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ELECTRONICS

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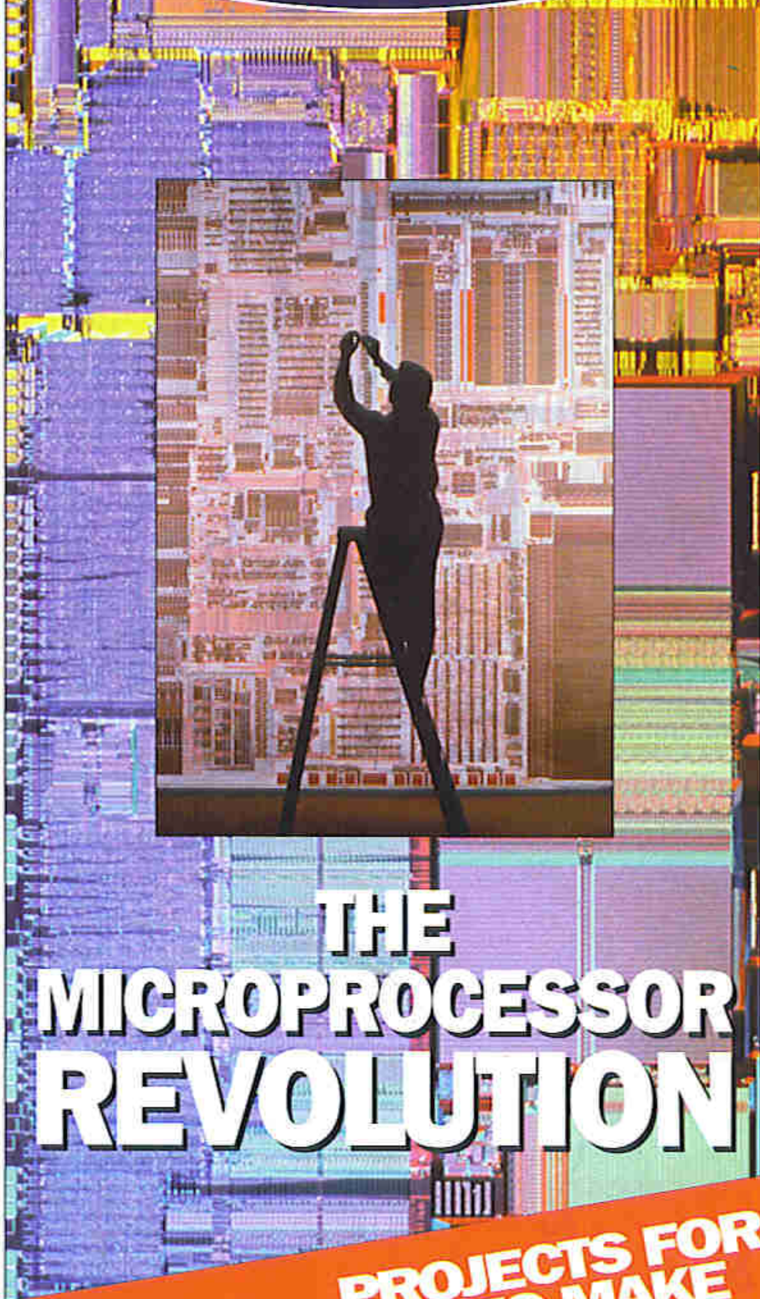

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A review

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May 1997

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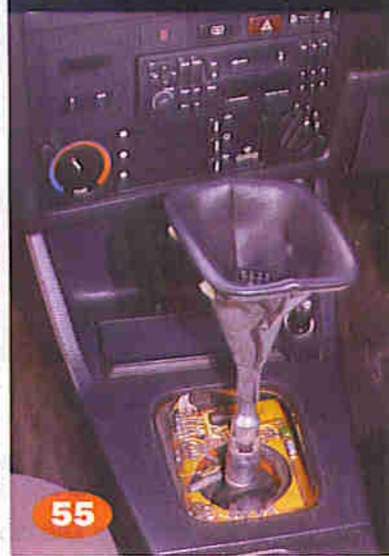

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ELECTRONICS and Beyond

PICs – We've heard and seen a lot about them in recent years. The appeal and versatility of these devices never ceases to amaze me. It is clear from your letters, particularly as a result of the series of articles on PICs from Stephen Waddington, that the reasons for using them are very varied. As a result, we will be featuring your practical applications in the coming months ahead. The first PIC application featured this month lies within the Rugby Clock.

However, their popularity puts these projects into another league where fewer constructors in this area can design and implement the software. The 'catch-all' PIC chip should not leave other younger constructors 'out in the cold' as very often the chips are available ready pre-programmed for a specific application.

More in Colour

From now on Electronics and Beyond will feature colour pages throughout and of course, being the lowest priced magazine in its field, it represents the best value for money ever.

Competition

Finally, our congratulations go out to the following for winning our Sailing the Internet competition that appeared in issue 111. The winner is Mark Townsend of Nottingham. The five runners up are: L Green of Pwllheli, Gwynedd, E Cassidy of Gt Chesterfield, Essex, S Walton of Selby, North Yorks, G Foster of Benfleet, Essex, and finally A Stone of Morcambe, Lancs.

Paul Freeman-Sear, Publishing Manager

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

Wideband Transistors Optimise Performance at Low Power

Philips Semiconductors has introduced a range of high performance low-voltage silicon bipolar RF transistors for use in the latest 1GHz cordless and cellular telephones. Fabricated using a recently developed double-poly buried-layer process, the range currently includes small and medium power types with collector current ratings suitable for use in all stages of a mobile phone's RF transciever.

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

3Com Expands in Europe

3Com has announced 200 new jobs in a £15 million project to expand its Hemel Hempstead facility. The announcement was made by Eric Benhamou, 3Com's CEO earlier last month as he opened the first building on the Hemel Hempstead site.

For further details, check: http://www.3com.com.
Contact: (01628) 856000.

VLSI GhostRider Sets New Standards for PC Data Encryption

VLSI Technology intends to make PCI-based computers, modems, web browsers and set-top-boxes safer for intellectual property distribution and electronic commerce through the hardware implementation of its new VMS230 GhostRide PCI bus-compatible real-time data encryption/decryption chip solution.

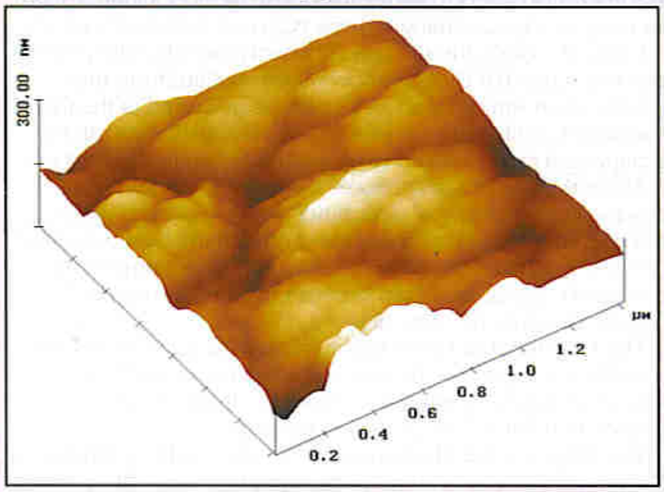
Already identified as a key element of Microsoft's interactive PC/TV Platform, the GhostRider security processor enables a full slate of functions, including file encryption, secure communications, safe distribution of high-value intellectual property, secure electronic commerce, private e-mail and user authentication with minimal impact on system speed or data throughput.

VLSI's security IC architecture vastly strengthens data security and privacy by performing all security encryption/decryption within a dedicated chip, closed to outside attack. In addition, VLSI security ICs integrate an on-chip RISC processor with encryption/decryption engine functional system blocks (FSB) that accelerate cryptography processing and relieve main CPUs of data security processing overhead.

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

Contact: VLSI, Tel: (01908) 667595.

Xyratex Investigate Life on Mars



Xyratex Engineering Laboratories, in conjunction with the University of Portsmouth and British Nuclear Fuel Laboratories, are using their extensive analytical facilities to investigate various aspects of the question, was there life on Mars?

Since Dr McKay at NASA made the announcement of life last summer, the scientific community has been somewhat split as to whether the rod-like structures NASA discovered are 'life' or, in fact, artefacts created by some of the processes used to examine the meteorite under powerful SEM (Scanning Electron Microscopy) microscopes.

The University of Portsmouth has obtained samples of ALH84001, a known Mars meteorite, from Dr McKay and has involved David Stapleton, Surface Science Specialist at Xyratex, in testing for sputtering. Sputtering is a coating technique which enables the detailed examination of samples at high resolution.

Stapleton's work is concentrating on evaluating the topographical detail created by different sputter coatings to assess whether artefacts can be deposited which would lead to spurious data during the examination of ALH84001 for the presence of fossilised life.

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

Contact: Xyratex, Tel: (0800) 614907.

Fujifilm Undercuts PC Colour Printing

Fujifilm has introduced a photo quality Thermo Autochrome printer for printing digital files from home PCs. At £399.99, the NC-3D costs less than any dye-sublimation printer currently on the market. The NC-3D requires no ribbons, just TA paper, to make colourful, sharp images on A6 paper at a cost of approximately 40 pence each.

For further details, check: **http://www.fujifilm.co.jp**.

Contact: Fujifilm

Tel: (0171) 586 5900.

Hitachi, Mitsubishi and TI join in Development of Gigabit DRAMs

Hitachi, Mitsubishi and Texas Instruments (TI) are jointly developing gigabit dynamic random-access memory (DRAM) chips. Joint activities include technology sharing, research and development of process and design capabilities continuing with prototyping gigabit DRAM chips.

Since 1988, Hitachi and TI have been cooperating on the research and development of 16-, 64- and 256-megabit DRAM chips, while Hitachi and Mitsubishi have jointly developed 8-, 16- and 64-megabit flash memory chips.

In 1995, TI and Hitachi also formed a joint venture, TwinStar Semiconductor Incorporated, a half-billion-dollar wafer fabrication facility located in Richardson, Texas.

For further details, check: **http://www.hitachi.com**, **http://www.mitsubishi.com** or **http://www.ti.com**.

Contact: Hitachi,

Tel: (01628) 585000.

NEWS BYTES

PictureTel and Microsoft Propose Internet Telephony Standard

PictureTel has joined Microsoft and other industry leaders to propose G.723.1 as the audio codec standard for Internet telephony to the Voice Over IP Activity Group of the International Multimedia Teleconferencing Consortium, an industry group overseeing multimedia communications standards.

David Andonian, vice president of PictureTel's Personal Systems Division told *Electronics and Beyond*, "By supporting G.723.1, the narrow-band audio codec recommended by the ITU, application developers will be able to guarantee interoperability among Internet telephony applications".

Other companies that have co-sponsored the proposal to support the G.723.1 standard include DataBeam, Intel, RADVision and VideoServer. A decision regarding the proposal is scheduled for the next meeting of Voice Over IP Activity Group in March.

For further details, check: http://www.picturetel.com **or** http://www.microsoft.com.

Contact: PictureTel, Tel: (01753) 673000.

St Paul's Rings Changes with BT

An ISDN solution from BT and third party supplier, Echo Communications, is ringing the changes at one of London's most popular and historic tourist attractions. The project to install 30 ISDN lines and a new telephone system at St Paul's Cathedral replaces an analogue telephone switching service which was unable to cope with the high volume of traffic.

For further details, check: **http://www.bt.co.uk**.

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

Apple Announces Cuts Across its Max Range

Apple has announced price reductions of up to 27% across its popular high-performance, multimedia Macintosh Performa range. Recent benchmarking tests found the PowerPC 603e – used in the Macintosh Performa – outperformed Intel's MMX processor by up to 300% and also ran over 50% faster than a Pentium Pro processor when running C code at the same clock frequency in a common multimedia task.

For further details, check: http://www.euro.apple.com/uk.

Contact: Apple, Tel: (0181) 569 1199.

NEWS BYTES

Dataquest Claims Mixed Memory Technology is Future

Recent new product and technology announcements herald the first tentative steps toward the integration of different types of memory on a single piece of silicon, according to Dataquest.

Richard Gordon, industry analyst for Dataquest's Memories program, told *Electronics and Beyond*, "Many of the most important semiconductor applications currently consume more than one type of non-volatile memory in addition to SRAM and DRAM".

"In response to end-user demand for an integration of memory devices to reduce chip count, semiconductor vendors have attempted to satisfy the need by offering devices that behave as if they contain both traditional EEPROM and flash arrays", added Gordon.

Whether the flash and EEPROM combination device is a success or a failure, however, depends on a number of factors, according to Dataquest.

To be of interest to the volume handset manufacturers, for example, the EEPROM/flash combination chip would have to be as cheap as the individual EEPROM and flash components, claims Dataquest.

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

Contact: Dataquest, Tel: (01752) 814600.

New TI Chip Clocks in at 1·6 Billion Instructions per Second

A new digital signal processor chip introduced by Texas Instruments may provide a long-awaited solution to the Internet bottleneck. The chip, which operates at the ultra-fast speed of 1·6 billion instructions per second, can power a rapidly emerging high-speed method to connect to the Internet. For example, a file that currently takes 10 minutes to download will take less than five seconds.

Digital signal processors, called DSPs, are powerful, specialised semiconductors that are ideal for very fast, maths-intensive computing. They are used in a variety of consumer electronics such as cellular phones, pagers, hard disk drives, modems, digital satellite systems and audio/video equipment.

The new TI chip, the TMS320C6201, has the speed and power to support the explosive growth of data communications, especially the use of the Internet. Estimates are that the number of Internet users is nearly doubling annually; it will grow from about 35 million worldwide today to 160 million in 2000. There is a critical need for technology to handle this glut of new on-line users and TI's DSP will be the platform for that new technology.

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

Contact: Texas Instruments, Tel: (01604) 633147.

Konica Launch Miniature Card-Based Digital Camera

The first digital camera to feature Intel's flash memory Miniature Card for image storage and transfer to the PC is now available by Konica.

Called the Q-EZ, the still digital camera comes bundled with a 2M-byte Series 100 Flash Memory Miniature Card from Intel. Images taken with Konica's Q-EZ camera are stored in the flash Miniature Card for easy transfer to a PC, where photos can be manipulated and enhanced using off-the-shelf software programs.

About the size of a matchbook, Miniature Cards are being designed into a variety of electronics products such as audio recorders, hand-held computers and other hand-held consumer devices, in addition to digital cameras. Miniature Cards enable compatible exchange of data between hand-held consumer devices and personal computers.

The Miniature Card form factor is based on an industry-wide specification supported by over 40 companies in the PC and consumer electronic market segments, including Konica Corporation, Intel, Microsoft and Compaq.

The Miniature Card Implementers Forum (MCIF) promotes Miniature Card specification technology and its benefits of lower system costs, improved interoperability and greater capabilities to the users of electronic devices. In addition to Konica, camera suppliers Eastman Kodak, Nikon and Olympus Optical are MCIF members.

For further details, check: **`http://www.konica.com`** or **`http://www.mcif.org`**.

Contact: Konica, Tel: +1 201 568 3100.

Clear Desktop Clutter with Sticky Notes

Scraps of paper and sticky-notes that clutter desktops and computers are now a thing of the past with the introduction of JOT-IT! from the leading European software republisher, Cross Atlantic Software.

The JOT-IT! software note replicates all the productivity, communication and ease-of-use advantages of the paper Post-it Notes, electronically, on the PC.

The recommended retail price for JOT-IT! is £24.99 inc VAT. The product is available from Cross Atlantic Software's UK distribution partners Gem and Ingram Micro.

Contact: Cross Atlantic Software, Tel: (0171) 228 6992.

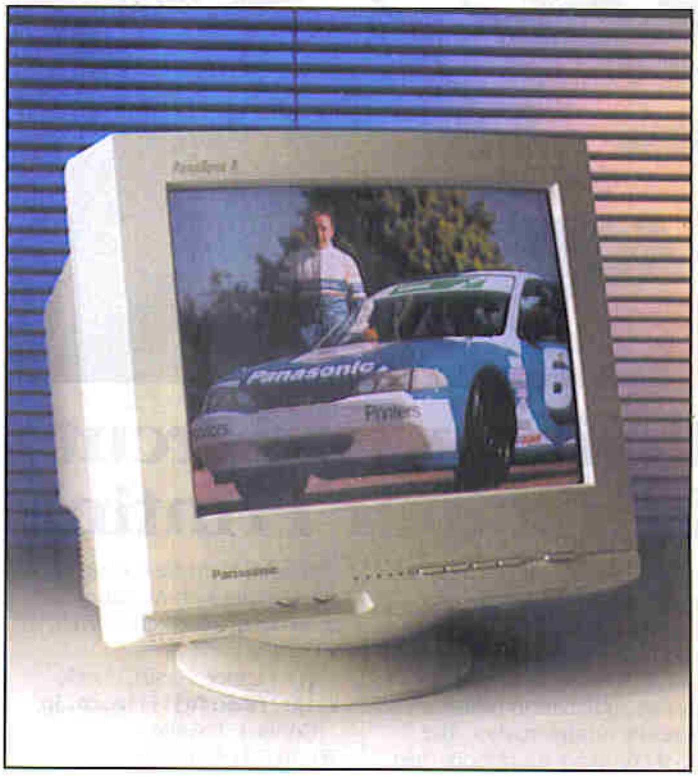
Low Cost Entry Level Monitor

Aimed at anyone who wants the best possible value, the PanaSync 4 TX-T1565 is a 15in. digital monitor which provides the two most essential requirements from an entry level machine – high quality and low cost. Based around a full digital chassis, the PanaSync 4's flat screen tube is cable of delivering a maximum resolution of 1,280×1,024.

The recommended retail value for the PanaSync 4 TX-T1565 is £249, which includes a two year on-site exchange warranty.

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

Contact: Panasonic, Tel: (0500) 404041.



The Ear AND HEARING

by Douglas Clarkson

The development of modern electronics has provided increasingly sophisticated means of recording, reproducing and transmitting audio signals. At a social level, the importance to many groups of people of listening to music of many shapes and forms cannot be over emphasised. In many respects, the development of technology is taking place within the framework of capabilities of both acoustics and the faculty of hearing.

Certainly, the practice of selling current models of sound systems in high street shops does not involve asking any questions about the acoustic environment where such units will be used. Also, the capabilities and limitations of the human hearing system is seldom ranked as a factor when choosing an audio system.

Also, manufacturers and large distribution chains provide no technical input that could, for example, explain the performance of their system in the light of fundamentals of acoustics and hearing. In the attempt to provide ever-increasing added value to consumer products, the process of questioning the relevance of such developments within the linked fields of acoustics and hearing is certainly relevant. It is the process of hearing which is certainly more complex and even mysterious.

The process of unravelling the mechanisms of hearing is certainly something of a revelation, especially where Scanning Electron Microscope (SEM) images of the cochlea are inspected. Also, the examination of current western system of music based on twelve geometrical semi-tones per octave begins to make sense when the working of the cochlea are considered. A fundamental study of hearing could also prove of benefit to budding music composers.

The Human Ear: General Structure

The human ear represents a highly developed item of sensory perception – the standard structure of which is shown in Figure 1. The ear canal acts to confirm a resonance broadly centred at 3,800Hz, while part of the outer ear – the concha – the depression surrounding the ear canal, serves as a funnel for directing frequencies above 3,000Hz into the ear canal. Ear wax is primarily designed to discourage insects from wandering into the ear.

The set of ossicles – the hammer (malleus), anvil (incus) and stirrup (stapes) – act to amplify the mechanical force oscillations of the ear drum surface by a factor of around ten. At 3,000Hz, the amplitude at the basilar membrane of the cochlea is of the order of a nanometre. It has been estimated that if the most sensitive human ear was some 5dB more sensitive, then the thermal agitation of air molecules would be heard as noise.

For some obscure reason, the bones of the ear canal had a strong religious significance for the neolithic peoples of Britain – with such items left as a key offering/exhibit in tomb contents.

The eustachian tube connects the tympanic cavity to the pharynx and has the primary role of emptying mucous secretions from the middle ear which is undertaken by cilia similar to those that remove mucus secretions from the lungs. In addition, the tube provides a means of equalising the pressure on both sides of the tympanic membrane. Any differential pressure will tend to make the ear drum more rigid with an associated loss of hearing sensitivity. Normal swallowing or yawning will tend to open the canal momentarily and thus achieve pressure equalisation.

Problems with middle ear infections in infants tend to occur because the ear canal is short and near-horizontal. Infections tend to spread from sinuses and throat to the middle ear. In adults, there is a more pronounced downwards sweep to aid drainage.

While the action of the outer/middle ear structures is generally well understood as an impedance matching device, the generation of nerve impulses within the cochlear is a much more complex problem. As the vibrational energy enters the cochlea through the oval window, a series of so-called hair cells along the organ of Corti within the cochlea are stimulated.
In general, the frequency of dominant resonance response decreases as a function of distance from the oval window, so that the perception of pitch is given by the selective excitation of hair cells along the Organ of Corti. A more detailed description of this process is given later.

Significant work was undertaken on the function of the cochlea by Georg von Bekesy, wherein it was demonstrated that in a similar resonating structure of the basilar membrane within the cochlea, regions of maximum resonant vibration could be seen to change pattern as the input frequency was altered. Thus, a field of complex noise will, at any one time, establish a pattern of resonance essentially determined by the

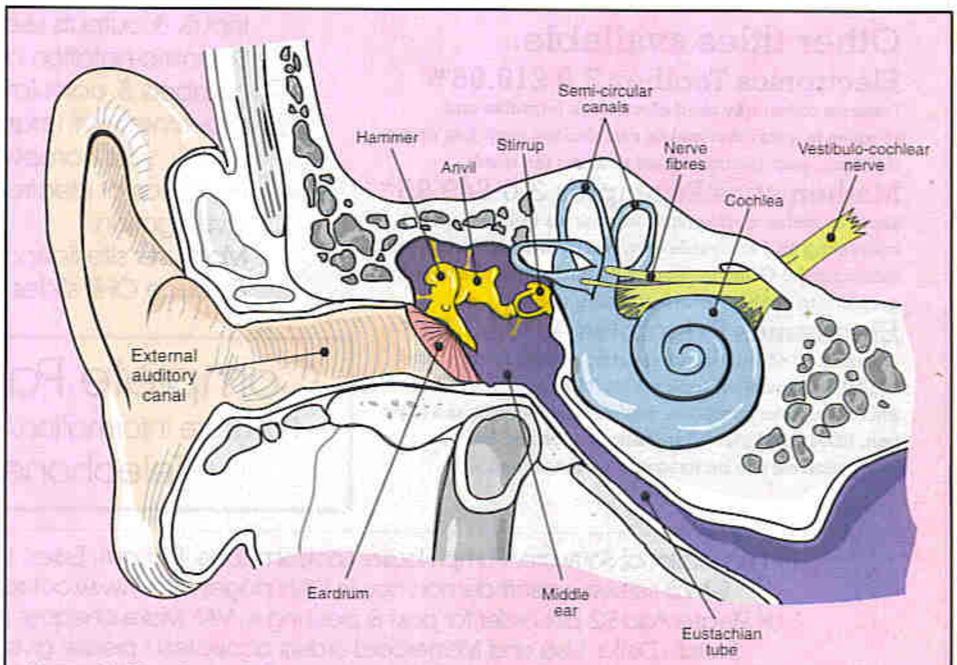


Figure 1. Structure of the human ear. (Courtesy Widak).

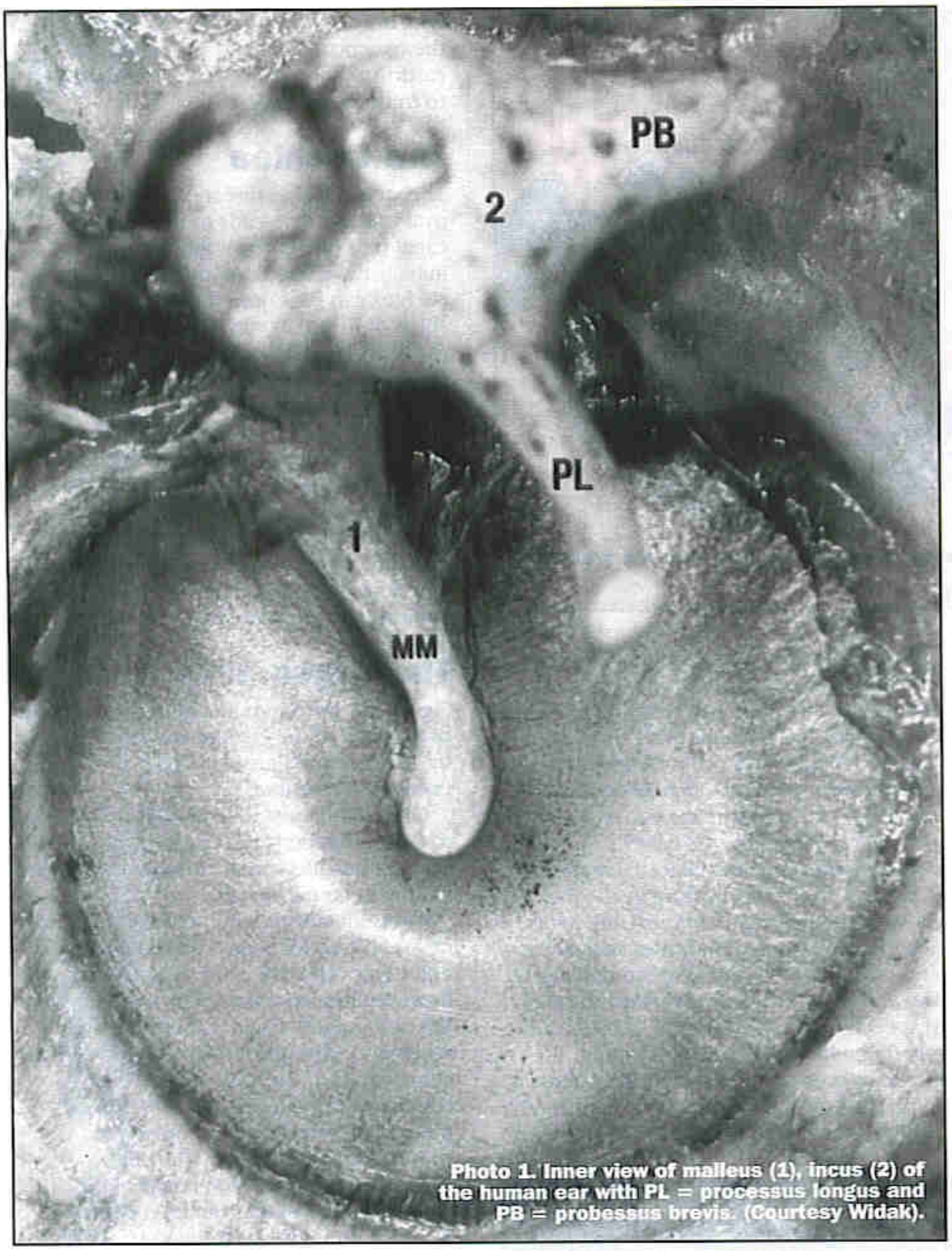


Photo 1. Inner view of malleus (1), incus (2) of the human ear with PL = processus longus and PB = probessus brevis. (Courtesy Widak).

individual components of the sound.

