer has interpreted the binary sequence.

If there is a steady tone at 1,300Hz, caused by incorrect tuning or another station, this will produce all zeros which is a valid VIS number (for Robot 12 second colour). With hindsight perhaps, this code should not have been allocated.

Software Decoding

Total software decoding using a PC requires a simple circuit to amplify the audio to serial RS232 level, which effectively turns the audio signal into a square wave. This output from the circuit is connected to one of the serial control pins. Each edge of the audio signal generates an interrupt for the serial communications controller. The PC's programmable interval timer is used to time each interrupt which, in effect, is the length of each cycle (wavelength). This is converted to a frequency by the software.

However, there are other sources generating interrupts that have to be handled by the microprocessor – such as keyboard, real time clock, video, mouse, etc.

The interrupt response time will slightly vary each time, depending on what instruction the microprocessor is currently executing – if it has just started an instruction, the interrupt is handled when the instruction has finished. If the interrupt occurs immediately after the current instruction has finished but before the next instruction, the response will be almost immediate.

This is sometimes referred to as 'interrupt latency' and means the length of time taken to respond to interrupts. This variation in response time shows up as slight 'blurring' of straight lines when displaying a received picture.

On transmit, this can cause a sinewave to be malformed with incorrect timing, and when received, this effect can show up a contouring around edges. Using the fastest microprocessor makes all these effects less likely or less visible.

There are several DOS-based programs that can decode SSTV this way and are capable of good results. All these DOS programs decode slow scan in real time. In effect, there are two timing loops – one does the timing of each cycle to determine the frequency and therefore, colour. The other loop determines at what point along the line the picture has reached.

Most of the DOS programs are capable of producing SSTV audio, either through the PC's built-in speaker or via the transmit data line on the serial port. The number of colours are generally limited to generating a total of 262,144 different colours (6 bit each colour or 64 different levels of brightness).

Although slow scan is an analogue system, the generation of the picture is generally done by digital electronics. The digital square wave output signal is passed through low pass filters to remove all the harmonics and what is left is the fundamental sinewave, which is fed to the transmitter.

The quality of the picture is primarily determined by the speed of the processor and the quality of the software. If the software is being run on a slow machine, this can result in poor pictures. In addition, the internal timer accuracy can vary slightly between computers and needs compensation in software, but this is rarely done. Tuning can correct for a small frequency offset but it does mean that there is no absolute reference that can be used to set up or align equipment.

There is variation among the quality of SSTV signals heard on the amateur band, in the same way that some stations have excellent voice quality while others have poor audio. Distorted voice audio makes it difficult to understand what is being said and similarly, poor audio quality with slow scan gives poor pictures.

Slow Scan Decoding Using a PIC

A better method of decoding slow scan is to keep the advantages of software decoding, but to use a dedicated external microprocessor. This microprocessor can concentrate on the intensive calculations required for the audio-to-frequency conversion. The PC software can then concentrate on the picture display.

The PIC is an ideal solution to the problem as it is a RISC (Reduced Instruction Set Computing) based microcontroller. The philosophy behind RISC is that these microcontrollers run faster compared with conventional microprocessors because they incorporate only a limited number of instructions. These instructions operate directly on the internal registers (no microcode). With a 4MHz clock, each instruction takes exactly 1μs; these are constant time values and this software 'time overhead' can be precisely calculated.

As well as fast execution speed, the interrupt latency is considerably less due to each instruction executing in exactly one cycle (two for a jump instruction), whereas the microprocessor inside the PC will take a different number of cycles depending on the actual instruction.

The source code is given for a PIC 16C84 to digitise receive slow scan and send this data to the PC to display. It has the advantage that all the timing is done by the PIC with a sample taken every 416μs, but has the disadvantage that the PIC is always transmitting data to the computer.

The actual interpretation of data processed by the PIC chip is done by the PC software; this allows the PIC software to concentrate on the frequency conversion. Any new slow scan format only requires a change in the PC software, not in the PIC microcontroller program.

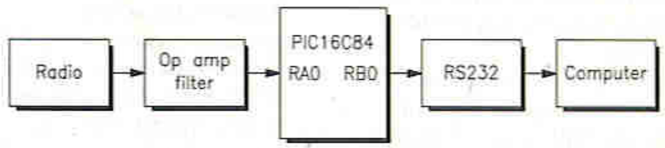


Figure 3. Block Diagram of Interface.

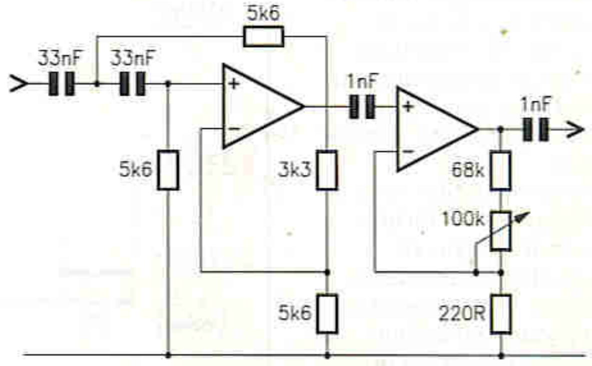


Figure 4. SSTV Interface Filter.

SSTV Interface Circuit

Figure 3 shows the block diagram of the Interface, while Figure 4 shows the SSTV Interface Filter circuit diagram. Audio is fed into the interface unit from the receiver, the signal input to the interface is taken from the loudspeaker or phones output. Consequently, the circuit can cope with large amplitude audio signals – this reduces the requirement for several gain stages in the interface.

The first half of the operational amplifier is configured as a high pass filter of VCVS (voltage-controlled voltage source) type design. This section does not amplify the audio but is used to filter the signal. The lowest frequency used by slow scan is 1,100Hz (VIS) so the filter cut-off frequency is set below this frequency. Any audio frequency below this, particularly mains hum and low frequency noise, will be attenuated. It is assumed that the receiver has a suitable single sideband (SSB) filter for amateur radio.

The other half of the op-amp is used is to amplify the wanted slow scan signal closer to TTL levels required for input to the PIC; the amplifier has variable gain set by the potentiometer. Care has to be taken not to overdrive the PIC input – this shows up as interference or patterning on the slow scan picture.

It is worth trying different audio volume levels and gain settings to achieve the best signal level for the PIC and most comfortable audio levels for listening. The op-amp output is fed to pin RA0 (port A) on the PIC microcontroller.

A more elaborate circuit could have been devised but this is a simple circuit to build and can be powered direct from the computer. Other filter designs can be used, provided they amplify the wanted audio close to TTL levels required to trigger the PIC interrupt.

The PIC circuit is very simple – see Figure 5 – and requires a 4MHz crystal and two 33pF ceramic capacitors. The RS232 output is taken from Port B via a 330Ω resistor.

The interface connects to any one of the serial ports on the personal computer. The PIC serial data is transmitted (from Port B) to the computer via a current limiting resistor.

There is no data handshaking between the PIC and the PC. Once the conversion is done, the PIC has to transmit data before processing the next sample. It is not possible to store any intermediate data with this algorithm.

The software had been tested using a PIC16C84, but it should work with most of the PIC range running at 4MHz.

Referring to Figure 6, power is supplied to the circuit via the 5V regulator, and the voltage for this is supplied directly from the computer via the serial RTS control line. The control line can only supply a limited amount of current, consequently, the op-amp used should be a low power device. PIC microcontrollers are manufactured using CMOS technology and consume around 3mA current.

The current through the LED should be strictly limited and high efficiency low current types are preferred. The LED indicates that power is being supplied to the circuit and the voltage regulator is working. This LED is not required for the operation of the interface circuit and is entirely optional.

Keep the serial lead short and use shielded cable for the RS232 connection, since this lead can be a source of radio interference. The circuit needs to be in a metal box to reduce to a minimum any radio interference.

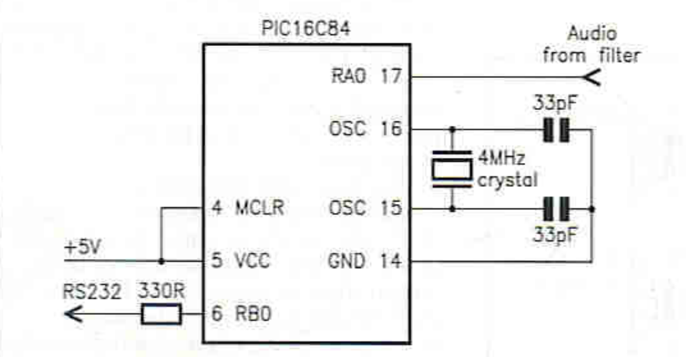


Figure 5. PIC Wiring Diagram.

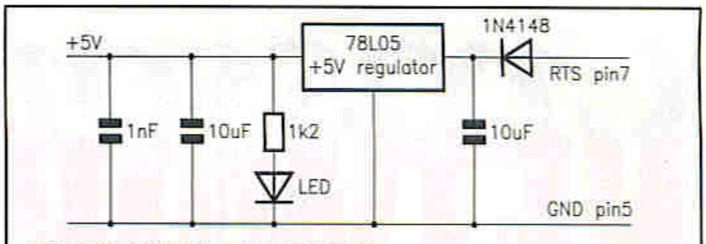


Figure 6. Power Supply for Interface.

Wiring of the 9-pin D-type connector

Pin 2 – RXD received data
Pin 5 – GND ground
Pin 7 – RTS

Windows 95

Despite the 'real time' nature of the Windows 95 operating system, it cannot react fast enough to the information coming in from the interface via the serial communications port. This means that a slow scan picture cannot be processed in 'real-time', so a different programming technique is required than that used by DOS programs.

Within Windows, the serial port is automatically read and stored for use by the application program that requested it. If the Windows program was run on the fastest computer available, then it would be possible to read each byte as it was received from the interface. However, with more modest computer processing, the program will run slower and the communications buffer will be read less frequently.

This results in the buffer holding a few hundred bytes between successive reads; the number of bytes is displayed and the lower the number, the faster the program is reading the buffer.

Clearly, the faster the processor, the better, but other factors have an impact on speed. The graphics card and data bus used plays a very important role in determining the speed of the computer response.

Because of the nature of the Windows operating system, if a form is moved or re-sized (or any mouse movement is made), Windows responds to these events at the expense of processing time for the slow scan program.

This results in a varying number of bytes read back from the communication buffer, depending on what other computer activity there is. If the computer is rather slow and cannot clear the buffer before more data is received, then it will eventually overflow; the buffer size is 64k-byte, which holds about 30 seconds of slow scan data.

Provided the graphics card is properly installed under Windows 95, there is no requirement for any setup graphics routines. DOS programs often require individual drivers for different graphic cards and this can bedevil the running of DOS programs.

A version of the slow scan program was written for Windows 3.1 but the program response was rather slow. The 64k-byte limit on program arrays, and 32k-byte limit on the communications buffers, caused difficulty. Windows 95 removed these limitations of array size and is more efficient when processing in real time.

A Windows 95 SSTV display program that is designed to display the byte information from the interface is available from the author. The Windows 95 software will display slow scan television pictures received in any of the following modes – 8 and 32 second black and white, Martin, Scottie, Wraase modes.

There are other slow scan modes but I have only incorporated into the software the modes that I have regularly seen on the bands. Giving long lists of different modes may seem impressive in the adverts, but if nobody is using the more obscure modes, then the result is a more complicated software – with options that will never be used.

The inclusion of 32 second black and white (to be honest, I have never seen a 32 second black and white picture transmitted) may seem to contradict previous statements. However, this is a useful reception mode as a properly received colour slow scan picture will be displayed as three separate pictures.

PART 2 NEXT MONTH

Crossover NETWORKS

How To and Why

by Robert Saunders

Remove the cover from a cheap 'n' nasty loudspeaker enclosure and you will invariably find little more than a pair of wires between the input terminals and the loudspeaker terminals. Remove the cover from a speaker cabinet of considerably better quality, and you may find a veritable spider's nest of wiring, with resistors, capacitors, coils and perhaps even whole circuit boards.

Why should this be so? Surely, the loudspeaker end of the audio chain ought to be the easiest part, all the necessary 'processing' having been done by the preceding amplifiers and whatnot.

In an ideal universe, a single loudspeaker driver system would adequately cover the whole audio frequency range, 20Hz to 20kHz, but in reality, a single driver able to cover that whole range has not yet been made. This is a matter of basic physics: to produce a sufficient sound pressure level at bass frequencies requires the movement of a lot of air volume, by either pushing a small cone a long way, or a large cone a short way.

At the other end of the range, the driver must, inevitably, be excessively directional unless it is fairly small compared with the wavelength of the sound. At a frequency of 20kHz, this works out at only 17mm, this being the maximum permissible radius of the diaphragm.

The established way of getting around these problems is to use several drivers, each constructed to best cater for a particular range of frequencies. This precludes that the electrical driving signal from the amplifier must be divided into these bands.

This is the function of a crossover, which, most commonly, is of the 'passive' variety, as it is invariably accommodated within the speaker cabinet and is the easiest to connect to, requiring only one pair of signal wires from the amplifier. What the crossover does is to divide the incoming broadband signal into two or more narrower bands, directing each to a particular design of driver that has been specifically developed to best operate in that range. Even so, such drivers are not perfect by any means and will still need some 'tweaking' for best results – more of that later.

Passive Networks

Passive networks typically consist of capacitors, inductors and resistors. There are three basic types of passive crossover network, based on three different orders of the filter circuit used. In essence, the order is the highest power of the variable representing frequency in the equation describing the attenuation characteristic of the filter.

First Order Filters

These have a rate of cut-off of only 6dB per octave (20dB per decade), which is too slow for anything except the simplest 'general purpose' designs, and shouldn't be used for 'serious' speaker systems. A first order network circuit is shown in Figure 1. The formulae for deriving the component values are as follows:

Rb = Bass driver impedance in Ω
Rt = Treble driver impedance in Ω
Fc = Crossover frequency in Hz

$$L = \frac{Rb}{2\pi Fc}$$

$$C1 = \frac{1}{2\pi FcRt}$$

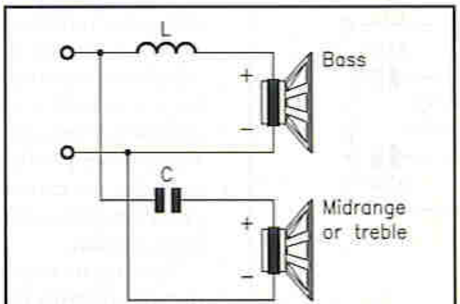


Figure 1. First order crossover circuit.

L is in Henries and C is in Farads. Here, the order of each filter requires that both drivers would have to work well for some two octaves beyond the crossover frequency, which is most unlikely. Tighter control from a first order crossover is just not possible, as the slope of the filter is too shallow.

It is very important to bear in mind that the value of Rb or Rt is not necessarily exactly the same as the DC resistance of the voice coil, as measured by an ohmmeter, but it can be quite close. Furthermore, voice coil impedances of exactly 8Ω or 4Ω, etc., are in fact extremely rare. The real value tends to be less; 7·6Ω, for example, or 6·5Ω. Sufficient manufacturer's data for the driver in question is essential, including Thiele/Small parameters. Failing this, the DC resistance should be a good guide.

Second-Order Filters

These have cut-off rates of 12dB per octave, which is better, and may be sufficient. A second order crossover circuit is shown in Figure 2. The formulae are as follows:
As before,
Rb = Bass driver impedance in Ω
Rt = Treble driver impedance in Ω
Fc = Crossover frequency in Hz

$$L1 = \frac{Rb}{2\pi Fc}$$

$$L2 = \frac{Rt}{\sqrt{2}\pi Fc}$$

$$C1 = \frac{1}{2\sqrt{2}\pi FcRb}$$

$$C2 = \frac{1}{2\sqrt{2}\pi FcRt}$$

Note that in Figure 2, the driver connections are marked '+' and '-', indicating that the tweeter connections are reversed.

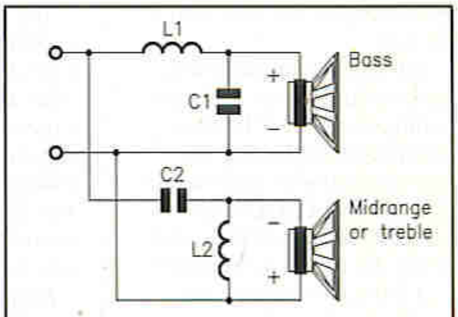


Figure 2.
Second order crossover circuit.

This is because the low-pass and high-pass filters that make up the crossover network each shift the phase of the signal, and with a second order crossover, the phase difference between the bass and treble arms turns out to be 180Ω at all frequencies.

This means that at the crossover frequency, where, by definition, the outputs of the two drivers are equal, there is a null in the response exactly on the axis of the system. This can be overcome by reversing the connections to one of the drivers, so that they would be in phase at the crossover frequency. But this will produce a +3dB peak in the response, which is better than a

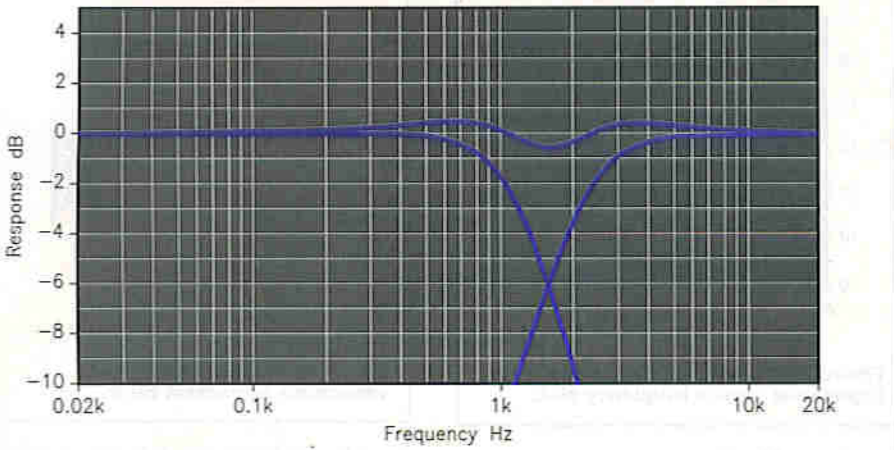


Figure 3. Individual and combined responses of a second order crossover with separated responses and one driver reversed.

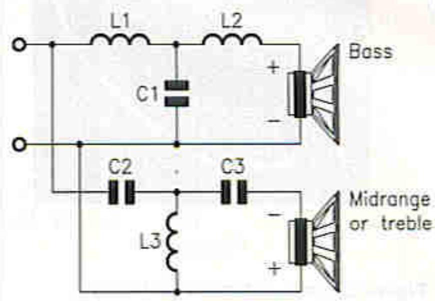


Figure 4. Third order crossover circuit.

null, but still not ideal. This comes about because each drive signal is 3dB down at the crossover frequency, but the two drivers are now in phase, so that their outputs add arithmetically, i.e., the sum is twice (+6dB) that of one driver alone.

One way of getting a truly flat response is to reverse the tweeter, which would result in a peak, but then shift the filter cut-off frequencies apart, by dividing the low-pass cut-off frequency by a factor of 4³, and multiplying the high-pass cut-off frequency by the same factor:

$$Fc\ bass = \frac{FC}{4^3}$$

$$Fc\ treble = Fc \times 4^3$$

So that both drivers are 6dB down, instead of 3dB down, at the frequency at which they are equal. Figure 3 shows the effect of this, where the individual roll-off points are pulled apart, but the net overall response with one driver reverse-connected is nearly flat.

In use, pressure response discrepancies will be small and occur only in a narrow frequency range. The inter-driver phase difference is only 45° at the crossover frequency if one driver is connected in reverse polarity.

Third-Order Filters

Another practicable crossover network is based on third-order filters, having cut-off rates of 18dB per octave. This is, supposedly, the best type to choose for true Hi-Fi aspirations and clearer, better defined sound reproduction (although some people would argue that a second order filter will sound more 'natural'). A circuit diagram of a third-order crossover is shown in Figure 4.

In this case, both the power response and the pressure response are constant in the crossover range, without having to manipulate the filter cut-off frequencies as with the second-order crossover. Each driver is 3dB down at the crossover frequency, and the inter-driver phase difference is 90°.

This means that whichever way round the tweeter (for example) is connected, the pressure response remains flat, but it can be shown that the group delay is three times less if it is (again) connected in reverse polarity. The power response is also flat, which means that the directional response varies in the crossover frequency range.