In Bekesy's pioneering work, a model of the cochlea was constructed using a plastic diaphragm whose stiffness varied with length. This was driven by a special electrical vibrator and the diaphragm placed on the exposed forearm of a human subject. In addition, the surface of the diaphragm could be inspected visibly using a stroboscope. It was seen that with the presentation of tones to the diaphragm, the region of maximum vibration could be seen to move as the frequency was changed. Also, the human subject could detect notes only a few cycles apart and the presentation of only a few cycles of a specific tone could be detected.

Hearing Processes

In general terms, the sensory processes of the brain is now more successfully modelled on concepts of neural networks. The key process of hearing, however, is a parallel operation. To listen to music is to be able to distinguish individual types of instruments from a 100-piece orchestra. The ability of the ear to discern music is not the end point of auditory perception of homo sapiens. Rather, it was the ability to hear a twig snap in a forest full of intrusive confusing sounds. Hearing, in evolutionary terms, has been about survival.

While the range of human hearing is described as 15 to 20,000Hz, neurophysiological studies indicate that auditory nerve signals above 20kHz can be detected and appear in the cochlear microphonic. The brain apparently does not choose to pay attention to these 'ultrasounds'. Could there be some foundation of sound purists, who consider that the upper frequency of recording is artificially cut off at too low a value with digital encoding systems such as Compact Disc? After all, perhaps the highest frequencies that we cannot actually hear are doing something useful within our sphere of awareness.There are, in fact, sound therapists that replay classical music (typically, Mozart) with all sounds shifted towards higher frequencies as some sort of wake up call to the brain to activate (safely) many of its dormant features. At the other end of the spectrum, as it were, the rave with flashing lights, loud music and what else, is using music as a tool to energise the brain in a slightly less dignified way. Clearly, our understanding of the 'greater picture' of hearing and cerebral activity is still in its infancy. Somewhere in all of this, there is probably a firm foundation of music as a holistic therapy for the individual.

Marvellous as our hearing is, nature has equipped other species such as the bat, whale and dolphin with much more highly advanced auditory systems. Yet, the entire human auditory system is surprisingly compact. The ear canal is typically only 24mm long and 9mm in diameter. The human cochlea is itself also remarkably small – cone-shaped with a base of 9mm diameter and 5mm in height, with a twisting length some 30mm long, tapering from a 2mm wide canal to a blind spot at the apex.

Operation of the Ossicles

In its response to air pressure oscillations, the eardrum tends to vibrate as a whole at low frequencies, while at higher frequencies, different areas respond selectively to resonance. The impedance change role of the middle ear is essentially increasing the force per unit area from the tympanic membrane to the oval window of the cochlea.

The malleus (hammer) is directly driven by its contact with the eardrum. This contact extends to the centre of the ear drum so that maximum amplitude is transferred. The incus (anvil) is attached to

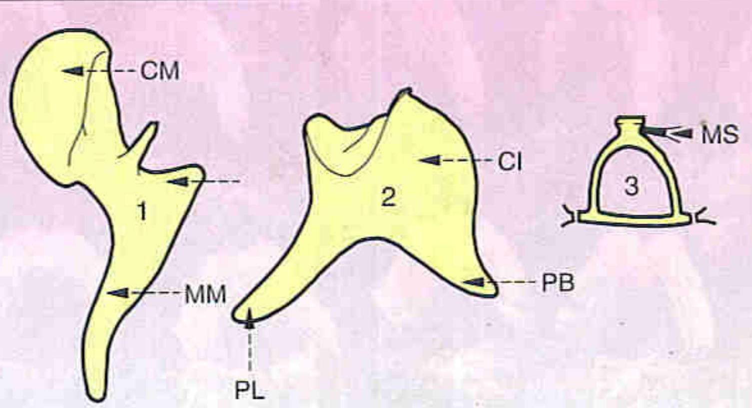


Figure 2. Schematic specific key sites of ossicles and associated features; malleus (1), incus (2) and stapes (3). MS is the tendon of the stapedius muscle, CM is the head of malleus, and CI is the corpus incudis. (Courtesy Widak).

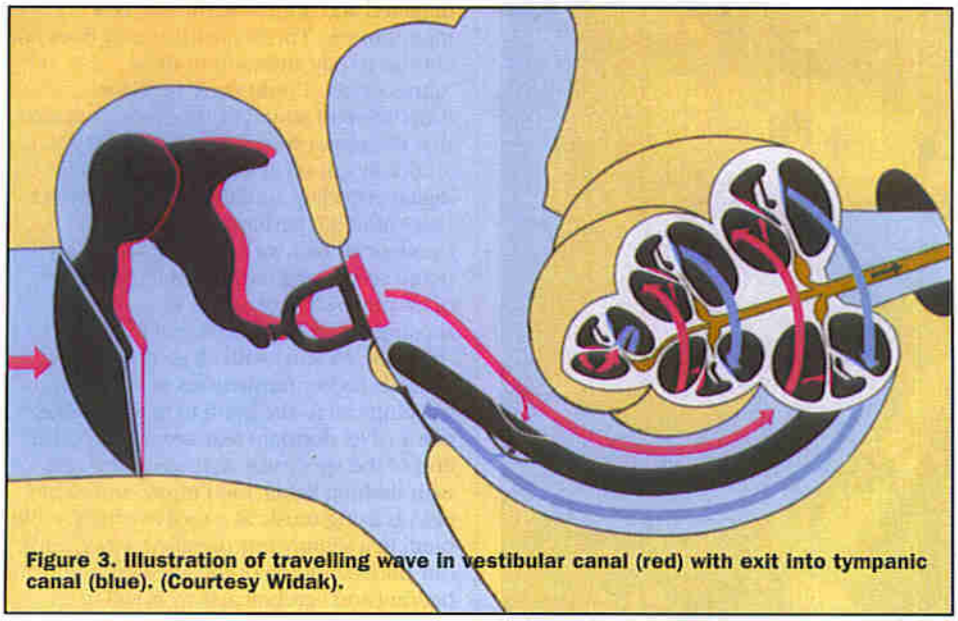


Figure 3. Illustration of travelling wave in vestibular canal (red) with exit into tympanic canal (blue). (Courtesy Widak).

the malleus, with these two structures oscillating about a fulcrum point. The incus transfers this oscillating motion to the stapes. Some descriptions of the function of the ear describe an amplification effect of the relative leverage of the malleus and the incus, while others describe a reduction in vibrational amplitude but an increase in force amplitude at the stapes interface. The ossicles are suspended by ligaments which act to damp the oscillations after stimulus has ceased. Without this feature, the sounds we hear would cease to be sharp and short-lived, and the process of hearing would be more confusing as sounds would merge together generally.

The impedance of the ear is influenced by the tensor membrane and the stapedius muscle. There can be activated by loud noises, especially of the stapedius muscle which pulls the stepes footplate outward and reduces the intensity of sound reaching the cochlea. It is thought that this muscle reflex is linked to a process of selection of high frequency sounds such as rustle of leaves or snap of a twig. Do you experience a change in hearing levels when encountering some element of danger?

Photo 1 shows a view from inside the ear, showing the malleus (hammer) and incus (anvil), while Figure 2 indicates specific key sites of the ossicles and associated features. The ear canal selectively amplifies the area of speech between 2,500 and 4,000Hz and together with the force amplification, increases pressure by a factor of around 14, so that the overall force amplification can be as high as around 60, or 30dB. The tensor tympani acts to pull on the opposite ends of the ossicular chain and so stiffens the eardrum. This reduces the responsiveness to frequencies under 1,000Hz.

The Cochlea

The stepes makes direct contact with the oval window that leads to the vestibular canal (red of Figure 3). Pressure waves initially travelling along this section of the cochlea can pass onto the tympanic canal (blue of Figure 3) which is terminated by the round window (end of blue arrow, Figure 3). This ensures that pressure waves are conducted along the vestibular canal and excite on their way the highly sensitive structure of the basilar membrane which lies between these two structures. The so-called organ of Corti, mounted along the basilar membrane, converts mechanical pressure waves into electrical impulses which are in turn communicated via the auditory nerve to the brain.

The Organ of Corti

Significant work in understanding the mode of function of the cochlea was undertaken by Georg von Bekesy, for which the Nobel Prize was presented.

One of the most difficult parts of the ear to conceptualise is the Organ of Corti – the actual 'transducer' that converts mechanical energy to neural signals.

It was initially thought that the majority of nerve fibre activity came from the lines of outer hair cells. The work of Spoendlin, however, has led researchers to re-consider this assumption. There is now growing acceptance that around 90% of nerve fibre connections in the acoustic nerve have contact with the inner hair cells, though there may be increased weighting to connections of the outer hair cells.

Photo 2 shows an SEM image of the outer hair cells of the human cochlea. Typically, there will be three rows of cells, though in some sections, four or five rows will be present.

The organ of Corti has in the region of 12,000 outer hair cells and some 3,500 inner hair cells – the latter being closer to the central axis of the cochlea where the auditory nerve collects nerve fibre inputs. There would appear to be a considerable degree of overlap between cells, since there are around 30,000 nerve fibres in the cochlear nerve. Thus, a single nerve fibre has connection on average to at least two hair cells.

The inner hair cell will typically have between 30 to 60 cilia and each outer hair cell between 75 to 100. The hair cell is highly sensitive and will emit a nerve impulse when a cilia moves as little as a trillionth of a metre. The high sensitivity of the basilar membrane is largely to do with the shearing action of the tectorial membrane to move the cilia and hence stimulate the outer hair cells with the inner hair cells responding to the relative velocity of the basilar membrane.

The width of the fibres of the basilar membrane have a total variation in length of around 12:1, and this defines essentially the frequency response of the auditory system. In its design, the basilar membrane is tuned to higher frequencies at the site near the

Photo 2. SEM image of outer hair cells of the human cochlea. (Courtesy Widak).

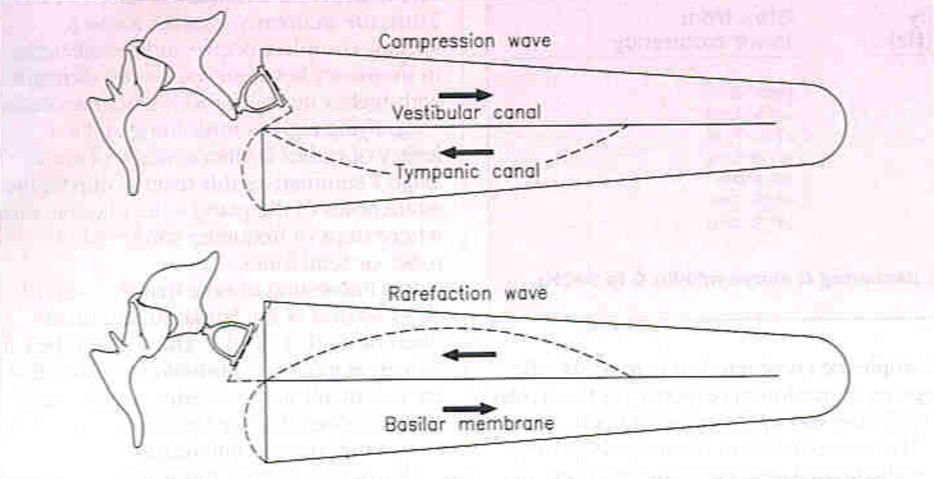


Figure 4. Method of excitation of the cochlea at low frequencies, where the basilar membrane is deformed due to incident pressure wave.

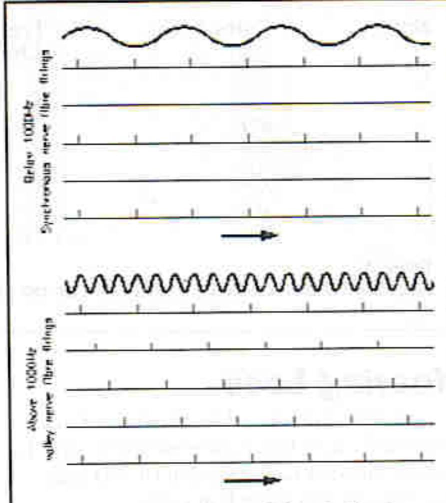


Figure 6. Illustration of the 'volley' theory of nerve cell response in the organ of Corti. At frequencies below around 1,000Hz hair cells can fire with every cycle of sound wave, though at higher frequencies, groups of hair cells will fire on, e.g., every other cycle, or every third or fourth and so on, depending on the stimulus frequency and cell characteristics.

oval window and to progressively lower frequencies towards the wider apex.

Cochlear Microphonic

If an electrical signal is taken from the round window – by way of picking up the signal sent to the auditory nerve and then electronically amplified, then the signal is largely found to correspond to the input sound signal. The auditory nerve serves essentially as a carrier of sensory information to the brain – the so-called efferent or ascending pathway. The brain, however, does also send information in the reverse direction – the descending or efferent pathway with around 2% of the nerve fibres controlling muscles of the middle ear and also influencing the firing of hair cells which is primarily to inhibit sounds considered unimportant. This is something like a microphone with a dynamic self-regulating frequency response.

Frequency Discrimination and Encoding

The response of the basilar membrane to excitation by the stapes at the oval window can be considered as a function of frequency. At low frequencies up to 100Hz, the whole of the basilar membrane can be considered to follow the in-out motion of the stapes. This is illustrated diagrammatically in Figure 4. Below around 25Hz, the rate of compression of the fluid is so slow that the fluid in the canal is simply moved around to the round window without excitation of the hair cells. This is one of the main factors that determines the limit of low frequency response of the ear.

At higher frequencies, the motion of the basilar membrane can be considered to be a travelling wave with the wave tending to build to a peak and then decay rapidly. Higher frequency sounds activate portions of the basilar membrane closer to the entrance point at the oval window.

The basilar membrane responds in an additive way to an input spectrum of sound. At progressively higher frequencies, the perilymph fluid offers increasing mechanical resistance and the amplitude of the travelling wave diminishes.

The discrimination of frequency is largely spatially organised – and termed 'tonotopic' organisation. There is a form of enhancement of this effect, however, by inhibition of cells surrounding the area where the travelling wave crests. The generalised frequency response of the organ of Corti is indicated in Figure 5.

While the encoding of frequency is strongly coded by location of maximum cochlear stimulation, there is also the data on frequency carried by the rate of firing of nerve cells. At frequencies below 1,000Hz, individual cells can fire as independent units when activated at the frequency of the stimulus. At higher frequencies, individual cells cannot fire as rapidly and instead, cells are thought to work together in groups where specific cells will fire on, e.g., every other cycle, or every third or fourth and so on, depending on the stimulus frequency and the recovery time of each cell.

This theory is the so-called 'volley' theory of nerve cell auditory activity, as indicated in Figure 6. In general, from a range of effects, the cochlear microphonic grows in direct proportion to signal intensity. This theory of hair cell excitation could explain why the ear finds harmonics more pleasing than sounds which have no harmonic relationship.

Oto-Acoustic Emission

One of the surprises in hearing research is that not only is the ear a device which detects sound, it can also generate sound through so called oto-acoustic emission. This process is thought to be the result of efferent nerve stimulation from the brain along auditory nerve pathways to the organ of Corti which sets up cyclical contraction of hair cells, resulting in the generation of sound waves. While this phenomenon has been investigated as a means of determining hearing function, it remains essentially a research-based technique.

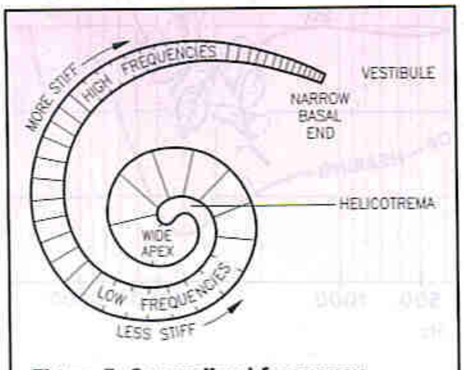
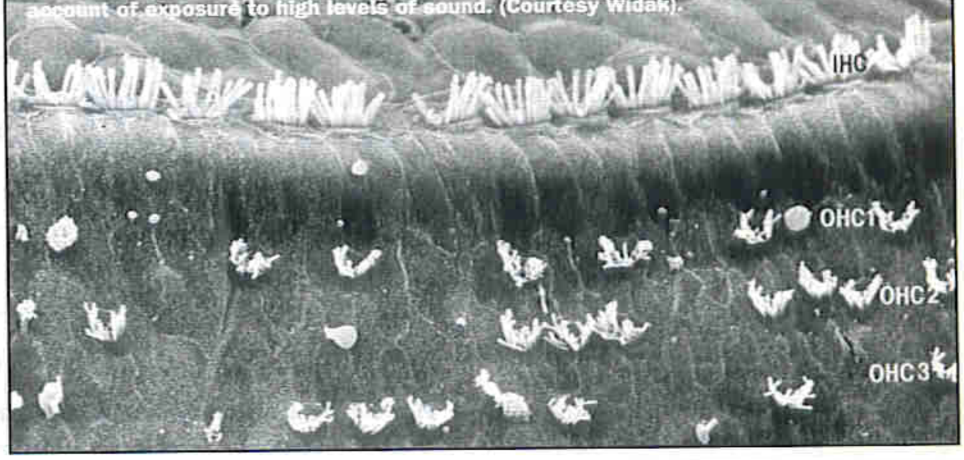


Figure 5. Generalised frequency response of the Organ of Corti.

Photo 3. Image of cochlea which has suffered significant damage to the hair cells on account of exposure to high levels of sound. (Courtesy Widak).



Note	Frequency (Hz)	Frequency Change (Hz)	Step from lower frequency
C	270	—	
B	286	16	semi tone
A	321	35	whole tone
G	360	39	whole tone
F	405	45	whole tone
E	429	24	semi tone
D	481	52	whole tone
C	540	59	whole tone

Table 1.
Notes of Diatonic scale (white notes on piano), assuming C above middle C is 540Hz.

Hearing Loss

It is widely appreciated that high levels of noise will cause hearing impairment. This is largely through degeneration of cilia and also loss of associated hair cells.

Photo 3 indicates a cochlear which has suffered significant hearing loss. The inner hair cells (IHC) are better preserved than the outer hair cells (OHC1, OHC2, OHC3), since these are less directly affected by contact with the tectorial membrane.

Bats

Bats tend to develop hearing 'technology' that is highly tuned to selective frequencies. Some species of bats can produce and distinguish frequencies above 100kHz. The discrimination of frequency is largely determined by selective activation of different parts of the cochlea. In nature, for example, in bats of one species, the region 83 to 86kHz is selectively expanded by as much as a factor of 20 in area to emphasise signals in this range. For all its acoustic sophistication, the bat's hearing is even more compact than that of the human ear.

The moustache bat (Pteronotus parmelli), for example, has an outer system that is sharply tuned to sounds between 61 and 62kHz. The process of sound emission of this species of bat involves initially the contraction of middle ear muscles between 4 to 10ms before sound emission, with corresponding relaxation 10ms after sound emission. This presumably reduces the internal crossover from sound generation to sound detection system within the ear. With the speed of sound of 330m/s, the echo location system will be able to process sound echoes from objects greater than around 1m distant.

Most of the processing, however, takes place at specialised acoustic brain centres which have echo locating neurons and frequency modulated specialised neurons. The echo location of bats is highly sensitive. In the species of small brown bats (myotis lecifugus), wires of diameter 0·2mm can be dodged. Presumably, therefore, all bats can 'see' power lines.

The Perception of Music

The so-called psycho acoustic quality of music has perplexed scholars from the times of Ancient Greece to today. While this is a very complex field, it is obvious that the cochlear-based mechanisms of sound detection have a bearing on how sounds are structured into present day musical scales. Individual notes struck on a piano can, for example, be considered to map to specific regions of maximum response on the basilar membrane within the organ of Corti.

The western system of music adopts the so-called equal temperament system of scales where an octave is divided into twelve notes or semi tones and where the frequency intervals are determined by a fixed geometrical ratio of 2 to the power one twelfth – or a numerical value of 1·0595. Thus, the frequency doubles across a specific complete octave and the difference in frequency between semi tones increases with higher notes. In this regard, the octave – signifying eight is misleading and is a legacy of earlier Roman systems of music. Table 1 summarises this relationship for the white notes of the piano – the diatonic scale where steps of frequency can be whole tones or semi tones.

It is interesting to note that the ratio of cross-section of the basilar membrane is often described as 12:1. Thus, when the ear perceives music, it is listening to tones that are essentially in a geometric progression and not tones that are set in intervals of constant frequency differences.

One way to inspect music is to observe its equivalent voltage waveform detected using a microphone. Another more abstract way to imagine music is as sections of the organ of Corti selectively activated. Would this not

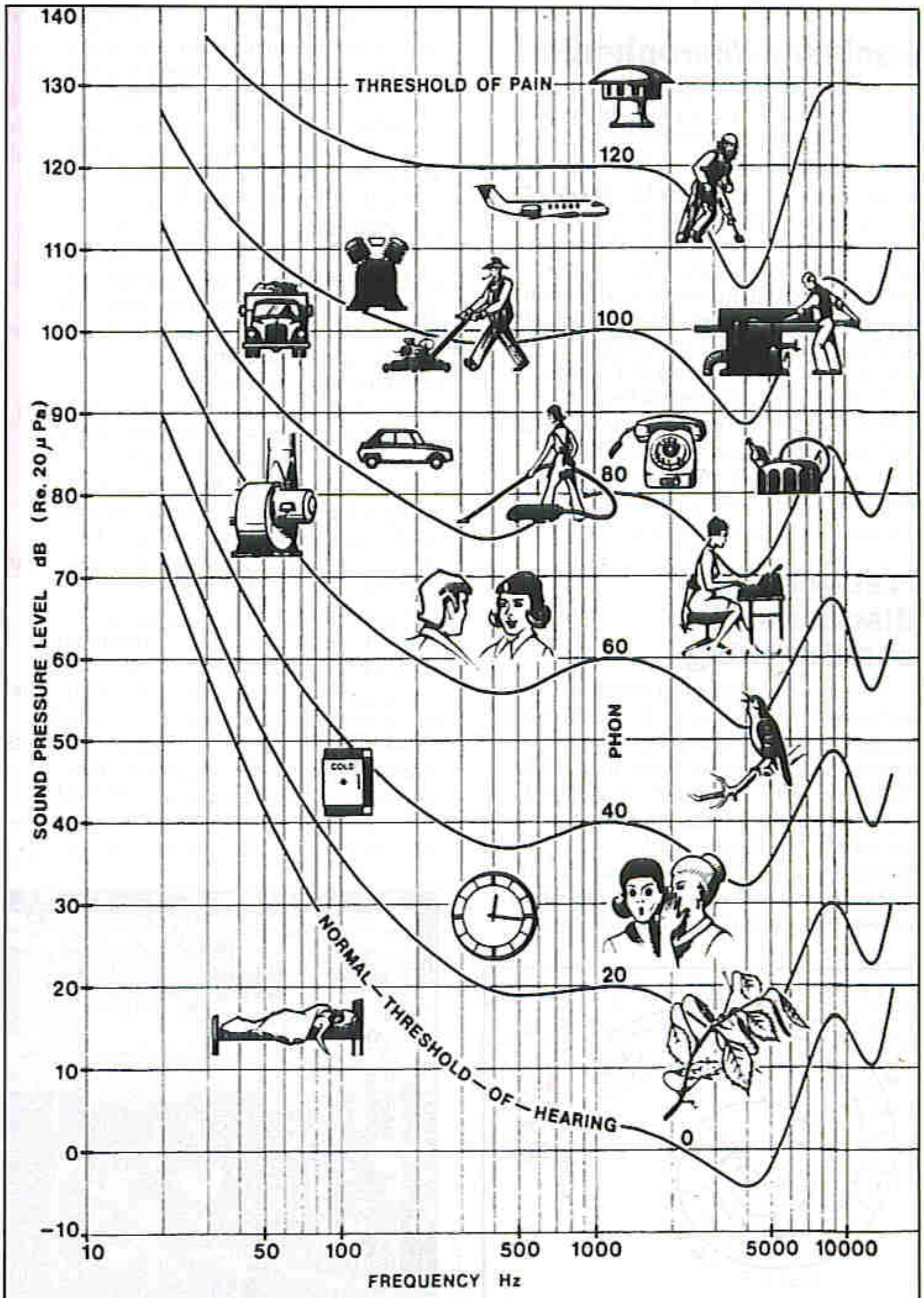


Figure 7. Contours of equal loudness of the human ear. (Courtesy B & K).