This variation is less damaging if the drivers are mounted vertically one above the other, and for some listening conditions, it may be better to have the tweeter below the bass driver rather than above. The necessary formulae are given below:

Using Rb, Rt and Fc as before for first-order filters:

$$L1 = 3L2 = 2L3 = \frac{Rb}{4\pi Fc}$$

$$C1 = 2C2 = \frac{2C3}{3} = \frac{2}{3\pi FcRb}$$

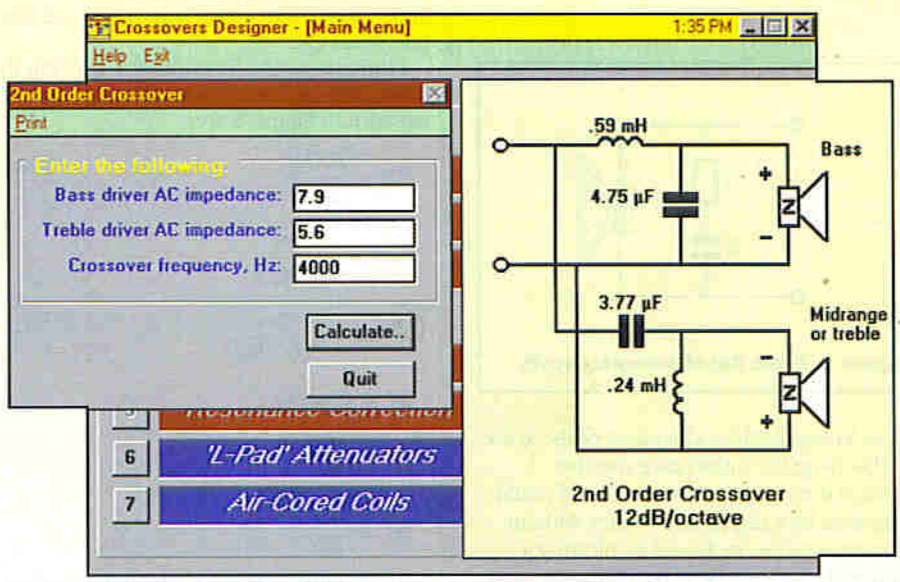
This will provide component values for the low-pass filter according to the value of Rb, ignoring C2, C3 & L3. To derive values for the high-pass filter, do the calculations again using Rt in place of Rb and ignore L1, L2 & C1.

These formulae assume that the impedance of each driver is constant over its operating range. This is, of course, not the case – a moving coil loudspeaker will offer different impedances at different frequencies. There are two significant things going on here – firstly, it is a spring and mass system which, therefore, has a natural frequency of resonance. Secondly, because the voice coil is an inductor, its impedance increases proportionally with frequency.

The resonance of a bass driver is more often than not addressed mechanically, by operating it in a ported, tuned cabinet designed to suppress this resonance and possibly improve the driver's operating range. (Note that many bass driver models have been specifically developed for operation in a ported enclosure.) This still does nothing to ensure an even voice coil impedance, or tackle the natural resonances of mid-range and treble drivers, which brings us neatly on to the next subject.

Zobel Networks

You may think that crossover networks are complicated enough, without bothering with Zobel networks. You might have found that there are many loudspeakers on the market that don't use them. Without them, however, the crossover circuit cannot ever give its best performance, since the varying impedance peaks and humps over the drivers' working range unavoidably wreaks havoc with crossover operation. The difference between otherwise identical systems that have or do not have Zobel networks can be quite profound.



The Crossovers Designer of the Speaker Design suite of software, showing a freshly calculated second order crossover.

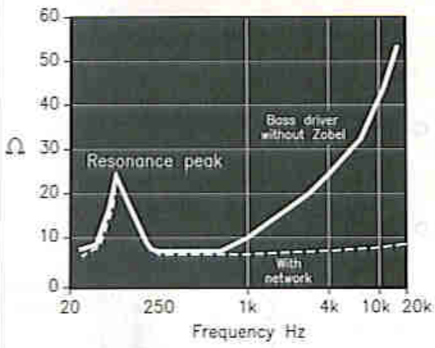


Figure 5. Bass driver impedance versus frequency plot.

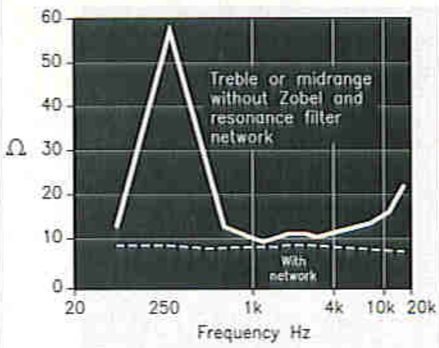


Figure 7. Treble or midrange driver impedance versus frequency plot.

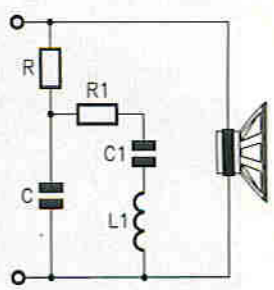


Figure 8. Zobel network with resonance correction filter.

Bass Drivers

Bass driver impedance typically remains more or less constant up 200 or 300Hz or so (ignoring the resonance region). Above this frequency, the impedance rises continuously, due to the inductance of the voice coil. Any crossover network designed on the basis that the impedance is 8Ω throughout and is purely resistive simply won't work properly. The effects of resonance and inductance on the impedance of a driver are shown in Figure 5.

Controlling bass resonance is usually a function of the enclosure, but a Zobel network is still required to compensate for the frequency dependent impedance rise at upper frequencies. All it has to do is provide an equal and opposite effect to that of the driver voice coil, which is effectively a resistor and inductor in series, so the basic Zobel network is simply a resistor and capacitor in series, as shown in Figure 6. The component values are related by:

$$R^2 = \frac{L}{C}$$

If the voice coil inductance is known, then the necessary simple circuit can be calculated thus:

R = *Voice coil DC resistance*

$$C = \frac{L}{R^2}$$

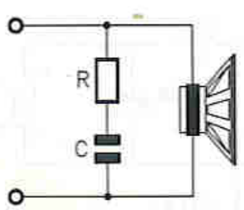


Figure 6. Basic Zobel network circuit.

Where VI equals the inductance of the voice coil. Deriving the inductance may be awkward if no data is available, but it could be derived by a digital multimeter with an inductance range, or found by plotting a graph with the help of a signal generator, a resistor and a 'scope or millivoltmeter. Figure 5 also indicates what the impedance plot should look like after adding a Zobel network.

Treble Units

Things are not so simple for a treble driver. It too needs high frequency impedance correction, which can be done as simply as for a bass unit, but its main resonance occurs at a much higher frequency than that for the bass. The resulting impedance peak is bound to completely upset the behaviour of the high-pass section of the crossover network, usually in the most critical frequency range. The impedance characteristics for a typical tweeter or midrange unit are illustrated in Figure 7.

Resonance Correction Filters

The cancellation of the resonant impedance peak, by means of a more generalised form of Zobel network, requires a series tuned circuit of the same resonant frequency and Q to be connected across the Zobel network capacitor, in series with the Zobel resistor, the whole combination being in parallel with the tweeter. Although the effects of tweeter voice coil inductance can complicate the issue, the starting Zobel network is, nevertheless, found by a simple approach which is valid for bass drivers.

The complete circuit, comprising the Zobel network with resonance correction, is shown in Figure 8. While R and C are as Figure 6 unchanged, values for R1, C1 & L1 must be found. For this, you need Thiele/Small data for the driver, specifically Re (DC resistance), Fo (resonant impedance), Qms (mechanical Q) and Qes (electrical Q).

From these, the formulae for deriving the resonance damping components of the network in Figure 8 are:

$$Res = \frac{ReQes}{Qms}$$

$$Lces = \frac{Res}{2\pi FoQes}$$

$$Cmes = \frac{Qes}{(2\pi FoRes)}$$

$$L1 = CmesRe^2$$

$$C1 = \frac{Lces}{Re^2}$$

$$R1 = \frac{Re^2}{Res}$$

Figure 7 illustrates the corrected as well as the uncorrected impedance curves. Note that the elimination of the effect of the voice-coil inductance makes the driver's impedance closer to its DC resistance than to the nominal value of 8Ω, and this must be allowed for when designing the proper passive crossover network.

Thiele/Small data for tweeters is rarely published. This makes it impossible to design the necessary network without testing the treble driver. Briefly, this involves doing the following to derive these parameters:

Re = *DC resistance*

Fo = *Frequency of resonance*

Zo = *Impedance at the frequency of reasonance (high)*

$$Ro = \frac{Zo}{Re}$$

$F1$ = *Frequency below Fo where impedance* = $\frac{Re}{\sqrt{Ro}}$

$F2$ = *Frequency above Fo where impedance* = $\frac{Re}{\sqrt{Ro}}$

$$Qms = \frac{Fo\sqrt{Ro}}{(F2 - F1)}$$

$$Qes = \frac{Qms}{(Ro - 1)}$$

Network Components

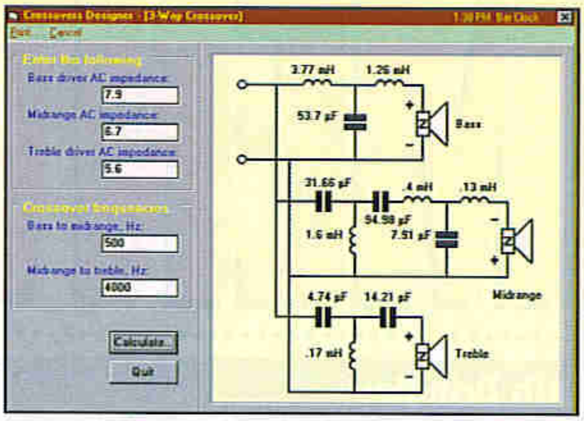
The calculations invariably call for non-standard values for resistors and capacitors, i.e., values that do not precisely match any of those in the familiar E12 or E24 standard ranges for resistors, for example. This requires values to be combined in series and/or parallel to achieve the closest match. The type of resistors used will typically be high power wire-wound types, the capacitors most often non-polarised electrolytics or dual-polarity polypropylene, polyester, etc., as non-electrolytic types.

Generally, non-polarised electrolytics are suitable for bass and midrange pass filters, but treble band pass filters should really use polypropylene. Ideally, all of the capacitors should be high quality, 'audio grade' polypropylene, but these can very expensive and the space they will all take up can be absolutely huge. Separate cabinets that are extra to the proper speaker cabinets and containing nothing but crossover circuitry are not unknown!

Capacitors and Inductors

Maplin Electronics have just expanded their range of audio-grade polypropylene capacitors, and taken a number of ferrite-cored inductors specifically for loudspeaker crossovers.

The new version of the Crossovers Designer includes a three-way third order crossover section.



Specially developed for crossover networks in domestic and studio monitoring systems, the capacitors are also ideal for valve amplifiers. The inherently low dissipation and dielectric absorption properties of polypropylene, coupled with excellent mechanical stability, result in an extremely pure sound, with low self-inductance and ESR.

Values now include 100nF (Maplin Order Code VM87U), 220nF (VM88V), 330nF (VM89W), 470nF (VM90X), 680nF (VM91Y), 1·0µF (KR78K), 1·5µF (KR79L), 2·2µF (KR80B), 3·3µF (KR81C), 4·7µF (KR82D), 5·6µF (VM92A), 6·8µF (KR83E), 8µF (VP09K), 10µF (VM93B), 12µF (VM94C) and 15µF (VM95D). The rated voltage of all is 630V DC. Sizes range from 20mm long x 30mm diameter, up to 65mm x 49mm, which are not too big.

In addition there is a high grade, low loss general purpose range of 160V DC working, offering values of 1µF (JY78K), 1·5µF (JY79L), 2·2µF (JY80B), 3·3µF (JY81C), 4·7µF (JY82D), 22µF (VM86T), 33µF (JE14Q), and 47µF (JE13P). Using these, one could completely eradicate the less than ideal non-polarised electrolytics from the system.

The chokes are wound on ferrite cores, which are moulded to form the complete shape of the bobbin. Hence, there is a fair amount of ferrite material present (as opposed to a plastic former with a ferrite rod shoved up the middle), so the number of turns required is kept low, minimising unwanted DC resistance.

The new values are: 1·0mH (VM18U), 2·0mH (VM19V), 3·5mH (VM20W), 3·5mH, (VM21X), 5·5mH (VM22Y), 6·5mH (VM23A), 7·5mH (VM24B), 9·0mH (VM25C), and 12·0mH (VM26D). (Smaller values may be added to the range at a later date.) These are wound with enamelled copper wire in the order of 18 to 16swg, so the resistance should be pretty low. The bared ends are drawn out for connection, and PCB mounting is quite feasible.

Air-Cored Coil Formula

On the other hand, you could try making your own air-cored coils, and this is the formula to use:

$$L = \frac{0{\cdot}8 \times (N \times r)^2}{6r + 9cl + 10b}$$

Where L is in microhenries, N = the total number of turns, r = the mean radius of the coil, that is to say, of the former plus half the total thickness of wire wound on it, in inches; cl = the length of the coil in inches, and b is again the total thickness of all the layers of wire, in inches. To make L up to millihenries, divide it by 1,000 (multiply millihenries by 1,000 for the formula). Note that if cl is less than 1 or r is less than 0·1, the formula may not work properly.

Help!

Of course, you could take the pain out of all these calculations by resorting to using some form of computer software. This article was largely derived from the help files of the Speaker Design Suite, a complete set of speaker design applications for the PC running under Windows, originally compiled by Mosaic Software UK and distributed by Three Crowns Publishing. This software has been featured in Electronics before, but has since been upgraded during 1996 and has improved graphics and a few extra functions.

The package includes a Crossovers Designer, which is able to produce first, second and third order circuit diagrams and component lists from simple input data. When evaluating a second order filter, it actually implements the shift described earlier for the filter cut-off frequencies, and the component values in the resultant filter circuit diagram are adjusted accordingly. This is so that one of the drivers can be reverse-connected, as described earlier.

The Crossovers Designer also produces Zobel circuits and the necessary additions for resonance correction. A basic Zobel network for a tweeter can be calculated by the Crossover Designer given DC resistance, Re, and voice coil inductance. In order for it to make the resonance correction enhancement, more complete Thiele/Small parameters for the tweeter are required.

These can be derived by the Speaker Parameters part of the suite, in the same way as can be done for a bass driver (all drivers are held in a database), using the data entry process invoked by clicking on the 'Don't Know' button in this window. This leads on to entering the results of testing the driver, for which there is a 'how to' topic in the main help file. All you have to do is follow the instructions, and the program does all the calculations.

The 1996 revisions to the suite are mainly aesthetic, but include some significant changes as follows: both Speaker Parameters and Cabinet Maker can now handle metric as well as English imperial units of linear measure and volume. Speaker Parameters can run the Cabinet Maker directly, passing the calculated box volume. Cabinet Maker adopts the scaling mode (metric or imperial) that was last set by Speaker Parameters, and can generate three different enclosure styles where the panel ratios are optimised to reduce internal standing waves and resonances.

The Drivers Library (a database manager) can now run Speaker Parameters directly, passing the selected driver on clicking a 'run' button. It also prints all the Thiele/Small data along with the other information if the item detail print option is selected.

The response graph window in Speaker Parameters can make up to six copies of itself for comparing different responses, each of which is re-sizeable and can print in colour, and can save its image as a bitmap or Windows metafile.

Last but not least, and of more relevance to this article, whilst the precise values of capacitors and resistors as calculated for the networks can be made up from standard value components, a specific value for an inductor may not be readily available. The Crossovers Designer includes a design option for producing multi-layered air-cored coils, so that you can make your own custom crossover chokes. There is also a drop-down list of readily available SWG wire sizes to select from when using this option.

To obtain your own copy of the Speaker Design Suite, just send £28.95 only to Three Crowns Publishing, PO Box 5773, Laindon, Essex SS15 5FJ.

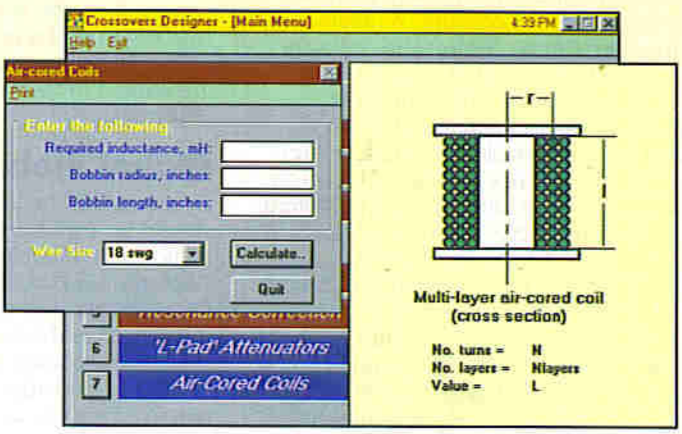
Acknowledgements

I am indebted to the authors of Speaker Design, John Woodgate and Associates and Wilmslow Audio for help with this article. All drawings reproduced with permission from Three Crowns Publishing.

Please Note

Maplin Electronics plc does not have any connections with the supplier listed in this article and is, therefore, unable to answer any queries relating to the advertised product. Maplin Electronics plc does not give or imply any warranty or endorsement to the software package described. Any monies sent to the supplier listed is at the sole risk of the sender.

The seventh item on Crossovers Designer's menu is for winding multi-layered air-cored coils.



COMMENT

by Keith Brindley

It's official – computer software is an art, not a science. Well, at least in the UK it is, anyway.

I'll explain. The UK Patent Office's brief for granting patents does not cover the patent rights of computer software producers. This means that any new software produced for computers simply cannot be granted a patent under present UK law. The software producer maintains copyright protection, of course, in the same way that an author maintains copyright over written words, and an artist maintains copyright over a picture, or a songwriter maintains copyright over a song.

But copyright protection does not necessarily give adequate protection in the same way that a patent does for the inventor of a mechanical invention, say. True, copyright – in principle – helps to ensure that others do not steal an idea, or manipulate it, or adapt it for financial or other gain. But it's sometimes difficult to prove that copyright has been breached, as it's often all too easy to change an idea in such a way that the idea is no longer apparent.

A patent, on the other hand, and all that goes with the application and granting of it, is proof that the invention is a physical thing – not just an idea.

The wording in the Patent Office literature is quite clear. The booklet Patent Protection published by the Patent Office states that an invention is not patentable if it is:

'merely a discovery; a scientific theory or mathematical method; an aesthetic creation such as a literary, dramatic or artistic work; a scheme or method for performing a mental act, playing a game or doing business; the presentation of information; or a computer program.'

In effect, this recognises that software can be an invention, but that – as it is merely software, and not a product capable of physical manufacture – it is simply not patentable in the letter of the law. And the law has been tested recently to determine the validity of the UK Patent Office's stance here. Fujitsu took the matter to the Appeal Court to give judgement, and the Court's recent ruling sided with the UK Patent Office.

In the world at large – specifically, the world's largest market for computer software, the US – things are different and much more up-to-date. Computer software can be patented, and so original software producers have much greater security in terms of the programs produced there. Perhaps it is time the UK woke up to reality in this respect. The need of patenting of computer software is not a problem which will reduce in size merely because the Court of Appeal has determined that the Patent Office has followed the law. The problem will develop, undoubtedly causing considerable damage to UK software producers, until the law is changed. Determining that it can't be done is simply avoiding the real issue. And what a waste of taxpayers' money to avoid the issue, eh?

It Could be . . . Schools?

At last, I've finally heard of a decent way money from the National Lottery might be used. Currently, some 20% of National Lottery money goes to five causes stipulated by the Government: art, charity, heritage, the millennium, and sport. In three years time, however, the Millennium Commission will be out of a job, and the money it currently receives will be looking for a new home.

Virginia Bottomley, the heritage secretary, has suggested in a consultation document that the money be used to fund an Information and Communication Technology (ICT) group after the year 2000, which would manage the money and distribute it among schools, museums, galleries, libraries and the tourist trade. Now, I'm not saying that I agree totally with the areas which might get the funding here, but schools and libraries in particular would be a good place to invest. After all, the money coming from the National Lottery is basically from the pockets of the general public. Returning that money as an investment in their futures seems a good idea.

Global mobile

By the end of the year, mobile telephones should be available which will be able to conform to multiple standards, including GSM, the US PCS, and others such as the Orange and one2one standards. What this means in the long-term is that a single mobile telephone handset will be capable of operation in just about any country throughout the world. Typically, while some handsets are usable throughout Europe, and others are usable throughout North America, what happens when a user goes from an area with one standard to another area with another standard is that another handset has to be bought or hired.

Motorola and Amstrad recently both announced the possibility of mobile telephone handsets which will be able to cope with multiple standards. In the short term, these will be usable throughout the world in countries where digital communications standards are used, but will not be usable in areas of the US where analogue communications systems still prevail in the main. Digital mobile services are increasing in the US, and the handsets will be usable in those areas, but it will be a little while until true worldwide ability is available.

Satellite Data

Hot on the heels of DirecPC, the computer-based data transfer system to give fast Internet access over Eutelsat satellites, SES (the Astra satellite owner and controller) has announced a deal with Intel (the microprocessor maker) to form a company called European Satellite Multimedia, with the purpose of creating a similar system for the Astra satellites. The new service, called Astra-Net, will have a data rate of up to 6M-bps to an ordinary personal computer.

The service does not initially alleviate the customer's requirement to log on to the Internet in the usual way, probably by modem. Data sent by the user's computer requesting a World Wide Web page, or a file transfer over the Internet, will travel conventionally to the Internet service provider over the telephone line connected to the computer with the modem. Once received, however, the data back to the user's computer from the server will be over the satellite link. It's the satellite link which speeds up the overall throughput, of course. Requests from computer to server are short and sweet – in the order of a few bytes, while data coming back can often be in terms of megabytes. In 1998 though, SES hopes to have a two-way satellite link service in place, with request rates of up to 400k-bps – opening out the service to include videoconferencing.

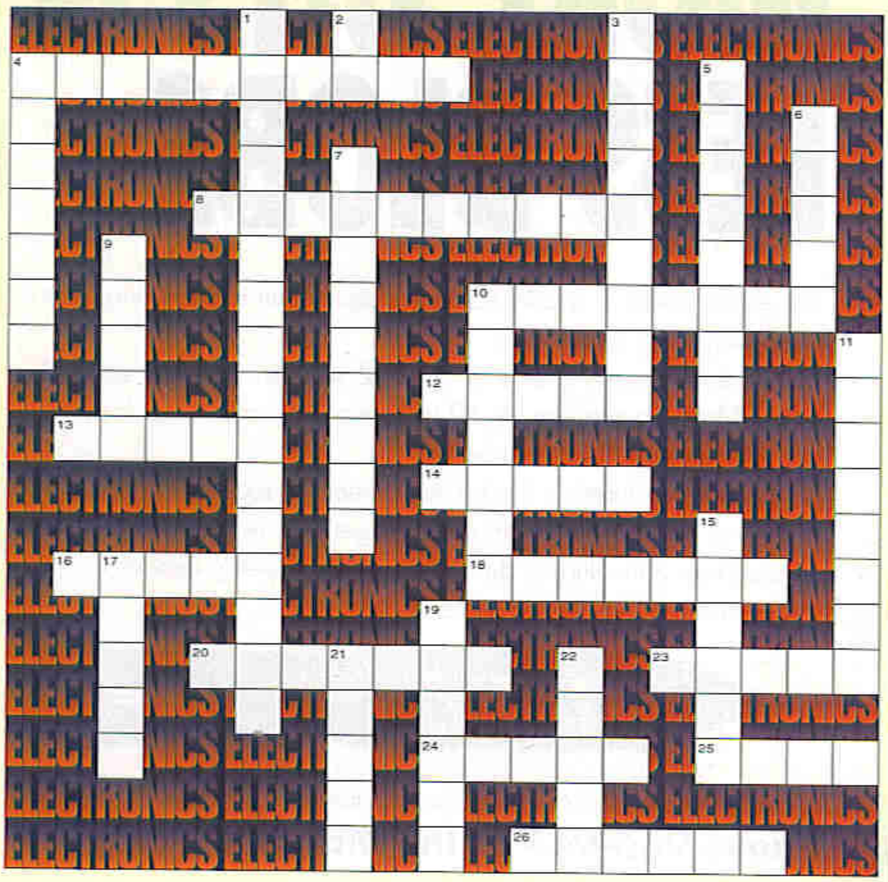
The system will rely on a PCI card installed in the personal computer, connected to a small satellite dish and special receiver.

ELECTRONICS and Beyond

£25 CROSSWORD COMPETITION

You will find some of the answers in our catalogue, so if you don't have a copy go out and search for one today and complete this crossword.

CROSSWORD No. 3 **June 1997**



Name

Address

Postcode

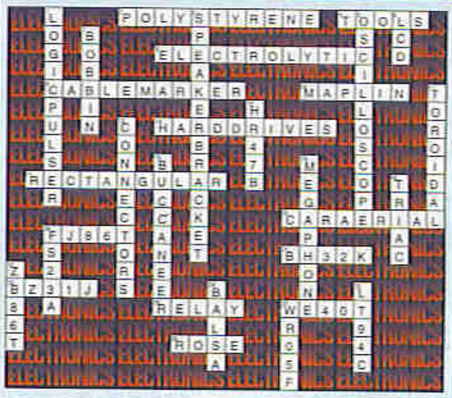
Daytime telephone number

No purchase necessary. Entries on a postcard, back of a sealed-down envelope or photocopies will be accepted.

We are giving away a cash prize of £25 to the first correct entry received by 14th May 1997. Send it to us at the following address:

Magazine Crossword 2, Maplin House, PO Box 777, Rayleigh, Essex SS6 8LU. All employees of Maplin Electronics are excluded from entering.

CROSSWORD No. 1 *Solution* April 1997



There was one correct entry to our first crossword. Our congratulations go to I.M. Tasker of Grantham, Lincs, who wins £25.

ACROSS

4. Analogue circuit whose output is the product of its two inputs.

8. (6 & 4), This flashes for effect not to embarrass, page 948 tells you more.

10. The frequency range of a signal used to modulate a carrier frequency.

12. Pages 113 to 168 show you lots for a good read.

13. How many binary bits make up the ASCII code ?

14. Device which permits electrons to flow through it in one direction only.

16. Light bulbs in equatorial Africa.

18. Dog character stops the wire from chaffing.

20. Hard and brittle material ? not these tweeters.

23. Video sync' seperator chip page 862, but whats the order code ?

24. This Lithium will help PC remember.

25. Four armed bridge circuit used as a frequency selective network.

26. Shift register non volatile type memory or ball of air in a liquid.

DOWN

1. (8 & 8), Equipment which displays a signals position in the frequency domain. Amplitude against frequency.

2. And gate with all inputs Hi, whats the output state ?

3. To throw these down helps safe handling. Page 118, but which one ?

4. VDU or type of large Lizard.

5. Pianos and computers use this, good selection on page 240.

7. (5 & 4), Device that uses the photo voltaic effect.

9. Stop, Tail and indicate for your holiday.

10. The process of loading a computer memory needed for it to operate.

11. Oscillator employing a parallel resonant circuit as its frequency selective network.

15. Component colour code representing the number 4. You may be called this if your a coward.

17. Step on this mat and you'll be alarmed.

19. Number system linked to the base of 2, i.e 1 & 0

21. Generate the rhythm with this chip

Audio Basics PART 2

by Ray Marston

Ray Marston continues to look at audio-system basic principles in the concluding part of his special feature article.

Signal Compression

The 'signal compression' method of dynamic range manipulation operates in the basic way illustrated in Figure 1. Here, the initial input signal is applied to the input of a dynamic range compressor unit, which, in this example, has a 2:1 dynamic compression ratio and can convert an input signal with a 90dB dynamic range into an output with a 45dB dynamic range. This 'compressed' output is applied to the input of the 'poor-dynamic-range' transmission/recording medium, and when required, is converted back into its original (90dB range) form by a matching dynamic range expander unit, which has characteristics that are the exact inverse of those of the compressor. This type of compressor-expander system is generally known as a 'compander' (or 'compandor') system, and was originally devised to improve the quality of various voice communication systems.

Note in Figure 1, that the '2:1' compressor/expander ratio applies to the systems dynamic range in terms of dB, and not to its actual range in terms of input and output voltages. This point is made clear in the table of Table 1, which shows that the compressor and expander work by giving highly non-linear variations in voltage gain to different input signals. The gain varies over a 175:1 range, from ×0·57 to ×100 in the compressor unit, and from ×1·75 to ×0·01 in the matching expander unit.

Practical compressor and expander circuits are both built around the basic dynamic range expander circuit that is shown in (a) descriptive and (b) symbolic forms in Figure 2. Here, the audio input signal is applied to the inputs of a current-controlled variable-gain cell (a high grade operational transconductance amplifier, or OTA) and an electronic rectifier that converts the mean input signal voltage into a proportional DC output current, which controls the gain of the variable-gain cell. The action is such that if the signal input rises by 10dB (from, say, -40dB to -30dB), the gain also rises by 10dB, to give an overall increase in output voltage of 20dB, i.e., a 2:1 ratio of dynamic expansion. The gain-control attack and decay times are controlled by capacitor C_T.

The gain cell's output signal appears in the form of a current, rather than a voltage, but can by converted into a proportional voltage via a suitably wired op-amp. Figure 3 shows ways of using the basic dynamic range expander to make practical voltage-in to voltage-out (a) expander or (b) compressor units. In the expander circuit, the gain cell's output current is simply fed directly into the inverting input terminal of the op-amp, which gives direct current-to-voltage conversion. In the compressor, the audio input signal is fed into the op-amp's inverting input via R1, and the basic expander is wired in series with the op-amp's output-to-input negative feedback path, causing the overall circuit to act as a voltage-in to voltage-out dynamic range compressor with dynamic characteristics that are the exact inverse of those of the expander circuit.

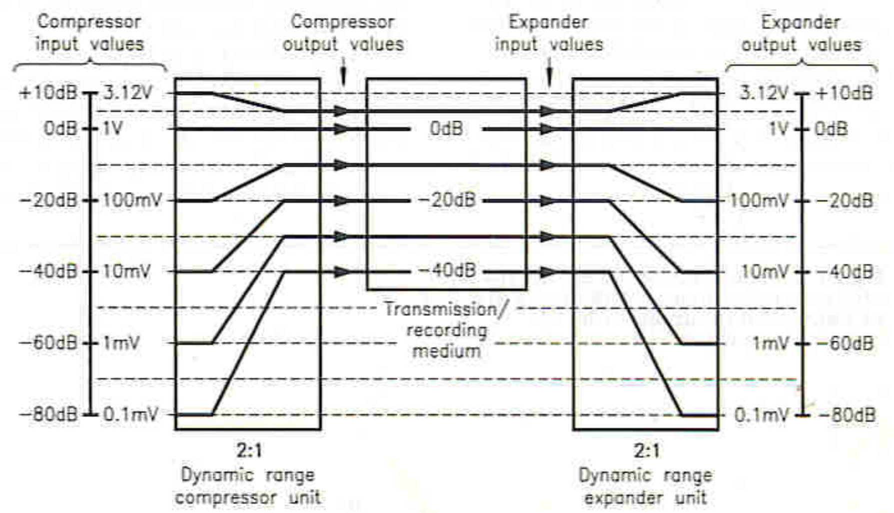


Figure 1. Diagram illustrating the basic principle of dynamic range companding, using a 2:1 companding ratio, over a 90dB operating range.

Table 1. Table showing the voltage gain variations of the basic 2:1 dynamic range compressor/ expander.

INPUT VALUE dB	INPUT VALUE Volts rms	OUTPUT VALUE dB	OUTPUT VALUE Volts rms	VOLTAGE GAIN	
+10dB	3.12V	+5dB	1.78V	x 0.57	2:1 Dynamic range compressor unit
0dB	1.0V	0dB	1.0V	x 1	
−20dB	100mV	−10dB	316mV	x 3.16	
−40dB	10mV	−20dB	100mV	x 10	
−60dB	1mV	−30dB	31.6mV	x 31.6	
−80dB	0.1mV	−40dB	10mV	x 100	
+5dB	1.78V	+10dB	3.12V	x 1.75	2:1 Dynamic range expander unit
0dB	1.0V	0dB	1.0V	x 1	
−10dB	316mV	−20dB	100mV	x 0.316	
−20dB	100mV	−40dB	10mV	x 0.1	
−30dB	31.6mV	−60dB	1mV	x 0.0316	
−40dB	10mV	−80dB	0.1mV	x 0.01	

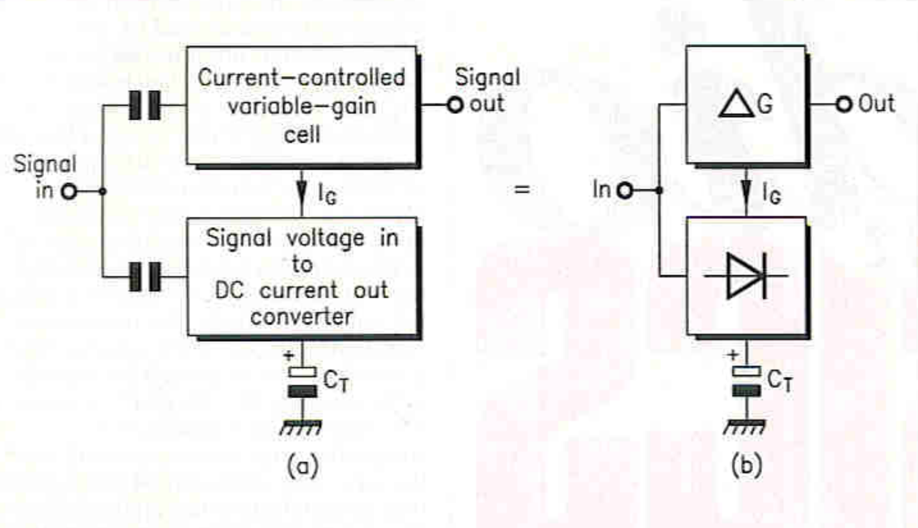


Figure 2. Diagram showing (a) descriptive and (b) symbolic versions of a basic dynamic range expander.

Hybrid Dynamic Range Control

At first sight, pre-emphasis and compression methods of dynamic range control seem to offer huge practical advantages, but in reality, both systems work by introducing various types of gain distortion and thus have weaknesses that limit their practical value in many Medium-Fi to Hi-Fi applications. The high-frequency gains of pre-emphasis filters should, for example, always be limited to about 20dB (in the manner shown in Figure 11 of Part 1, Issue 113) to avoid overdriving unusually large high-frequency signals that are generated as fundamental – rather than harmonic – waveforms.

Compander systems should be treated with special caution. They originated as strictly 'Low-Fi' voice processing units, as typified by the popular NE570 IC, and usually generate rather high levels of noise, THD, tracking distortion and output DC-tracking shift; these defects become magnified if the system's compression ratio is artificially raised above its basic 2:1 value. The system's greatest defects are caused by a problem known as 'breathing' or 'pumping', which occurs when a large transient input waveform is followed by a near-zero input signal, causing the expander gain to drop sharply on the arrival of the transient, but (because of the system's AGC action) to rise sharply to its maximum value a few moments later, to produce the distinct hissing sound of system noise.

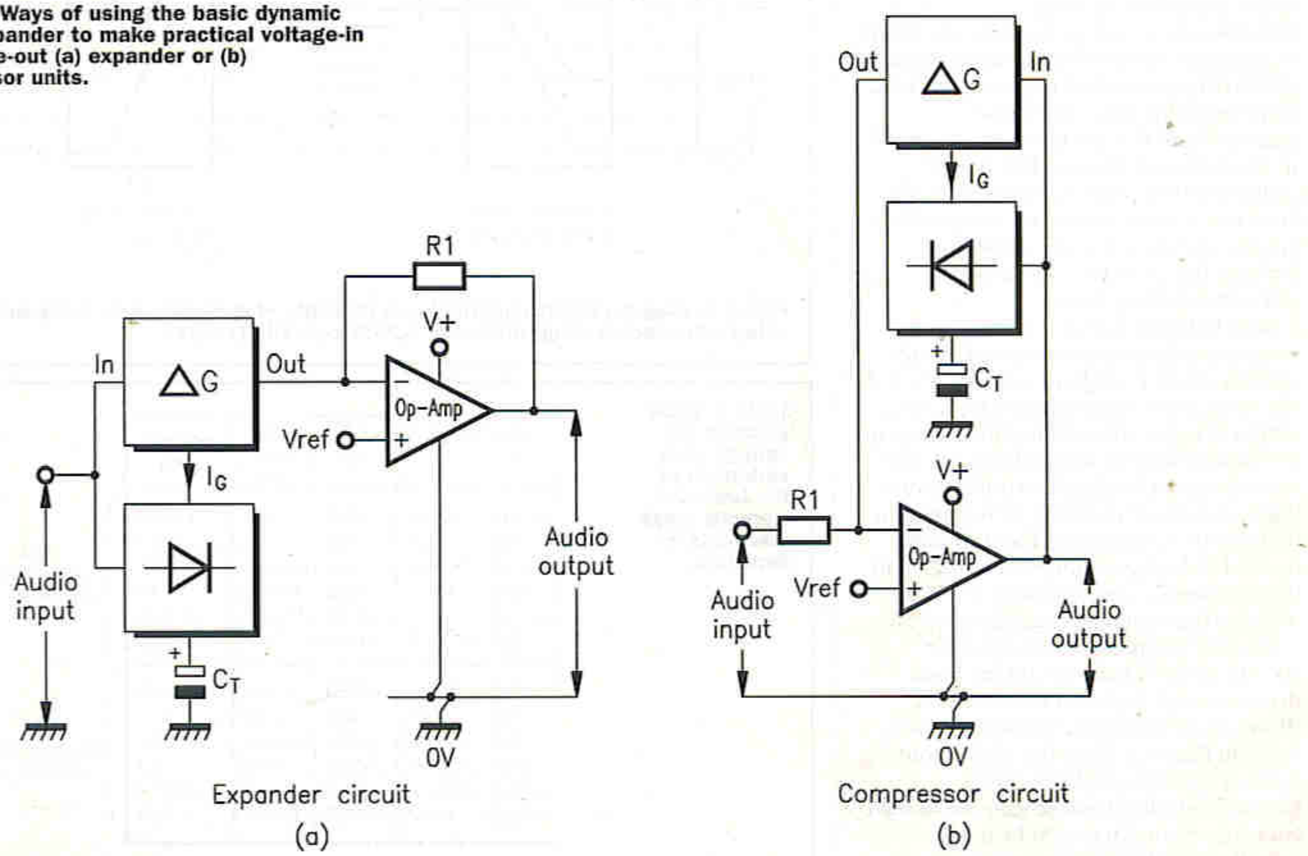
The best way to obtain really good dynamic range manipulation in Hi-Fi applications is to use a hybrid system that uses a subtle combination of pre-emphasis and/or filtered companding techniques, as in the cases of the dBx and Dolby magnetic recording/playback systems, which each give a large increase in useful dynamic range but without suffering 'pumping' problems.

Digital Audio

Audio systems are designed to convert acoustic input signals into remotely located acoustic output signals, and are basically analogue systems. In modern audio electronics there is, however, one area of the system in which digital electronic techniques offer definite advantages over analogue ones, and that is in the area of high-quality signal storage (as in CDs). This advantage occurs because digital signals have only two amplitude levels – either 'high' or 'low' – and thus (unlike analogue signals) cannot be corrupted by normal levels of system noise or non-linearity.

Figure 4 shows the basic elements of a digital audio-signal 'storage' and 'replay' system. On the 'storage' side of the system, the audio input signal is subjected to normal signal processing (amplification and/or filtering, etc.). It is then applied to the input of an ADC (Analogue-to-Digital Converter) unit, which converts the analogue input signal into a digital equivalent, which is then superimposed on the system's storage medium (a CD or tape, etc.). On the 'replay' side of the system, the

Figure 3. Ways of using the basic dynamic range expander to make practical voltage-in to voltage-out (a) expander or (b) compressor units.



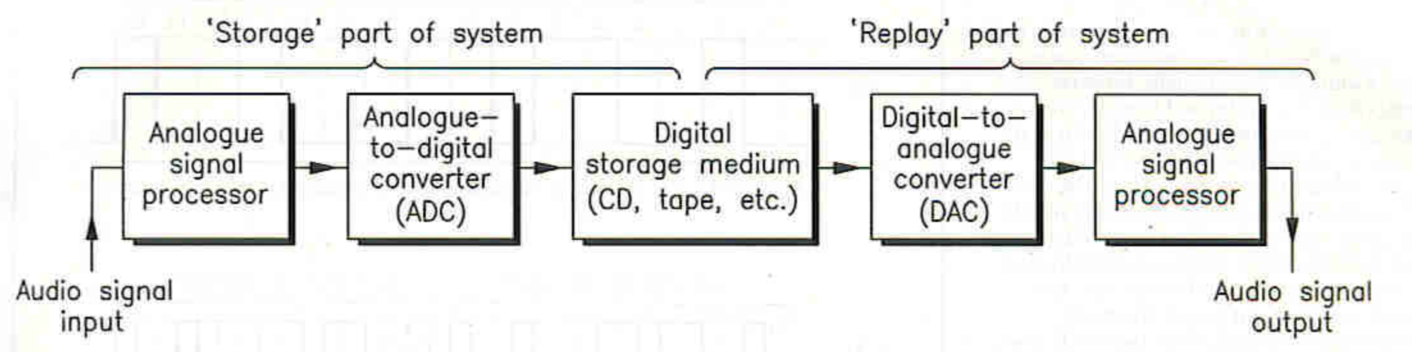


Figure 4. Diagram showing the basic elements of a digital audio-signal 'storage' and 'replay' system.

storage medium's digital signals are inspected by a DAC (Digital-to-Analogue Converter) unit, which converts them back into analogue form and passes them onto the outside world via another signal processing analogue circuit.

Figure 5 illustrates some of the basic operating features of the ADC part of the system, as applicable to a normal 16-bit CD. Here, the system repeatedly takes high-speed samples of the audio input signal's instantaneous analogue amplitude, converts each new sample's amplitude measurement into a multi-bit digital output word and passes it onto the recording media before carrying out a similar operation on the next sample. To be effective, the system's sampling frequency must be at least double that of the highest signal frequency of interest. Modern CD systems are designed to handle signal frequencies of up to 20kHz, and to attain this, they use a standard sampling frequency of 44·1kHz and thus execute 44·1 sampling operations during a 1kHz signal cycle, 14·7 samplings in a 3kHz cycle (see Figure 5(a)), and 3·67 samplings in a 12kHz cycle (see Figure 5(b)).

The effective signal-to-noise ratio and dynamic range of an ADC unit's output is directly proportional to the unit's 'bit' size, and can be simply calculated from the equations:

(1). Signal-to-noise ratio $= 6 \times n$ *dB*

(2). Useful dynamic range $= 6 \times (n - 1)$ *dB*

Where n is the ADC's bit size. Thus, 16-bit ADCs have S/N-ratios of 96dB and have useful dynamic ranges of 90dB. The current generation of CDs are recorded via 16-bit ADC, which generate 16-bit outputs in the basic format shown in Figure 5(c) and can thus generate up to 65,536 different codes or level-measurement values. The next generation of CDs (for which players are already available) are scheduled to use 20-bit data recording, which offers S/N-ratios of 120dB and useful dynamic ranges of 114dB and can generate up to 1,048,576 different codes.