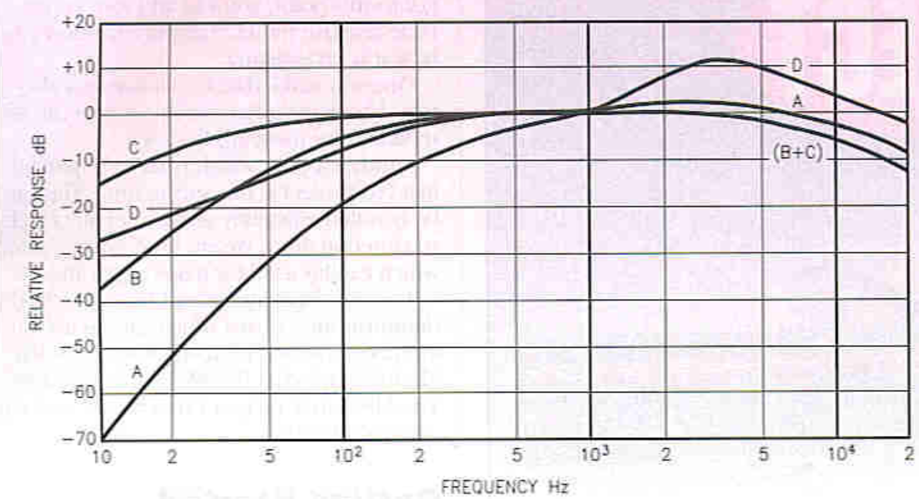


Figure 8. Weighting networks for sound perception. (Courtesy B & K).

make an excellent pop video – a synthesised Organ of Corti?

Measuring Sound

Sound pressure level in dB SPL of a sound of root mean square pressure, Prms, is given by:

$$SPL = 20\log_{10}\left(\frac{P_{rms}}{Po}\right)$$

Where Po is a reference amplitude of 0·00002Pa or 20μPa. The resonance between 2 and 4kHz is largely the result of the resonance of the ear canal. This measurement is essentially an absolute measurement which is not specifically related to levels of hearing threshold at any particular frequency.

The human ear can hear over a wide range of frequencies and levels, as Figure 7 indicates, where contours of equal loudness are indicated. The exact nature of the ear's frequency response at any part is the result of a very complex interaction of a multitude of factors.

While the curves which intersect 1,000Hz at 20dB SPL, 40dB SPL, etc., have a similar shape, the dynamic range of the ear as a function of frequency is compressed with increasing signal level. A curve which intersects, e.g., at 40dB SPL at 1,000Hz, is termed a loudness curve of 40phons.

This complex frequency response poses a problem for so-called sound level meters, where it is required that the frequency response of the instrument is matched to the SPL levels that are detected. A series of so-called weighting networks – A, B, C and D, were initially devised and where the A-weighted network was used for loudness levels below 55 phons, B weighting between 55 and 85phons and C-weighting above 85phons and with the D-weighting used, for example, to assess high frequency of aircraft noise. These are indicated in Figure 8. It is more common now, however, to use the A-weighting scale over a broad range of sound levels.

Measuring Hearing Levels

The greater part of audiology is about measurement of hearing threshold levels. One of the basic problems for such measurement was to define an acceptable and relevant standard for 'normal' hearing. A set of international standards has evolved with considerable use of former UK national standards to provide a reference point for a broad range of hearing parameters. The key standard relates to definition of normal air conduction hearing levels in relation to testing with standardised headphones and which can be calibrated using specialised reference cavities such as the 9A coupler with a nominal volume of 6cc. The use of free field sound for testing hearing thresholds is not practical to undertake, since it is difficult to establish accurately known free field sound levels at the ear of the individual being tested.

Summary

To be able to hear is to be allowed to communicate with the world at large. Hearing is, therefore, a very precious faculty. Even this very brief tour of the ear, however, reveals it to be a marvellously well-adapted item of biological engineering. Although much of the process of hearing has been unravelled, it is more than likely that a great deal more awaits discovery – and especially of the interaction of sound to other processing centres in the brain.

Reference Material

The ear is a very complex structure and one which requires numerous images to make it come alive. A highly informative series of illustrated booklets has been made available by Widex in Denmark and reflect the skill of Professor H. Engstrom and Dr. B. Engstrom of Uppsala, Sweden. Such material is available, subject to availability, via requests through PC Werth Ltd., Audiology House, 45 Nightingale Lane, London. SW12 8SP. Tel: (0181) 675 5151. Some additional titles are also listed.

Textbook of functional anatomy of speech, language and hearing, W. H. Perkins and R. D. Kent, Taylor and Francis, 1986.

Human senses in action, Roland Harper, Churchill Livingstone, 1972.

The Widak Series by Prof. H. Engstrom and Dr. B. Engstrom;
A short survey of some common or important ear diseases.
Structure and function of ear the inner ear.
The Ear: With some notes on the structure of the human ear.
Hearing: Some notes on structure and function.
Pathways for sounds and nerve fibres in the inner ear.

PROJECT

PUTTING PICS TO WORK

PART 1

Demonstration Board for LCD Displays and Serial Transfer

by Dr. Mike Roberts

How do you know what your PIC microcontroller is doing? Well if you link it to a LCD Character Display Module you can get it to tell you – in words! Alternatively, you can connect it to a PC serial port and get it to tell you using Windows 'Terminal'.

In this two part article, I will first show how PICs can easily be interfaced with LCD Character Display Modules and how to make a simple serial link to send data to another device, e.g., a PC. I hope this will show some of the potential of PICs and spur readers to do some experimenting. My second part details an elegant MSF clock/time decoder project which uses these techniques on the demonstration board.

I have completed six different PIC projects. All but one uses a LCD Character Display Module to show what is going on. The prices of these modules are now quite reasonable. For example, the MAPLIN 16 × 2-line module is under £14 at the time of writing. Compare this with say, 5 × 7-segment LED displays plus driver circuits. The LCD modules are much easier to drive, are more cost effective and you can use any text, number or custom character you wish.

By the end of part one, you should be able to write code to put text to LCD Character Display Modules. Once you have got to this point, you can add your own code and use the LCD module to show you how it is progressing.

One-way serial data transmission is also easy. I have included routines which can be modified for most applications.

Another aspect which is often important in a PIC project is measuring time. This can be handled efficiently using interrupts and the internal timer. Again, I will cover a setup which can be used for many applications.

To assist experimenters, I have designed a demonstration board which can be used to interface both with LCD Character Display Modules and via a RS232 serial link to a PC. The MSF clock project I describe in part two uses this board.

Getting Started

The first section of code in any application has to set up the PIC configuration for the required duty. The code in Listing 1 is designed for the PIC16C71 which is supplied with the PICSTART 16B1 kit. It is easy to modify this for the other PICs. Also, if the analogue facilities are not being used, you can program a PIC16C61 as if it were a PIC16C71 and it works. This shows the upwards/downwards compatibility. I fix the input/output (PORTA, PORTB) pins, the analogue to digital converter and the interrupts.

A quick comment on assembly language programming. It is much easier to use text descriptors rather than numbers. For example, when doing many mathematical functions (e.g. 'incf', 'addwf'), one has to define the destination file either as '0' for file register or '1' for the 'W' register. It is much easier to define "W equ h'0', F equ h'1'" and then use 'W' and 'F' instead of '0' and '1'. I have assumed that the programmer has access to the pic16c71.inc file which defines these and a whole load of useful addresses, e.g. for STATUS, RP0. This is included with the PIC software and can be 'cut and pasted' using the Windows 'NOTEPAD' text editor. 'NOTEPAD' reads and produces plain ASCII files. Note that if you use Windows '95 'WORDPAD', you must save the file as a text document (and use the .asm extension) in order to produce a plain ASCII file.

The details of the registers are covered in the Microchip manuals. For those who have not yet 'taken the plunge', TRISA and TRISB are 8-bit 'bytes' defining the PORTA and PORTB input/output pins. A '0' means output and a '1' means input. The pins are denoted RB0 to RB7. In the case of PORTA on a 16C71, only the five pins 0 to 4 inclusive are implemented so the top 3 bits have no impact. The bit RP0 of the register STATUS directs the processor to the bank 0 or 1 set of registers. INTCON defines the interrupts that will be accepted. OPTION_REG sets a number of different options. Here, it is enabling the weak pull-up on the PORTB pins and dividing the system clock (crystal frequency/4) by 32 and using this to drive the internal timer TMR0 (see later). ADCON1 sets the combination of PORTA pins used for analogue input. On reset, this is set to '0' which sets RA0 – RA3 as analogue inputs. Hence the need to redefine it when we do not need any analogue inputs.

```
        ; data register definitions
temp    equ      h'C'          ;temporary register
temp2   equ      h'D'          ;temporary register
cnt     equ      h'E'          ;serial bit counter
csec    equ      h'F'          ;1/100 second counter
serpin  equ      h'2'          ;serial output pin on PORTA
        org      0
        goto     Start
        ; start of main programme
        ; set up system
Start   bcf      STATUS,RP0    ;bank 0
        movlw    b'10100000'
        movwf    INTCON        ;interrupts from TMR0 only
        clrf     PORTB         ;port b all off
        clrf     PORTA         ;port a all off
        bsf      STATUS,RP0    ;bank 1
        movlw    b'00000100'
        movwf    OPTION_REG    ;set option, pull up, /32 clk
        clrf     TRISB         ;portb all output
        movlw    b'00000011'
        movwf    ADCON1        ;porta digital only
        movlw    b'00011000'
        movwf    TRISA         ;porta bits0-2 out 3,4,in
        bcf      STATUS,RP0    ;bank 0
        clrf     csec          ;seconds counter to 0
```

Listing 1. PIC16C71 configuration code.

Timers and Interrupts

This area is much easier than it sounds. Often, one wishes to execute a section of code either at a regular frequency or in response to an external stimulus. The PIC16C71 can respond to a range of these. The one I will describe here implements code every 10ms. I then use a software counter (0 to 99) to generate seconds. Further software counters can be used to generate minutes, hours, days, etc.

TMR0 counts from any starting number to 255 and generates an interrupt when it overflows from 255 to 0. A few clock pulses are consumed every time TMR0 is setup. Hence, it is best to let it run continuously, counting over the full range of 0-255. This then points to particular crystal frequencies. A good starting point is to use a 3·2768MHz crystal which can be used with 4MHz devices. The PIC divides this by 4 to 819,200Hz. The prescaler in the OPTION_REG divides this by 32, giving 25,600Hz. Then, TMR0 makes 256 counts and gives an interrupt every time it counts down to zero, i.e. at 100Hz. This setup is great for anything which requires time to be kept. Also, just in case you think 100Hz is a bit quick, the PIC with this crystal has time to execute 8,192 instructions every 10ms! This is plenty for most conceivable applications. The ability to implement one instruction per machine cycle gives the PICs fantastic speed.

When the interrupt is implemented, the processor simply starts at location 4 of memory. You also have to give the processor something to do while it is waiting for the next interrupt. If there is no background activity needed, just put the code in Listing 2 at the end of the startup sequence in Listing 1. I am glad I don't have to spend most of my life saying 'no operation, do it again'.

```
        ; operating loop

loop    nop
        goto     loop
```

Listing 2. Code required to execute a loop prior to the next interrupt.

The interrupt routine will be whatever you want. The bare essentials are shown in Listing 3. This section of code is inserted after "go to start" in Listing 1.

Driving LCD Character Display Modules

This is dead easy! Hitachi-type LCD character displays have a capability of up to 2 lines of 40 characters. They all have this capability and hence, are all driven in the same way. The smaller displays simply show only a limited number of characters. The simplest is 1 line of 8 characters. Also, a word of caution; a 1 line of 16 characters module is likely to actually be 2 lines of 8 stuck end-to-end. Hence, the 9th character has to be addressed as line 2.

The Hitachi interface has 14 pins – see Table 1. Eight are for data, which I usually link into PORTB of the PIC. Two more are used to accept the data. One of these acts like a 'clock' signal to say 'enable reading the data'. The other tells the display whether the data is information instructing the display drivers actions (e.g. 'scroll data into left of display' or 'goto the second line, third letter') or is data (in ASCII code) for the display to show. Two are for power supply (5V). There is a third power rail for the display, which also controls the contrast. The last pin can be used to take information from the display module. One need for this is to check that an instruction has been completed before sending the next one. I have always avoided using this pin by making sure I give the display enough time to implement instructions before sending the next data. With the exception of some of the startup instructions (which take longer times), this is handled in my subroutine code.

On my demonstration board, I use pin RA0 to connect to the 'its data to control the display or data to display' pin and RA1 to drive the 'clock' or 'enable' pin.

The code to send an 'H' to the display from the main program is:

```
movlw 'H'
call    DOUT ;send data in W
             to display
```

This puts the 'data', i.e., the ASCII code for H into the 'w' (working) register.

Note that 'H' is interpreted as the ASCII code for 'H'. Alternatively, you could use d'72' (decimal) or h'48' (hex) or b'01001000' (binary). I only resort to the alternatives for special characters.

The basis of the subroutine is:

```
DOUT  bsf     PORTA,0   ;RA0=1,
                        i.e. data
                        to display
      movwf   PORTB     ;portb=w
      bsf     PORTA,1   ;enable
      bcf     PORTA,1   ;disable
      return
```

I did say it was easy, didn't I? The next thing to realise is that if we are to send data for control of the display, then the only difference is that we need a: 'bcf PORTA,0'

Serial data link to a PC via D-type connector.

```
org       4              ;interrupt routine
bcf       INTCON,T0IF    ;clear interrupt flag
                         ;your code here
retfie                   ;return from interrupt
```

Listing 3. Basic interrupt routine.

Pin No.	Function
1	0V
2	5V
3	Negative supply to LCD and contrast adjustment
4	L=Instruction code input, H=Data input
5	H=Read, L=Write
6	H=Enable (i.e., read on H->L transition)
7-14	Data DB0-DB7

Table 1. Hitachi Display Module Pin Designation.

```
; display output subroutines
COUT    bcf      PORTA,0     ;RA0=0 control data for display
        goto     out1
DOUT    bsf      PORTA,0     ;RA0=1 data to display
out1    movwf    PORTB       ;portb=w
        bsf      PORTA,1     ;enable
        bcf      PORTA,1     ;disable
                             ;wait > 40µs
        movlw    d'13'       ;w=13
        movwf    temp        ;temp=13
out2    decfsz   temp,F      ;dec skip zero
        goto out2
        return
```

Listing 4. Subroutine for data and control of the display module.

to set RA0 to '0'. And lastly, we need to give time for the display to implement the instruction. Typically, this is 40µs. Hence, the simple 3-cycle loop (a goto takes 2 cycles) counting down from 13. This, plus the other few instructions plus the fact that the system clock is going a bit slower than 1MHz (actually (3·2768/4)MHz) gives more than a 40µs delay. The complete combined subroutine for data and control of the display module is given in Listing 4.

The display needs some initial setting up. This is usually done immediately after the startup routine. I have put an example case in Listing 5.

This sets up the display with two lines, with data entered from the left with no cursor and no blinking on the character position being addressed. This includes code for a software reset of the display. I have found that the display modules do not always reset on power up. If you have problems, try adjusting the speed with which you bring up the power voltage (if you are using a variable voltage power supply). If this is not an option, power up then carefully short pins 4 & 5 on the PIC.

This will reset the PIC and then the display module.

Now we have got all the fundamentals covered, we can do something useful – like write 'Hello Fred' to the display. This is clearly an advance on the usual 'Hello World' (which you can do as your first experiment). The code is in Listing 6.

If you want to start at a different location, just add the display location to h'80'. Hence, you would use the following to start at position 18 (note, we are working in hexadecimal).

```
movlw   h'92'
call    COUT    ;RAM address to 1st
                line character 18
```

The second line starts at location 64 (decimal) and so is addressed by:

```
movlw   h'C0'
call    COUT    ;Start 2nd line
```

The ability to write text to a display is a good starting point for writing programs, since you can write a section of code and then display a result or just 'Done' to show it has worked.

If you want to have a go at putting together the complete code for writing 'Hello Fred', proceed as follows: Use the pic16c71.inc file followed by the startup code in Listing 1. The interrupt handling routine (Listing 3) has to be entered after the 'goto Start' in Listing 1. The display initialisation in Listing 5 should follow the startup code and this in turn should be followed by the 'go round in circles' code of Listing 2. The 'Hello Fred' code of Listing 6 should be placed in the interrupt routine (Listing 3), where it says 'your code here' and lastly, the display subroutines of Listing 4 should be placed at the end, after the startup and 'go round in circles' code. One more bit; add 'END' to tell the assembler it has got to the end of the code. Programme the PIC with 'XT' oscillator and 'Power Up Timer On' (only).

```
movlw   h'80'
call     COUT    ;Display RAM
                 address to 0
movlw    'H'
call     DOUT
movlw    'e'
call     DOUT
movlw    'l'
call     DOUT
movlw    'l'
call     DOUT
movlw    'o'
call     DOUT
movlw    ' '
call     DOUT
movlw    'F'
call     DOUT
movlw    'r'
call     DOUT
movlw    'e'
call     DOUT
movlw    'd'
call     DOUT
```

Listing 6. Code required to display "Hello Fred".

Why not have a go at writing code to display the state of the PORTA input pin 3? If you get stuck, see Listing 7.

Serial Data Transfer

Again, this is tons easier than one first might guess. It always seemed like magic to me how you connect up a lead and your PC links to another. If you strip of all the 'Data Terminal Ready' lines and so on, all serial data transfer is a single output pin waggling up and down at the right timing. If you only want to transfer data out, then you can survive using only one pin on the PIC. You also have to transfer the voltage swings to the RS232 format. The proper way of doing

```
        ; set up display
        movlw     h'38'
        call      COUT          ;2 lines

        clrf      temp2
        movlw     d'6'          ;delay for 4,100µs
        movwf     temp
st1     decfsz    temp2,F
        goto      st1
        decfsz    temp,F
        goto      st1

        movlw     h'38'
        call      COUT          ;2 lines
        movlw     d'20'         ;delay for 60µs
        movwf     temp
st2     decfsz    temp,F
        goto      st2

        movlw     h'38'
        call      COUT          ;2 lines
        movlw     h'38'
        call      COUT          ;2 lines

        movlw     h'06'
        call      COUT          ;entry mode cursor right
        movlw     h'0C'
        call      COUT          ;display on,no cursor,no blink
        movlw     h'01'
        call      COUT          ;clear + address 0
        ; wait 1,600µs (not needed wait interrupt)
        clrf      temp2
        movlw     d'2'          ;delay for 1,600µs
        movwf     temp
st3     decfsz    temp2,F
        goto      st3           ;3 X 256 = 768
        decfsz    temp,F
        goto      st3
```

Listing 5. Display set-up routine.

```
movlw   h'80'
call     COUT  ;RAM address to 0
movlw    'R'
call     DOUT
movlw    'A'
call     DOUT
movlw    '3'
call     DOUT
movlw    '='
call     DOUT
movlw    'L'
btfsc PORTA,3
movlw    'H'
call     DOUT
```

Listing 7. Code to display the state of the PORTA input (pin 3).

```
;main program text
        movlw       'H'                 ;w=ASCII 'H'
        call        SERIAL              ;send out 'w' as serial data

        ;sub to output w as serial info
SERIAL  movwf       temp                ;temp=w
        movlw       8
        movwf       cnt                 ;cnt=8
        bcf         PORTA,serpin        ;start bit
        goto        ser1
ser1    call        SDEL
        rrf         temp,F
        btfsc       STATUS,C
        bsf         PORTA,serpin
        btfss       STATUS,C
        bcf         PORTA,serpin
        decfsz      cnt,F
        goto        ser1
        goto        ser2
ser2    call        SDEL
        bsf         PORTA,serpin        ;stop bit
        call        SDEL
        call        SDEL
        return

        ;delay for serial(3·2768/4/9,600)
SDEL    movlw       d'24'
        movwf       temp2
sdel1   decfsz      temp2,F
        goto        sdel1
        return
```

Listing 8. Main program 'call' code and serial output subroutine.

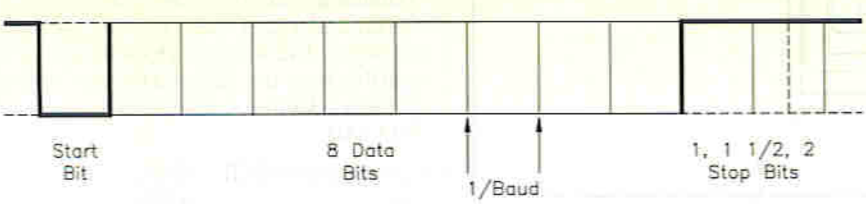
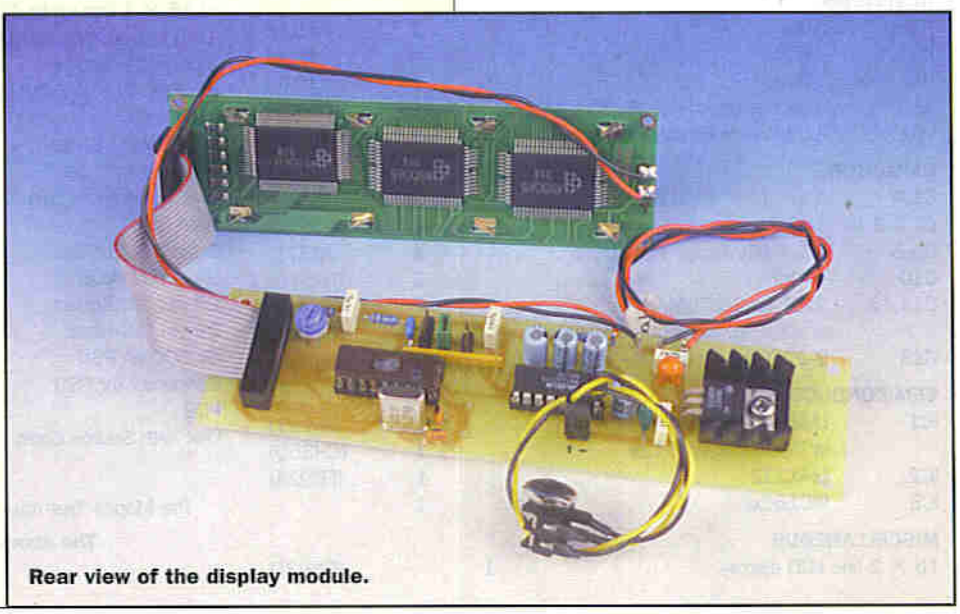


Figure 1. A typical serial data transfer of 1 byte.

```
        incf        csec,F          ;increment seconds counter
        movlw       d'100'
        subwf       csec,0          ;w=csec-100
        btfsc       STATUS,Z        ;skip if csec<>100
        clrf        csec            ;reset csec=0

        movf        csec,F
        btfsc       STATUS,Z        ;skip if csec <>0
        call        HELLO
        decf        csec,W          ;w=csec-1
        btfsc       STATUS,Z        ;skip if csec <>1
        call        FRED

        retfie      ;return from interrupt


HELLO   movlw       'H'
        call        SERIAL
        movlw       'e'
        call        SERIAL
        movlw       'l'
        call        SERIAL
        movlw       'l'
        call        SERIAL
        movlw       'o'
        call        SERIAL
        return

FRED    movlw       ' '
        call        SERIAL
        movlw       'F'
        call        SERIAL
        movlw       'r'
        call        SERIAL
        movlw       'e'
        call        SERIAL
        movlw       'd'
        call        SERIAL
        return
```

Listing 9. Code for insertion in the interrupt routine.



Rear view of the display module.

this is to use a converter such as the MAX232 which has the benefit of running on 5V and having its own +10V and –10V generators. A typical serial data transfer of 1 byte is shown in Figure 1. This is for the case of 8 bits data, no parity, 1, 1 1/2, or 2 stop bits.

The speed of data transfer is set by the 'baud' rate, e.g., 9,600 baud is 9,600 bits per second. So, the key sum we need to do is 'how many machine cycles are there for each bit'.

If we take the case above using a 3·2768MHz crystal, one machine cycle is 1/(3·2768/4)µs, i.e. 1·2207µs. 9,600 baud is 1/9,600 seconds per bit or 104µs, which is 85·3 machine cycles. Using 85 is close enough.

Note that if you wished to do a lot of serial data transfer, you would want to pick a crystal frequency which divides down conveniently, so you could use the TMR0 to generate interrupts rather than using code to wait the correct number of cycles. For example, a 2·4576MHz divides down by 256 (2^8) to give 9,600 baud.

The main program 'call' code and the serial output subroutine is shown in Listing 8. I hope, given the explanations above, that the code is self explanatory. Please note that the number of instructions and/or the number of loops in subroutine SDEL must be adjusted to suit the clock frequency of the PIC.

The pin used for the serial transfer (serpin) must be defined (after the PIC16Cxx.inc file header), as must the location in data memory of cnt, temp, temp2 (see start of Listing 1).

The code in Listing 8 actually has two stop bits. This can be used with 1 or 2 stop bits set at the receiving end.

Please note that serial transfer does take some time. With 11 bits per piece of data (1 start, 8 data, 2 stop) and 9,600 bits per second, we can send up to 8 bytes of data in 10ms. Hence, to send 'Hello Fred' to a PC (once per second), we have to split the data and send it in two 10ms time slices. Suitable code for insertion in the interrupt routine is given in Listing 9.

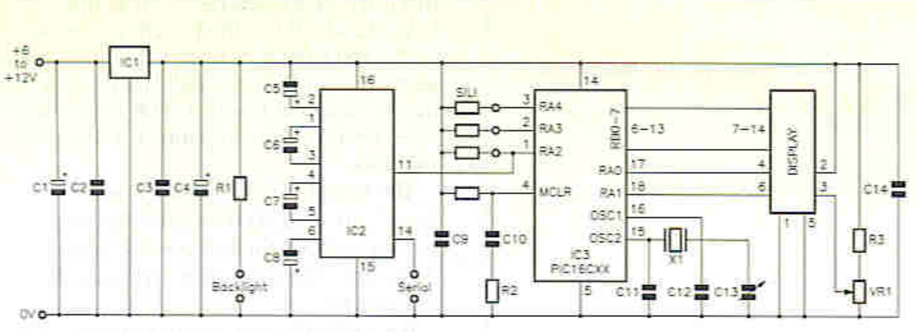


Figure 2. Demonstration board circuit diagram.