The above explanation of CD encoding is, of course, much simplified, and merely illustrates the basic principles. Figure 6 shows a more realistic picture of the actual coding system used in 16-bit CDs. Here, each 16-bit data word is made up of two 8-bit symbols, as shown in (a). All CDs give stereo outputs, so two words are generated at the same time, one for the L/H channel and one for the R/H channel, and are applied to the CD encoding system in series, as a 32-bit sample, as shown in (b). Each of these samples is modified and enlarged by the CD encoding system and is then incorporated in a CD frame. Each of these frames commences with 8-bits of display data, followed by three of the modified samples, which are followed by a group of parity bits, plus three more samples and another group of parity bits, and ends with a synchronisation code. The CD frames each contain 588 data bits, and are generated at a 7350 per second rate. The CD data is thus processed (at both the record and replay ends of the system) at a rate of 4·3218M-bps.

At the 'player' end of the CD system, the decoder circuitry copies and stores each frame of data as it becomes available, then converts its samples and words back into their original analogue forms (via a 16-bit or larger DAC) and passes them to the appropriate channels of the audio Hi-Fi unit – in the correct time sequence – before moving on to the next frame, and so on.

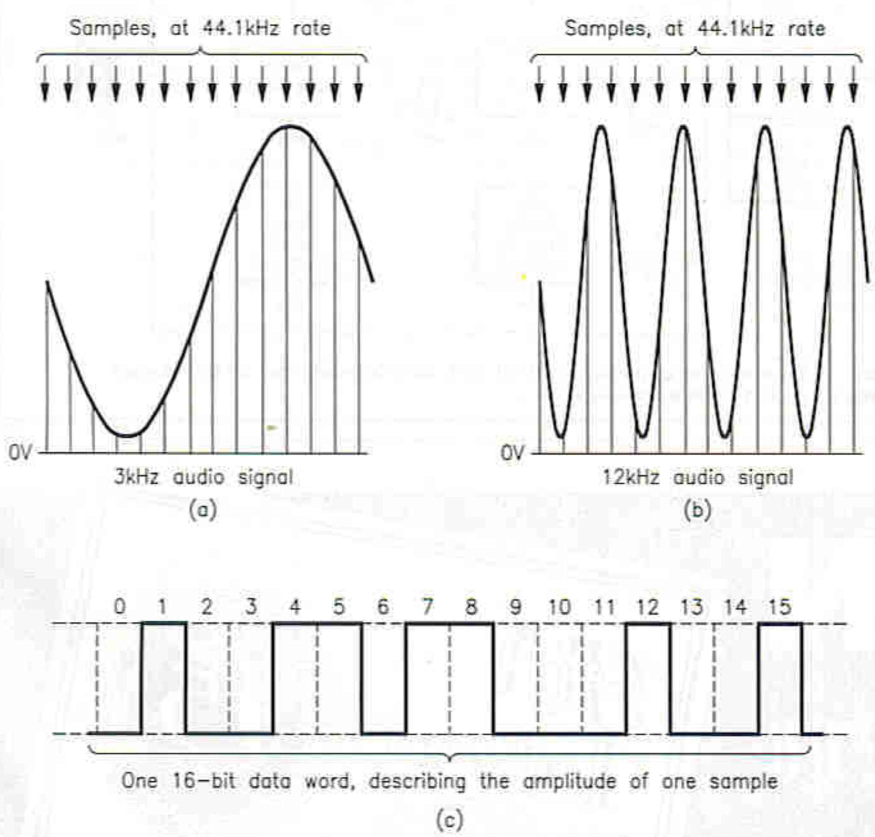


Figure 5. Diagram illustrating some basic features of analogue-to-digital conversion in 16-bit CD systems (see text for explanation).

The Hi-Fi Unit

In its simplest form, a Hi-Fi unit may consist of little more than an input selector, a pre-amplifier, a power amplifier, and a pair of loudspeakers. Usually, however, the unit is fairly elaborate, and typically may take the form shown in Figure 7, which (in the main amplifier unit) shows just one channel of a stereo system. Thus, the main amplifier contains an input selector switch (S1), plus tone and volume control circuitry that feeds the input of the speaker-driving power amplifier. It also houses a power supply unit that can power the main amplifier and (usually) the other Hi-Fi units (tuner, CD player, etc.), plus one or two LED display units that give visual output indications of parameters such as the volume control setting and the instantaneous output amplitude values of the power amplifier.

In most cases, switch S1 can select inputs from an AM/FM tuner, a CD player, a cassette player unit, a phono pick-up and pre-amplifier/equalizer unit, and from an 'Auxiliary' input terminal. This auxiliary input may be driven from a source such as an audio mixer unit, a TV sound-channel tuner, or a remote sound monitor such as a baby alarm, etc. Often, the main amplifier is designed for operation via a remote control unit, in which case, the tone and volume control circuitry usually take the form of voltage-controlled units that are driven via the remote decoder, and S1 takes the form of a multi-way electronic switch that is driven via the decoder. If the Hi-Fi is a really elaborate one, it may also incorporate one or more audio delay lines, in the form of an ambience synthesiser or an echo-reverb unit.

The two most important basic items in the Hi-Fi system are its loudspeakers and its power amplifier. Inferior loudspeakers can make even the very best power amplifier sound bad, and an inadequate power amplifier can make even the very best of loudspeakers sound awful. Assuming, however, that a Hi-Fi unit's loudspeakers and power amplifier are both of excellent quality and are well matched, it will still be found that different listeners will each gain their own individual subjective impressions of the system's quality, and will probably tweak the tone controls until the system 'sounds right'. And 'sounding right' is, of course, the most important function of the entire Hi-Fi system.

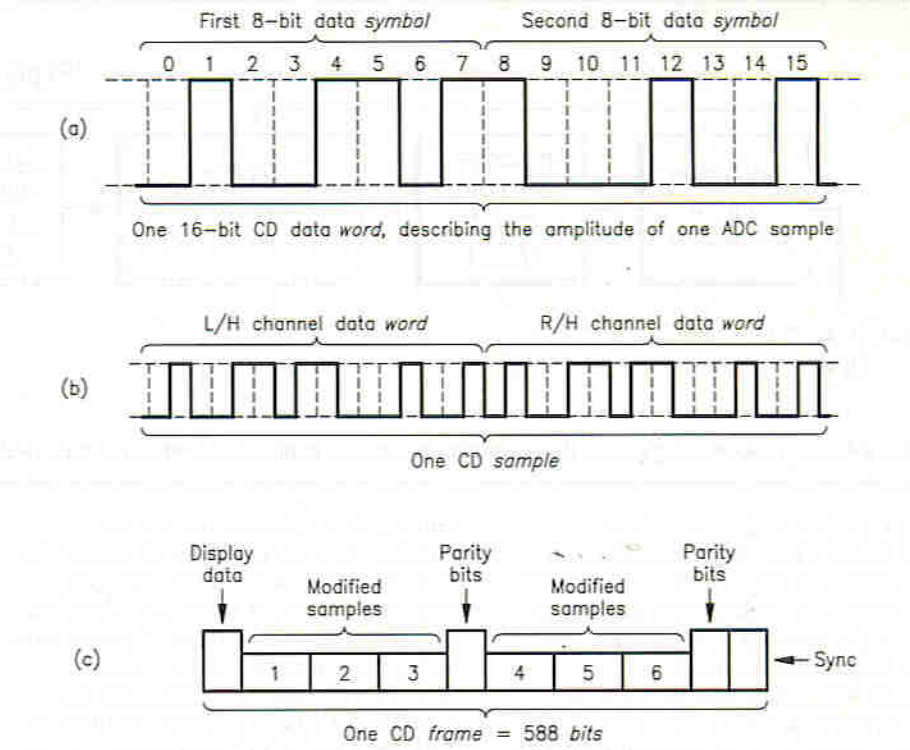


Figure 6. Diagram illustrating the formatting of a standard frame in a 16-bit CD; these frames are generated at a 7,350 per second rate.

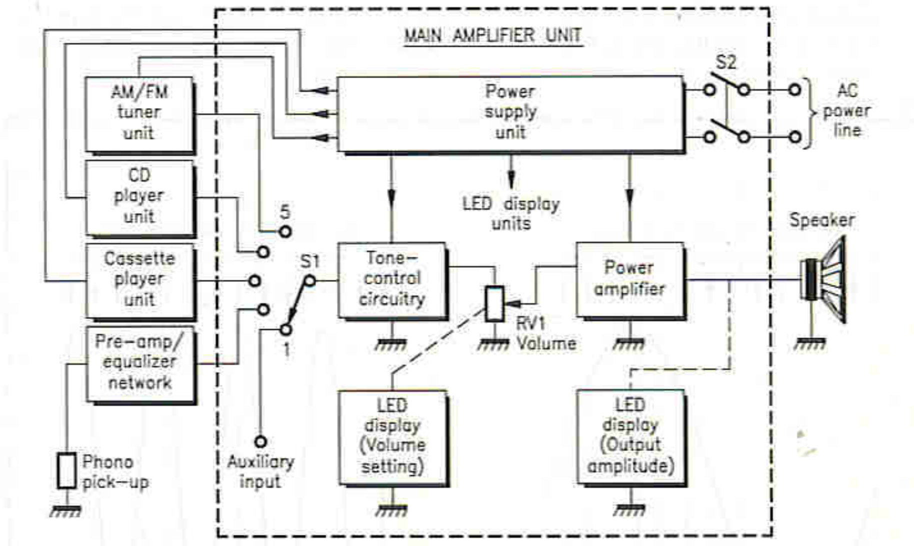


Figure 7. Typical form of a modern Hi-Fi unit, showing only one of the stereo channels of the main amplifier unit.

WHAT'S IN A NAME PART 4

Credit Where It's Due

by Greg Grant

" . . . Come sir, credit where it's due; most of the glory goes to YOU. . . " sang Colonel Pickering in 'My Fair Lady'. In the previous essay in this series, however, matters were frequently somewhat different.

Lingering in the background throughout the piece was the problem of litigation and the hassle such action causes. Did this help or hinder either technical progress or the fame and fortune of the individual inventors involved? In general, it seems, such matters tended to be governed by the choice of one's employer.

Meissner, Hartley, Round, Colpitts and Franklin all worked for what were undoubtedly the big battalions, such as Marconi, Bell Laboratories and Telefunken. All of these men were prolific inventors and all were credited with the inventions they made in the majority of cases, although the patents were usually held by the company. That meant that they could be defended vigorously – and usually were – when they needed to be.

How successful these companies were, and how well rewarded the individuals felt, can be judged from the fact that all of the former are still very much in business today and where the latter are concerned, a Meissner or Hartley oscillator remains just that.

Going it Alone

Edwin Armstrong and Lee de Forest, on the other hand, were classic loners, subjected to litigative challenges throughout much of their working lives.

Where the company men had their discoveries named after them, the loners – ironically – are remembered, if at all, by *what* they invented, such as the Triode Valve and the 'Superhet' receiver. No hint of whose brainchild it was at all!

It's easy to understand from this why certain men develop conspiracy theories, the belief, for example, that the legal profession – a field rotten with the restrictive practices it so condemns in others – would reason that challenging an individual would mean but one thing: a killing for lawyers, whatever the outcome. Armstrong, for example, seems to have been prone to such ideas.

Mix and Match

Yet there was – indeed still is – a third way of working as an inventor which, to my mind, gives more satisfaction perhaps than industry on its own and far less hassle than that suffered by the lone developer. It could be called 'Mix and Match', and consists of moving seamlessly between industry on the one hand and academe on the other. Two distinguished names in electronics did exactly this for most of their working lives, with great success.

Cause and Effect

The Swiss-German electronics engineer, Walter Schottky and the American electronic physicist, Clarence Zener, gave their names to both a Device and an Effect. Where the latter, ultimately, settled for academe, the former, eventually, decided on industry.

Born in Vincennes, Indiana, in 1905, Zener is one of those astonishing individuals who has mixed and matched for most of his lengthy and busy life.

He joined Westinghouse Research Laboratories in 1951, becoming their Director of Science before returning to academic life 15 years later, firstly as Dean of Scientific Research at Texas A&M University and then as Professor of Science at the Carnegie-Mellon University in Pittsburg.

At the latter, he became deeply interested in solar power, although he is universally known for his investigation of the diode called after him. Figure 1 shows the reverse voltage aspect of the Zener diode.

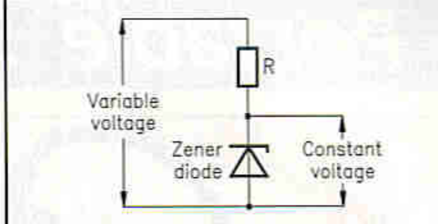


Figure 2. A practical voltage stabiliser circuit using a Zener diode.

Between points **A** and **B**, the current increases considerably. However, observe the voltage: it has increased hardly at all. This means that the Zener diode can maintain a voltage at a steady level despite increasing, or varying, levels of circuit current. In a word, it *stabilises* the voltage.

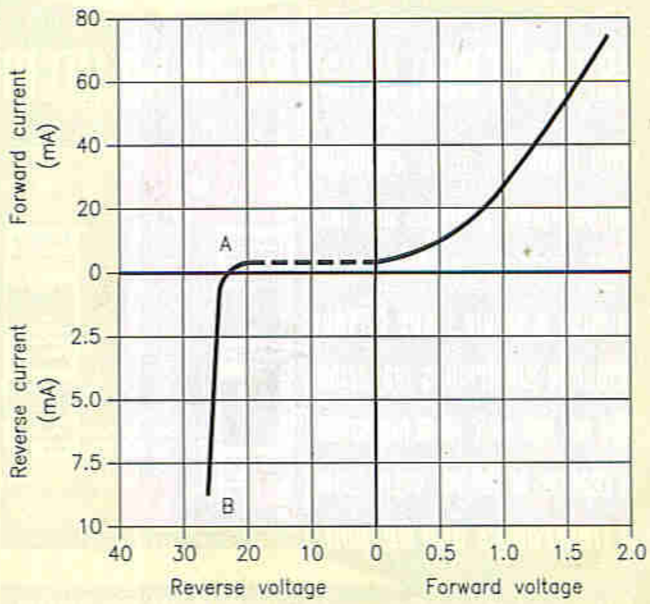
Figure 2 is a simplified, practical electronic circuit diagram of a voltage regulator or stabiliser board. Such circuits are near-universally used in modern communications equipment, electronic navigational aids for civil and military aircraft, many electronic measuring and control devices and, naturally, in that ubiquitous electronic totem of our time, the computer. The resistor **R** limits the reverse current through the diode to a safe level.

Avalanche!

Science and Technology, of course, are subject to advances and further developments in a manner all other fields are not, and so presently, the Zener Effect is thought to be due to Townsend Discharge rather than Zener current. Consequently, the device is also known as an Avalanche or Breakdown diode.

Townsend Avalanche, named after the British physicist, Sir John Townsend, is a multiplication process where a single charged particle, accelerated by a strong electrostatic field causes, through collision, a considerable increase in ionised particles. Townsend was the first scientist to calculate the charge on a single gaseous ion as far back as 1897, in the course of a most significant contribution to the theory of ionised gases.

Figure 1. The reverse voltage aspect of a Zener diode.



Schottky – The Noise Expert

Like Clarence Zener, the Swiss-German electronics engineer, Walter Schottky (1886-1976), has given his name to both a device and an effect. Like Zener too, he moved effortlessly between industry and academe, finally settling on the former.

The son of a university mathematics lecturer, Schottky graduated with a Ph.D from Berlin's Humboldt University in 1912. Two years later, he joined Siemens Research Laboratories and began working on the problem of noise in valve amplifiers.

At this time, a number of electronics engineers worldwide were attempting to improve valve manufacture, the better to ascertain the true parameters, and therefore, performance, of these devices. Many concentrated on such matters as improving the internal structure and its welding, whilst others concentrated on improving the vacuum by developing better vacuum pumps, which had hardly improved since Johann Geissler had invented the first effective modern pump in 1855.

Whilst he could see that such work could be very valuable, Schottky concentrated on the physics of noise, concluding that there were, in effect, two fundamental noise sources in valve amplifiers.

Firstly, there was the input circuit noise caused by random molecular movement in the wires and components, today known as Thermal Noise, and secondly, the noise caused by the valve itself, in particular, the random nature of the electron emission from the cathode and the differing velocities of these liberated electrons, now known as Shot Noise.

The current, i.e. the electrons, emitted or 'boiled off' from a valve's cathode depends in part on the cathode material's Work Function, in other words, the MINIMUM energy needed to transfer an electron from within the material to a point just outside the material's surface.

This is shown in Figure 3, where the cathode surface can be regarded as a 'Junction' between two dissimilar 'Substances', i.e., the metal and the vacuum.

In the course of his research, Schottky found that the Work Function could be reduced from its normal value as a result of the electric field at the cathode and the presence of image forces. This discovery is known as the Schottky Effect.

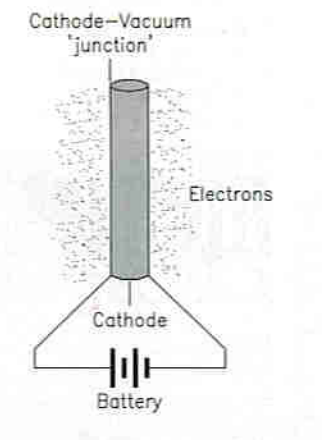


Figure 3. The cathode of a radio valve. The glass envelope has been omitted for clarity.

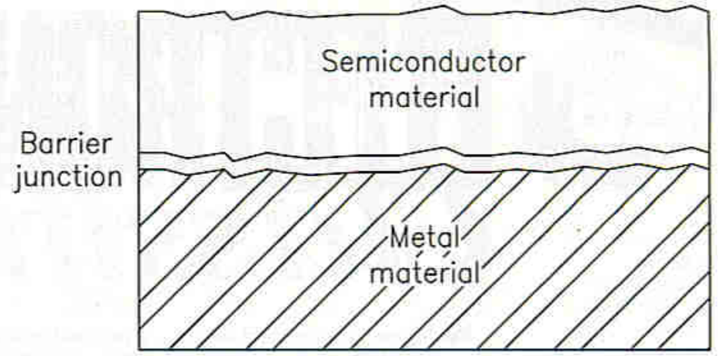


Figure 4. Diagram of a Schottky diode's construction. The barrier has been enlarged for clarity.

Three years after publishing his now-classic paper on noise in 1918, Schottky's colleague, C. A. Hartman carried out the earliest experiment to identify and measure Shot Noise.

In 1924, Schottky and Erwin Gerlach invented the Ribbon Microphone and its complement, the Ribbon Loudspeaker. Shortly, however, Schottky turned his formidable mind to semiconductors, in particular, metal-semiconductor devices, which were in fairly common use in radio engineering at this time.

After extensive research, Schottky published his Schottky Diffusion Theory of Current Flow in semiconductor diodes, from which, present-day understanding of such devices grew. Consequently, these devices are known among electronics engineers and technicians as Schottky diodes. Moreover, his Effect applied equally well to semiconductors as it did to thermionic valves.

If, as shown in Figure 4, we look on the metal-semiconductor junction as being essentially similar to the metal-vacuum 'junction' of a valve, the 'Barrier Lowering' in this case, whilst less than the reduction in Work Function in the valve example, nevertheless shows that the Schottky Effect is even more striking.

When Transistor-Transistor-Logic (TTL) was developed in the early 1960s, greatly speeding up computer operations, the principal component in this development was the Schottky Diode, which gave the computer industry Schottky TTL.

By *any* standards, it was a stunning achievement to have made outstanding contributions to both vacuum and semiconductor electronics. It was even more so to have influenced computer circuitry.

Wheatstone's Bridge?

Another brilliant individual who moved between his own companies and the academic world of his day – in his case the Professorship of Experimental Philosophy at King's College London – was Charles Wheatstone, whom we've already met.

Among his many other achievements, he initiated the use of electromagnets in electric generators and invented the Playfair Cypher. He was also one of the first British scientists to recognise the importance of Ohm's Law. Although his honours and awards were such that they supposedly filled a cubic-capacity trunk, he held one distinction he not only didn't earn, but in fact, did everything possible to ensure that its originator received the credit for. You see, the one device Charles Wheatstone did NOT invent was the Wheatstone Bridge.

In 1833, the British mathematician, Samuel Hunter Christie, developed the 'Bridge' principle of measuring resistance. A decade or so later, Wheatstone concluded that electrical measurement had to be put on a far firmer footing, especially the fundamental units of current, resistance and voltage.

Using Georg Ohm's recent development, Wheatstone made a standard resistance and created his own measurement units. In the course of this work, he also made use of Christie's 'Bridge' technique, illustrated in Figure 5, and gave Christie full credit for his invention.

Despite this endorsement, the sort *any* inventor would have been delighted with coming, as it did, from one of the greatest scientists of the day, it was Wheatstone's name that prevailed. And to this day, it still does, by and large. Why?