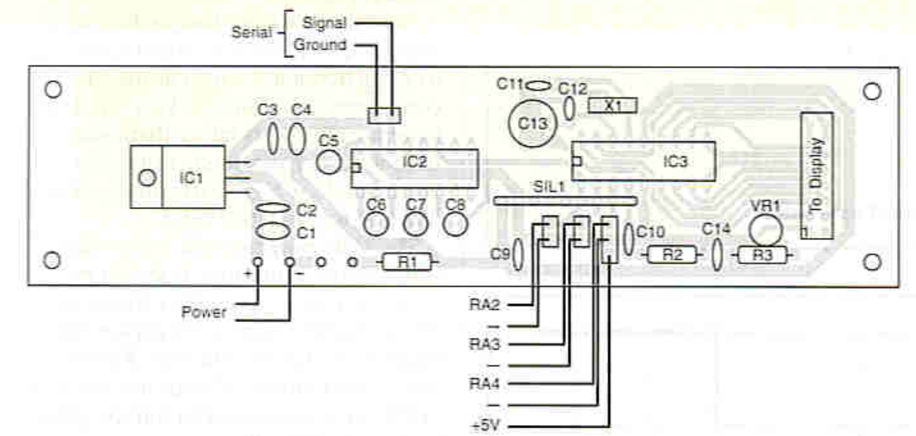


Figure 3. PCB layout and component placement.

Hardware Considerations

You can award yourself a medal if you have made it to here. My demonstration board circuit diagram is shown in Figure 2. The PCB layout and component placement is shown in Figure 3.

The board is set up to take either conventional crystals or the ceramic resonators often used with PICs. Some of the ceramic resonators include capacitors connected to a third pin and hence, there is no need for C11 & 12. C13 can be included to fine-tune the crystal frequency. If it is included, subtract about 12pF off the value of C12.

The interface to the Liquid Crystal Display Module is designed for use with ribbon cable via a transition header on the PCB and IDC socket on the cable, connecting to a section of 7 × 2-pin strip soldered into the BACK of the connector on the module. In this mode, the cable does not follow the connection numbers as each pair is swapped over, i.e. 2, 1, 4, 3, 6, 5, etc. Double-check you have got it right by following the 0V connection (denoted '1' on the PCB layout and on the module).

The serial link requires a special lead. The connections are as follows:

	9-pin DIN	25-pin DIN
ground / '-'	5	7
data/signal	2	3
connect DTR, DSR	4,6	20,6
connect RTS, CTD	7,8	4,5

Windows 'Terminal' Settings

Baud	600
Data Bits	8
Stop Bit	1
Parity	None
Flow Control	None
Connector	COM1 or COM2

Demonstration Board and Code

The demonstration board and a disc containing code to put 'Hello Fred' to a display and to a PC (also with PC software to receive data from the clock in part 2) are available from the author, Dr. Mike Roberts, 4 Thames Avenue, Guisborough, Cleveland TS14 8AD.

Demonstration PCB	£7.50
Disc	£3.00

(The above prices include postage)

Recommended Reading

Microchip Embedded Control Handbook, Application Note AN510 Implementation of an Asynchronous Serial I/O. Stock Code AD28F.

Microchip Data Book. Stock Code AD29G.

Liquid Crystal Character Display Modules, Hitachi.

PIC DEMONSTRATION BOARD PARTS LIST

RESISTORS			
R1	10Ω	1	(M10R)
R2	1kΩ	1	(M1K)
R3	10kΩ	1	(M10K)
SIL1	10kΩ Single In-line Resistor Array	1	(DL65V)
VR1	1kΩ Preset Potentiometer	1	(WR40T)
CAPACITORS			
C1,4	10μF 16V Radial Electrolytic	2	(WW68Y)
C2,3,9,14	100nF	4	(CX21X)
C5-8	22μF 16V Radial Electrolytic	4	(AT37S)
C10	470nF	1	(RA52G)
C11,12	12pF for 3·2768MHz	2	(WX45Y)
	or 33pF for most other crystals	2	(WX50E)
C13	2-22pF (optional – see text)	1	(WL70M)
SEMICONDUCTORS			
IC1	LM2940CT supply 6-12V	1	(AV22Y)
	or 7805 supply 7-12V	1	(CH35Q)
IC2	MAX232	1	(FD92A)
IC3	PIC16Cxx	1	
MISCELLANEOUS			
	16 × 2 line LCD display	1	(DK63T)
	or 16 × 1 line up to 40 × 2 line	1	(DK63T to DK67X)
	16-way Transition Header	1	(FA47B)
	2 × 8 IDC Socket	1	(FG44X)
	Pin Strip 2 × 36 (Cut Off 7 × 2)	1	(JW62S)
	IDC Cable	1	(XR73Q)
	3·2768MHz Crystal	1	(FY86T)
	Pin Strip 1 × 36 (Cut Off As Required for Connectors)	1	(JW59P)
	Heat Sink	1	(JX21X)
	9-pin DIN Socket	1	(RK61R)
	9-pin DIN Hood	1	(FP27E)
	25-pin DIN Socket	1	(YQ49D)
	25-pin DIN Hood	1	(FP29G)
	6V 300mA PSU	1	(JC90X)
	Connector for PSU	1	(JK10L)
	PCB	1	* See Text *
	Disc with Source Code	1	* See Text *

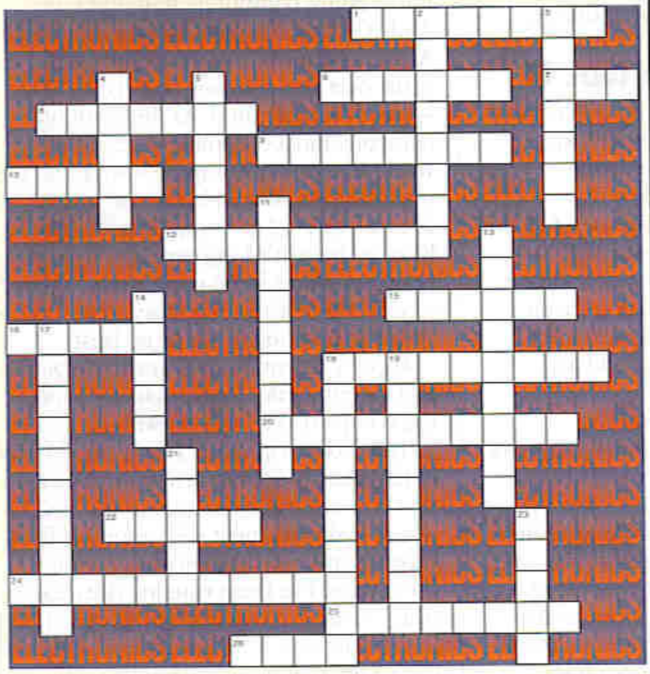
The Maplin 'Get-You-Working' Service is not available for this project.

The above items are not available as a kit.

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. 2 — May 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.

ACROSS

1. It's a positive or negative output to input circuit
6. Invented before the transistor but still alive, see for yourself on page 905
7. Where the micro does its sums
8. Programming language
9. Beach sandals or memory
10. You'll see clearer with this on your masthead
12. The answers to the crossword are in the ----
15. Professor Niklaus Wirth invented this computer language
16. Converts cigar lighter to mains voltage
18. Exact multiples of the fundamental frequency
20. Device used to convert physical energy into electrical voltage or current
22. Five disc CD player
24. Maplin branch in area 7
25. A fundamental negative particle of matter
26. Increase it to reduce the current

DOWN

2. Attack, sustain, decay, retain or post a letter perhaps
3. Screened wire used for aerial connections
4. Car blows the 30 amp fuse you need this
5. He discovered electromagnetic induction
11. Range of frequencies
13. Phone 01702-556001 for what service?
14. Touchscreen order code
17. Device that compares its inputs and outputs the difference
18. Five sound choices on page 57
19. Natural frequency of an object
21. Sold by the metre for the meter
23. This product on page 520 will help me find my way

We are giving away a cash prize of £25 to the first correct entry received by 14th April 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.

COMMENT

by Keith Brindley

A recent survey of the UK's top companies has shown how far behind new technology much of our industry is. Romtec and Durlacher Multimedia's survey shows that only around 40% of companies have installed an internal intranet network (the company-wide equivalent of the global Internet) and are effectively using it as a management tool. Companies such as BT and Rover are included in this group.

About a third of UK companies, on the other hand, see no purpose in adopting an intranet strategy, with the remainder being undecided. Interestingly, around a fifth of all UK industry does not appear to use any modern technology tools (for example, e-mail) at all. Most often, the reason cited as to why no step into the modern world of technology is taken is that any benefits are hard to perceive. I can understand that – I'm sure that some companies didn't use the telephone when it was first invented for the very same reason (mind you, those companies have also disappeared or changed their minds, too).

In contrast to those companies dragging their collective technology heels, almost all of the companies with an intranet strategy (well, over a third of all UK industry, in fact) use e-mail extensively. This proves almost without doubt that once companies make the electronic step to having a cohesive intranet strategy, they take to it and get some of its benefits directly.

Interestingly, and as a pointer to how the computer market will go over the coming few years, more than half of the companies which have embraced intranet technology expect the Network Computer (NC) to replace networked personal computers within five years. This is worth pondering on. Intranets allow companies to create their own ways of working and supplying information to its staff and customers. In effect, they are not bound by the use of large, complex and processor-hungry applications, requiring large, complex, and processor-strong computers. This expectation to use NCs rather than PCs comes from the very companies which use intranets. If they see no need to continue to use personal computers, then – as intranet technology catches on more widely (which it will do) – more and more of the world's businesses will presumably do the same. We might be about to see the death of the personal computer in industry.

Europe – You're Not IT

President and chief executive officer of Intel (yes, the Intel of the Intel Inside logo), Andy Grove, was in Europe recently and gave a grim view of European use of IT. Likening use of IT in European companies to that in US companies around ten years ago, Grove was forthright in his conclusion that if this continues, Europe will continue to slip behind the rest of the world in technology.

This, of course, is true in some respects. In the US, some 60% or more of the population has a computer, while in Europe, the figure is only just over 10%. But these figures can be a little deceptive. While 60% of Americans have a computer, that's not necessarily to say that there is a similarly great uptake of computers in industry. No doubt, there is some greater uptake, as the preceding story proves, but maybe it's not so bad (600%, indeed) as it first looks. After all, there's a significantly greater uptake of computers in the home in the US. Here in Europe, computers aren't such a priority in the home (while the old Sega or Nintendo is, I might add – but they're not exactly what Grove classes as computers, after all). This means that while industry figures for computer uptake are still abysmal in Europe, they're not perhaps as abysmal as you might first think.

Still it's all relative, and – yes – Europe is behind the rest of the world, particularly the US. But the man making the point is bound to say that isn't he? I mean, what he's trying to get us in Europe to do is buy more computers, most of which use his company's integrated circuits. Maybe Europe could take this computer deficit as a gift horse and, not looking in its mouth (which is where my tongue is at this moment!), buy Network Computers instead of personal computers, thereby making Andy Grove's company redundant. Oh, I've just had a wicked thought – that's not why he was trying to instill us with blind panic, was it?

Way to Go, Apple

Finally, talking of computers (and more importantly, computers that don't use Andy Groves' integrated circuits), news of Apple Computer's demise have been – as usual over the company's 20 years of life – greatly exaggerated. As the computer company ranked number three in the world in terms of computers sold, and the manufacturer almost everyone (except, of course, users of its computers, that is) loves to hate, it's long been the case that no news seems to be good news. Almost weekly, there appears a story that Apple is about to be bought out or go bust.

Apple's recent internal staffing troubles and external sales performances aside, the company marches on with its software development. The latest release of the MacOS operating system (System 7.6) is about to be released in the UK, where it should meet with approval from existing and new Macintosh computer users here. I've been running the system (the US version released at the end of January, in fact) for a few weeks now, and can testify that it's an incredibly stable release with some wonderful tools which should do a lot to quell anti-Mac opinion from the uninformed press and non-Mac (that is, PC) userbase. Beats Windows 95 hands down for stability, as well as incorporating and indeed, evolving even further the traditional Mac ease-of-use.

Included in the release are several new system parts (as well as some parts which actually have been available for quite a while now as separate components). System 7.6 brings them together in a unified installation. Particularly strong is the system's overall Internet capabilities, with advanced Apple technologies such as OpenDoc and CyberDoc in the forefront. Included too is the Apple Internet Connection Kit, which makes a doddle the process of signing up with an Internet Service Provider (ISP) for a raw Internet recruit. As operating systems go, and as always, the new MacOS is the most advanced and friendly mass-market operating system in the world. If you're a Mac user, get it now. If you're in the market for a new computer and haven't thought of Mac before, check it out and compare – you'll not be disappointed. If you're a non-Mac user, weep.

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

Full Marks, Edinburgh!

Dear Sir,

I would just like to express our team's thanks for the help you offered in your Edinburgh store. Our team consisted of four pupils from Madras College in St. Andrews. We were participating in the Engineering Education Scheme, Scotland, which is organised by The Royal Academy of Engineering and The Royal Society of Edinburgh. Our project was to develop a childs' toy with many educational games. The code we had written for the PIC16C74 needed changing at the last minute before our presentation. We rushed along to the Maplin store to see if another chip was available. As there weren't any in stock, your staff opened up a UV Eraser and erased our chip for us so we could have a working demonstration. My web pages are at **http://web.ukonline.co.uk/members/tim.kerby/**, while my PIC site is at **http://web.ukonline.co.uk/members/tim.kerby/pic/** It needs your projects!

Tim Kerby, Newport on Tay, Fife, Scotland.

It is pleasing to hear that the Edinburgh Maplin store was able to help you with your predicament. Perhaps our readers may be able to pass on some suitable projects for Tim's needy cause?

Trailing Leads

Dear Editor,

I am pleased to see the interest which other readers have displayed in the subject of water descalers and the number of different opinions which have been expressed. It was refreshing to read the novel approach of J. G. Wilkinson (March Star Letter), complete with circuit diagram and component details, and to know that he is quite convinced that an electrical approach is satisfactory. I think a strong warning should be given to would-be constructors (who, in these days, normally work with voltages under 15V) that the sockets, plugs and cables which will be operating at 400V DC can be damaging and even lethal, and may prevent them from enjoying the benefits of descaled water! I am still hoping (and so is John Aston – March) that a reader who has first-hand industrial or university design experience in this field will come up with answers to the questions in my February letter. With reference to John Aston's ultrasonic unit, I have found that the M810 Digital Multimeter (Maplin ZC60Q) set to the automatic frequency range will convincingly measure the frequency (68kHz) of one of the low-energy electronic lamps by trailing the positive lead over the tops of the tubes (the negative lead dangles unconnected). At these higher frequencies, the energy is readily transferred to the high impedance input of the DMM.

Wilfrid A. Sawyer, Beaconsfield, Bucks.

Your original letter concerning water softening devices certainly generated an impressive response; as this month's letters pages indicate, we've yet to hear the last of it! As you suggest, readers should remember that suitable precautions should be taken when working with high voltages – which even at a few milliamps can cause shock – and that high voltage DC is generally considered more dangerous than the equivalent AC voltage. When working with such circuits, it is advisable to work with one hand in your pocket/behind your back to avoid the possibility of forming an electrical path across one's chest.

In this issue, Ron Cook, of Frome, Somerset, wins the Star Letter Award of a Maplin £5 Gift Token for describing his experiences of going soft by way of high-tech extracts of passed water.

£5 MAPLIN GIFT VOUCHER

Star Letter

Dear Sir,

I was very interested in your readers' experiences with electronic devices for softening water and repelling pests, and decided to try some modifications of my own. My ideas were based on the fact that very low frequency waves are the best for communications with distant submarines, and that eddy-current losses in metal pipes are greatly reduced at lower frequencies. I used more-or-less the circuit given by J. G. Wilkinson in Issue 112, with R-C values for the lower frequency of 0·1Hz, a 1,000H inductor, and without the 4µ7F smoothing capacitor. Instead of the copper foil strips on the insulated water pipe, I wound a pair of coils, 15 turns of 22 swg enamelled copper wire (BL27E) each, 30cm apart, and connected them in series opposing. The unit was powered by a PP3 battery.

The results were immediate and spectacular. All scale cleared rapidly from the kettle, and the brown stains disappeared from the teapot. Central heating costs were reduced by 32%. The bath filled and emptied more quickly and the smell of chlorine vanished. The basin tap stopped dripping, a small leak in the bedroom radiator stopped, and the cat started to drink water instead of milk. Encouraged by these successes, I built another drive unit, this time for the lower frequency of 0·01Hz, and driving a 5-turn coil around the letter box. Since fitting this, I have not had a single sales circular or unwanted letter, and I did receive a small win on the football pools. My next project is already well advanced. The operating frequency is reduced to 0·001Hz, and it will power a 2-turn loop around the front door. I anticipate this will put and end to visits from double-glazing sales persons, Jehova's Witnesses, market surveys and political canvassers. My ultimate ambition is to put a huge single-turn coil around the house, to protect the roof tiles from storm damage and the foundations from subsidence. But there is one peculiarity of these systems which I cannot understand; they work just the same with the battery leads reversed, or even disconnected.

Can anyone explain this?

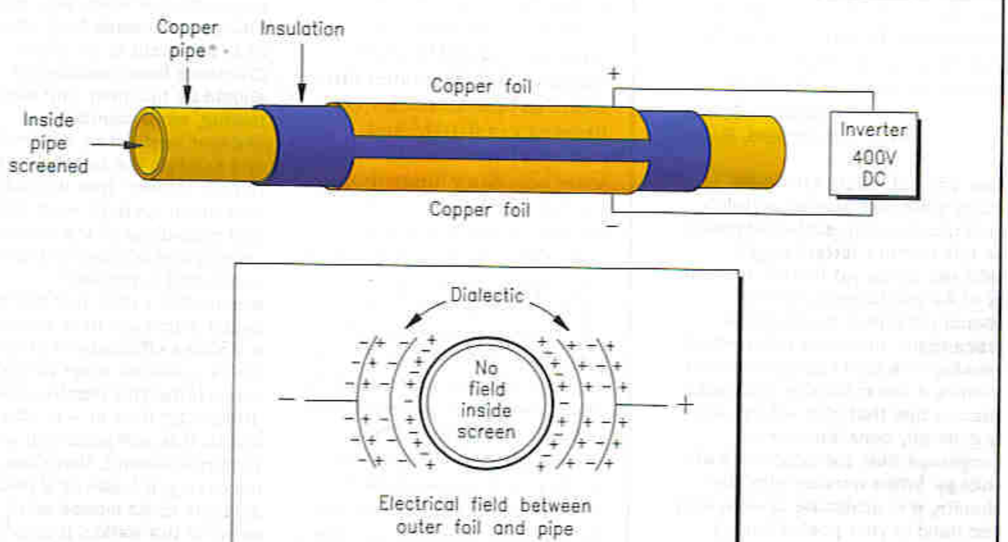
Judging from your experiences, it would appear that electronic water softeners would be beneficial wherever water systems exist. But why stop with a loop around the house? It would clearly be worthwhile installing a loop encircling the Earth to soften water at source – in the oceans, seas and rivers. This could be more cost-effective than might at first be imagined, since much of the infrastructure is already in place, with existing pylons on land to support the wire loop, while strategically-placed oil rigs, lighthouses, etc. could be employed to support the cable where it passes overseas. The various countries that benefit from this scheme could pool their resources (from National Lottery funds, etc.) to share the cost of installing and maintaining the system, which would in any event supply considerable savings in the long run, even if many plumbers world-wide were put out of business as a result of its effectiveness at preventing leaks and hose blockages. Other potential benefits would be ships never requiring dry-docking to clean off their hulls, and reduced pollution of shores from sewage or in the event of oil slicks. Creatures living underwater should be healthier with better-tasting, more plentiful and cheaper seafood as a spinoff, and sand on the beaches would remain cleaner. Your discovery that these systems work equally well regardless of the battery polarity and whether one is even connected is possibly explainable by the fact that the circuit which you have used has a claimed efficiency in excess of 100% – see the other Air Your Views letter this month, entitled 'Better Out than In' – in other words, it is self-powering, and a battery shouldn't, therefore, be necessary. It looks as if these systems could indeed solve many of the world's problems at the drop of a hat.

Fur and Froth

I was interested in the circuit for the water descaler in Issue 112. Our electric kettle quickly built up a layer of fur and needed descaling about every 6 months. A few years ago, I taped some large bar magnets from old loudspeakers to the main water pipe and whether by the magnets or coincidence, after two years, there is now just a trace of scale on the element. It is also an interesting phenomenon that boiling water taken before the magnets appears to boil with a more 'frothy' appearance with larger and longer-lasting bubbles floating on the surface than that which has passed the magnets. One point I have not mentioned is that water pipes come in different forms. Copper, iron, plastic or good old-fashioned lead. Each would have a different effect on any device on the outside of the pipe and could be a possible cause of differing opinions as to effectiveness. Iron would reduce any effect on the water of permanent or DC-generated magnets. Any metal pipe would have a screening effect on electrostatic methods. While magnetic fields would interact with the water, the circuit outlined in the letters page, while generating 400V, defies all logic and technical reasoning to have any effect on the water itself, so adds to the debate on how and why such devices are said to work. I understand from the description that it was used on 15mm copper pipe as it first had to be insulated. The strips attached to the pipe form two capacitors in series with the pipe, the centre plate to which approximately 400V DC is applied. These charge up to 400V in a fraction of a second and generate an electrical field. However, this field is on the outside of the pipe with the electrical stress caused by the potential difference in the layer of insulation. In theory, the copper pipe itself forms a Faraday screen between this electrical field and shields the water from its effect (see Figure 1). Being DC, there is no current flowing once the capacitors formed by the strips are charged. There is no magnetic field generated which would be able to pass through the copper pipe. As this theory contradicts the description, it was decided to make up the idea and put both electrical and magnetic sensors inside the pipe. With the voltage applied, there was not any trace of measurable energy inside the pipe but an electrical field measured on the outside, as expected. The sensitivity of the sensors was such that a BBC transmitter some 20 miles away was detectable even inside the screening effect of the pipe. So, if there was any field being generated inside the pipe, it was well below the level of this stray signal and its effect would be microscopic. I cannot disagree with the designer's statement that it works as I do not have laboratory means to analyse the water, just that I fail to see how. Trying out both permanent and an electromagnet with 50Hz did produce fields within the pipe. I would consider that the DC voltage on the two plates would effect the water if used on plastic pipes, as the pipe would form the dielectric and the water itself form part of the capacitor. Finally, are the new energy-saving lamps a real money saver? My recent experience would indicate perhaps not such a good buy as the sales pitch would have us believe. Savings of £30 to £45 and a life of 8,000-10,000 hours are quoted, but one of mine has failed after just 18 months and an estimated life of less than 2,000 hours in a room that is only used periodically, not even a main living room. I estimate that the 'saving' is actually a £7 loss compared with using a standard filament bulb for the same period. On another point, while long life is a selling point, they are in general only guaranteed for 12 months, but with average domestic use, the life should be nearer 4 years for the hours quoted, which is well in excess of the guarantee period and also bearing in mind most domestic equipment can be repaired after the guarantee expires, but these are throwaway items. On a practical point for the more experienced, when a lamp fails, do not simply discard it like the makers intend. It is likely that just the tube has failed, so by carefully opening the unit, the choke and starter from the older or electronics from the newer type will drive a standard linear or possibly shaped tube of similar wattage, thus extending its life and recovering some of the initial costs. I have found the tube does sometimes need an earthed metal strip to help it strike. A convenient method is to tape a 5A fuse wire the length of the tube and in contact with metal end caps but clear of pin connections. If the tube is held by spring clips, these can make the earth connection or use bi-pin connectors with earthing contact. Final word – remember that this is at mains voltage, so all safety precautions need to be taken with wiring, connections fully insulated and components contained in a suitable enclosure.

M. Perry, EngTech AMIETE, C&G & HNC Elec Eng., Kidderminster.

Good point about the water pipe material affecting the operation of electronic water descalers – perhaps, then, these devices only work well with plastic/clay pipes? Regarding the failed bulb, it's possible it failed prematurely because of a manufacturing defect that had gone unnoticed in quality control checks. Presumably, your other long-life bulbs are still working, as you mention that only one of them failed. Thanks for supplying the tip on getting your money's worth when they do fail – one for the 'scrimper's guide', perhaps!



Piping Up

Dear Editor,

About 30 years ago, an elderly neighbour of mine moved to Bridport, where she was troubled by limescale in her kettle. An engineer friend of hers made for her what she called her water softener, which she had fitted herself. In outward appearance, it was made from a piece of aluminium bar about 4 × 1·5 × 1·5in. It had been drilled through on its long axis the outward diameter of a half inch water pipe and then slit apart lengthwise so that the two halves could be clamped snugly around the main copper water pipe at the point where it entered the house. It was an entirely static and passive device, there being no wires or external connections, or contact with the water in the pipe. She was obviously delighted with the device and stated categorically that not only did her kettle no longer scale up, but that the existing scale had now disappeared. I was not aware of anything within the body of the device, but from the current spate of advertisements, I would imagine that it may have contained one or more strong permanent magnets. As an experiment, it is suggested that some seeker after the truth may care to tape some bar magnets around their water pipe, suitably orientated so that the water passes through a strong magnetic field. There is no point in my doing so as I am not troubled with limescale. Perhaps somebody else may care to report their findings. It would seem that they are not all outrageous swindles as some people may suggest. This is a fascinating subject and it would be interesting to learn more from your excellent publication.

Derek N. Bonner, Lingfield, Surrey.

See M. Parry's letter, 'Fur and Froth', to discover the intriguing results of attaching bar magnets to a water pipe!

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.

CIRCUIT MAKER

Alarm Zone Filter

by Steve Adams

Whilst modern alarm systems are designed to have a high degree of immunity to electromagnetic interference, older panels are considerably more vulnerable. Interference usually enters the system via one of two routes:

1. Mains-borne interference, often caused by power tools or old unsuppressed motorised equipment; usually, this can be overcome by the use of a transient suppressor (HW13P) or additionally in more severe cases, a mains filter (KR96E).

2. Radio interference, from Taxi or CB transmissions received by the wiring around individual zones acting as an aerial. This can be minimised by installing a simple low-pass filter to each affected zone.