Well, authoritative works like the *Encyclopedia Britannica* certainly don't help. Even in its latest edition, it continues to perpetrate the myth in, it has to be said, a somewhat sly way. This reference work's view of the affair is that Wheatstone manufactured the bridge at Christie's instigation and then popularised its use.

That smacks not so much of hedging your bets, more of avoiding litigation!

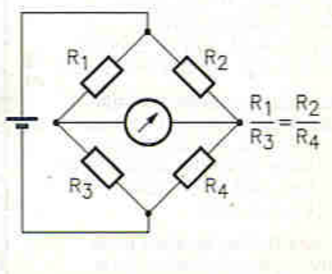


Figure 5. Christie's 'Bridge' technique for measuring resistance.

ELECTRONICS *Classified*

Computers

A1200 Hawk RAM Board Accelerator 4M-byte populated battery-backed clock, user guide, £20. Tel: (01480) 52329.

Build a Quality 486 PC for Under £200. No special skills or knowledge required. Send SAE for details to: Richard Garland, 10 Barford House, Bow, London E3 5HP.

Various

Back Issues For Sale As new. Numbers 23-100, £90. Tel: (0181) 643 5077.

Fostex E16 16-track Tape Deck with patchbay, flightcase and six reels of tape, £2,000. TDA 16-channel pro mixer and multicore system, £1,150. Immaculate condition. Tel: Trevor (01670) 829227.

Tektronix 7904 Oscilloscope with 2 × 7A26 dual-trace amplifiers, 7B85 delaying timebase, 7D01 logic analyser, pods & manuals, £250. Tel: (01844) 338959 eves.

Wanted

Robot Voice PCB, Order Code GJ09K, page 603. Good quality home-made PCBs accepted. Tel: (01722) 320493.

Spectrum INTERFACE ONEs – aiming to network 64 Spectrums like Uncle Clive said you can! (Actually, three or four would do – model railway timetable and distributed route indication project awaits. Tel: (01273) 844530.

Club Corner

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

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

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

Crystal Palace and District Radio Society meets on the third Saturday of each month at All Saints Church Parish Rooms, Beulah Hill, London SE19. Details from Wilf Taylor, (G3DSC), Tel: (0181) 699 5732.

Derby and District Amateur Radio Society meets every Wednesday at 7.30pm, at 119 Green Lane, Derby. Further details from: Richard Buckby, (G3VGW), 20 Eden Bank, Ambergate DE56 2GG. Tel: (01773) 852475.

Placing an advertisement in this section of *Electronics and Beyond* is your chance to tell the readers of Britain's best magazine for electronics enthusiasts what you want to buy or sell, or tell them about your club's activities – Absolutely Free of Charge! We will publish as many advertisements as we have space for. We will print the first 30 words free, but thereafter the charge is 10p per word for each added advert per reader.

Placing an advertisement is easy! Simply write your advertisement clearly in capital letters, on a postcard or sealed-down envelope. Then send it, with any necessary payment, to: *Electronics Classified*, P.O. Box 777, Rayleigh, Essex SS6 8LU.

Advertisements will be published as soon as possible, space allowing. No responsibility is accepted for delayed publication or non-inclusion of advertisements.

Readers who have reasonable grounds to believe they have been misled as to the nature of an advertisement are advised to contact the Publisher and their local Trading Standards Office.

Electronic Organ Constructor's Society. Details of programme magazine and membership from: Don Bray (Hon. Sec.), 34 Etherton Way, Seaford, Sussex BN25 3QB. Tel: (01323) 894909.

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

The Lincoln Short Wave Club meets every Wednesday night at the City Engineers' Club, Waterside South, Lincoln at 8pm. All welcome. For further details contact Pam, (G4STO) (Secretary). Tel: (01427) 788356.

MERG? 2 first class stamps (or 4 IRCs) to John Weal, 23 Chapel Street, Yaxley, PE7 3LN brings you a substantial introductory pack to the Model Electronic Railway Group – actively applying electronics and computers to the model railway operation.

Preston Amateur Radio Society meets every Thursday evening at The Lonsdale Sports and Social Club, Fulwood Hall Lane, Fulwood, (off Watling Street Road), Preston, Lancashire PR2 4DC. Tel: (01772) 794465. Secretary: Mr Eric Eastwood, (G1WCQ), 56 The Mede, Freckleton PR4 1JB, Tel: (01772) 686708.

Science At Your Fingertips. Want to meet friends interested in Science? Send an SAE to: Daniel Gee, S.A.Y.F., 37 South Road, Watchet, Somerset TA23 0HG, or Scott Mason, S.A.Y.F., 58 Park Avenue, Devonport, Plymouth PL1 4BP. `http://homepages.enterprise.net/icedragon/says.htm`.

SEEMUG (South East Essex Mac User Group), meet in Southend, every second Monday of each month. For details Tel: Michael Foy (01702) 468062, or e-mail to `mac@mikefoy.demon.co.uk`.

Southend and District Radio Society meets at the Druid Venture Scout Centre, Southend, Essex every Thursday at 8pm. For further details, contact: P.O. Box 88, Rayleigh, Essex SS6 8NZ.

Sudbury and District Radio Amateurs (SanDRA) meet in Gt. Cornard, Sudbury, Suffolk at 8.00pm. New members are very welcome. Refreshments are available. For details please contact Tony, (G8LTY), Tel: (01787) 313212 before 10.00pm.

TESUG (The European Satellite User Group) for all satellite TV enthusiasts! Totally independent. TESUG provides the most up-to-date news available (through its monthly 'Footprint' newsletter, and a teletext service on the pan-European 'Super Channel'). It also provides a wide variety of help and information. Contact: Eric N. Wiltsher, TESUG, P.O. Box 576 Orpington, Kent BR6 9WY.

Thanet Electronics Club. For school age Ham Radio and Electronics enthusiasts, enters its 16th Year. Meetings held every Monday evening from 7.30pm at The Quarterdeck, Zion Place, Margate, Kent. For further details contact: Dr. Ken L. Smith, (G3JIX), Tel: (01304) 812723

Wakefield and District Radio Society meet at 8.00pm on Tuesdays at the Community Centre, Prospect Road, Ossett, West Yorkshire. Contact Bob Firth, (G3WWF), (QTHR), Tel: (0113) 282 5519.

The (Wigan) Douglas Valley Amateur Radio Society meets on the first and third Thursdays of the month from 8.00pm at the Wigan Sea Cadet HQ, Training Ship Sceptre, Brookhouse Terrace, off Warrington Lane, Wigan. Contact: D. Snape, (G4GWG), Tel: (01942) 211397 (Wigan).

Winchester Amateur Radio Club meets on the third Friday of each month. For full programme contact: G4AXO, Tel: (01962) 860807.

Wirral Amateur Radio Society meets at the Ivy Farm, Arrowe Park Road, Birkenhead every Tuesday evening, and formally on the first and third Wednesday of every month. Details: A. Seed, (G3FOO), 31 Withert Avenue, Bebington, Wirral L63 5NE.

Wirral and District Amateur Radio Society meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF hunts, demonstrations and junk sales. For further details, please contact: Paul Robinson, (G0JZP) on (0151) 648 5892.

BBS Corner

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

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

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

Please write your classified advert using one word per box below.
Adverts of 30 words or under will be printed free of charge, but thereafter the charge is 10p per word. Please include any payment for extra words with your advert.

ELECTRONICS *Classified*

Name ______________________

Address ______________________

____

____

Daytime Telephone ______________________

Return your advert to: *Electronics Classified*, P.O. Box 777, Rayleigh, Essex, SS6 8LU.

DEVELOPING APPLICATIONS AROUND THE PIC ARCHITECTURE

PART 8

Final Word

by Stephen Waddington

In the final part of this series, Stephen Waddington looks at how to select a PIC device for a particular application and examines some of the advanced features of individual devices within the PIC family of microprocessors.

This article brings the series on 'Developing Applications Around the PIC Architecture' to a close. That is in terms of covering the theory, at least. We are now running a series of project-based articles, from a variety of authors, which examine practical implementations of PIC-based designs.

If you have followed this series from the beginning, you should by now have good basic understanding of the PIC architecture. If electronics enthusiasts or amateur designers do have a concern about working with microprocessor devices, it is usually rooted in a fear of software. This is a clear issue, but hopefully, this series has removed much of the complexity.

Ultimately, the best way of overcoming fear is to have a go. This is our maxim to anybody who is considering experimenting with microprocessor development. With the basic programming and simulation tools required to get started all available for free from the Microchip Web site at `www.microchip.com` and programmers such as Maplin's PIC16C84 Programmer Kit priced £19.99, the cost of microprocessor development is comparable to working with discrete semiconductor devices, yet it is a lot more versatile.

In this article, we cover all the bits and pieces that there hasn't been chance to cover in previous parts of the series. Selecting a PIC microprocessor for a particular role is top of this list, followed by advanced features of individual devices within the PIC family.

Judging by the number of letters we have received, it is clear that microprocessor development is a hot issue in the Maplin community. Table 1 outlines the topics covered in the earlier parts of this series. If you want to order back copies of the magazine, they are available from Maplin on Tel: (01702) 554002 priced £2.25.

Selecting a Device

Throughout this series, we have focused on a single member of the PIC microprocessor family – the PIC16C84 – rather than try and describe the differences between each microprocessor in terms of individual hardware and software 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 two additions to 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 devices in the PIC family.

Perhaps even more attractive, is the fact that the PIC16C84 has 1k-byte of local EEPROM. This makes it an ideal device to learn programming techniques on, since it can literally be programmed and re-programmed electronically within 20 seconds. By comparison, other devices in the PIC family are EPROM-based. This means that they can be programmed electronically but require exposure to ultra-violet (UV) light to erase the device prior to re-programming.

PIC Overview and Roadmap

PIC16/17 microprocessors from Microchip combine high performance, low cost and small package size, offering the best price/performance ratio in the industry. More than 100 million of these devices ship each year to cost-sensitive consumer products, computer peripherals, office automation, automotive control systems, security and telecommunication applications.

Microchip offers four families of 8-bit microprocessors: PIC12CXXX 8-pin, PIC16C5X 12-bit program word, PIC16CXXX 14-bit program word and PIC17CXXX 16-bit program word microprocessor families. All families offer One-Time Programmable (OTP), low-voltage and low-power options, as well as various packaging options. Selected members are available in ROM and reprogrammable EEPROM versions.

Details of the four families within the Microchip product portfolio are outlined below. Details of each family, architectural features, product name and technology is shown in Table 2.

◆ PIC12CXXX: 8-pin, 8-bit Family
The PIC12CXXX family packs Microchip's powerful RISC-based PIC16/17 architecture into an 8-pin dual-in-line package. These PIC12CXXX products have a 12-bit wide instruction set, a low operating voltage of 2·5V and small package footprints. Future versions of the PIC12CXXX will include devices with the 14-bit wide instruction set, interrupt handling and a deeper hardware stack.

Magazine	Part No.	Title	Contents
107	1	Introduction to microprocessors	Overview of embedded microprocessors
108	2	Pickled processors	Characteristics and architecture of PIC microprocessor
109	3	More than just a microprocessor	Special features. Reset; power on reset; power-up timer; oscillator start-up timer; time-out sequence; watchdog timer; clocking; configuration fuses; and code protection.
110	4	Talking to the outside world	Review of input/output hardware and registers.
111	5	Soft option	Code development; the PIC instruction set; instruction types; timing
112	6	Building a complete solution	Design process; assembler; code development; example flip-flop application; software debugging and simulation; and target circuit.
113	7	Advanced development techniques	Mixing input and output; input addressing; output addressing; Interrupts; Watchdog timer; Sleep; and RTCC.
114	8	Final word	Selecting a device for a particular application; PIC roadmap; lookup tables; low power operation; analogue-to-digital-conversion; and online resources.

Table 1. Topics covered throughout this series.

Family	Architectural Features	Name	Technology	Devices
8-bit instruction word family, 8-pin	12-bit wide instruction set DC – 4MHz clock speed 1,000ns instruction cycle @ 4MHz	PIC12C5XX	OTP program memory, digital only	PIC12C508, PIC12C509
12-bit instruction word family	12-bit wide instruction set DC – 20MHz clock speed 200ns instruction cycle @ 20MHz	PIC16C5X PIC16C5XA	OTP program memory, digital only	PIC16C52, PIC16C54, PIC16C54A, PIC16C55, PIC16C56, PIC16C57, PIC16CR58A
		PIC16CR5X PIC16CR5XA	ROM program memory, digital only	PIC16CR54A, PIC16CR57B, PIC16CR58A
14-bit instruction word family	14-bit wide instruction set Internal/external interrupts DC – 20MHz clock speed 200ns instruction cycle @ 20MHz	PIC14CXXX	OTP program memory, with A/D & D/A functions	PIC14C000
		PIC16C55X	OTP program memory, digital only	PICC554, PIC16C556, PIC16C558
		PIC16C6X	OTP program memory, digital only	PIC16C62, PIC16C62A, PIC16C63, PIC16C64, PIC16C64A, PIC16C65, PIC16C65A
		PIC16CR6X	ROM program memory, digital only	PIC16CR62, PIC16CR63, PIC16CR64, PIC16CR65
		PIC16C62X	OTP program memory, with comparators	PIC16C620, PIC16C621, PIC16C622
		PIC16C7X	OTP program memory, with analogue functions	PIC16C710, PIC16C71, PIC16C711, PIC16C715, PIC16C72, PIC16C73, PIC16C73A, PIC16C74, PIC16C74A
		PIC16CF8X	Flash program and EEPROM data memory	PIC16C84, PIC16F83, PIC16F83A
		PIC16CR8X	ROM program and EEPROM data memory	PIC16CR83, PIC16CR84
		PIC16C9XX	OTP program memory, LCD driver	PIC16C923, PIC16C924
16-bit instruction word family	16-bit wide instruction set Internal/external vectored interrupts 14-bit instruction word family DC-25MHz clock speed 160ns instruction cycle @ 25MHz Hardware multiply	PIC17C4X	OTP program memory, digital only	PIC17CR42A, PIC17C43, PIC17C44
		PIC17CR4X	ROM program memory, digital only	PIC17CR42, PIC17CR43
		PIC17C75X	OTP program memory, with mixed-signal functions	PIC17C756

Table 2. Architectural details of the four families within the Microchip product portfolio.

- PIC16C5X: 12-bit Architecture Family
  The PIC16C5X family is a well established baseline family. These PIC16C5X products have a 12-bit wide instruction set and are currently offered in 18-, 20- or 28-pin packages. In the SOIC and SSOP packaging options, these are amongst the industry's smallest footprint microprocessors. Low-voltage operation down to 2·0V for OTPs make this family ideal for battery operated applications.
- PIC16CXXX: 14-bit Architecture Family
  The PIC16CXXX family offers a wide-range of options, from 18-pin to 68-pin packages as well as low to high levels of peripheral integration. This family has a 14-bit wide instruction set, interrupt handling capability and a deep 8-level hardware stack. The PIC16CXXX family provides the performance and versatility to meet the requirements of more demanding, yet cost-sensitive, mid-range 8-bit applications.
- PIC17CXXX: 16-bit Architecture Family
  The PIC17CXXX family offers the world's fastest execution performance of any 8-bit microprocessor family in the industry. The PIC17CXXX family extends the PIC16/17 microprocessor's high-performance RISC architecture with a 16-bit instruction word, enhanced instruction set and powerful vectored interrupt handling capabilities. A powerful array of precise on-chip peripheral features provide the performance for the most demanding 8-bit applications.

Selecting a Device

Selecting a microprocessor for a particular application is relatively straightforward. The key issue is defining the hardware requirements. Do not be concerned about the memory requirements as these can be reviewed as the design develops. Most important are the I/O needs. These should be defined at the start of a project in order to determine the target development device.

Initially, the user should calculate the number of I/O lines required and determine other hardware requirements such as analogue-to-digital conversion, LCD drive capability or interrupt functionality. Use the reference table (Table 3) to select most appropriate product family. Having selected the most appropriate device family, match the hardware requirements against the most appropriate device. This can be done using a reference table such as that shown in Table 2 or the '1996 Microchip Data Book'.

Under most circumstances, if the hardware features of the microprocessor match the needs of the target application, the microprocessor's programme memory will be adequate – even 1k-byte of code is an awful lot of software. If, during the development process, you find yourself in the unlikely position of running short of memory, there are two options: either optimise and condense existing code; or opt for a more sophisticated device.

Advanced PIC Microprocessor Features

As this is the last article in the series, we're picking up all sorts of issues which are not necessarily related, but have not been covered previously, and should be considered by the designer new to the topic of development around the PIC microprocessor. Here, we look at three advanced software techniques including lookup tables, minimising the power consumption of a PIC microprocessor, and analogue-to-digital conversion.

```
CONVERT  ADDWF PC, F           ; Add contents of the W register
                               ; to the Program Counter and
                               ; place result in the Program Counter
         RETLW     0.32        ; line 0 returns 32F if W = 0
         RETLW     0.34        ; line 1 of table
         RETLW     0.36        ; line 2 of table
         .
         .                     ; conversion table
         .
         RETLW     0.81        ; line 28 of table
         RETLW     0.82        ; line 29 of table
```

Listing 1. Subroutine use lookup table to convert temperature from Celsius to Fahrenheit.

	Microprocessor Families Increased complexity/functionality		
Hardware requirements	• I/O • 8-bit timer with pre-scaler • Watchdog timer • Internal Oscillator	• I/O • Multiple timers • PWM • Capture/compare • USART • ADCs • Voltage reference • LCD driver • Data EEPROM • In-circuit programmer • Watchdog timer	• I/O • Multiple timers • PWM • Capture/compare • USART • 10-bit ADC • Hardware multiply • Brownout circuitry • Watchdog Timer
Device	12-bit instruction word family	14-bit instruction word family 8-bit instruction word family, 8-pin family	16-bit instruction word family

Table 3. The Microchip Microprocessor product families.

```
         MOVF     BCD, W          ; load BCD into W register
         CALL     CONVERT         ; call conversion return
         MOVWF    PORTB           ; output to display
CONVERT  ADDWF    PC              ; add contents of W to the program
                                  ; counter
         RETLW    B'01000000'     ; complement output to
                                  ; 7-segment display
         RETLW    B'01001111'     ; 1
         RETLW    B'00010010'     ; 2
         RETLW    B'00000110'     ; 3
         RETLW    B'01001100'     ; 4
         RETLW    B'00100100'     ; 5
         RETLW    B'01100000'     ; 6
         RETLW    B'00001111'     ; 7
         RETLW    B'00000000'     ; 8
         RETLW    B'00001100'     ; 9
```

Listing 2. Subroutine using lookup table to convert binary to 7-segment display format.

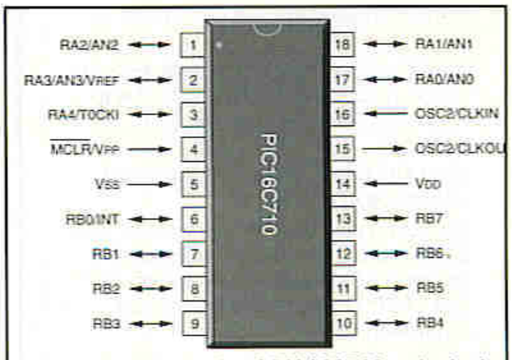


Figure 1. Schematic of PIC16C710, a typical ADC device from the PIC product portfolio.

Lookup Tables

The lookup table is a useful method for data conversion and reference. Implementation using the PIC microprocessor is relatively straightforward. The Program Counter is manipulated using a subroutine call to return a value from the lookup table.

An example of this technique is shown in the subroutine in Listing 1, which converts temperature from Celsius to Fahrenheit. The Celsius value is placed in the W register prior to the subroutine being called. The Fahrenheit equivalent value is returned from the subroutine in the W register. If, for example, the value 29 is present in the W register at the time the subroutine is called, this value is added to the Program Counter (PC), which is incremented 29 steps to return the value 0·82 in the W register.

Lookup tables can be used for pulse width measurement where the value of the pulse width is compared with a table to determine a 1, 0 or noise. They can also be used to convert between different number or code formats. Listing 2 shows a lookup table for a binary to 7-segment display convertor. The value to be outputted is held in a register called BCD and outputted to the display attached to PORTB. The output data is in the format 'x a b c d e f g' for common anode LED displays, where x is an unused bit.

Low Power

Minimising the power consumption of a microprocessor is a key challenge for designers of battery powered applications. While devices in the PIC microprocessor family typically have a low power consumption, by applying a series of design rules as shown below, the designer can further optimise power consumption.

- Run the clock at the slowest speed feasible for your application.
- Disable the watchdog timer.
- Put the microprocessor to sleep whenever possible.
- Use the MCLR function to wake part from sleep instead of the WDT if possible.
- Do not let any inputs float. If a pin is not to be used you can leave it disconnected and drive it low or high, or put a pull up or down resistor on it as an input.
- Minimise capacitive or inductive loads on switching I/O pins, or resistive loads on other driven pins.
- Turn off all timers when not in use. For instance, TMR0 can be incremented from the instruction clock or an external pin.
- Turn off any I/O peripherals when not in use.

Analogue-to-Digital Conversion (ADC)

So far, we have considered microprocessor application design solely from a digital perspective. We have totally ignored the PIC microprocessor's ability to handle analogue and mixed signals. This section of the article examines the analogue-to-digital features of the PIC family and demonstrates how a PIC device might be configured for an analogue-to-digital (A/D) application.

Not all devices within the PIC microprocessor portfolio have A/D functionality. The PIC16C710, PIC16C71 and PIC16C711 have four analogue inputs, the PIC16C72, PIC16C73 and PIC16C73A have five inputs, while the PIC16C74 and PIC16C74A both have eight. The A/D allows conversion of an analogue input signal to a corresponding 8-bit digital number. The analogue reference voltage is software selectable to either the device's positive supply voltage (V_{DD}) or the voltage level on the RA3/AN3/V_{REF} pin. The PIC16C710, a typical ADC device from the PIC product portfolio is shown in Figure 1.

The A/D module on each PIC device has three registers, comprising:

- A/D Result Register (ADRES)
- A/D Control Register 0 (ADCON0)
- A/D Control Register 1 (ADCON1)

The ADCON0 register, shown in Figure 2 and Figure 3, controls the operation of the A/D module. The ADCON1 register, shown in Figure 4 and Figure 5, configures the functions of the port pins. The port pins can be configured as analogue inputs – RA3 can also be a voltage reference – or as digital I/O.

The ADRES register contains the result of the A/D conversion. When the A/D conversion is complete, the result is loaded into the ADRES register, the GO/DONE bit (ADCON0 register, bit 2) is cleared, and A/D interrupt flag bit ADIF is set.

After the A/D module has been configured as desired, the selected channel must be activated before the conversion is started. The analogue input channels must have their corresponding TRIS bits selected as an input. After this acquisition period has elapsed, the A/D conversion can be started. The following steps should be followed for doing an A/D conversion:

1. Configure the A/D module; configure the analogue pin/voltage reference and digital I/O (ADCON1); select A/D input channel (ADCON0); select A/D conversion clock (ADCON0); and turn on A/D module (ADCON0).
2. Configure A/D interrupt if required; clear ADIF bit; set ADIE bit; and set GIE bit.
3. Wait the required acquisition time.

R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADCS1	ADCS0	—(1)	CHS1	CHS0	GO/$\overline{DONE}$	ADIF	ADON
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
-n = Value at POR reset

bit 7-6: **ADCS1:ADCS0:** A/D Conversion Clock Select bits
00 = Fosc/2
01 = Fosc/8
10 = Fosc/32
11 = FRC (clock derived from an RC oscillation)

bit 5: **Unimplemented:** Read as '0'

bit 4-3: **CHS2:CHS0:** Analogue Channel Select bits
00 = channel 0, (RA0/AN0)
01 = channel 1, (RA1/AN1)
10 = channel 2, (RA2/AN2)
11 = channel 3, (RA3/AN3)

bit 2: **GO/$\overline{DONE}$:** A/D Conversion Status bit
If ADON = 1
1 = A/D conversion in progress (setting this bit starts the A/D conversion)
0 = A/D conversion not in progress (This bit is automatically cleared by hardware when the A/D conversion is complete)

bit 1: **ADIF:** A/D Conversion Complete Interrupt Flag bit
1 = conversion is complete (must be cleared in software)
0 = conversion is not complete

bit 0: **ADON:** A/D On bit
1 = A/D converter module is operating
0 = A/D converter module is shutoff and consumes no operating current

Note 1: Bit5 of ADCON0 is a General Purpose R/W bit for the PIC16C71 only. For the PIC16C710/711, this bit is unimplemented, read as '0'.

Figure 2. ADCON0 register for PIC16C710/71/711 (Address 08h).

4. Start conversion and set GO/DONE bit (ADCON0).
5. Wait for A/D conversion to complete, by either: polling for the GO/DONE bit to be cleared, or waiting for the A/D interrupt.
6. Read A/D result register (ADRES) and clear bit ADIF if required.
7. For next conversion, go to step 1 or step 2 as required. The A/D conversion time per bit is defined as TAD. A minimum wait of 2TAD is required before next acquisition starts.

Configuring Analogue Port Pins

The ADCON1, TRISA, and TRISE registers control the operation of the A/D port pins. The port pins that are to be used as analogue inputs must have their corresponding TRIS bits set as inputs. If the TRIS bit is cleared (output), the digital output level (V_{OH} or V_{OL}) will be converted. The A/D operation is independent of the state of the CHS2, CHS1, CHS0 bits and the TRIS bits.

Speed Versus Resolution Trade-off

Not all applications require a result with 8-bits of resolution, but may instead require a faster conversion time. The A/D module allows users to make the trade-off of conversion speed to resolution. Regardless of the resolution required, the acquisition time is the same. To speed up the conversion, the clock source of the A/D module may be switched so that the T_{AD} time violates the minimum specified time.

Once the T_{AD} time violates the minimum specified time, all the following A/D result bits are not valid. The clock sources may only be switched between the three oscillator versions. The equation to determine the time before the oscillator can be switched is as follows:

Conversion Time $= 2T_{AD} + NxT_{AD}(8\text{-}N)(2T_{OSC})$

Where: N = number of bits of resolution required.

Since the T_{AD} is based on the device oscillator, the user must use some method such as a timer or software loop, to determine when the A/D oscillator may be changed.

Table 4 shows a comparison of time required for a conversion with 4-bit resolution, versus the 8-bit resolution conversion. The example is for devices operating at 20MHz and 16MHz – The A/D clock is programmed for $32T_{OSC}$ – and assumes that immediately after $6T_{AD}$, the A/D clock is programmed for $2T_{OSC}$.

A/D Examples

The examples shown in Listing 3 and Listing 4 show how to perform an A/D conversion in software for the PIC16C710/71/711 and PIC16C72/73/73A/74/74A, respectively. First off, the RA pins are configured as analogue inputs. The analogue reference (V_{REF}) is the device V_{DD}. The A/D conversion clock is FRC. The conversion is performed on the ROA channel. Note that the GO/DONE bit should not be set in the same instruction that turns of the A/D.

Clearing the GO/DONE bit during a conversion will abort the conversion. The ADRES register will not be updated with the partially completed A/D conversion sample. That is, the ADRES register will continue to contain the value of the last completed conversion – or the last value written to the ADRES register. After the A/D conversion is aborted, a $2T_{AD}$ wait is required before the next acquisition is started. After this wait, an acquisition is automatically started on the selected channel.

For further details of analogue-to-digital conversion, check the Microchip '1996 Microchip Data Book', data sheets pertaining to specific A/D devices or the Microchip Web site at **www.microchip.com**.

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	–	ADON
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
-n = Value at POR reset

bit 7-6: **ADCS1:ADCS0:** A/D Conversion Clock Select bits
00 = Fosc/2
01 = Fosc/8
10 = Fosc/32
11 = FRC (clock derived from an RC oscillation)

bit 5-3: **CHS2:CHS0:** Analogue Channel Select bits
000 = channel 0, (RA0/AN0)
001 = channel 1, (RA1/AN1)
010 = channel 2, (RA2/AN2)
011 = channel 3, (RA3/AN3)
100 = channel 4, (RA5/AN4)
101 = channel 5, (RE0/AN5)(1)
110 = channel 6, (RE1/AN6)(1)
111 = channel 7, (RE2/AN7)(1)

bit 2: **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit
If ADON = 1
1 = A/D conversion in progress (setting this bit starts the A/D conversion)
0 = A/D conversion not in progress (This bit is automatically cleared by hardware when the A/D conversion is complete)

bit 1: **Unimplemented:** Read as '0'

bit 0: **ADON:** A/D On bit
1 = A/D converter module is operating
0 = A/D converter module is shutoff and consumes no operating current

Note 1: A/D channels 5, 6, and 7 are implemented on the PIC16C74/74A only.

Figure 3. ADCON0 register for PIC16C72/73/73A/74/74A (Address 1Fh).

U-0	U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0
–	–	–	–	–	–	PCFG1	PCFG0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
-n = Value at POR reset

bit 7-2: **Unimplemented:** Read as '0'

bit 1-0: **PCFG1:PCFG0:** A/D Port Configuration Control bits

PCFG1:PCFG0	RA1 & RA0	RA2	RA3	V_{REF}
00	A	A	A	V_{DD}
01	A	A	V_{REF}	RA3
10	A	D	D	V_{DD}
11	D	D	D	V_{DD}

A = Analogue input
D = Digital I/O

Figure 4. ADCON1 register for PIC16C710/71/711 (Address 88h).

U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0
–	–	–	–	–	PCFG2	PCFG1	PCFG0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
-n = Value at POR reset

bit 7-3: **Unimplemented:** Read as '0'

bit 2-0: **PCFG2:PCFG0:** A/D Port Configuration Control bits

PCFG2:PCFG0	RA0	RA1	RA2	RA5	RA3	RE0(1)	RE1(1)	RE2(1)	V_{REF}
000	A	A	A	A	A	A	A	A	V_{DD}
001	A	A	A	A	V_{REF}	A	A	A	RA3
010	A	A	A	A	A	D	D	D	V_{DD}
011	A	A	A	A	V_{REF}	D	D	D	RA3
100	A	A	D	D	A	D	D	D	V_{DD}
101	A	A	D	D	V_{REF}	D	D	D	RA3
11x	D	D	D	D	D	D	D	D	–

A = Analogue input
D = Digital I/O

Note 1: RE0, RE1, and RE2 are implemented on the PIC16C74/74A only

Figure 5. ADCON1 register for PIC16C72/73/73A/74/74A (Address 9Fh).

Resources

We have tried to be as comprehensive as possible throughout this series. Inevitably, there are areas of PIC development which we have been unable to cover. If you require further information, check the web sites and online resources below, or the reference books listed at the end of the article.

Microchip Online Support

Microchip provides three methods of online support: a Bulletin Board Service (BBS); a file transfer (FTP) site; and a web site. The BBS is provided as a communication channel for customers to get current information and help about our products and allow interaction with Microchip microprocessor and memory experts.

To provide the most responsive service possible, the Microchip Development Systems Team monitors the BBS, posts the latest component data and software tool updates, provides technical help and embedded systems insights, and discusses how Microchip products provide project solutions.

The web site and file transfer site provide a variety of services. Users may download files for the latest development tools, data sheets, application notes, user's guides, articles and sample programs. Other data available for review is: Latest Microchip Press Releases; Technical Support Section with Frequently Asked Questions; Design Tips; Device Errata; Job Postings; and Links to other useful web sites related to Microchip Products.

Connecting to Microchip

The Microchip web site is available at: **www.microchip.com.** You can telnet or ftp to the Microchip BBS at the address: **mchipbbs.microchip.com.** The file transfer site is available by using an ftp service to connect to: **ftp.mchip.com/biz/mchip.**

Third Party Web Sites

In addition to the Microchip Web site, there is an immense amount of PIC-related information and data available on the on the Web. Microchip list a selection of third party sites at **www.microship2.com/3rdparty/3rd party.htm.** In addition, a selection of third party and enthusiast sites are shown in Table 5.

Book

We are considering compiling this series into a reference book about the PIC microprocessor. If you have any comments or thoughts on aspects of the series you would like to be see covered in greater detail or elements you think we have omitted, please let us know. Write to the usual address given on the 'Air Your Views' page or e-mail swaddington@cix.compulink.co.uk.

Reading List

The books and online resources shown in Table 6 discuss many of the issues raised in this article in greater depth. They also provide examples of the PIC development cycle, including many specific projects.

Microchip has produced documentation for all of its development tools. It has also produced data sheets for each of the PIC microprocessors. These can be downloaded in Acrobat PDF format from the Microchip Web site at **www.microchip.com.** An Acrobat reader can be downloaded from the Acrobat Web site at **www.adobe.com.** ELECTRONICS

	Frequency MHz	Resolution	
		4-bit	8-bit
T_{AD}	20	1μ6μs	1μ6μs
	16	2μ0μs	2μ0μs
T_{OSC}	20	50ns	50ns
	16	62μ5ns	62μ5ns
$2T_{AD} + N \times T_{AD} + (8 - N)(2T_{OSC})$	20	10μs	16μs
	16	12μ5μs	20μs

Note: The PIC16C71 has a minimum TAD time of 2μ0μs. All other PIC16C7X devices have a minimum TAD time of 1μ6μs.

Table 4. 4-bit versus 8-bit conversion times.

Third Party Site Web Site	Web Address	Description
PIC16C84 Information site	ds.dial.pipex.com/town/parade/mx22/index.htm	The site is dedicated to the PIC16C84 run in a similar way to a bulletin board, with Readers Projects and Programs, ideas for projects, Questions & Answers
Centre for Design Research (CDR)	cdr.stanford.edu/people/luehrb/up/pic/current/index/html	The CDR is a research institute affiliated with the Design Division of the Department of Mechanical Engineering at Stanford University.
Bluebird Electronics	www.bluebird.co.uk	Specialist UK-based PIC consultancy
List of PIC Resources	www.eetoolbox.com/gatoxpic.htm	Reference index of PIC resources
Andy Errington's PIC Project Page	www.lancs.ac.uk/people/cpaame/pic/pic.htm	Example PIC projects

Table 5. Selection of third party and enthusiast PIC web site.

Description	Reference	Cost
A Beginners Guide to the Microchip PIC	AD31J	£19.95
PIC Cookbook	DT76H	£19.90
Embedded Control Handbook	AD28F	£9.50
Microchip Databook	AD29G	£9.50
MPSIM for DOS User's Guide	microchip2.com/devtools/devtools.htm	-
MPASM User's Guide	microchip2.com/devtools/devtools.htm	-
PICStart-16B1 User Guide	microchip2.com/devtools/devtools.htm	-
PIC16C84 Application Note	microchip2.com/appnotes	-

Table 6. PIC reference books and online resources.

```
BSF     STATUS, RPO          ; Select Page 1
CLRF    ADCON1               ; Configure A/D inputs
BSF     PIE1, ADIE           ; Enable A/D interrupts
BCF     STATUS, RPO          ; Select Page 0
MOVLW   0xC1                 ; RC Clock, A/D is on,
                             ; Channel 0 is selected
MOVWF   ADCON0               ;
BCF     PIR1, ADIF           ; Clear A/D interrupt flag bit
BSF     INTCON, PEIE         ; Enable all peripheral
                             ; interrupts
BSF     INTCON, GIE          ; Enable all interrupts
;
;
;       Ensure that the required sampling time for the selected input
;       channel has elapsed. Then the conversion may be started
;
;
;       BSF    ADCON0, GO    ; Start A/D conversion
.                            ; The ADIF bit will be set and
.                            ; the GO/DONE bit is cleared
.                            ; upon completion of the A/D
.                            ; conversion
```

Listing 4. A/D conversion using PIC16C72/73/73A/74/74A.

```
BS      STATUS, RPO          ; Select Page 1
CLRF    ADCON1               ; Configure A/D inputs
BCF     STATUS, RPO          ; Select Page 0
MOVLW   0xC1                 ; RC Clock, A/D is on,
                             ; Channel 0 is selected
MOVWF   ADCON0               ;
BSF     INTCON, ADIE         ; Enable A/D interrupt
BSF     INTCON, GIE          ; Enable all interrupts
;
;
; Ensure that the required sampling time for the selected input
; channel has elapsed. Then the conversion may be started
;
;
;       BSF    ADCON0, GO    ; Start A/D conversion
.                            ; The ADIF bit will be set and
.                            ; the GO/DONE bit is cleared
.                            ; upon completion of the A/D
.                            ; conversion
```

Listing 3. A/D conversion using PIC16C710/71/711.

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**

Doubting Thomas?

Dear Sir,

The recent correspondence in your letters page prompted me to look for the file I have maintained on this subject for the last ten years or so. Too late! It was thrown out in one of those ill-advised purges that seem like such a good idea at the time. Nevertheless, I can recall some details, which may be of interest. The phenomenon of electronic descaling was first reported by a Dutch group in the late '70s. Their work was picked up at a West London College of Technology (Lime Grove, Shepherds Bush?) in the mid-'80s and a number of experimental systems were produced. These were intended for commercial applications in laundries, etc., and were successful in removing existing scale as well as preventing new deposits. Impressive results were published in various reputable journals, including that of the Institute of Measurement and Control. Prompted by the success of these one-off systems, several manufacturers developed small packaged units for domestic installation. These began to appear in the early '90s. Typical of first-generation was the Aquasilk Macro, produced by Aquasilk Ltd., Ware SG12 9PY. I purchased one of these in 1991, and it has been in continuous use at my house in Seaford ever since. This area of Sussex is notorious for hard water. The chalk content is always high, and during recent periods of water shortage, has risen to unprecedentedly high levels. Water heaters, washing machine valves, etc. can be a constant source of problems and expense, but use of the electronic descaler has been completely successful in eliminating furring and the consequent need for frequent servicing and replacement. I believe that the descaler has saved me several hundred pounds over the last six years. The box described by Mr. Sadler in your March issue was plainly a 'con'. Proper electronic descalers put out a range of frequencies between 2 and 8MHz, and sweep up and down continuously between these limits. The RF is fed to a pair of relatively crude coils wound round the main cold water feed, and to quote the manufacturer, "The varying frequency of the electromagnetic waves changes the ion charge of the molecules of calcium and magnesium bicarbonates dissolved in the hard water. This causes the calcium crystals which form when the water is heated to be soft and powdery instead of the usual hard and scaling variety. These microscopic crystals are carried freely by the water flow and do not deposit on vulnerable points such as heating elements, shower sprays, etc. in the water system." You are very unwise to cast doubts on the effectiveness of electronic descalers. The extent to which they are advertised (including direct mail by water supply companies) surely indicates that there are many satisfied customers, and though the design of the widely advertised commercial units is inevitably a compromise and results vary from one area to another, the products on the whole do a very worthwhile job. A Maplin project for an electronic descaler would be very welcome.

Philip J. Thomas, Seaford, Sussex.

While it is pleasing to hear that you are a satisfied water descaler user, it is always worthwhile to have a healthy suspicion of certain products where it is not immediately clear how or why they operate – and where in some instances, even their manufacturers can't explain their operation convincingly. If people didn't raise doubts once in a while, all sorts of scams would be perpetrated and never exposed, so it isn't really 'unwise' to do so! But we concede that not all electronic water softeners/conditioners/descalers should be tarred with the same brush, since many clearly do operate as claimed.

In this issue, D. N. Bonner, of Lingfield, Surrey, wins the Star Letter Award of a Maplin £5 Gift Token for offering a water-soluble solution to the operation of electronic descalers.

£5 MAPLIN GIFT VOUCHER

Star Letter

Dear Editor,

With regard to M. Perry's letter, 'Fur and Froth' (Issue 113, May 1997), I too was puzzled as to how an electric field could penetrate an earthed copper water pipe, as per J. G. Wilkinson's star letter of the previous issue. Whereas pure water is an insulator, water containing dissolved salts is to a varying extent, a conductor. The water filled copper pipe should, I think, be considered as a solid conducting rod rather than as a hollow screening can. What I believe to be happening is illustrated by the following diagrams. Figure 1 shows two capacitors in series across a DC supply. On completing the circuit, free electrons will drift clockwise round the circuit producing a surplus on plate D and a deficit on plate A. The positive charge on plate A will attract free electrons to plate B and the negative charge on plate D will repel free electrons from plate C. Hence, there will be a drift of free electrons through the connecting wire from plate C to plate B, leaving them charged as shown. In Figure 2, plates B and C and the connecting wire have been replaced by a solid block of copper, E. By a similar reasoning, free electrons flow from the bottom of the block to the top, leaving the charge distribution in the block as shown. Note that the potential of the block relative to earth does not change during the initial charging process; there is merely a re-distribution of the electrons within the block. Hence, the block can be earthed without upsetting any of the circuit conditions. Likewise, from the symmetry of the system, the midpoint of the DC supply can also be earthed as shown in the diagram (see later). In Figure 3, the middle of the copper block has been hollowed out and the cavity filled with a conducting substance, namely water with calcium salts in solution. It seems reasonable to suppose that the composite block will still conduct in a similar way to the solid one. Hence, free electrons in the conducting liquid will drift upwards leaving the water charged (i.e., ionised), as shown. It still remains to be explained how the water retains its ionised state during its passage through the pipes, cold water cistern, hot water cylinder, etc., to the bathroom taps. I eagerly await next month's thrilling instalment.

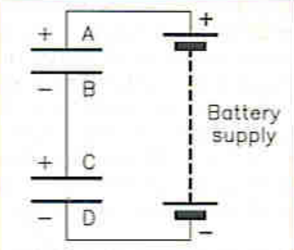


Figure 1

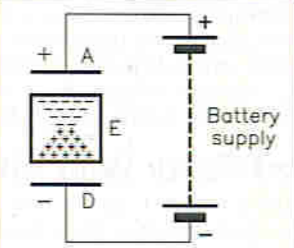


Figure 2

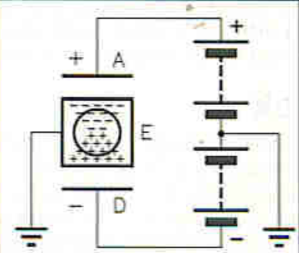


Figure 3

Your explanation and diagrams certainly appear to offer a plausible theory on how the water ionisation process operates. However, can we be certain that water softeners actually work by ionising the water? After all, ultra-soft, scale-free (pure?) water exists in the form of deionised water for the topping-up of car batteries, etc., which as you mention, has its ionised constituents removed. Philip Thomas' letter this month suggests it is the dissolved calcium/magnesium bicarbonate molecules in the hard water that have their ionic charge altered by descalers, not the actual water itself.