Details of a suitable device are shown in this article. The circuit diagram is indicated in Figure 1, while Figure 2 shows a suitable stripboard layout (9 holes × 5 tracks).

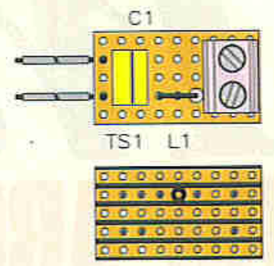
After fitting the components to the board and soldering, bend the wires of the transient suppressor such that they emanate from the end as shown above. Fit short lengths of sleeving to the leads but do not trim, as the extra may be necessary during installation. Crop off all other component spills.

It is feasible to construct this project 'dead bug' style, however, for improved reliability, it should be constructed as shown, or better still, on a custom-etched PCB.

Interference is a complex problem that can often involve extensive 'detective work' to track down and eliminate, but it is hoped that this short article will assist in rectification in the majority of instances.

Figure 3 shows a typical installation of the various described interference protection devices into an alarm control panel.

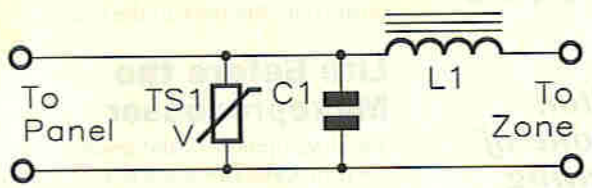
Figure 2. Stripboard layout (component positioning) and track details.



Note

The specified transient suppressor (TS1) is rated at 14V DC. Therefore, the maximum continuous supply voltage to the Alarm Zone Filter circuit must not exceed 14V DC.

Figure 1. Alarm Zone Filter circuit diagram.

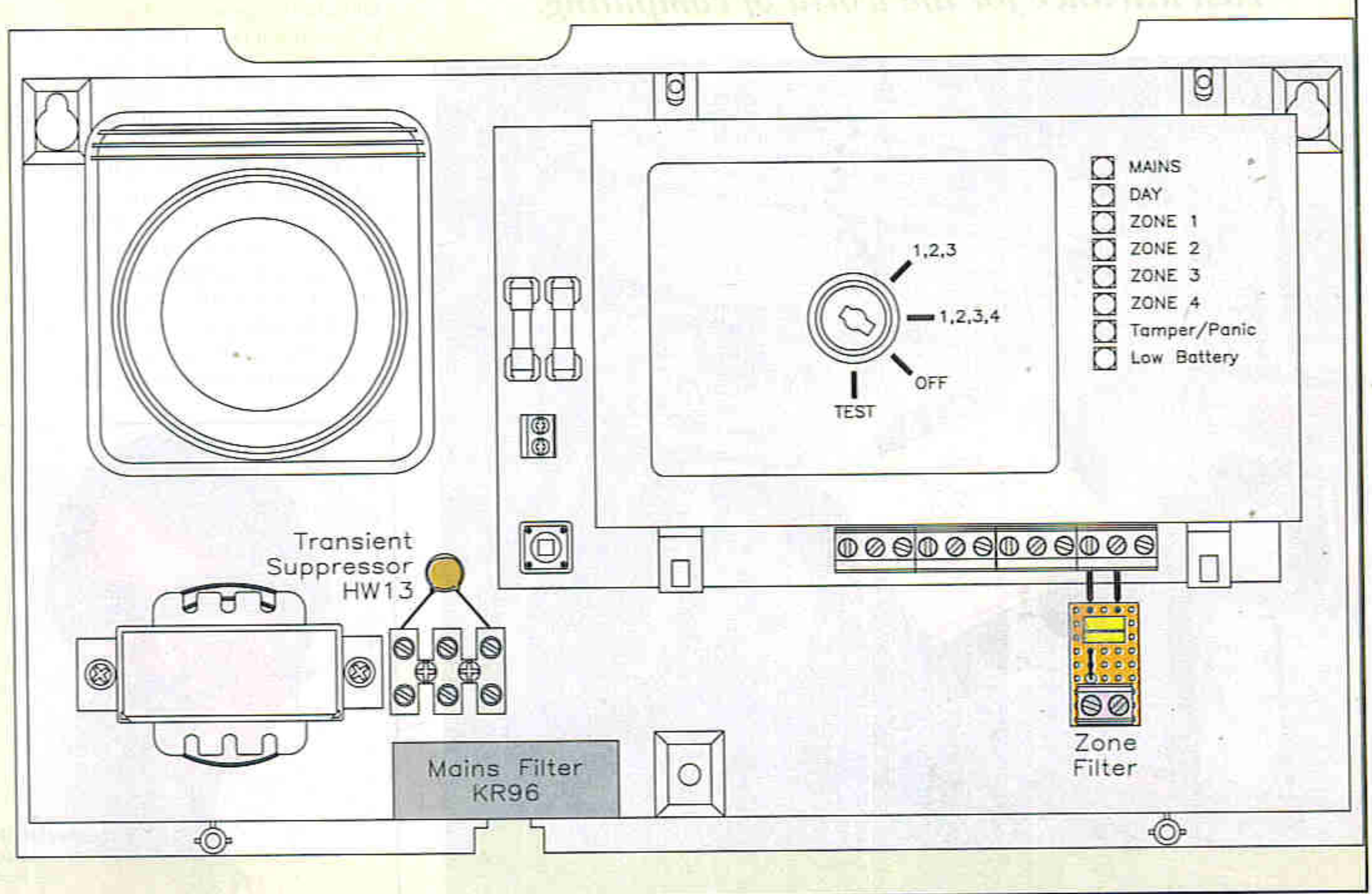


ALARM ZONE FILTER PARTS LIST

TS1	14V Transient Suppressor	1	(CP68Y)
C1	100nF 50V Ceramic Disc	1	(BX03D)
L1	1μH RF Choke	1	(WH29G)
	2-way 5mm PCB-mounted Terminal Block	1	(JY92A)
	Stripboard 1039	1	(JP46A)*
	Sleeving	As Req.	(BH00A)

* The actual size of board required is 9 holes × 5 tracks. Therefore, one 1039 board is sufficient for 8 filters.

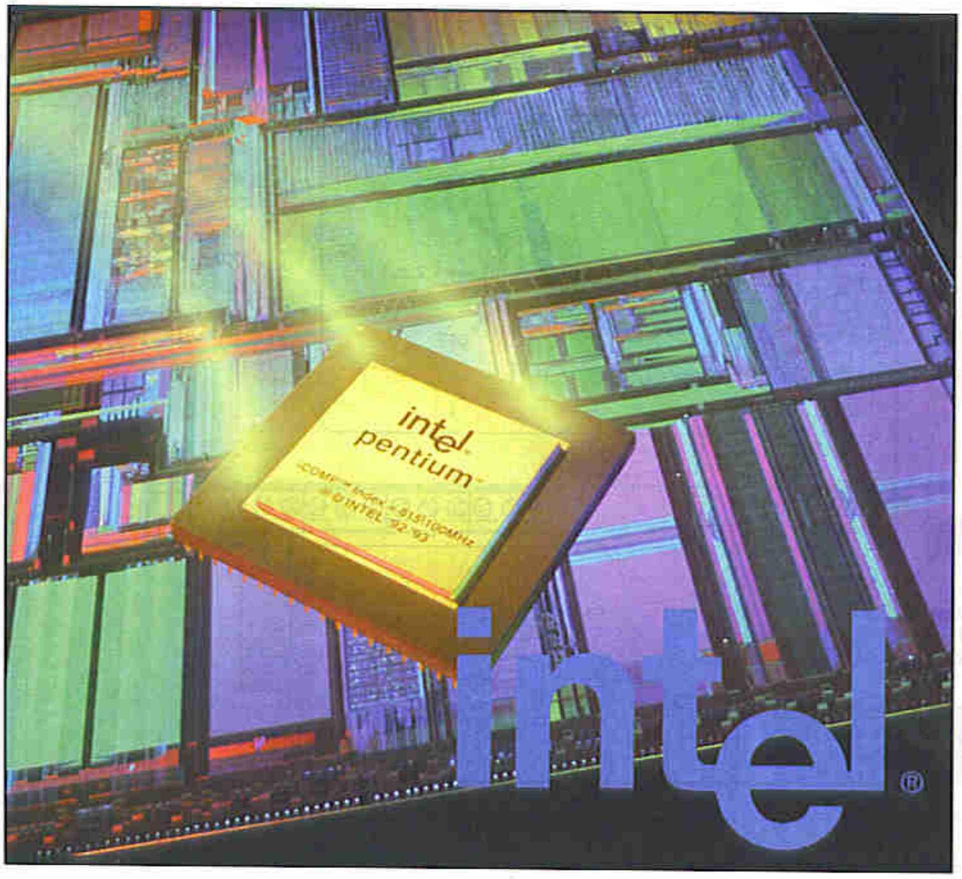
Figure 3. Typical installation of interference protection devices into an alarm control panel.



Intel: THE ARCHITECT OF THE MICROPROCESSOR REVOLUTION

Text by Alan Simpson

Our intrepid Out & About features writer, Alan Simpson, traces the rise and rise of one of the world's most innovative and pace-setting companies, Intel recently announced worldwide the Intel Pentium Processor with MMX Technology. Just one more step along the way for Intel – but a vast advance for the world of computing.



When it comes to being in the forefront of high technology, there is no greater IT player than Intel. Last year, the company celebrated it's 25th UK birthday – a celebration which could include the 25th anniversary of the microprocessor. With over 26,000 employees around the world and annual revenues approaching $10 billion, Intel has many claims to fame. Back in 1968 in the US, the company developed the process and first products that launched Intel on the road to becoming the world's largest semiconductor company.

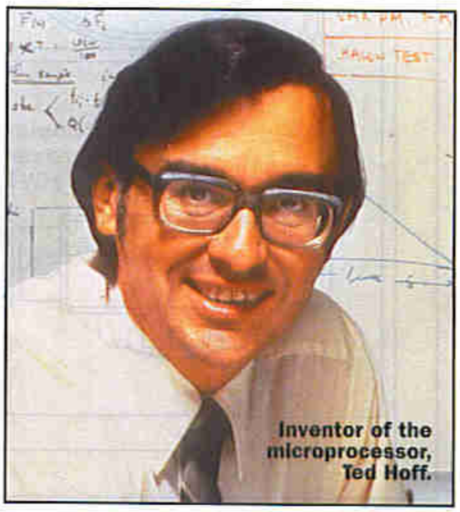
In 1971, Intel introduced the first microprocessor, a product that has changed the world. Today, Intel supplies the computing industry with microprocessors to create advanced computing systems, each offering more performance that the previous one. As of today, more than 150 million systems are powered by Intel processors, making the 'Intel Inside' logo known and respected all over the world.

The processor is the heart of the PC: The 'Intel Inside' logo means that the PC is based on a genuine Intel processor. PC buyers look for the logo because it not only certifies the origin of the processor, but combines quality, reliability and investment protection. But back to the history.

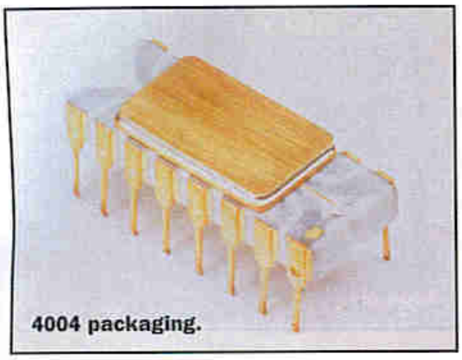
Life Before the Microprocessor

The development of the revolutionary microprocessor product is a story of vision, willingness to embrace change, and just plain luck – a story that put Intel at the very heart of the Information Age. In fact, the microprocessor has changed our lives in so many ways that is difficult to recall how different things were before its invention. As Intel point out, in the 1960s, computers filled entire rooms. Their expensive processing power was available only to a select few in government labs, research universities and large corporations. The mid-1960s development of integrated circuit had enabled the miniaturisation of electronic circuitry onto a single silicon chip. However, the world was still sceptical. The large scale integration of transistors onto silicon was still an emerging business.

At its founding in 1968, Intel had carved out a unique challenge to make semiconductor memory practical. This was



Inventor of the microprocessor, Ted Hoff.



4004 packaging.

quite a stretch, considering that silicon memory was at least 100 times more expensive than magnetic core memory, the leading technology at the time. But Intel's founders felt that semiconductor memory's advantages – smaller size, greater performance, reduced energy consumption – would convince manufacturers to try the new technology.

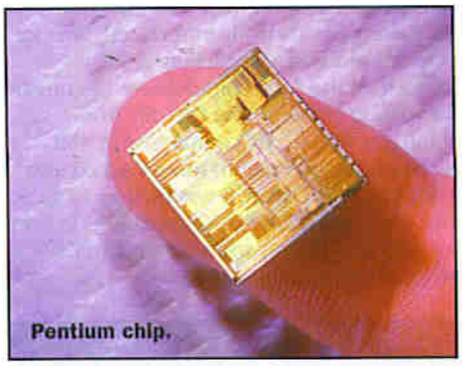
Busy developing the first profitable semiconductor memory products, the company barely noticed the beginnings of the microprocessor revolution. It started modestly, when a Japanese manufacturer asked Intel to design a set of chips for a family of high-performance programmable calculators. At the same time, all logic chips (those which perform calculations and execute programs as opposed to memory chips which store instructions and data) were custom-designed for each customer's product. By definition, this process limited the widespread application of any one logic chip.

But that was all about to change. The Japanese order for their calculator called for at least 12 custom chips. But Intel rejected the unwieldy proposal and instead designed a single-chip general-purpose logic device which retrieved its application instructions from semiconductor memory. As the core of a four-chip set, this central processing unit not only met the customer's needs, but could be plugged into a variety of applications without needing to be re-designed. As of today, more than 150 million systems are powered by Intel processors, making that 'Intel Inside' logo known all over the world.

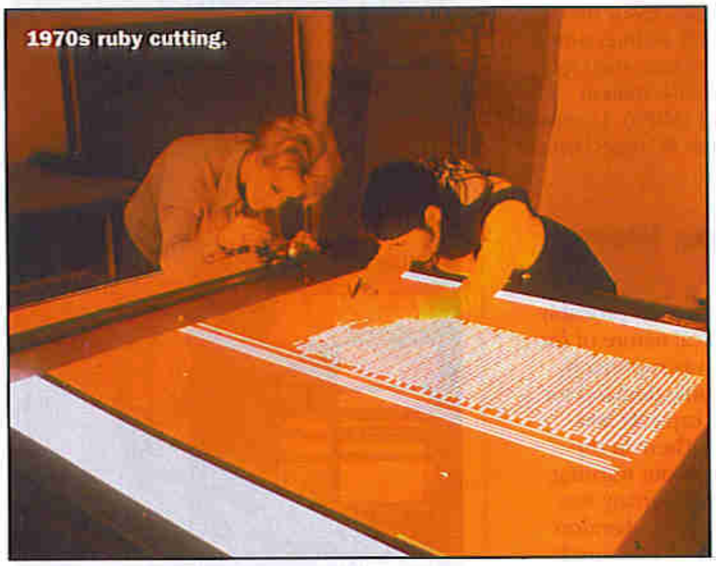
The Revolution Commences

1968 was a year of revolution: reports of war, anti-war demonstrations, assassinations, riots and drugs filled the daily papers. Little-noted was the incorporation of a new company, Intel, in Mountain View, California. The company started with 12 people in a single room and first year revenues were $2,672. This, as the company admits, this was hardly the stuff of legends, and amid the tumult of 1968, one would had to have been a true visionary to endorse Intel's statement that "we are the true revolutionaries".

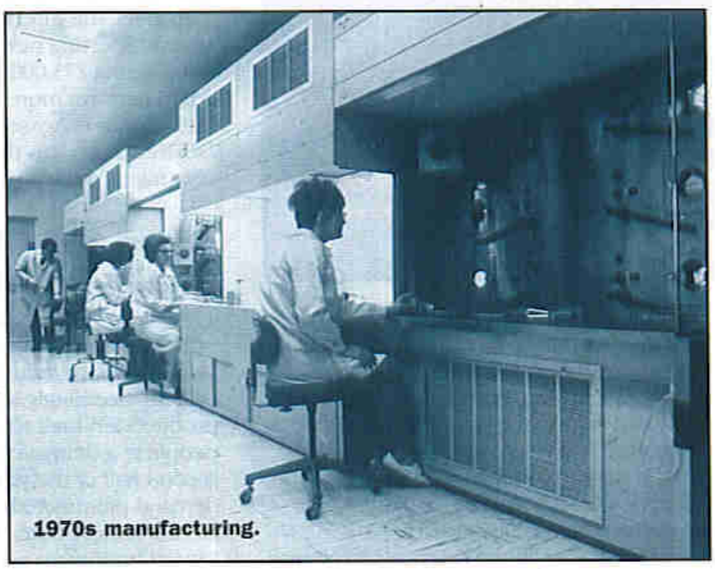
When Intel started, three different approaches to semiconductor memory offered promise: Intel pursued all three – the Goldilocks technology strategy. Multichip memory modules proved too hard and the technology was abandoned without a success product. Schottky bipolar worked just fine but was so easy that other companies copied it immediately and Intel lost its advantage. However, the silicon gate metal-oxide semiconductor (MOS) process proved to be just right. Even though MOS was 'just right', making memories proved difficult. Those present recall the fab area looking like Willy Wonka's factory, with



Pentium chip.



1970s ruby cutting.



1970s manufacturing.

1990s plot design.

1990s manufacturing.

hoses and wires and contraptions chuffing along – the semiconductor equivalent of the Wright Brothers' jury-rigged airplane. It may have been state-of-the-art manufacturing at the time, but by today's standards, it was unbelievably crude.

For the record, these opening years were also memorable for Neil Armstrong becoming the first man to set foot on the moon, with the hit song of the time being 'Bridge Over Troubled Water'.

Hello to the Microprocessor

Five years on, Intel had developed the process technologies necessary to achieve the large-scale integration of transistors onto silicon. The 4001 microcomputer set (the term *microprocessor* was not coined until later) was formally introduced. Smaller than a thumbnail and packing 2,300 transistors, the $200 chip delivered as much computing power as the first electronic computer, ENIAC. By comparison, ENIAC relied on 18,000 vacuum tubes packed into 3,000 cubic feet when it was built in 1946. The 4004 executed 60,000 operations in one second, primitive by today's standards, but a major breakthrough at the time.

Pentium Pro packaging.

Soon after the 4004, Intel developed the 8008 microcomputer, which processed eight bits of information at a time, twice as much as the original chip. For the first time, affordable computing power was available to designers of products – and this potential sparked boundless creativity and innovation, including digital scales, traffic lights which can detect waiting cars, medical instruments, and airline reservation systems, to name but a few. Even so, the idea that Intel could outfit an 8000 processor with a keyboard and a monitor and sell it in the home was dismissed without a further thought.

A further unanticipated happening was the significance of the EPROM, introduced by Intel in 1971. The Erasable, Programmable Read-Only Memory was at first conceived of as a prototyping device. It was not until the blossoming of the microprocessor that the full potential of the EPROM was realised. As an alterable storage medium, the unit gave OEMs a flexible, low-cost way to store microprocessor programs. The unexpected synergy between the two chips is legendary. For many years, Intel was the only company that could make EPROMs in high volume. As a result, the EPROM was a significant product family for the company through the mid-1980s. For the record book, the hit song of the period was 'Tie a Yellow Ribbon Round the Old Oak Tree'.

Moving on to 1975, the company decided to create the 8086 as its first 16-bit microprocessor. A few years later, IBM's selection of the 8088 CPU for its first PC created a large installed base that cemented the commitment to compatibility for future generations. The Pentium processor, the latest powerhouse chip in the family, still can run every piece of software ever written for any microprocessor based on the Intel architecture.

The Crush is On

In 1979, – hit song 'Stayin' Alive' – Intel was facing stiff competition from the likes of Motorola. But what swung the battle Intel's way was their long-term commitment to the 8086/8088 line. Even so, the market generated just 10,000 units a year – a far cry from that of supplying tens of millions of units a year. In 1982, Intel introduced the 286 chip. With 134,000 transistors, it provided about three times the performance of other 16-bit processors of the time. Featuring on-chip memory management, the 286 was the first microprocessor that offered software compatibility with its predecessors. This revolutionary chip was first used in IBM's benchmark PC-AT. 1982 was also noted for the hit song 'Bette Davis Eyes' as well as the marriage of Prince Charles and Di.

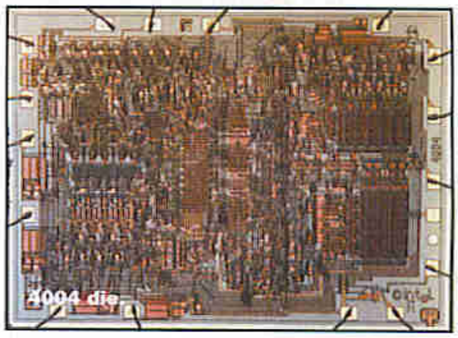
In 1985, the Intel i386 processor hit the streets. Sporting new 32-bit architecture and a staggering 275,000 transistors, the chip could perform more than five million instructions every second (MIPS). Compaq's DESKPRO 386 was the first PC based on the new microprocessor.

When the Chips Were Really Down

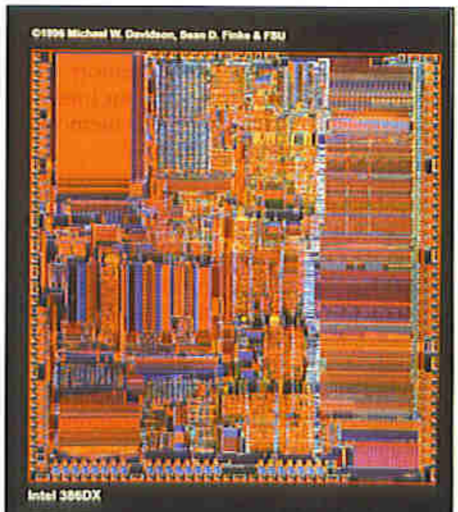
1984 was a year that Intel would probably prefer to forget. The cyclical nature of the semiconductor industry was supremely evident. Seemingly insatiable demand for products led Intel to add capacity and people at a dramatic rate. Then, in the second half of the year, without warning, demand plummeted. The company was forced to close seven factories, abandon several businesses and cut head count by one-third. However, the R&D budget was not cut. This was the year when divers found the Titanic in the Atlantic Ocean.

In 1988, with revenues exceeding $2 billion, Intel took the opportunity for a new technology known as flash memory. Flash offers the non-volatility of EPROMs with the added bonus of electrical erasability. The potential for flash is so significant that Intel has phased out its EPROM design and production in favour of flash. In 1993, with revenues approaching $6 billion, the company introduced its celebrated Pentium processor, setting new performance standards with up to five times the performance of the i486 processor. The Pentium processor uses 3·1 million transistors to perform up to 90 MIPS – about 1,500 times the speed of the original 4004.

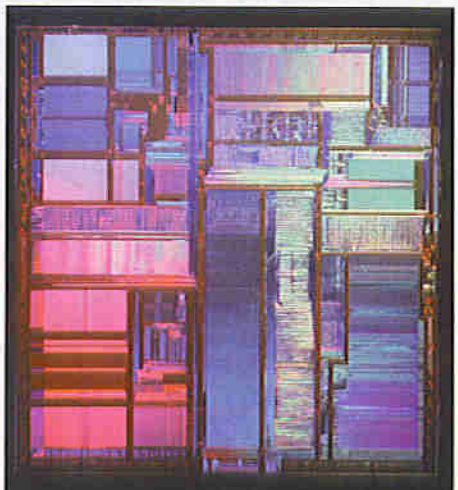
Aptly, the song of the year was 'A Whole New World'.



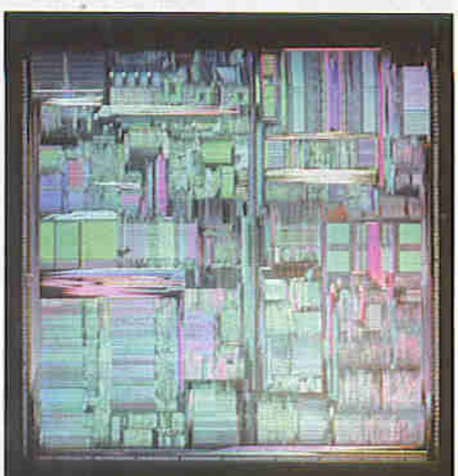
4004 die.



386 die.



Pentium die.



Pentium Pro die.

The Powerhouse Shockwaves

Two years later saw the introduction of Intel's previous powerhouse, the Pentium Pro processor. With 5·5 million transistors, this chip is packaged with a unique second die containing high-speed memory cache that further accelerated its awesome performance. Capable of performing up to 300 MIPS, the 'chip on the block' rapidly became popular for running servers and high-performance workstations.

In 1991, PCs based on the Intel486 processor cost about $225 per million instructions per second of performance. The Pentium Pro delivers dramatically increased performance at a cost of only about $7 per MIPS. As Intel chairman, Gordon Moore, says, "If the auto industry advanced as rapidly as the semiconductor industry, a Rolls Royce would get half a million miles per gallon, and it would be cheaper to throw the car away than to park it."