Searching for a Sine on the Ocean Waves

Dear Sir,

We live on a yacht which is now in the S. Pacific. In common with many other cruisers, we use generators, inverters and battery chargers, but come across problems which are shrugged off by suppliers. None of us are sufficiently qualified to ascertain the facts about the size or nature of the problem. We have a Honda 1000EX petrol generator and a Cetrek 28 amp electronically controlled battery charger. The latter works perfectly on mains power but only produces up to 12 amps with the generator. After years of going to 'XSPURTS', I was at last advised by one that his oscilloscope showed a 70V drop as the wave reaches its peak, thus presumably fooling the electronic charge control into thinking that the generator is only putting out 170V instead of 240V. By increasing the speed of the generator, the charge rate goes up to 28A but only when the voltage is up to about 360V! This seems in line with 12A @ 240-70V. The Auckland Honda Agent responded by confirming that the 1000EX does have a rotten sine wave and suggested that the solution was to buy the latest 1500 which, it seems, has a good sine wave! Our second problem is with inverters which come in 3 types, the commonest and cheapest having a modified or stepped sine wave. I have one of these, a Statpower 200, which is fine for use with a soldering iron or electric drill. However, I am convinced that it fools intelligent battery chargers as supplied with laptops, videocams, etc. These batteries get extremely hot and the life of these is extremely short on board. My suspicion was reinforced when I used it to power the charger for a friend's Bosch battery drill as the battery case was part melted/distorted. My suspicion is further reinforced by the recent introduction of pure sine wave inverters by companies such as Heart Interface, although I am sure that no manufacturer of a modified wave model would admit to the probable destruction of huge numbers of Nicads. Indeed, against my belief is the fact that Statpower are now the supplier of small inverters recommended for use by the importers of various top name laptops. As a matter of interest, I wonder if your Ni-Cd Charger MkII would be fooled? I suppose I shall never know, as you make it clear that you never reply to mail. Suffice to say that I am sufficiently convinced that I have now purchased a new pure sine wave inverter from Merlin.

John Hollamby, S. Pacific.

Wherever possible, we are pleased to respond to mail or e-mail – hence the existence of these letters pages. (Thousands of other general enquiries get answered each year which don't necessarily get published.) Inverters and generators invariably do suffer the problem that under load conditions, the purity of their sinewave deteriorates exponentially with load unless the unit is of sufficient capacity. Ideally, the output waveform should always be checked with an oscilloscope to ensure it is appropriate to the load being driven, taking into account that for a pure sinusoidal AC power source, the root mean square (rms) voltage is calculated by measuring the peak voltage and dividing by $\sqrt{2}$. Thus, for an output equivalent to the 230V mains voltage, you would need to set the peak voltage to $230\sqrt{2} = 325V$. You could instead use a multimeter set to its AC volts range to measure the output, but most will only give a realistic (rms) reading when the sinewave is pure. Most generators in any case are designed and used not to power sophisticated and relatively delicate electronic equipment but comparatively crude and tough electrical gear such as welders, drills, lighting, etc.; perhaps you were simply asking too much from the generator/inverters you were using? (The manufacturer's instructions should provide reasonable guidance on the limitations of their products.) Hopefully, your new inverter will put an end to your battery destruction problems. I trust you didn't dispose of the spoiled batteries overboard – cadmium is highly poisonous and wouldn't do the marine life any favours. Happy sailing!

Retaining the Human Touch

I was slightly worried at the prospect of going into someone else's house and rigging up a 400V circuit protected only with a bit of insulating tape, but kept on reading. You've got to get the width of the tape right to cover 33% of the circumference? OK, this is obviously not worded very well. I continued. How can it produce a strong electric field if it's insulated? There must be something subtle here that my lack of a degree in electronics, physics or chemistry is missing. I'll continue. The molecular structure stuff was a bit vague but it's a letter – it needs to be short. I kept on reading. Why on earth are they advertising other suppliers' products – and without giving phone numbers? Why else – to give Greenweld, Electrovalue and Directory Enquiries lots of grief between the 1st of March and the 1st of April, of course! Nice one. Please try to retain Maplin's human touch. It's what makes people shop there. Do let us in on the in-jokes though: Who is J. G. Wilkinson – and Coxford? Why is it stressed that we have to ask for a B78108S? By the way, RS Components stock 8V 100mA regulators for £1.04.

Andy North@compuserve

Sorry to disappoint you, but there were no mysterious in-jokes associated with the letter, which was genuinely sent in by one J. G. Wilkinson from Coxford – we didn't fabricate or re-word it, and certainly didn't intend creating any hassle for directory enquiries or other suppliers! (Apologies if we inadvertently did.)

Pigeonholed

Dear Editor,

There has been much interest shown in your readers' letters concerning 'electronic' water softeners. I live in a soft water area but, even so, I used to take an academic interest in the subject when they first appeared several years ago. However, I soon lost interest when I saw adverts claiming that these devices worked when clamped on to the OUTSIDE of an earthed copper pipe. No better Faraday screen could be devised if you tried! I could almost accept the idea if used with plastic pipes but, even then, I've never seen a convincing explanation of how they are supposed to work. All the literature I've seen refers to mysterious 'fields' and 'waves', which sound too much like a con to me. I won't say, categorically, that they are a con, but I reserve judgement until I see a convincing technical description written by someone who knows what they're talking about and are not trying to sell these things or justify having bought or made one. Until then, I will place them in the same pigeonhole as copper bracelets, magnetic fuel economisers and air powered extractor fans (remember them?)!

Roly Williams
Roly_W@compuserve.com

I'm inclined to agree with your scepticism, but there are many others who swear by these 'miracle' products. Perhaps in the end, it all boils down to a question of faith, or luck of the draw, as to whether such gadgets work or not?

Sound Location

Dear Editor,

I am enquiring about a directional microphone, as I have tinnitus and cannot pinpoint where exactly noise is coming from. As I live in a block of flats and washing machines are being used at night after 10pm and even later, I would love to have something that could pinpoint the area of noise and also a sensitive meter with enough gain (output of around 5W), also a not-too-large funnel for the microphone. The unit could also be used for bird-watching and such like. Has there been such a project described before?

W. Gibson, Glasgow.

A project that could be used to satisfy your requirements, or at least, be easily modified to do so, would be the Microsonic Audio Booster, detailed in Issue 55 of Electronics, and available as a kit (Stock Code LP52G). It uses a very small built-in electret microphone (an external one could be added for remote listening), features adjustable sensitivity and incorporates VOGAD (Voice Operated Gain Adjustment Device) amplifier circuitry so that headphone volume is more-or-less constant regardless of gain (of up to 52dB), allowing comfortable listening even if the unit is set to high sensitivity and a sudden increase in noise occurs. The unit is capable of detecting very faint sounds indeed across a bandwidth of 300Hz to 3kHz, and if the (external) microphone is housed within a tube, it will have effective directional sensitivity.

It's Brilliant!

Dear Editor,

I have been reading your magazine for about 6 months now and I think it's brilliant. It saves me buying individual electronics, science and computer magazines. I thought your educational supplements were good and would like to see the return of them, however, if you do, could you include stripboard layouts; I had trouble working them out for some of the projects. I also think that your Internet page should have more reviews of sites with info and downloads for amateur electronics enthusiasts. I downloaded a logic circuit analyser (written by Arthur Tanzella), which is brilliant. I am compiling a list of good electronics/science web sites and this list can be obtained by e-mailing a request.

Philip Frampton,
LFrampton@msn.com.

Thank you for your comments and offer of the web site list. Where possible, we will try to include stripboard layouts with future educational supplement circuits.

Bathed in a Glow of Goodwill

Dear Editor,

I am writing as a follow-up to my letter printed in Issue 113, and to be fair to some makers in respect of my previous letter on the early failure of energy-saving lamps. The one that failed in 18 months with less than 2,000 hours use but which had a life shown on the box of 12,000 hours was replaced by the makers as a 'gesture of goodwill', although it was outside the 12-month guarantee period and they stated they would normally expect a customer to purchase a replacement – irrespective of actual use, it seems. Their reply was also enlightening in that they explained the life quoted on the box was only an average. It is expected that some 50% of the lamps will never reach this figure but this is offset by those that last longer. Now compare the explanation above with the wording on the packet of a different well-known brand. The life is given as 10,000 hours and the lamp is guaranteed for 5 years in domestic use where the annual usage is less than 2,000 hours. In other words, the lamp is effectively guaranteed for a life of up to 10,000 hours (industrial use is excluded). This is more representative of normal domestic use and seems a far better buy. The moral is read the terms of guarantee carefully, write the date bought on the lamp and keep the receipt. Be wary of vague terms such as '12,000h' and 'Guaranteed' underneath as I found out it has nothing to do with the actual life but the unstated 12 months.

Mr. M. Perry, Kidderminster, Worcs.

Thanks for writing in to follow up on this illuminating saga. Good to hear it turned out well in the end!

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.

ELECTRONICS CORRIGENDA

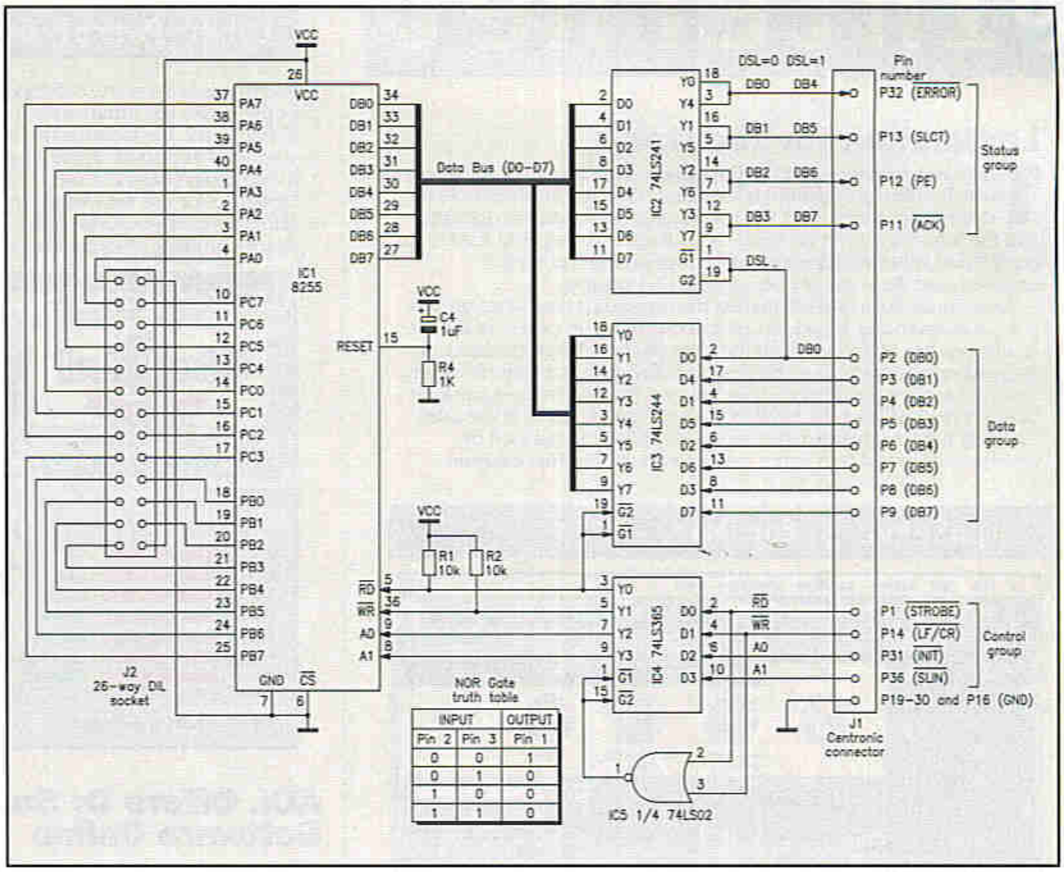
Heat Temperature Controller, Issue 112, April 1997.

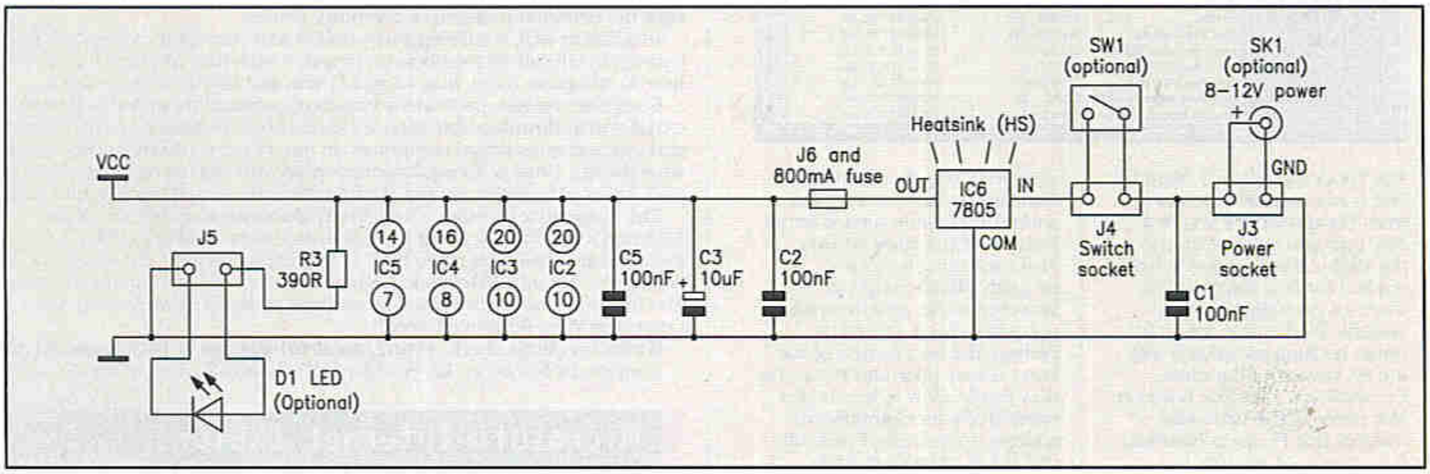
The bottom right hand oscilloscope picture is incorrect.

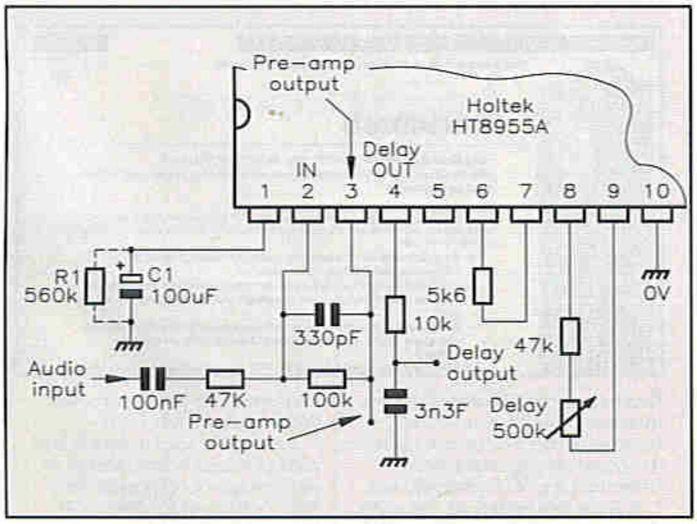
The PCB drawing was actually printed to scale. The reader needs to ignore the scaling statement. The terminal blocks in the parts list should be JY93B 10mm. An updated version of the PCB will be published next month.

Centronic 24-line Input/Output Card Part 2, Issue 112, April 1997.

The two diagrams appeared with no interconnecting wires. We reproduce them here on the right and below.

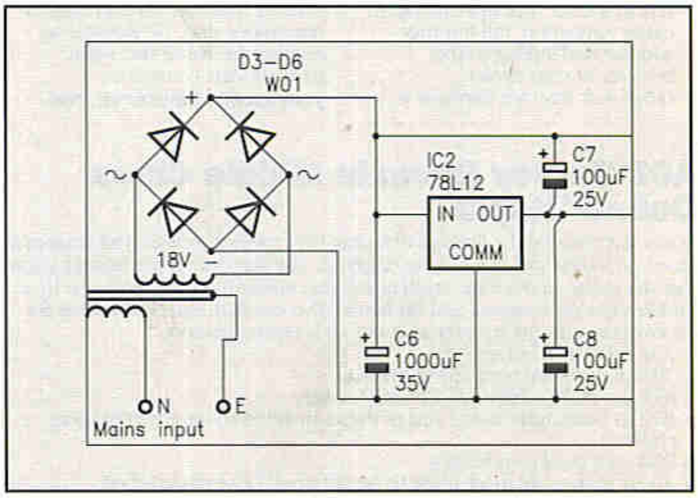






Audio Delay Line Systems Part 4, Issue 112, April 1997.

Figure 6 should have no earth connection to pin 5 as shown here.



Video Optical Isolator, Issue 112, April 1997.

Figure 9. There should be no direct connection between the + and – of the diode bridge. The correct section of the diagram is reproduced here.

@Internet

Legislation for the Net?

They say what happens in the US happens here later. And, in a move which will create significant rumblings throughout the whole of the Internet community, the US Congress looks likely to legislate that the Internet cannot be taxed. Several states throughout the US are considering imposing sales and usage taxes on Internet service providers, and that's just not on, says the US Congress.

Taxes imposed on ISPs will burden the system at a time when growth is at a maximum and would be unfair, reckons the proposers of the act. As a by-product of the act, the Internet would be officially declared an international duty-free zone. It already is, of course, as anyone from any country can already download software over the Internet and pay for it by credit card, without the need of paying import taxes or home sales tax. Long may that be the case. Seeing it officially recognised by governments would be a rather large plus in the Internet's favour.

CompuServe 3 for Mac

The US CompuServe 3 client for Mac is out (and downloadable from CompuServe if you're a Mac user and can't wait), and the UK localised version is being readied for final shipment, so there's a possibility it will be available by the time we go to press. Looking remarkably like the PC version of the client, CompuServe 3 for Mac brings to Mac users all the same new features that PC users have had for a couple of months, so there's nothing dramatic to report. Better mail management, easier navigation, full Internet support and linking to the browser of your choice (Microsoft Internet Explorer is supplied), together with the standard benefits of the tried and tested on-line service are all features of the latest version. Mail messaging is still not properly MIME-compliant however, so file attachment isn't yet quite what it should be. Perhaps the best feature of the latest clients (Mac and PC) is that they finally allow a decent alias naming of your CompuServe address, so instead of your silly, traditional, mind-bogglingly difficult-to-remember, numerical address, you can have an easy-to-remember alias. Go Register to register the name you want, then address yourself as `yourname@compuserve.com`.

AOL Survey Reveals Middle Class Online Utopia

AOL today released the findings of its first UK member analysis. The findings are based on a survey of AOL's active database. The survey overwhelmingly shows that the image of the lone, student Internet surfer has to be replaced by a middle class professional and his family who use AOL and the Internet for information, education, entertainment and communication.

Among AOL members:

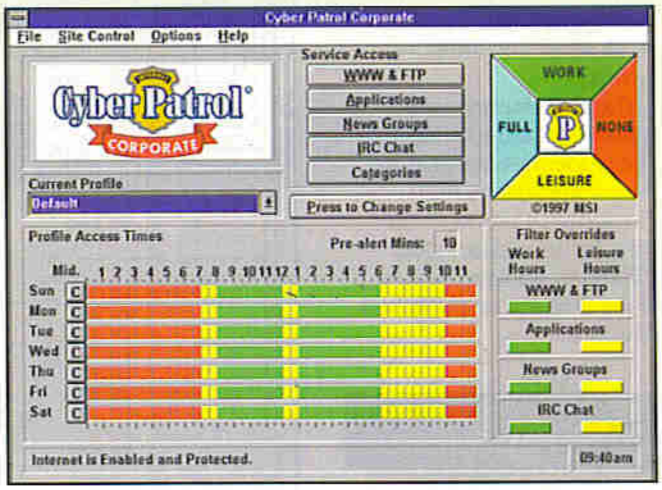
- 70% of them are between 35 and 64
- 89% are male, while only 11% are female
- Half as likely again as the rest of the population to have two or more children
- 89% own their own homes
- These homes are more likely to be detached or semi-detached
- Over half of AOL households have two or more cars
- A quarter live in London and the South-East
- They are more likely to holiday in USA/Canada and the Far East
- AOL members enjoy squash, golf, and DIY
- Over 30% have taken between 1 and 10 business flights in the past 5 years
- 27.9% own a cat

For further details, check: `http://www.aol.co.uk`.
Contact: AOL, Tel: (0800) 279 1234.

Cyber Patrol Office Internet Filter

Microsystems Software, developer of the consumer Internet filter, Cyber Patrol, has launched a version of its popular application for office and business use. Designed for use with Windows NT and Novell networks, Cyber Patrol Corporate gives companies the ability to effectively manage and control employee access to the Web.

Further details, check `http://www.microsys.com`.
Contact: Microsystems Software, Tel: (01344) 874111.



AOL Offers Dr Solomon's Anti-Virus Software Online

AOL is to make Dr Solomon's Anti-Virus software – including a free Windows 95 demo version of FindVirus scanner – to AOL's 8 million members to help fight the common problem of computer viruses.