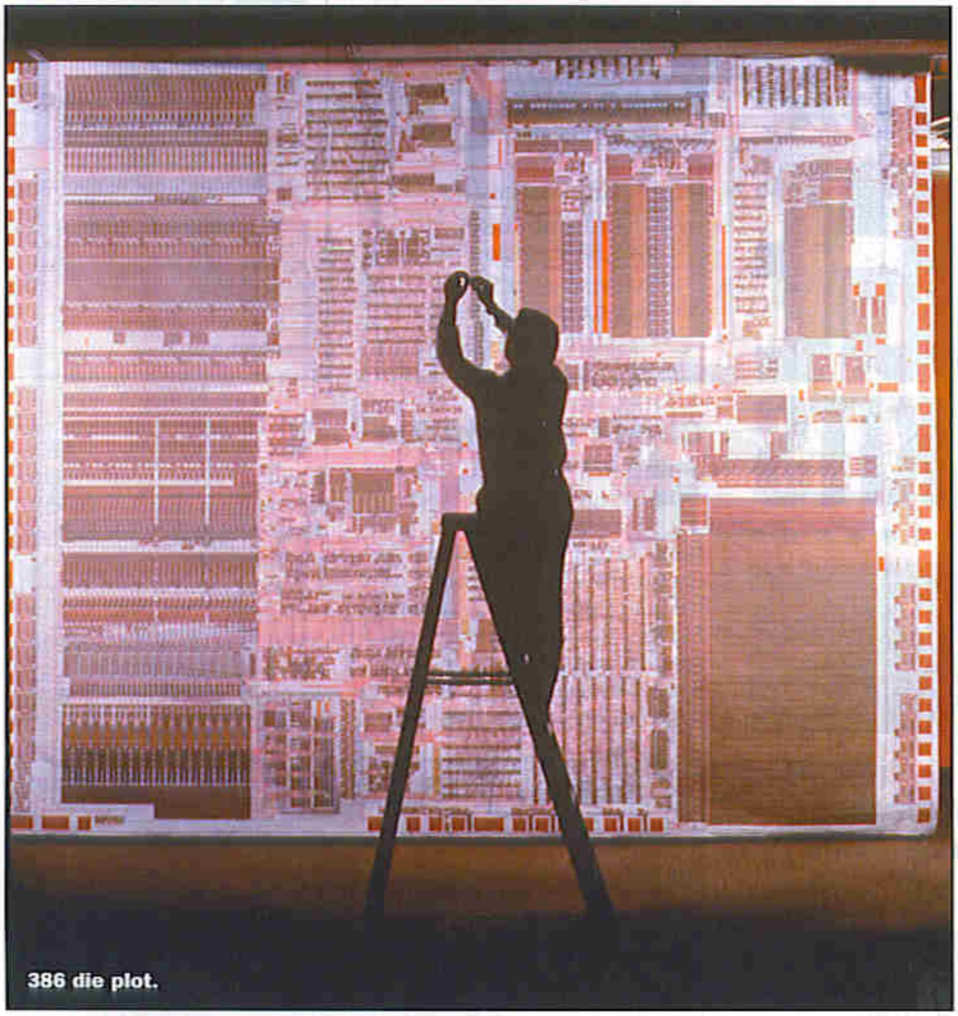
In fact, advancements in processor architecture and manufacturing technologies have enabled microprocessors to become smaller and more powerful, providing direct benefit to end users, including:

- Faster processors (running at higher clock speed)
- Simultaneous execution of several instructions (superscalar architecture)
- Lower cost (more processors on a single silicon wafer).

Moore's law states that transistor density doubles every 18 to 24 months, giving chip designers more flexibility to develop increasingly sophisticated processing engines.

Power the World

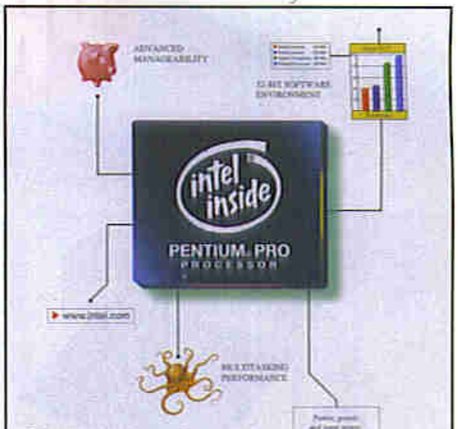
That first PC sparked a computer revolution. Today, the PC is everywhere, with over 200 million in use throughout the world. A child using a Pentium processor-based PC has more computing power than was available to mainframe computer operators just a decade ago; more power than the US government first used to send men to the moon. Today, the PC's emerging status as the linked communications device of choice is



386 die plot.

What	1971	1996
Number of transistors	2,300 on the 4004	Over 5 million on the Pentium Pro Processor
Instructions per second	60,000	300 million
Number of process steps	25 for the 4004	Over 200 major steps to produce the Pentium Pro Processor
Size of typical wafer fab	Approx. 5,000ft.²	Approx. 80,000ft.² (two American football fields)
Cost to build and equip a fab	Approx. $1 million	Approx. $1·5 billion

Table 1. The Microprocessor: Then and Now.



The next wave in business computing – PCs equipped with Intel Pentium Pro processors.

revolutionising modern life again. PC-based video conferencing, internal networking and the Internet are becoming the new business communications tools. People everywhere are turning to their PCs to tap into the Internet, to connect, explore and create new worlds of entertainment, information and communication. As microprocessor inventor Ted Hoff reflects, "Information is power. I like the way the microprocessor has spread that power around."

Into the Future

In its first 25 years, the microprocessor has enabled developments that were unimaginable a quarter century ago. However, we may be even more amazed at what emerges over the next 25 years. If current trends continue, Intel believes that microprocessors will become ten times faster and more powerful than they are today, facilitating an endless array of new applications. Audio, video and conferencing capabilities will be integrated with the World Wide Web. At home, people will be able to view and print family photos from their digital camera, using an intuitive photoshop program to remove red-eye, lighten dark backgrounds, and incorporate the photos into family newsletters and web pages. Software and hardware improvements are converging to bring users many exciting applications.

The increase in computing power will also be used to make computers easy to use. Voice and handwriting recognition, local control of complex Internet-based applications, and life-like animation demands considerable computing power. It takes thousands of hours of computer time to generate the animation for a movie like 'Toy Story', and today, it can't be played back on a PC. So, Intel customers will want a microprocessor design with millions of transistors that will be able to do 3-D animation on the desktop in real. Wow!

For the final record, those Spicey Girls are riding high. ELECTRONICS

Contact

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Pipers Way, Swindon, Wiltshire SN3 1RJ.
e-mail: http://www.intel.com/

±1·5A Variable VOLTAGE REGULATOR KITS

Power Supply Regulation

Design by
Tony Bricknell and Alan Williamson
Text by Tony Bricknell

This article describes two versatile, compact, easy to build and use variable voltage, positive- and negative-rail regulator kits. These regulators are suitable for almost any application requiring a DC power supply stage capable of providing a smooth and steady voltage level at currents of up to 1·5A. The positive and negative regulators may also be combined to create a dual-rail supply.

PROJECT RATING 3

Kit Available
Order as LU86T
(+1.5A Variable PSU)
Order as LU87U
(–1.5A Variable PSU)
Price £10.99 Each

FEATURES

- Output reverse polarity and back-voltage protection
- LED power on indication
- Variable voltage output
- Low Noise
- Compact dimensions

APPLICATIONS

DC power supplies

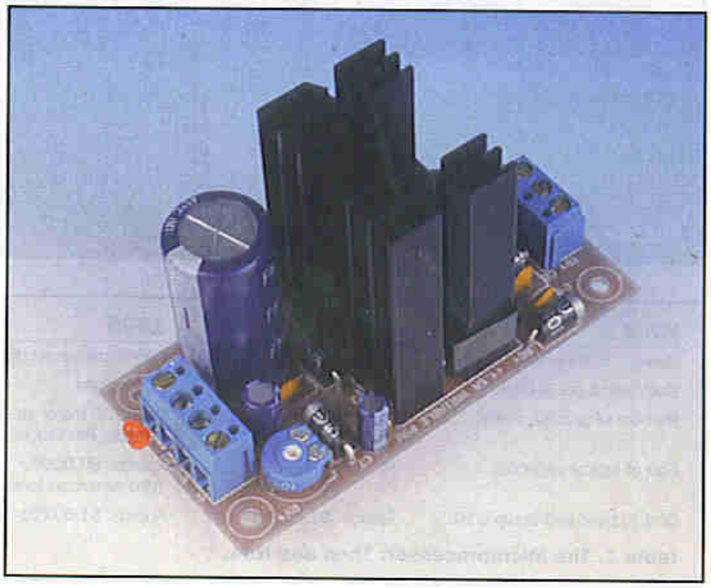
Important Safety Note

It is important to note that mains voltage is potentially lethal. Full details of mains wiring connections are shown in this article, and every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit, which should never be operated with the box lid removed. Safe construction of the unit is entirely dependent on the skill of the constructor, and adherence to the instructions given in this article. If you are in any doubt as to the correct way to proceed, consult a suitably qualified electrician or engineer.

Circuit Description

Figures 1 and 2, show the circuit diagrams of the two regulator types. Both circuits share a similar design, the only difference being in component polarities. In each case a bridge rectifier is formed from D1-D4, to convert the AC voltage from the transformer secondary winding into a DC level. Capacitors C1-C4 serve to reduce noise from the bridge rectifier diodes, to help meet compulsory EMC (Electromagnetic Compatibility) requirements.

Reservoir capacitor C5 provides low-frequency decoupling of the DC supply, and C6, high-frequency decoupling. RG1 is the voltage regulator employed to govern



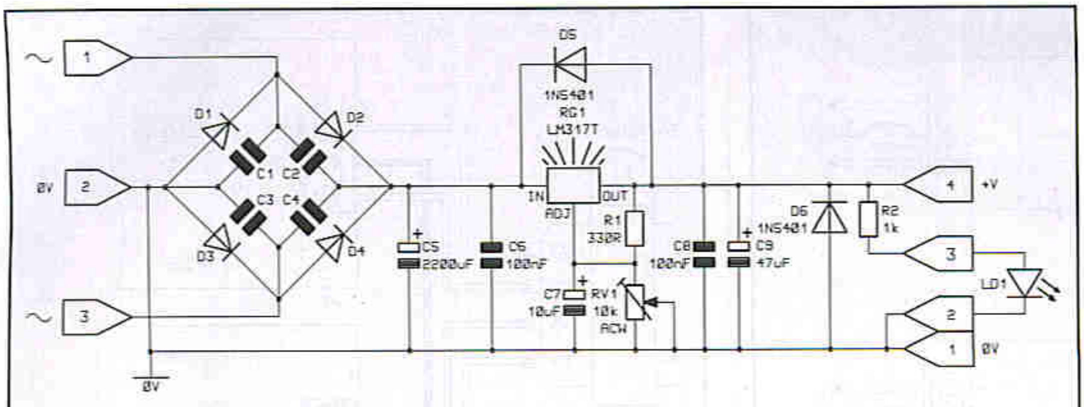


Figure 1. +1·5A Regulator Circuit Diagram.

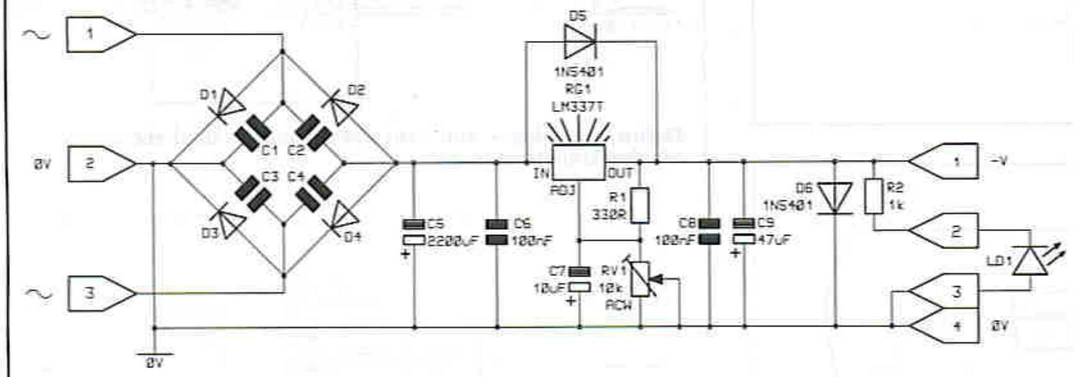


Figure 2. –1·5A Regulator Circuit Diagram.

the output voltage at the required current. Diode D5 is connected in reverse-bias between the RG1's input and output terminals, and protects the regulator if a voltage (of the same polarity) is applied to the output terminals (i.e. from a circuit with a large supply capacitance, for example). D6, conversely, protects the regulator if a voltage of reverse polarity is fed into the output terminals.

In operation, RG1 develops a nominal 1·25V reference voltage between the output and adjustment terminals. This reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current then flows through the output set resistor RV1, giving an output voltage of approximately:

$$V_{OUT} \approx 1.25\left(1+\frac{RV1}{R1}\right)$$

C7 serves to improve the ripple rejection of the regulator. C8 provides high-frequency decoupling of the output, while C9 is used for low-frequency decoupling of same. LED LD1 is used to indicate that power is present at the output terminals, and also to provide the required minimum load; if an LED is not required, an equivalent resistive load (minimum 5mA) MUST be fitted in its place.

This is very important as it ensures the output voltage does not 'float' under low load conditions. The value of the LED current limiting resistor, R2, will need to be selected depending on the chosen output voltage, see Figure 3; a nominal value of 1kΩ is supplied in the kit.

PCB Construction

The PCB is of single-sided construction – see Figures 4 and 5, showing the legend and track of the positive and negative regulators, respectively. Remember that removal of a misplaced component can be quite difficult, so please double-check each component type, value, and polarity where appropriate, before soldering! Construction is fairly straight forward; beginning with the smallest components first, working up in size to the largest. Be careful to correctly orientate the polarised devices i.e., electrolytic capacitors, IC and socket.

Assemble the board in order of ascending component size, but do not fit C5 or the voltage regulator RG1 yet. Ensure that the polarised components (i.e., diodes, electrolytic capacitors and LED) are fitted the correct way round, in accordance with the PCB legend/wiring diagram.

Heatsink Fitting

The heatsink chosen is a large vaned aluminium heatsink which should be soldered to the PCB before fitting the regulator. The procedure then is to ensure that the surfaces are clean prior to placing the semiconductor insulator pad between the regulator's metal back and the heatsink. Next, with the regulator in place with its leads in the appropriate PCB holes, affix the clip, by pushing

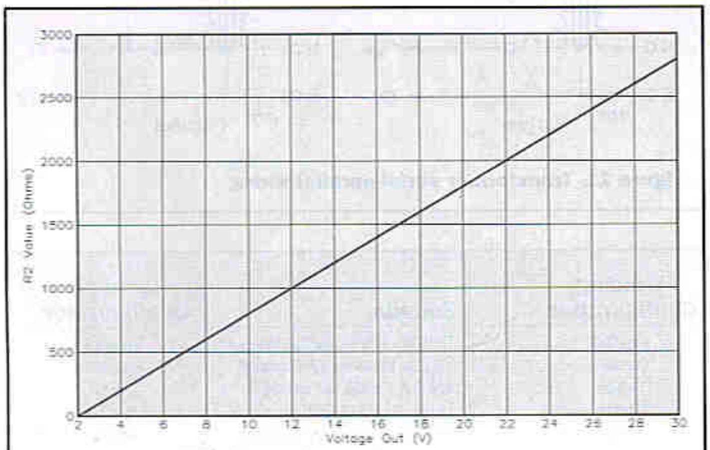


Figure 3. Selection of resistor R2.

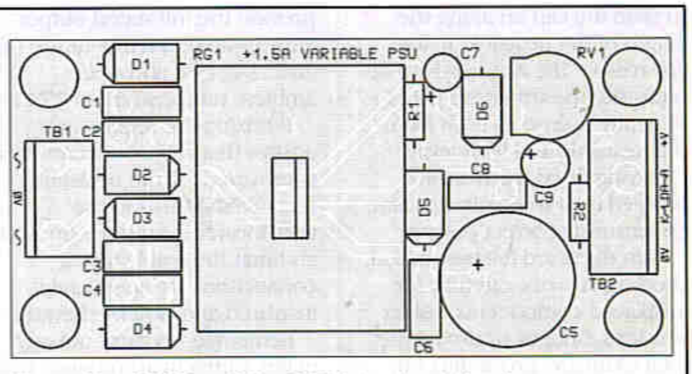


Figure 4. +1·5A Regulator PCB legend and track.

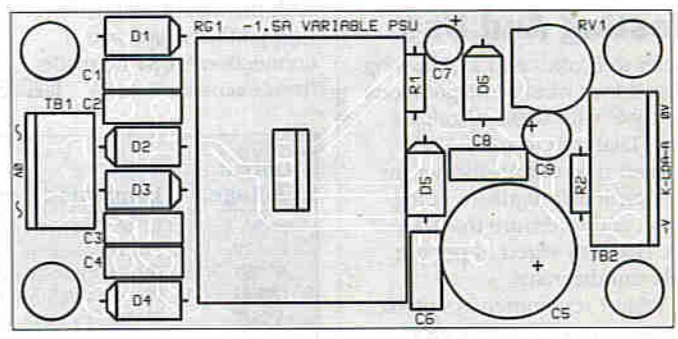


Figure 5. –1·5A Regulator PCB legend and track.

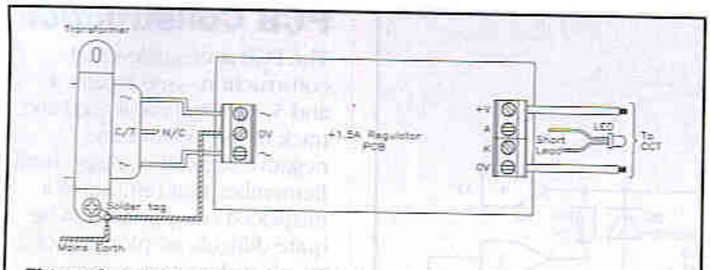


Figure 6. +1·5A Regulator wiring.

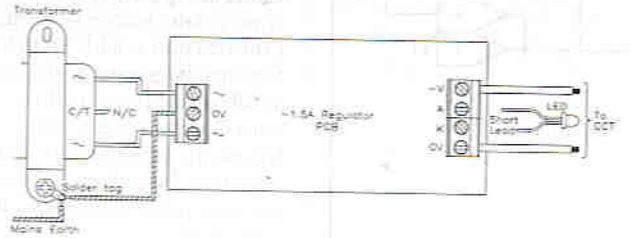


Figure 7. –1·5A Regulator wiring.

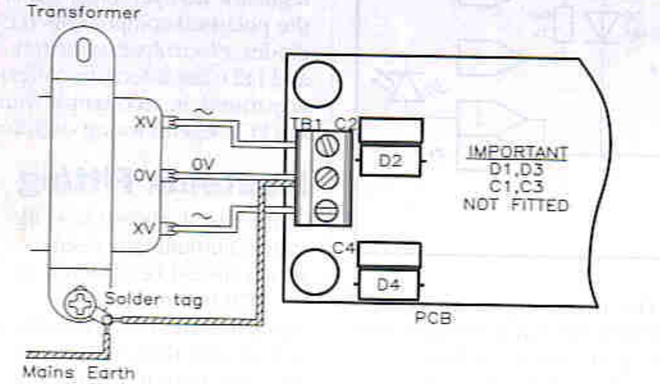


Figure 8. Regulator centre tap wiring.

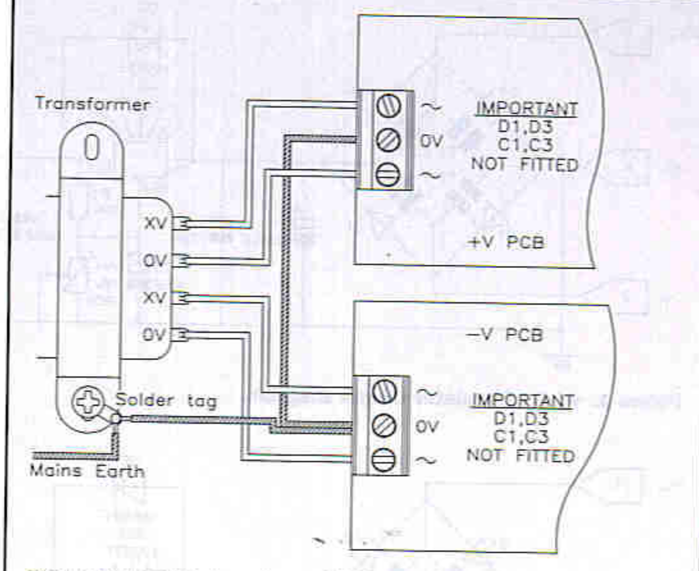


Figure 9. Linking + and – regulators using a dual secondary winding transformer.

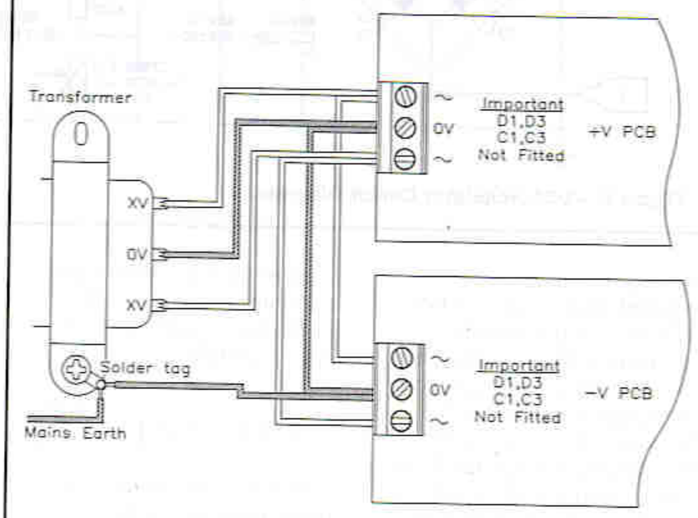


Figure 10. Linking + and – regulators using a centre tap transformer.

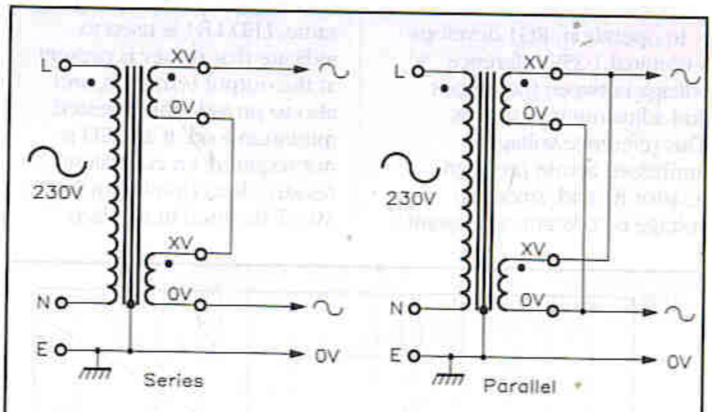


Figure 11. Transformer serial/parallel wiring.

it on at the front, having placed it at the correct height (to match that of the regulator body – NOT the metal tab). DO NOT attempt to slide the clip on along the length of the heatsink. If, for any reason, the clip needs to be removed, use thin-nose pliers to gently release its ends from the heatsink, and lift it away.

Having fitted the heatsink, proceed to fit reservoir capacitor, C5, ensuring correct polarity.

With the board fully assembled, check your work carefully for misplaced components, solder whiskers, bridges or dry joints, then clean any excess flux off the board using a suitable solvent.

Testing And Use

Refer to Figures 6 to 12, showing the various wiring configurations possible with these Regulator kits. Take care to select the correct type of transformer for the particular regulator being used, and to ensure that they are correctly wired as per the relevant diagrams.

Table 1 recommends suitable transformers for use at spot voltages; stock codes are given for both conventional 'laminated' types and toroidal types. Using the specified transformer and heatsink enables the regulators to provide the full stated output current up to a temperature of 70°C, i.e. 45°C above an ambient temperature of 25°C.

If boxing the regulators, ensure that sufficient ventilation is provided for the heatsink(s). It is ESSENTIAL that the transformer is properly housed, and that the mains wiring connections are adequately insulated and 'strain-relieved'.

Remember to carry out any mains wiring in accordance with the safety warning printed in this article, and to ensure compliance with the Electromagnetic Compatibility directive, a connection MUST be made from mains earth to 0V. ELECTRONICS

Output Voltage	Laminated Core	Winding Configuration	Toroidal	Winding Configuration
+/-5V	YJ50E (Std 12VA 6V)	Parallel	DH55K (15VA 9V Toroidal)	Parallel
+/-12V	DH27E (Std 25VA 15V)	Parallel	YK10L (30VA 12V Toroidal)	Parallel
+/-15V	DH30H (Std 50VA 9V)	Series	YK09K (30VA 9V Toroidal)	Series
+/-24V	WB26D (Std 50VA 12V)	Series	DH60Q (50VA 25V Toroidal)	Parallel
+/-30V	DH31J (Std 50VA 15V)	Series	YK16S (50VA 15V Toroidal)	Series

Table 1. Transformer vs Output Voltage.

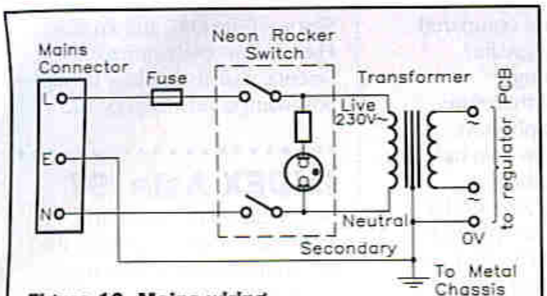


Figure 12. Mains wiring.

+1·5A REGULATOR PARTS LIST

RESISTORS: All 0·6W 1% Metal film (Unless specified)			
R1	Min Res 330Ω	1.00	(M330R)
R2	Min Res 1kΩ	1.00	(M1K)
RV1	Hor Encl Preset 10kΩ	1.00	(UH03D)
CAPACITORS			
C1-4,6,8	Disc 100nF 50V	6.00	(BX03D)
C5	GenElect 2200μF 50V	1.00	(AT72P)
C7	GenElect 10μF 63V	1.00	(AT77J)
C9	GenElect 47μF 50V	1.00	(AT67X)
SEMICONDUCTORS			
RG1	Reg LM317T NSC	1.00	(AV29G)
D1-6	1N5401	6.00	(QL82D)
LD1	Mini LED Red	1.00	(WL32K)
MISCELLANEOUS			
	Heatsink BW50-2	1.00	(AX85G)
	Heatsink 6801	1.00	(AX86E)
	Insulator TO218	1.00	(UL74R)
TB1	3 Way PC Terminal 300	1.00	(JY94C)
TB2	4 Way PC Terminal 300	1.00	(KE52G)
	+1.5A Variable PSU PCB	1.00	(GG42V)
	±1.5A Variable PSU Leaflet	1.00	(XZ40T)
	Constructors Guide	1.00	(XH79L)

–1·5A REGULATOR PARTS LIST

RESISTORS: All 0·6W 1% Metal film (Unless specified)			
R1	Min Res 330Ω	1.00	(M330R)
R2	Min Res 1kΩ	1.00	(M1K)
RV1	Hor Encl Preset 10kΩ	1.00	(UH03D)
CAPACITORS			
C1-4,6,8	Disc 100nF 50V	6.00	(BX03D)
C5	GenElect 2200μF 50V	1.00	(AT72P)
C7	GenElect 10μF 63V	1.00	(AT77J)
C9	GenElect 47μF 50V	1.00	(AT67X)
SEMICONDUCTORS			
RG1	Reg LM337T NSC	1.00	(AV32K)
D1-6	1N5401	6.00	(QL82D)
LD1	Mini LED Red	1.00	(WL32K)
MISCELLANEOUS			
	Heatsink BW50-2	1.00	(AX85G)
	Heatsink 6801	1.00	(AX86E)
	Insulator TO218	1.00	(UL74R)
TB1	3 Way PC Terminal 300	1.00	(JY94C)
TB2	4 Way PC Terminal 300	1.00	(KE52G)
	–1.5A Variable PSU PCB	1.00	(GG43W)
	±1.5A Variable PSU Leaflet	1.00	(XZ40T)
	Constructors Guide	1.00	(XH79L)

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

The above items are available as kits, which offers a saving over buying the parts separately.

Order as LU86T (+1·5A Variable PSU), LU87U (–1·5A Variable PSU)

The following new items (which are included in the relevant kit) are also available separately.
+1·5A Regulator PCB Order As GG42V
–1·5A Regulator PCB Order As GG43W

RESEARCH NEWS

by Dr. Chris Lavers

New Mid-IR Chalcogenide Lasers

A team headed by Dr Dan Hewak at the Optoelectronics Research Centre (ORC) Southampton, have succeeded in drawing multimode fibre of a new chalcogenide glass (GaLaS) 200m in length with a core diameter of 125μm for the first time (see Photos 1 & 2). Such fibre will act as potential laser sources in the mid-infrared (MIR) region and for applications including the detection of atmospheric trace gases, laser surgery and LIDAR.

Photo 1. Core of GaLaS fibre. (Courtesy ORC, UK).

Unfortunately, few lasers operate in the MIR region and none operate with diode pumping. Fibre lasers usually involve a section of silica-based fibre doped with rare-earth ions, e.g., erbium Er^{3+} forming the basic erbium-doped fibre amplifier (EDFA). The doped section is pumped with intense light, typically from a semi-conductor laser diode, and the doped section acts as a gain medium. Unfortunately, silica does not transmit above 2·5μm and the decay of closely spaced rare-earth energy levels is dominated by non-radiative decay processes preventing practical laser action.

Chalcogenide glasses have improved optoelectronic and acoustic properties compared with silica, having greater transparency at longer wavelengths (and therefore, lower loss due to phonon vibrations), and low non-radiative decay because of the low vibrational frequencies of the glass bonds. The low phonon energy of GaLaS glass shifts its absorption edge to a longer wavelength, giving transmission up to 8μm and a minimum loss of a few dB/m is found at 4·8μm, and agrees closely with theory.

The group has been working in this area for over three years and has several future applications in mind, including: passive IR waveguides for power delivery, remote sensing and imaging, in addition to active laser sources. The group hopes to dope the chalcogenide glass host with dysprosium or praseodymium to realise a 1·3μm optical amplifier which was initially funded by a LINK photonics project sponsored by Merck Ltd., which has been continued by Pirelli.

The work is supported by six industrial partners and also the Department of Trade and Industry, and is known as project LONGWAVE, the largest collaboration of its kind to date. The objective of LONGWAVE is to accelerate the development and exploitation of both passive and active long wavelength applications in chalcogenide glass. Passive fibres will act as a low loss transmission medium for the applications already mentioned, whilst active fibres will provide MIR laser sources for remote sensing, imagery and environmental sensors.

Such rare-earth dopants are preferred as low non-radiative decay rates results in higher quantum efficiencies, which increases the probability of laser emission at the desired wavelength. The group is also looking at developing laser emission in GaLaS glass at 4·3μm (doping with dysprosium Dy^{3+}), 3·9μm (holmium Ho^{3+}), and 2·7 or 3·4μm (erbium Er^{3+}). The high glass transition temperature of GaLaS (833K) is significantly higher than other IR and low phonon energy glasses, providing improved glass stability, moisture resistance, and a wider operating temperature range compared with other contenders such as fluoride based glasses, e.g. ZBLAN. The main task is now to improve glass quality by reducing impurity levels and to pull core/cladding composite structures.

Photo 2. Worker pulling GaLaS fibre. (Courtesy ORC, UK.)

The success of fibre fabrication has led to work on planar optical waveguides, which is being pursued conjointly by Dr Rob Eason of the ORC and Professor Harvey Rutt of the Infrared Science and Technology Group, Southampton University, UK.

IMDEX Asia '97

South East Asia's first naval exhibition is set to become the key to unlocking British naval exports. The first Asian International Maritime Defence Exhibition and Conference, IMDEX Asia '97, will take place at the World Trade Centre in Singapore between 6-9th May.

With the end of cold war superpower rivalry, the Pacific Rim nations are now reassessing how best to preserve their national integrity and vital economic resources. This has resulted in a major shift in emphasis towards expanding the capabilities of their naval forces for the first time.

Surface vessels dominate naval acquisitions – principally corvettes, frigates and patrol vessels. Regional market projections over the next decade estimate that naval funding could exceed $85US billion for ship purchases alone. It has been estimated that up to 17 destroyers, 70 frigates, 25 corvettes, 45 submarines, 90 minehunters and up to 50 amphibious warfare ships will be required. At least 18 shipbuilders will be present at IMDEX Asia '97, including Vosper Thornycroft UK, and the Royal Navy is set to send a modern frigate and major capital ship.

The conference will act as an important platform for sales of sophisticated radar and electronic equipment, sonars, communications systems and navigation equipment. The specific scientific sessions begin on Wednesday 7th May with sonars and continue with environmental modelling and above water sensors. The second day covers a variety of topics, including: stealth, air defence and simulation. The last day of the conference, Friday 9th May, details underwater platforms.

Further information about IMDEX Asia '97 and details of delegate fees may be found by faxing: +44 (0) 181 949 8168.

New Long Wavelength Quantum Well Infra-red Camera

The JET Propulsion laboratory, Pasedena California and the imaging company, Amber of Goleta, California, have recently announced that they are to collaborate on developing a cooled long wavelength infra red

(LWIR) camera. The aim is to design an infra-red imaging system combining JET's successful technology using quantum well infra-red photodetectors (QWIP's) and Amber's 256 × 256 readout multiplexers.

Infra-red (IR) photodetectors made from materials already tested in laser fabrication promise a superior new generation of IR cameras and night-vision devices. These quantum sensing devices are made from alternate layers of semiconductor materials arranged atom by atom into layers just a few atoms thick, incorporating familiar materials such as Gallium Arsenide (GaAs) and Indium Gallium Arsenic Phosphide (InGaAsP).

Quantum wells are already widely used in lasers to generate light from electricity but in night-vision devices and infra-red cameras, this process is reversed. With conventional quantum well devices, electrons can only exist in one of two energy bands, either a low energy 'valence' band or a high-energy 'conduction' band. In conventional detectors, a photon striking the detector surface liberates an electron into the conduction band which may generate an electrical signal if a voltage is applied across the detector head. The most recent QWIPs are so sensitive that incident photons may be detected which only have enough energy to shift electrons within the bands.

Such GaAs/InGaAs materials may be fabricated into large 2-Dimensional arrays sensitive to both the 3-5μm and 8-13μm infra-red radiation transmission 'windows'. Since the Earth's atmosphere is relatively transparent across these two wavelength ranges, an infra-red QWIP array camera mounted on a plane, low Earth orbit satellite or even ground-based system should be capable of high resolution infra-red images. QWIP detectors also offer several additional advantages over other LWIP detector materials such as CdHgTe, including: higher detector-to-detector uniformity, easier semiconductor fabrication, higher yield and therefore, lower unit cost.

It is possible that the Amber Radiance infra-red camera and JPL's QWIP focal-plane array will be combined together to create a powerful analytical infra-red imaging tool. Amber was the first company to connect computers to infra-red focal-planes. Jeff Heath, on the Radiance Design Team, states that the built-in general-purpose processor program may be configured for any number of applications such as long distance tracking. ELECTRONICS

REVIEW

The Consumer ELECTRONIC SHOW 1997

Text by J. A. Rooney G4-PXZ

The Consumer Electronic Show (CES) in January in Las Vegas, saw 94,000 international visitors examine the products of nearly 2,000 companies exhibiting in one million sq. ft. of display area. This is the biggest show in the world and is a barometer of the latest products designed to enhance and improve consumers' lifestyles.

Latest figures show consumer growth in the Electronics Industry as 10% last year compared to a gross domestic product of 2% – a 5:1 ratio over GDP. New technology has had to be innovated because general household items like televisions, speakers and video recorders had reached a peak of development and market saturation where even compact disc players that were 'state-of-the-art' left a lot to be desired.

After CD was introduced in 1982 with a promise of perfect sound forever, a promise which quickly eroded, recordable versions were finally developed in 1989. These were WORM players (Write Once Read Many). Unfortunately, the music industry stumped on this new technology; fearing a loss of copyright, they introduced SCMS (Serial Copyright Management System). This only permitted single copies of a pre-recorded CD, but prevented anyone making a copy from that copy by encoding inhibitors into the technology. Mini-discs will record digitally, on 2″ magneto-optical discs, and will store a few seconds of recording on a solid-state memory chip to act as a buffer, preventing skipping, which can result from jolts or bumps. An MD can record up to 74 minutes of digital audio, and Mini-Disc is now in revival with Sony and Denon offering Mini-Disc home recorders. Of more interest is the Mini-Disc camera just introduced by Sharp, using 140M-byte to provide 2,000 still-frame images of high quality. A fully erasable/recordable system for Compact Discs was launched last year and called CD Erasable (CDE).

CD-ROM has long been developed for computer use and in 1995, Quad-Speed ROM Drives became a common feature of multimedia PCs.

The CES Show saw the launch of Digital Versatile Discs (DVD) offering almost limitless potential. DVD comes in single or double density discs and special new short wavelength (635nm) lasers can read video data at 0·6mm into a disc and pick out audio data resting at 1·2mm. They offer seamless interruption of full-length movies without stopping to flip the disc over. They can also decode PCM data to provide true 20-bit words at up to 96kHz.

Freeze-frame on DVD offers an absence of digital vibrations and frame-by-frame in 2, 10 or 30 produces sequential images without strobe effect, so common to Laser Disc. Typical audio specs. are 4Hz to 44kHz, with a signal-to-noise ratio of 106dB. and a dynamic range of 96dB, with total harmonic distortion of 0·003%. This offers new horizons for audiophiles, but true blue purists may still opt for the analogue route of a record deck, while they can still purchase turntables like Gold Signature Proscenium from Walker Audio (see Photo 1).

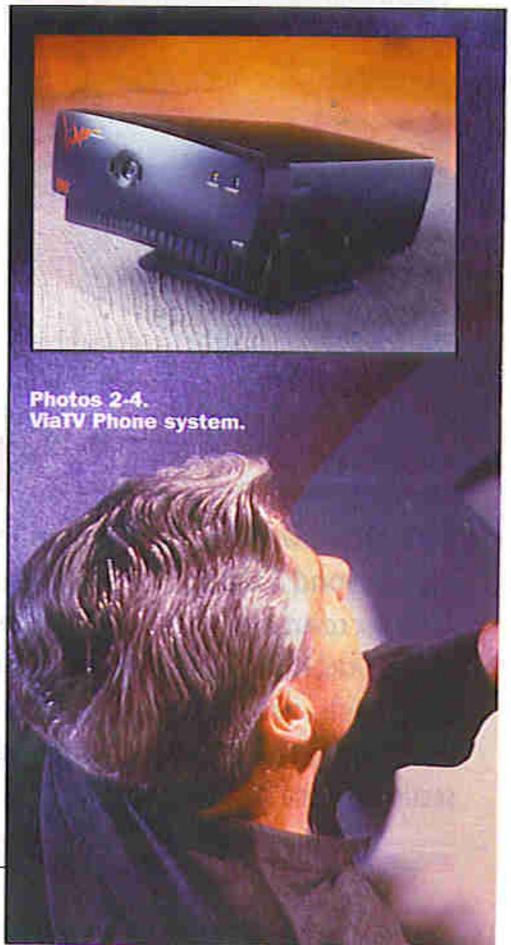
The tangential arm has true air suspension, employing a high pressure of 50psi. It contains eight fixed jets and a quad-vent outlet, resulting in a close tolerance with rigid carbon-fibred, brass-bonded, silver-wired arm-shell. Here, of course, a

Photo 1. Gold Signature Proscenium turntable from Walker Audio.

remote-drive motor is *de rigeur*. The rest of your mortgage could go on a compatible cartridge and some valve-powered mono-blocks which are currently in renaissance.

At present, DVD/ROM machines are available, but TDK promise DVD/RAM (erasable/recordable) players and discs for 1997 with technology so staggering it verges on science fiction. Currently, DVD/RAM can only store half as much as DVD/ROM (2·6G-byte as opposed to 5G-byte per side), but shorter wavelength (635nm) lasers will alleviate the critical density issue. Using AVIST phase-changing, the error rate does not increase however large the number of write-over cycles and a wide range of speeds from 1-20m/s can accommodate all data rates from CD to DVD. On re-recordable DVD, the recording layer is sandwiched between two dielectric layers (zinc sulphide and silicone dioxide) and is backed by a reflector.

The laser penetrates through the polycarbonate surface and first dielectric to focus onto the recording layer. When the temperature reaches 600°C, this layer melts. The recording layer comprises a phase-change alloy which can exist in two different



Photos 2-4. ViaTV Phone system.

states; in a crystalline state where the atoms form regular patterns, or in an amorphous state where they are randomly arranged. The state of this alloy layer at any one time depends on how fast it cools.
The polycarbonate surface would melt at 130°C, but the fine focusing laser only melts the layer between the two dielectrics. By pulsing the laser between high and low power, the bits that cool quickly remain amorphous, and the bits that cool slowly tend to crystallise. The recording layer then resolves itself into crystal (highly reflective) or amorphous (low reflection) states, ready for the laser to read on playback.

In the beginning was vinyl. Vinyl begat flower-pots (oops – sorry); vinyl begat CD; then CD begat Mini-Disc and CD WORM; they begat Video CD and CD-E. They begat MD-R, and DAT, which begat the great Laser-Disc.

Then there was heard a great wailing of audiophiles and a gnashing of vinyl freaks, and lo and behold, DVD was begat. It begat DVD-ROM and it begat DVD-RAM and there was peace in all the land.

DVD offers 500 lines (twice that of video) for 133 minutes, in three screen formats in a choice of eight languages with up to six separate audio channels, and up to 32 sub-titled languages, and that is just the start.

If we use DVD in conjunction with Home Theatre and a Home Computer, a picture evolves for the future family lifestyle. Central to the set-up would be a Plasma or LCD screen monitor which could be moved from wall to wall or placed at any convenient viewing angle. It would receive high-definition television (HDTV) in Dolby Digital, promising twice the resolution of current broadcasts, and would also be fed from a Home Theatre system, providing 6-channel audio with multi options, such as movies on Laser Disc or DVD, or CD/Audio piped via IF and RF to the bedrooms, while another room could view or record video through, say, the JVC Satellite Tuner capable of operating simultaneously with a digital camcorder, which itself could be linked to a Video-Snappy, giving high resolution capture shots off video or off a TV or camera. Reasonably priced at $500, it is currently available in the U.S.A. only. This device captures instant images frozen from the screen which can be cropped and even morphed to provide snap shots with 1,500×1,125 resolution. One may even prefer a direct instant telephone link using a modem by Via-phone, or even a video conference link-up via C-phone. Their modems plug into a television, and having a built-in colour camera, they provide the party at the end of the line, who has a similar, but not necessarily proprietary (same brand) system, full two-way viewing. Room lighting and call distance also affect the video quality, but the range goes to 15 frames per second (fps), normally.

Television is about 30fps and film about 24fps. The systems are full duplex, echo-cancelling to give clear audio and can be set up for conference facilities. They transfer data at 33k-byte/s, in both directions (see Photos 2-4).

T.T. Systems are offering a Tele-recorder which records 90 minutes of calls digitally on a 3·5″ floppy disc and their TA 2000 phone can have motion detectors, smoke and medical alert alarms incorporated. Mum can check if the kids are in bed and see them via BellLabs 2″ Video-phone by the bedside. She could pick a bedtime CD from a selection of 200, stored in a Sony CX200 Player with digital readouts of album, tracks and artist details offering limitless shuttle selection.

Ideally, a PC would be the centre of such sophistication, and a plasma monitor is a viable option, being only 150mm thick, while Sony have just perfected a triple LCD screen which, although twice as thick, carries over one and a half million pixels for a true lifelike display. This is their KL372 TV. If not deploying a computer in the system, and access to the Internet is required, Mitsubishi offer an Internet television, and Sony's Power-Wide television offers a TV image on one half of the screen and a computer image on the other.

Ancillary Network-Computer boxes (NC boxes) also give Internet information to products and goods which viewers can buy instantly by swiping a smart card through the slot in the box. These NC boxes will soon appear at banks and supermarkets, offering instant shopping on the Net.

The Mitsubishi 40″ Plasma Monitor boasts 160° viewing, both vertically and horizontally, and encompasses 16·7 million colours. Plasma produces its own luminescence, via many thousands of individually charged chambers filled with neon/xenon gas mixtures. When electrically charged, they glow and a picture is formed. Sharp and Sony are jointly developing a Plasma Added Liquid Crystal (PALC) monitor which results from Sharp's research into wide-angle LCD technology, combined with Sony's Plasma expertise.

This leading edge technology now provides state-of-the-art resolution. Plasma Screens currently cost about $15,000 Dollars, but Kodak's Digital LCD camera sold for $10,000 3 years ago; it now costs a few hundred dollars, so plasma screens should be drastically cut in price as the technology develops.

In such a sophisticated system, a computer could control the security system, heating and air conditioning for the house with automatic video phone recording. Infra-red technology can be combined with RF technology using 2·4GHz to avoid interference in transmitting audio and video through walls and ceilings. Different speakers in different rooms will require no wiring; just plugging in, of the wireless receptors. Link Technology Inc. even offer phones that monitor valuable family possessions where movement detectors can be attached to, e.g., a set of golf clubs which, when moved out of its 100ft. range, can activate the phone to ring the police. JVC and Fisher both offer Speed Watch VCRs, where tapes can be viewed at double speed to sample content. The audio is condensed but none is lost because in normal speech, there are many pauses between words, which when eliminated, can play back conversations at normal speed, while picture speed is actually doubled. There is extensive peripheral technology to enhance the family lifestyle; for example, the video Discbaby is a DVD player with a 4in. LCD colour screen, offering Hi-Fi stereo and MPEG quality playback. Being completely portable at 3lbs, it can play full-length movies, videos and audio CDs, as well as Karaoke.

Nu-vision offer an LCD screen to fit over a monitor which provides different polarisation for left and right eye images. Special glasses called 3-D Specs resolve the circular polarisation to provide very realistic 3-D images.

Photo 5. Kenwood 1090VR Dolby Digital Audio/Video receiver with Futureset remote control.

Photo 6. The Bass Shaker Plus by Aurasound.

Photo 7. Bazooka Sub-woofer.

The heart of any audio-visual system must be a Home Theatre Processor. This should be a Dolby Digital receiver or amplifier offering AC3 which provides six separate channels of stereo, e.g., the Kenwood 1090 (see Photo 5) giving 120W for each of the 5 channels, being left, centre and right, with two surround channels and a pre-amp feed for a sub-woofer. Hence, the designation of 5.1, which is the official Dolby classification. The 1090 will send independent audio and visual to two separate rooms, giving different on-screen displays, while the CD plays in one room and a movie shows in another. Great value at $1,200.

Ronco have just introduced the world's first THX Lucas Certified Laser-Disc Player, offering line-doublers and even a line-quadrupler. Essential to Home Theatre reproduction are DSP facilities. Normally built into the amplifier, they acoustically re-shape the music to simulate different listening environments by generating reflected wave patterns that signify the acoustics of different venues. The listening room is then transformed into a stadium or a Cathedral, or even an intimate Jazz Club. The new Onkyo Integra receivers are the first to use the new Motorola DSP chips; the 56009 for Dolby Digital and the 56004 for more life-like modes. Their DS939 offers THX certification as well as AC3. It punches 100W to all channels and retails at $2,800 in the States. This is a premium product at a premium price.

New kid on the block for Home Theatre in AC3 and currently a big Dolby rival are Digital Theatre Systems (DTS). They claim their system can deliver 24-bit sound at 96kHz into 5.1 music channels; that is as good at it gets! This noticeable improvement over Dolby Digital is achieved by using more space for sound on Laser Discs or DVDs. The '.1' in this configuration refers to decoding and controlling bass frequencies. Past studies have shown that below 100Hz, stereo separation is imperceptible, and bass placement of little consequence, but many experts now believe that localising low frequencies is critical, even to the point of separate left and right channels. This is said to be due to sub-harmonics, and the sensing ability we all possess to define the constriction of a room or building, which emanates speech or music. Each environment produces a distinctive audio signature. This is also the reason current CD technology does not offer "perfect sound for ever", as initially claimed. Although few of us hear about 20kHz which is the approximate cut-off frequency for Compact Disc, the ambience of the harmonics is missing. Consequently, the greater the bandwidth, the more enhanced the audible and tactile range of perception. Technology is now exploring new depth (sic) in regards to low frequency response. Motor-driven Turbo-Bass speakers are fed very low bass to a piston motor which pumps and pulls a diaphragm in positive and negative response to move large volumes of air very quickly. These are big in price and dimension, necessitating an inbuilt Acoustic Bass resonator; an extra free-floating diaphragm which oscillates in opposition to the dynamics of the piston-driven speaker, avoiding implosion or explosion of wooden enclosure.

The Carver Corp. have just introduced their Sunfire Subwoofer Cube. It has a built-in 2,700W amplifier (sic) and measures less than 1ft^3.

Aurasound have introduced neodymium magnets for high excursion in small speakers, using PVDF accelerometers, as used in car air-bag sensors to develop a servo system for extended bass and low distortion in a small enclosure.

I was very excited, literally and figuratively, by Aurasound's Bass-Shakers (see Photo 6). These are compact metal-frilled resonators that screw under the seat of your car or even your armchair. They are fed by 100W digital amplifiers and give four times more bass than conventional subwoofers by causing the surrounding area to which they are attached to resonate with deep-felt bass without the damaging effects of high pressure sound levels.

Southern Audio extend their Bazooka Series of subwoofers using bass tube enclosures to compliment computer-terminal speakers. These little 6W tubes offer computer work stations a master volume for all speakers plus subwoofer levels with bass contour control; suitable bass responses can be found for voice, music or game applications (see Photo 7).

Manufacturers like L. G. Foster are realising that there will be a great demand for super-thin wall-hanging speakers because so many are required in a Home Theatre System. They use mutually repulsive magnetic circuits to provide full-frequency super-thin speakers with an overall depth of 32mm. Toshiba's SST6200 uses Linaem's line source speaker technology for a free-standing dipole tweeter. Also in use are piezo-electric film speakers configured in an arc to provide bipolar and di-polar radiation patterns giving wide, horizontal and narrow vertical sound fields.

Sound Tubes offer a full 360° sound dispersion of all frequencies by eliminating standing wave distortion via ingenious tube-like enclosures (see Photo 8). Now that we have our PC controlling all this lovely gear, we need a simple remote control to sit back and operate it all, from another room perhaps, by using a Kenwood 1090 receiver (see Photo 9). You can dial their Freephone number and by holding the receiver's remote control up to the phone, program up to eight ancillary pieces of equipment. Other firms like 'One For All' offer digital-display remotes for up to eight channels, where each ancillary can be reprogrammed by ringing the company whose selection of 60,000 library codes can be pulsed down the phone line into your remote. For Home Theatre, 6-axis steering is available in the Citation DSP 7.5 where discrete stereo surround soundfields can be acoustically hologrammed to any specific position in the listening area. Currently selling for $3,000, it represents state-of-the-art in this modern hi-tech world.

Photo 8. SoundTube Visual-Audio speaker system.

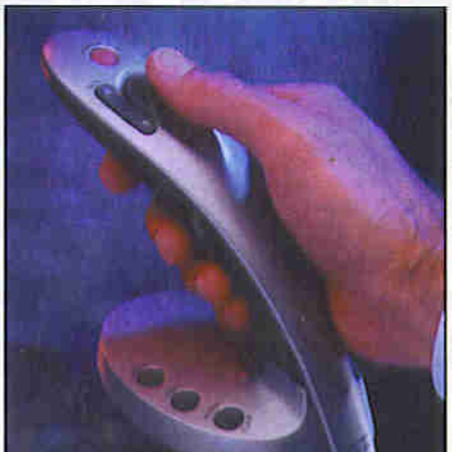


Photo 9. Programmable remote control transmitter.

Short Wave LISTENING TODAY

by Ian Poole

Short wave listening is a fascinating pastime. It combines the latest in technology with the excitement of receiving signals from all corners of the Earth. For those with an interest in computing, it is possible to combine both interests to receive many of the new formats of data and picture information which can be heard. It is also possible to gain many hours of enjoyment listening to the variety of broadcast, amateur and other stations which can be found.

Radio Spectrum

The radio spectrum covers a vast range of frequencies. From the very lowest radio signals at a few kilohertz, up to signals around a few hundred gigahertz using the latest devices, there is an enormous amount of spectrum. To refer to different areas within the spectrum, it is split up into different bands, shown in Figure 1. The short wave part of the spectrum broadly covers between 2-30MHz. This covers the whole of the high frequency (HF) part of the spectrum as well as a small amount at the top of the medium frequency (MF) part.