In addition, AOL is creating a new online area, 'Computer Virus Resource Centre', to educate its members on viruses – what they are, how they work, how to recognise them, how to avoid them and how to combat them.

Computer viruses, particularly viruses transmitted though attachments to e-mail and in downloadable files, are increasingly prevalent on the Internet and can hurt consumers' computers. In one of many recent studies about virus threats, Ernst & Young/Information Security Survey reported that 62% of all losses of business computer information are caused by computer viruses.

The agreement provides a free 30-day demonstration version of Dr Solomon's FindVirus scanner to all AOL members. FindVirus detects, identifies and disinfects more than 11,000 known viruses and utilises Dr Solomon's Advanced Heuristic Analysis to detect new and unknown viruses. The free anti-virus software will be available today for download in AOL's Computer Virus Resource Centre.

For further details, check: `http://www.drsolomon.com` or `http://www.aol.com`.
Contact: Dr Solomon, Tel: (01296) 318700; or AOL, Tel: (0800) 279 1234.

Microsoft Internet Explorer 3.0 is Fastest-Growing Browser

Recent surveys indicate Microsoft Internet Explorer is now the fastest-growing Web browser across the board among corporations, consumers and Web professionals.

A Zona Research study released today reports that use of Microsoft Internet Explorer in corporations has more than tripled to 28% of total use in the past three months.

Meanwhile, a study by Market Decisions reports that overall consumer use has grown over 260% since March 1996.

Finally, TRG, an independent market research firm, shows the percentage of corporate Web sites optimised for Microsoft Internet Explorer rose by 38% over the past three months.

For further details, check: `http://www.microsoft.com`.
Contact: Microsoft, Tel: (0345) 002000.

Surftime Blues

When you're cruising the Internet and picking up URLs of sites you like and want to keep in case you want to visit again, the usual way is to keep Bookmarks (if you use Netscape Navigator) or Favorites (if your Web browser is Microsoft Internet Explorer). That's great for just a handful of URLs, and by using hierarchical folders to categorise your URLs, you can maintain quite a few, fairly effectively. But if your URLs start to take over your life, Navigator's and Internet Explorer's manner of keeping them simultaneously starts to get klunky and not adaptable enough.

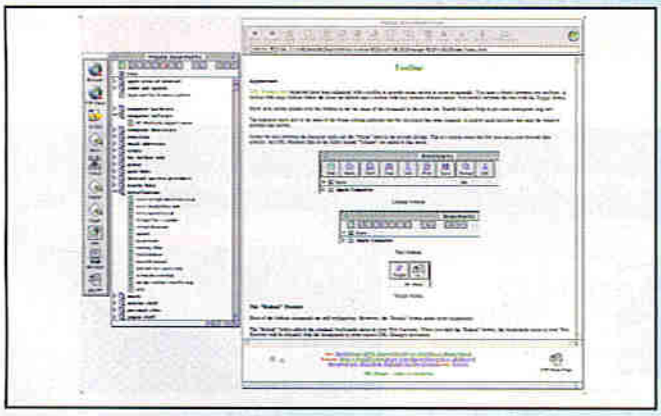
That's when you need a URL management utility to help you do the job independently of whatever Web browsers you choose to use. It's no surprise that as the Internet's most popular computer (it's a fact that you're three times more likely to surf the Internet from a Mac than from any other make of computer), there are some very nice URL utilities out there for the Mac. We looked at one a few months ago (CyberFinder) which does the job neatly and effectively. This month, we take a look at another, URL Manager Pro, which in many respects, is even more powerful. I'd advise PC users not to read this description, as it may do serious damage to your sanity – what URL Manager Pro is capable of is beyond PC terms, believe me.

First, URL Manager Pro allows you to manage bookmarks following the Mac's Finder metaphor. So, you can drag and drop URLs between folders, as well as creating folders and folder hierarchies on the fly as you need. Second, you can drag URLs (individually or as complete browser-maintained bookmarks files) in from and out to the desktop. Third, bookmarks you encounter as hyperlinks in a Web page or e-mail message can be dragged directly or imported en masse from your browser into a URL Manager window. Fourth, in a more conventional way, you can enter a keyboard command to grab the bookmark of whatever URL your browser is currently pointed at.

Now, if all that wasn't enough, URL Manager Pro has some even nicer features. It can be set to auto-launch whenever the browser of you choice is launched (so that it's always there just when you need it). You can double-click a URL Manager Pro bookmark to launch and point your Internet helper to the URL, or simply drag it into your helper window to do the same. When URL Manager Pro is running, it gives an extra menu to your Internet helper with several value-added features. Finally (well, not finally, as it happens – I've just run out of space to list any more of its features), URL Manager Pro links with InternetConfig, to auto-configure itself to the helper applications of your specified system-wide choice.

URL Manager Pro is shareware (costing $25) and a protected trial copy can be downloaded from: **http://www.xs4all.nl/~alco/urlm/.**

Believe me, this utility is well worth the shareware fee.



Netscape and Yahoo Announce Navigation Service

Netscape and Yahoo are unlikely bedfellows, yet the pair have announced an agreement to run a high-profile Internet information navigation service which showcases the best sites on the Web. The service will be called Netscape Guide by Yahoo.

The personalised guide is designed to provide users with a central comprehensive source of sites, news and other valuable services on the Web. Netscape Guide by Yahoo will be accessible through the Netscape Internet site and from the toolbar of Netscape Communicator by clicking on the 'Guide' button. The navigation service will provide users with central access to eight of the most popular information categories on the Web.

The new service is scheduled to launch during the second quarter of 1997. Users with previous versions of Netscape Navigator will be able to access the service by clicking on the Destinations button or from Netscape's home page at **http://home.netscape.com.**

Contact: Netscape, Tel: +33 1 41 97 55 44; or Yahoo, Tel: +1 408 731 3300.

Microsoft Ships Explorer 3.0 for Macintosh

Microsoft Internet Explorer version 3.0 software for the Macintosh is here. This release of Microsoft's acclaimed Web browser offers Macintosh users the fastest access to the widest selection of Internet content while running in as little as 4M-byte of memory.

Heidi Roizen, vice-president of developer relations at Apple Computer, told Electronics and Beyond, "The Macintosh is a great platform for Web clients and servers". "Working closely with Apple, the Microsoft Internet Explorer team has delivered what Macintosh users demand from the best Mac applications – power, ease of use and integrated support for the leading Apple technologies," added Roizen.

Built for Macintosh from the ground up, Microsoft Internet Explorer 3.0 for Macintosh takes advantage of native Macintosh multimedia and networking technologies and offers these key features not found in other browsers for the Macintosh.

For further details, check: **http://www.microsoft.com/ie/mac.**

Contact: Microsoft, Tel: (0345) 002000.

RealMedia Platform Wins Wide Industry Support

More than 60 companies from the broadcast, entertainment and technology industries, such as ABC, Canadian Broadcast, Children's Television Workshop, MCI, Macromedia, News, NYNEX, and Starwave, today announced their support for Progressive Networks' RealMedia platform, an open platform for third-party developers to deliver tools, streaming multimedia applications, and broadcast programming over the Internet.

The RealMedia platform is designed to stream any media type, such as audio, video, animation, MIDI, 3D images, and text. It is an open platform that supports Windows, Unix, and the Power Mac. The RealMedia platform also delivers a 'real' business model that allows developers to build a financial future on developing streaming media applications and tools.

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

Contact: Progressive Networks, Tel: +1 206 674 2700.

SSEYO Brings Electronic Music to the Web

Award-winning music software manufacturer, SSEYO, has launched its Koan 'generative' music software over the Internet on UUNET UK's innovative electronic commerce system. Musicians, Internet users and Web site developers can now buy music software programs directly off the Internet.

Music making has previously been the preserve of those who can read, understand or play music, but with the SSEYO Koan software, there is no need to use notation or own a music keyboard – all the creation is done visually via a traditional computer keyboard.

Low bandwidth Musical Instrument Digital Interface (MIDI)-based KoanMusic can be created easily and effectively for use on the Internet. The files created with the Koan authoring tools are driven by a local Koan Music Engine, be that a Koan plug-in, Koan Player or Koan ActiveX control, interpreting the files into real-time KoanMusic.

KoanMusic, a new genre of music, is created fresh every time it is played – it is never played exactly the same way twice. KoanMusic authoring software enables anyone with a multimedia PC and soundcard to make contemporary music from the desktop, quickly and easily. Prospective users range from musicians creating personal compositions to Web site developers improving an creating sites by adding music.

Koan Pro, SSEYO's flagship products was used by Brian Eno, the celebrated avant garde music producer, to create the twelve pieces of 'Generative Music 1', the KoanMusic title published by SSEYO.

For further details, check: **http://www.sseyo.com** or **http://www.uunet.net.**

Contact: SSEYO, Tel: (01628) 29828; or UUNET, Tel: +1 703 206 5600.

Analyst Report Predicts Uncertain Future for Kids Online Market

The kids market is still struggling to find its footing in the online marketplace, according to a new study from Jupiter Communications' Consumer Content Group.

The prospects for kids-centric revenue generation on the Web for the next two years are limited. This is in equal parts due to the fact that there is a perception of safety within 'sheltered' environments such as AOL's Kid's Only channel, and consumers overall are still not paying for content specifically, but for access, which they get from Internet Service Providers or online services. Sites that make money today from subscriptions or advertising are few and far between.

These and other findings are part of 'The 1997 Online Kids Report', now available from the US Internet analyst, Jupiter Communications.

Liz Randolph, editor of the 'The 1997 Online Kids Report' at Jupiter Communications told Electronics and Beyond, "In the short term, cross-media programming is keeping the vast majority of children's online ventures afloat. Today's kids represent tomorrow's larger, more Internet-savvy audience. Venture capitalists and marketers are still slow to realise the viability of this market, but developers' creative programming and innovative revenue strategies are beginning to lure them."

However, growth in the number of kids accessing online services and the Internet from home continues to grow at a healthy rate. During 1996, in the US, the number of children aged 2 to 17 using online services nearly doubled over 1995 levels to four million. By 2002, Jupiter Communications expects that the number of children going online from home to grow to 20.2 million.

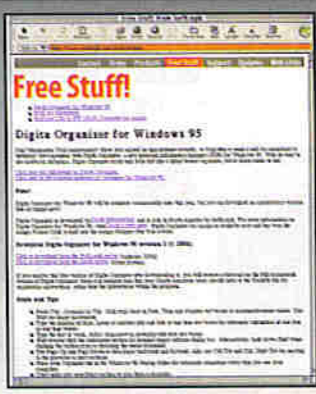
For further details, check: **http://www.jup.com.**

Contact: Jupiter Communications, Tel: +1 800 773 4545.

Site Survey

The month's destinations

Ever on the lookout for freebies, Site Survey this month has located a site for all Internet users, of just about whatever computing persuasion you belong to. SoftLogik has gathered together a few nice utilities at **http://www.softlogik.com/freestuf.html**, which is worth a look and a download. Digita Organiser is a personal information manager (PIM) for Windows 95. The free version on the site is an early release of a commercial product due to be released soon. BME for Macintosh is an image processor with some classy effects. It's not going to take over Photoshop on the Mac's industry lead in the graphics editing field, but it is a nice utility nevertheless. Finally, Convert is a small Amiga utility that can convert Professional Draw Clip files into the more standard IFF format, allowing them to be used in other Amiga programs.

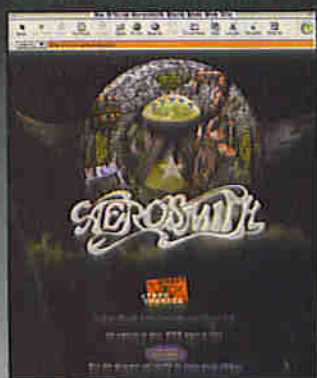


Above: Softlogic site.

If you suffer from (or even think you suffer from) injury due to typing long hours over a hot keyboard, look at the Typing Injury FAQ home page, at: **http://www.cs.princeton.edu/~dwallach/tifaq/.**

Below: Typing Injury FAQ page.

Below: Aerosmith's site.



There are plenty of links and references, which could help you in a quest for a less painful way to work.

Lastly, if your taste in music is as wild as mine, take a few minutes to browse Aerosmith's Web site at: **http://www.aerosmith.com**, where you'll find lots of information about the group, together with links to lyrics, sound clips and tour details. Talking of which, see you at the NEC in May!

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.

PAL Colour Encoder

Manipulate Phase Alternation, Line (PAL) colour TV signals with this useful project.

PLUS Radio Receiver Development History by Ian Poole charters how radios have progressed since the days of coherers and cat's whisker' crystal sets.

SDH & Sonet Interworking by Frank Booty describes transmission standards for high-speed digital telecommunications networks.

Surface Mount Technology Today and Tomorrow from Ian Davidson picks and places present and future developments in component miniaturisation.

Part 5 of What's in a Name? by Greg Grant focuses on the pioneers of transistor devices and their impact on technological advance.

In Lights, Camera, Action!, Alan Simpson pays a visit to the National Museum of Photography, Film and Television in Bradford – the most visited museum outside of London.

Part 2 of Cave Radio continues to burrow deep beneath the surface of subterranean communications systems.

Ray Marston's new series, User's Guide to Special Audio Processing ICs, looks at practical applications for special types of audio processing chips.

Oil Tank Level Controller

Avoid running on empty by using this project to gauge oil levels. Features a PIC microcontroller and an alphanumeric LCD display.

Slow Scan TV Decoder

Part 2 of the simple PIC microcontroller-based interface for reception and decoding of slow scan television signals, for display on a PC monitor.

Issue 115 on sale Friday 6th June

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.

Technical Enquires

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

These days, it is hard to find a personal computer that *doesn't* have a CD-ROM drive. Originally conceived in 1980 by Philips and Sony as a digital successor to the vinyl record, the compact disc has also made a major impact as a read-only storage device that can access up to 650M-bytes of data. Red Book, the initial audio format which included some error checking, was deemed insufficient for computer data. Yellow Book fixed this by adding more advanced error correction; it's used for commercially-available data-only CD-ROMs.

Yellow Book offers two modes. Mode 2 doesn't employ error correction, and allows the full 2,328 bytes of a block to be provided. Mode 1 offers less capacity for data because 280 bytes from every block are used for error correction. This leaves 2,048 (i.e., 2k-) bytes exactly – handy, eh? A subsequent development, Green Book, allows Red Book audio and Yellow Book data to be incorporated on the same disc; it's used for magazine multimedia' cover CDs. Green Book was originally intended for the ill-fated Philips CD-i system. There have been subsequent standards, such as White Book, which caters for the storage of MPEG video.

Orange Book was developed for CD-Recordable (see later) and magneto-optical media. It supports multi-session, which allows users to compile data on the disc in more than one recording session. To see all the files on the disc as a single logical structure, the CD-ROM drive needs to be a multi-session type (most are these days). The cross-platform file format is standardised on ISO9660, although Microsoft invented its own system (Joliet) for supporting its long filenames (the latest ISO revision now handles them, however). A new standard (CD-UDF) is now available, although its benefits are directed at users of CD recorders.

The very latest is a completely new standard, DVD (Digital Versatile Disc) which uses completely different technology (such as lasers that operate at a higher wavelength) to cram as much as 4·7G-byte onto a single disc. The standard will be enhanced before long to increase capacity still further. Both sides of the disc will be used, and different wavelengths will be used to provide two layers of data on each side. Potentially, around 17G-byte is possible. DVD is, however, backwards-compatible with conventional CDs. The industry believes that DVD, using MPEG-2 video and Dolby AC-3 multi-channel sound will be the eventual replacement of rental videotape as a playback medium. The thing is, we've seen that all before with 1982's Philips Laservision, which only lives on as a niche format for well-heeled home cinema addicts.

The difference between 1982 and now is that the hardware companies now pretty much own the software companies (music labels and film studios), a factor that might have some bearing on the matter. Might we see DVD's capacity used to put the entire repertoire of an artist onto a single disc? I doubt it; people think they're getting better value for money when they see six discs instead of one. In any case, the music industry is notoriously slow to adapt to new technology – how many, for example, have harnessed the power of the Internet? It's unlikely that we'll see the extra capacity used to give users an interactive multimedia experience; that's only been tried by a few established musicians with complete artistic control (such as Peter Gabriel and Mike Oldfield), and only then with limited success. At the end of the day, the music companies believe that, with some justification, the majority of customers just want to stick a disc in, hit the play button and chill out – they don't want interactivity to distract them from the listening experience.

My bet is that DVD will live on primarily as a computer data medium, and will replace CD-ROM as we now know it. Even now, an eight-speed DVD-ROM drive with SCSI interface is available from Toshiba. Hopefully, the extra capacity won't encourage 'shovelling' or sloppy programming as we have seen with some software houses – notably, the very big ones. More positively, it could, for example, encourage the development of information-rich multimedia encyclopedias, and games of stunning visual appearance. Other developments in data CD include ever-faster drives – the latest 12-speed models give a theoretical transfer rate of 1·8M-byte/sec, which is faster than some hard disks of not so long ago. It will equate to less finger-tapping when files are loading (the next level of a game, or a high-resolution Photo-CD image, for example).

In recent months, the price of CD-Recordable drives has fallen dramatically. Only two years ago, they sold for around £3,000. You can now pick them up for a tenth of that. The 650M-byte discs sell for around a fiver. CD-Recordable is a WORM (Write Once, Read Many times) medium, but that doesn't make it any less attractive as a backup or archiving medium. I have been using CD-R to store a wide range of research material gathered from a variety of sources, and in doing so, have managed to unclutter my hard drive without recourse to floppies or expensive removable media, such as Jaz or Syquest.

Preparing a CD-R is much quicker than archiving to a tape streamer – 600M-byte takes around half an hour to write – and the discs can be read in any machine with a CD-ROM drive. The only caveat is ensuring that there's a steady stream of data between PC and writer, otherwise you may get a 'buffer under-run' error and render £5's worth of disc useless. You can also produce your own Red Book-compliant audio compilation CDs; mastering software, such as Adaptec's Easy-CD Pro (PC) or Astarte's Toast (Mac), supports this. Switched-on musicians can send in demo CDs, rather than audio cassettes, to record companies. Using MPEG audio, you can cram around 11 hours of music on a single disc – great for parties and background music, although it means you need an MPEG-compatible player. What's more, your mastering software needs White Book support. There are rumours that some CD-R discs won't read properly on the new DVD players.

Two major developments are waiting in the wings. Philips' CD-Rewritable system – the first hardware for which, in the form of the CDD3600, will be available imminently – gives you most of CD-R's benefits plus the ability to erase or change the contents of the disc. Unfortunately, I say 'most' because the CD-RW discs won't read in the vast majority of CD players or CD-ROM drives; Philips reckon that the latest CD playback hardware will handle them. Fortunately, though, the CD-RW drive also allows users to write CD-R discs. It is also a 6-speed CD-ROM and audio CD player.

Unfortunately, Philips have made a bit of a cock-up in so far as the machine employs the IDE interface, which is inferior to SCSI. In doing so, they have alienated the world of Mac users – who, with their typical multimedia and design backgrounds, would have been ideal customers for the system. Expected prices are £600 for the drive, and £10 for the discs. The second announcement – leaked out – concerns Pioneer's DVD-Recordable drive. This – the world's first device of its type – will apparently be available in September. No further details were available, although the prospect of archiving at least 4·7G-byte at a time is undoubtedly an attractive one. Seeing that Pioneer's existing CD-R model sells for over £2,000 (i.e., somewhat overpriced), expect to pay through the roof for its DVD-R, which is likely to be in a class of its own for some time to come.

Martin Pipe welcomes comments and ideas. E-mail him at whatnet@cix.compulink.co.uk.

ELECTRONICS and Beyond

SUBSCRIBER'S SPECIAL OFFERS

SUBSCRIBE TODAY AND QUALIFY FOR THESE AMAZING SAVINGS!

HURRY! OFFERS END 30TH MAY 1997

Code 52000

SCREWDRIVER/ SOCKET SET

CATALOGUE PRICE £7.64

SUBSCRIBERS' PRICE £4.99

SAVE £2.65

POWER BREAKER

CATALOGUE PRICE £17.99

SUBSCRIBERS' PRICE £14.99

SAVE £3

Code 51997

TOOLBOX

CATALOGUE PRICE £21.92

SUBSCRIBERS' PRICE £14.99

SAVE £6.93

Code 51999

SUBSCRIBE TODAY

see page 5

15M MAINS CABLE REEL

CATALOGUE PRICE £16.99

SUBSCRIBERS' PRICE £12.99

SAVE £4

Code 51998

CONTINUITY TESTER

CATALOGUE PRICE £7.13

SUBSCRIBERS' PRICE £5.99

SAVE £1.14

Code 52001

As a fully paid-up subscriber you can use the special Subscriber-only order codes and save up to 40%

When ordering any of these special offers which apply only for Subscribers and new Subscribers of *Electronics and Beyond*, please quote your Subscribers' Membership number (telephone Customer Services on 01702 554002 if not sure) and the special order code number. All items are subject to availablility. Prices include VAT. Catalogue prices refer to the 1997 Maplin MPS Catalogue. Overseas subscribers telephone +44 1702 554000 Ext. 326 for carriage charges. A £2.95 Carriage Charge will apply to all UK orders under £30.00 (MPS Account Holding Customers exempt).