Propagation

Signals in the short wave bands can cover enormous distances. Often, they can be heard from the other side of the world, using the layers in the ionosphere to reflect the signals around the Earth.

Signals naturally spread out from the transmitter over the Earth's surface. These ground waves can be heard over distances of many tens of miles in the medium wave band. However, as frequencies rise, the signal strength falls much further and skywaves reflected from the ionosphere are used.

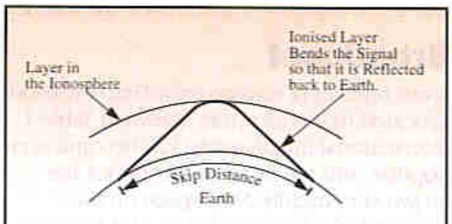


Figure 2. Reflections from the ionosphere.

The ionosphere is an area high above the Earth's surface where radiation from the sun causes the molecules in the air to split. These ions have the effect of bending radio waves, sometimes to the extent that they can be returned to Earth – see Figure 2.

There are a number of areas where the level of ionisation reaches a peak. These can be viewed as separate layers, as shown in Figure 3. The actual heights vary dependent upon a variety of factors and as a result, only approximate figures can be given.

The lowest layer is called the D layer. As shown in the diagram, it occurs at an altitude of around 60km. Here, the density of the air is relatively high, and as a result, the ions recombine very quickly so that the layer is only present during hours of daylight when the sun's radiation is available to generate the ions. Also, this layer has the effect of absorbing low frequency signals.

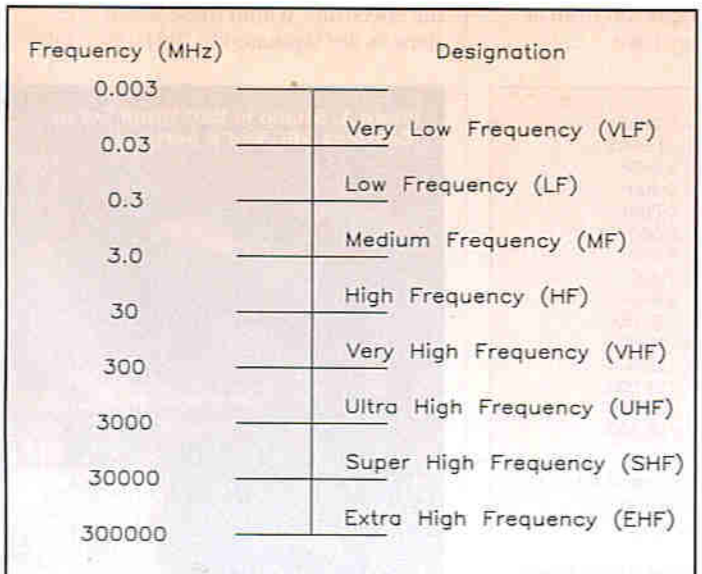


Figure 1. The radio spectrum.

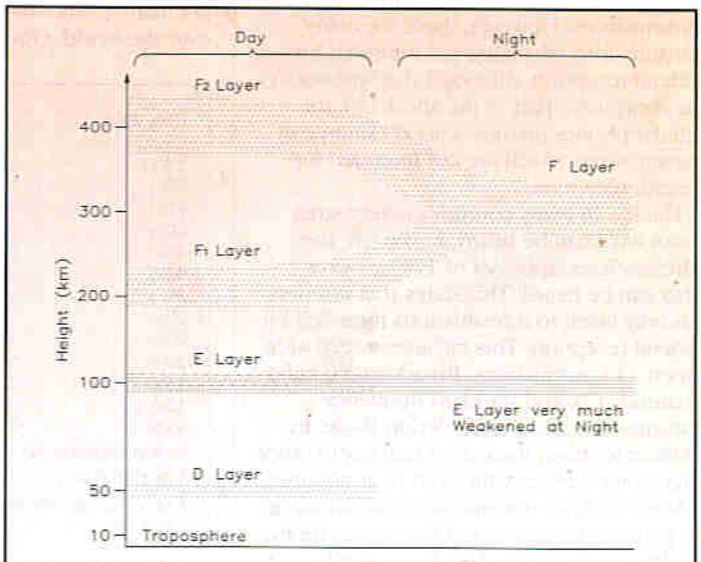


Figure 3. Layers in the ionosphere.

Medium wave broadcast stations are affected by this. When it is present during the day, it absorbs any signals in this band. At night when it disappears, signals from much further afield are heard and interference levels rise dramatically.

Signals which are slightly higher in frequency are able to pass through the D layer, and they travel on until they reach the E layer. This layer is present in the day, and virtually disappears at night. However, unlike the D layer, its major effect is to reflect signals. This can travel back to Earth, as shown in Figure 4.

However, it is found that as signal frequencies increase, they are able to pass through this layer and reach the F layer. Although the F layer does not disappear at night, its level of ionisation decreases at night. It is also found that it usually splits into two layers during the day – the F_1 and the F_2 layers.

As signals reach the F_1 layer, they may be reflected, but like the other layers, higher frequencies may pass through to reach the F_2 layer. Again, the same process takes place, and eventually, the highest frequencies may pass through altogether.

Apart from the time of day, a number of other variables affect the state of the ionosphere. The seasons have an effect because the amount of radiation received by the ionosphere decreases in winter just as the amount of heat. Also sunspots affect propagation conditions. As the number of sunspots undergo a cycle of approximately 11 years, the same is true of radio conditions. At the peak of the cycle, frequencies at the top of the short wave part of the spectrum and beyond are able to support long distance communications. However, at the bottom of the cycle, radio signals pass through all the layers of the ionosphere at much lower frequencies. This means that signals will pass through all the layers at much lower frequencies and some bands may appear to have no signals on them.

Listening and the Law

Many different types of organisation use the radio spectrum for communications. Those like broadcasters obviously intend as many people as possible to listen to their transmissions. However, there are many transmissions which are not intended for general reception. Although they are not in the short wave part of the spectrum, the cellular phones provide a good example of transmissions which are not intended for general reception.

The law in many countries is very strict about what can be heard. In the UK, the Wireless Telegraphy Act of 1949 governs what can be heard. This states that listeners can only listen to transmissions intended for general reception. This includes a very wide variety of transmissions. Broadcasters, radio amateurs, CB, and standard frequency transmissions are all included in these. In addition to these, there are a number of other interesting services which can be monitored.

Many weather transmissions are broadcast for general reception, and this makes them legal to receive in the UK. These can be particularly interesting to receive as many of these transmissions are in the form of maps showing conditions over various areas of the Earth.

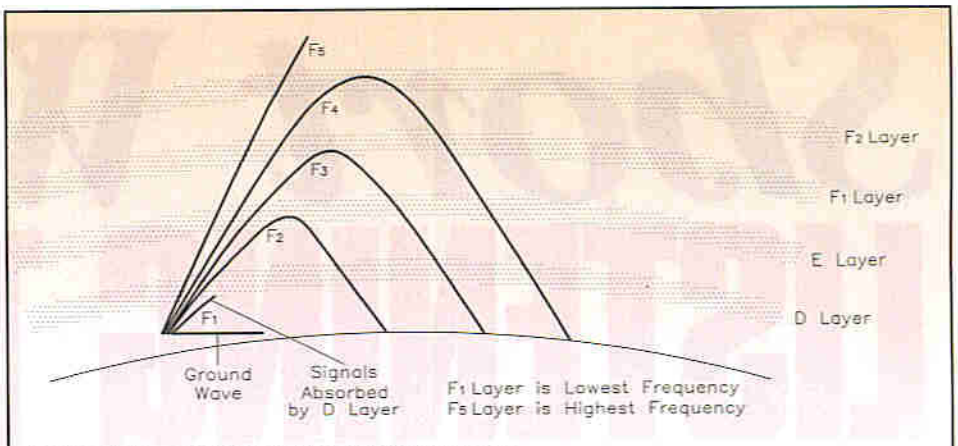


Figure 4. Propagation at different frequencies.

Some press transmissions also fall into the categories of transmissions for general reception. Some countries broadcast press releases, and these are intended for widespread reception and not a specific individual. Obviously, those news transmissions sent to a specific station should not be monitored.

In countries outside the UK, it is necessary to check what can be legally received over the air. Laws change from one country to the next, and transmissions which may be legally received in the UK may be illegal in other countries.

Despite the fact that it is not possible to listen to a variety of transmissions on the short wave spectrum, there is still a good variety which can be heard. From amateur radio to broadcast stations and a wide variety of other stations, there is plenty to ensure that there is plenty of interest for the listener.

Broadcast

A vast number of stations crowd into the bands allocated to broadcasters shown in Table 1. International broadcasting has become very popular, and the number of stations has grown very rapidly. Now space on the allocated bands is very fierce, and in recent World Radio Communication conferences, more space has been allocated for this use.

Listening to these broadcasts can be fascinating. Stations can be heard from all over the world. Often, they have programmes describing the countries where they are located, enabling the listener to discover about far away countries. News broadcasts can also be very interesting. As each country has its own view point, these are usually reflected in the country's broadcasts. In fact, it is often interesting to compare the different perspectives given by different countries. Naturally, this is particularly true when there is an international conflict. In times like these, listening to short wave broadcasts can reveal many new aspects to the conflicts as each side airs its views over the radio waves.

Although short wave broadcasting is often used for propaganda, many countries now are following the lead of the BBC World Service, which has earned an enviable reputation for high quality broadcasting, and impartial news reporting. In times of trouble, like the Gulf War, people from all sides turned to the 'World Service' to listen to the news bulletins in preference to those from their own country – see Photo 1.

The short wave bands are also used for religious broadcasts. A number of stations including famous stations like Vatican Radio broadcasting from the Vatican City, and HCJB broadcasting from its site in the Colombian Andes broadcast the Christian faith. Naturally, there are many other stations putting forward their faiths as well.

There are a number of broadcast bands located throughout the short wave part of the spectrum. Within these bands, the stations are separated by 5kHz. By adopting

Long Wave	0·150 – 0·285
Medium Wave	0·5265 – 1·6065
120m	2·300 – 2·495*
90m	3·200 – 3·400*
75m	3·900 – 4·000†
60m	4·750 – 5·060*
49m	5·950 – 6·200
41m	7·100 – 7·300
31m	9·500 – 9·990
25m	11·650 – 12·050
22m	13·600 – 13·800
19m	15·100 – 15·600
16m	17·550 – 17·900
13m	21·450 – 21·850
11m	25·670 – 26·100

All frequencies are in MHz
* Tropical Bands only for use in tropical areas
† Only allocated for broadcasting in Europe and Asia

Table 1. Long Medium and Short Wave Broadcast Bands.

Photo 1. Studio in BBC World Service (Courtesy BBC World Service).

a fixed separation like this, interference is reduced as much as possible.

Each band has its own flavour, bringing in stations from different places at different times of the day. The lower frequency bands tend to bring in stations over distances of 1,000 to 2,000km by day, and more distant stations by night, with the promise of very distant stations at dusk and dawn.

The higher frequency bands support the best communications by day, often closing at night. However, when they are open, they often produce some very long distance stations.

There are three bands known as tropical bands. These are used by stations in the tropical areas between latitudes of 23 N and 23 S. They are used for domestic broadcasting because the medium waveband or VHF frequencies do not give sufficient coverage for many of the countries in question. For the listener, the 60m band is usually the best. There are many high power stations and the propagation on this band means that long distance stations are more likely to be audible.

Listening to the medium and long wave bands can also be very interesting. It is surprising how many interesting stations can be found. In the UK, there is a great variety of local radio stations, but on some channels, it is possible to hear stations much further afield. To do this, it is necessary to wait until after dark, when stations over 1,000km can sometimes be heard. One station to look for is Radio Moscow World Service, with its high power transmitter and high gain antenna system. This can usually be heard in Britain after dark on 1,496kHz even on a modest portable or car radio. Similarly, other stations can be heard, but it can take some patience to seek them out because of the high interference levels from the large number of local stations. However, patience can be rewarded because it is even possible at times to hear transatlantic stations.

At the moment, all broadcast transmissions in this part of the frequency spectrum use amplitude modulation (AM). Although there are much more efficient types of transmission, AM is still used because of the vast number of sets in use around the world. Eventually, it is planned to use a form of single sideband transmission with a reduced carrier level.

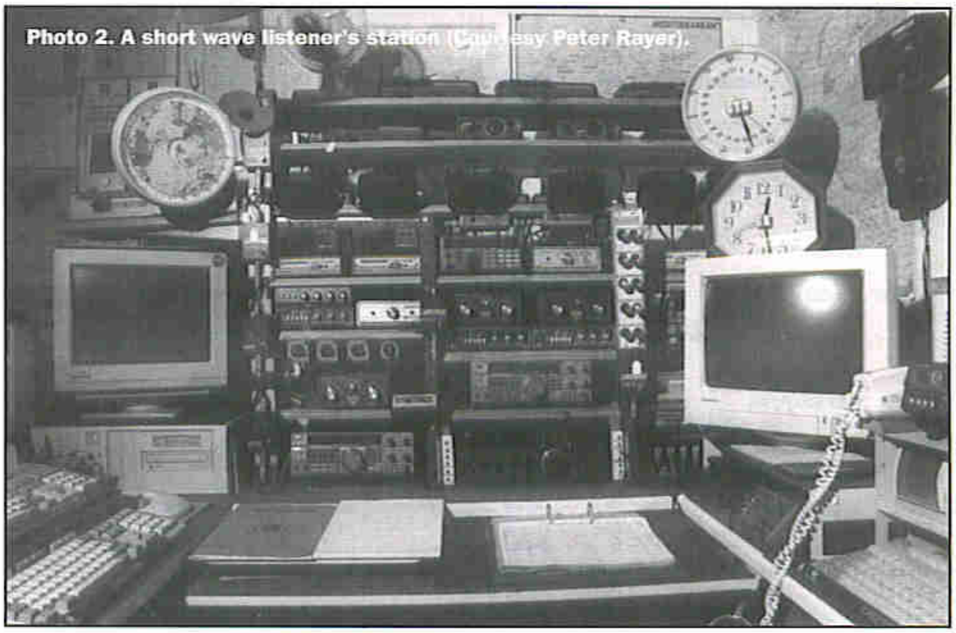


Photo 2. A short wave listener's station (Courtesy Peter Rayer).

However, the date for its introduction has been put back and it will not become standard in the near future.

Amateur

Around the world, there are many thousands of people who enjoy being able to transmit to one another. These radio amateurs or 'hams' communicate with one another, talking about a variety of different topics from the technicalities of the equipment to describing the area of the world in which they live. Often, people located in remote areas of the world use amateur radio as a means of talking to other people and this means that stations are often heard from very remote corners of the world, including places like Antarctica and small islands in the middle of the oceans. Photo 2 shows a short wave listener's station (or 'shack').

Amateurs are allocated a number of bands in the short wave part of the spectrum, as shown in Table 2. Often, they spend a lot of their time on these bands experimenting with different forms of radio. This means that a wide variety of modes of transmission are used. Morse (see Table 3) and single sideband are very popular, but a number of other modes are also very popular. Slow scan television is one such mode and pictures are often sent around the globe using this mode. Data transmissions are also very popular. Radio teletype (RTTY) was the first of these modes to be used, and this was characterised by the large mechanical teleprinters which were used. Nowadays, RTTY is still used by amateurs who usually press computers into operation for these modes. Using computers also enables more sophisticated types of data transmission to be made. These modes include Amtor, packet, and Pactor, and they are all being used increasingly, as they offer additional facilities and resilience to errors.

When amateurs talk to one another, a large number of abbreviations and codes are used. Some of these are normal electronics and radio terminology, but a large number are specific to amateur radio and radio communications. Many of them have arisen out of the need to communicate quickly and concisely, especially when using morse. Their use has now become commonplace, even when using other modes. A number of

Frequency Limits (MHz)		Approximate Wavelength and Band Name
1·81	2·0	160m (Top Band)
3·50	3·80	80m
7·00	7·10	40m
10·10	10·15	30m
14·00	14·35	20m
18·068	18·168	17m
21·00	21·45	15m
24·89	24·99	12m
28·00	29·70	10m

Table 2. UK Amateur Bands.

A	·–	N	–·
B	–···	O	–––
C	–·–·	P	·––·
D	–··	Q	––·–
E	·	R	·–·
F	··–·	S	···
G	––·	T	–
H	····	U	··–
I	··	V	···–
J	·–––	W	·––
K	–·–	X	–··–
L	·–··	Y	–·––
M	––	Z	––··
1	·––––	6	–····
2	··–––	7	––···
3	···––	8	–––··
4	····–	9	––––·
5	·····	0	–––––

Punctuation

Full Stop	·–·–·–
Comma	––··––
Question Mark (?)	··––··
Equals sign (=)	–···–
Stroke (/)	–··–·
Mistake	········

Procedural Characters

For procedural characters made up of two letters they are sent as a single letter with no break between them.

Start of Work (CT)	–·–·–
Invitation to Transmit (KN)	–·––·
End of Work (VA)	···–·–
End of Message (AR)	·–·–·
Invitation to Transmit (K)	–·–
Invitation to a Particular Station to Transmit (KN)	–·––·

Table 3. The Morse Code.

Abt	About	FONE	Telephony	SA	Say
Agn	Again	GA	Good Afternoon	SIGS	Signals
A.M.	Amplitude Modulation	GB	Goodbye	SRI	Sorry
Ant	Antenna	GD	Good	SSB	Single Sideband
B.C.I.	Broadcast Receiver	GE	Good Evening	STN	Station
	Interference	GM	Good Morning	SWL	Short Wave Listener
BCNU	Be Seeing You	GN	Good Night	TKS	Thanks
B.F.O.	Beat Frequency Oscillator	GND	Ground	TNX	Thanks
BK	Break	HBREW	Homebrew (home made)	TU	Thank You
B4	Before	HI	Laughter	TVI	Television Interference
CFM	Confirm	HPE	Hope	TX	Transmitter
CLD	Called	HR	Here	U	You
CONDX	Conditions	HV	Have	UR	Your, You Are
CPI	Copy	HW	How	VY	Very
CQ	A general call indicating a	LID	Poor Operator	WID	With
	contact is wanted.	MOD	Modulation	WKD	Worked
CU	See you	ND	Nothing Doing	WUD	Would
CUAGN	See You Again	NW	Now	WX	Weather
CUD	Could	OB	Old Boy	XCVR	Transceiver
CW	Continuous wave (used to	OM	Old Man	XMTR	Transmitter
	denote a morse signal).	OP	Operator	XTAL	Crystal
DE	From	OT	Old Timer	XYL	Wife
DX	Long Distance	PA	Power Amplifier	YL	Young Lady
ERE	Here	PSE	Old Timer	Z	GMT – added after the
ES	And	R	Roger (OK)		time, e.g. 1600Z is
FB	Fine Business	RCVD	Received		16.00 GMT
FER	For	RTTY	Radio Teletype	73	Best Regards
F.M.	Frequency Modulation	RX	Receiver	88	Love and Kisses

Table 4. Abbreviations.

abbreviations are used, as shown in Table 4. Some of them are quite obvious, like TVI for television interference, but those like 73 and 88 are less clear, their origins possibly having come from the early days of wire telegraph operation. A number of words are changed to enable them to be sent more easily in morse, as an example, the word 'for' is changed to 'fer'. This is because the letter 'O' consists of three dashes instead of one dot for the letter 'E'.

Another commonly used code is called the Q code. This is used by a variety of radio services, including some maritime and aeronautical services. The full Q code is very comprehensive, but a number are widely used by amateurs and these are given in Table 5. The table shows that they can be used in either a question or answer format. However, they are used a little less rigorously in speech contacts. Often, someone will be heard talking about a QRP transmitter, meaning a low power transmitter, or the fact that there is plenty of QRM on the band, i.e. there is a lot of interference.

When using speech it is often necessary to spell out names or give callsigns. To prevent the confusion which often occurs, even over telephones, a phonetic alphabet is usually used. Whilst there is no legal requirement to use any particular code, the one shown in Table 6 is recommended.

A	Alpha	N	November
B	Bravo	O	Oscar
C	Charlie	P	Papa
D	Delta	Q	Quebec
E	Echo	R	Romeo
F	Foxtrot	S	Sierra
G	Golf	T	Tango
H	Hotel	U	Uniform
I	India	V	Victor
J	Juliet	W	Whisky
K	Kilo	X	X-ray
L	Lima	Y	Yankee
M	Mike	Z	Zulu

Table 6. Phonetic Alphabet.

It is often important to be able to give meaningful signal reports. Not only is it interesting to discover how one's signals are being received, but if strengths are low and interference is high, transmissions can be kept short to minimise the risk of all contact being lost.

To be able to give concise and consistent reports, a scheme called the RST or readability strength and tone system is used – see Table 7. Numbers are assigned to different levels and these are used in the report. The tone section of the report is only used for morse signals to indicate the quality of the signal being received. With most of today's equipment, the signal quality is good and most tone reports are "nine". To give a typical example, a signal which is perfectly readable and moderately strong would be given a report of five and seven. Another code called the SINPO code, given in Table 8, is often used when sending short wave listener reports to broadcast stations. This code gives more categories than the RST one, but is never heard over the air.

By using a scheme of this nature, some measure of consistency can be kept between different reports, although they are still very subjective and should only be taken as a rough guide. Even the 'S' meters on receivers are relatively inaccurate and care should be used when interpreting results.

One aspect of amateur radio which has become a side interest is that of collecting QSL cards. These cards are postcard sized cards which are used to confirm a contact. The idea started in the early days of amateur radio, when some people wanted some tangible proof of the contact they had made. Although people sometimes used letters to confirm a contact, the idea of QSL cards soon arrived. They derive their name from the Q code meaning I confirm receipt, and they are widely used these days, especially on the HF bands. Many of the cards are very colourful, and as a result, many people like to display them on the walls of their radio room or shack – see Photo 3.

QRA	What is the name of your station? The name of my station is . . .	QRS	Shall I send more slowly? Send more slowly.
QRB	How far are you from my station? I am about . . . from your station.	QRT	Shall I stop sending? Stop sending.
QRG	What is my exact frequency? My exact frequency is . . .	QRU	Do you have any messages for me? I have no messages for you.
QRH	Does my frequency vary? Your frequency varies.	QRV	Are you ready to receive? I am ready to receive.
QRI	Does the note of my transmission vary? Your note varies.	QRZ	Who is calling me? You are being called by . . .
QRJ	Is my signal weak? Your signal is weak.	QSK	Can you hear between your signals? i.e. use break in on morse transmissions. I can hear between my signals.
QRK	What is the readability of my signal? The readability of your signal is . . .	QSL	Can you acknowledge receipt? I can acknowledge receipt.
QRL	Are you busy? I am busy.	QSP	Can you relay a message? I can relay a message.
QRM	Is there any (man made) interference? There is (man made) interference.	QSV	Shall I send a series of Vs? Send a series of Vs.
QRN	Is there any atmospheric noise? There is atmospheric noise.	QSY	Shall I change to another frequency? Change to another frequency.
QRO	Shall I increase power? Increase power.	QTH	What is your location? My location is . . .
QRP	Shall I decrease power? Decrease power.	QTR	What is the exact time? The exact time is . . .
QRQ	Shall I send faster? Send faster.		

Table 5. Q Codes.

Readability	
R1	Unreadable
R2	Barely readable
R3	Readable with difficulty
R4	Readable with little difficulty
R5	Perfectly readable
Strength	
S1	Barely detectable
S2	Very weak signals
S3	Weak signals
S4	Fair signals
S5	Fairly good signals
S6	Good signals
S7	Moderately strong signals
S8	Strong signals
S9	Very strong signals
Tone	
T1	Extremely rough note
T2	Very rough note
T3	Rough note
T4	Fairly rough note
T5	Note modulated with strong ripple
T6	Modulated note
T7	Near DC note but with smooth ripple
T8	Near DC note but with trace of ripple
T9	Pure DC note

Table 7. RST Code for Readability, Strength and Tone.

Photo 3. A collection of QSL cards.

Like the RST code, this one is used to give signal reports. It is more comprehensive than the RST code giving indications for signal **S**trength, **I**nterference, **N**oise, **P**ropagation disturbances (e.g. fading etc.), and **O**verall reception quality. This code is most widely used for giving reception reports to broadcast stations.

	S	I	N	P	O
1	Just Audible	Extreme	Extreme	Extreme	Unusable
2	Poor	Severe	Severe	Severe	Poor
3	Fair	Moderate	Moderate	Moderate	Fair
4	Good	Slight	Slight	Slight	Good
5	Excellent	None	None	None	Excellent

Table 8. SINPO Code.

Apart from collecting QSL cards, many people like to measure their achievements by working towards obtaining operating awards. There is a wide variety of awards which can be gained. One of the most famous is called DXCC (DX Century Club), and as the name suggests, it is obtained by radio amateurs for making contact with 100 countries. After the basic 100 countries, endorsements can be obtained, and some stations have over 300 countries to their score.

There are many other awards which are available. Another is issued by the Radio Society of Great Britain and called the IARU (International Amateur Radio Union) Region 1 Award. This is gained by making contact with stations in countries of member societies in Region 1 (broadly, Europe and Africa).

In most instances, it is necessary to submit documentary evidence of having made the contacts. This is usually in the form of QSL cards, another reason for collecting them. These awards are not confined to transmitting radio amateurs. Listeners can also earn many of them. In fact, many are open only for listeners.

At certain weekends during the year, the amateur bands erupt with activity. This is normally as a result of one of the contests which are arranged over certain weekends each year. During the contests, stations endeavour to make contact with as many stations as possible. Obviously, the exact aims of the contests vary from one to another. One of the largest is called the CQ Worldwide contest. In this, stations make contact with as many stations anywhere in the world as possible. In the ARRL DX contest, stations in Northern America try to make contact with stations outside the USA and Canada, and vice-versa. These contests can be great fun to listen to. Often, stations are set up in rare countries, and it is a time when short wave listeners interested in hearing as many countries as possible can pick up new countries. See Photo 4.

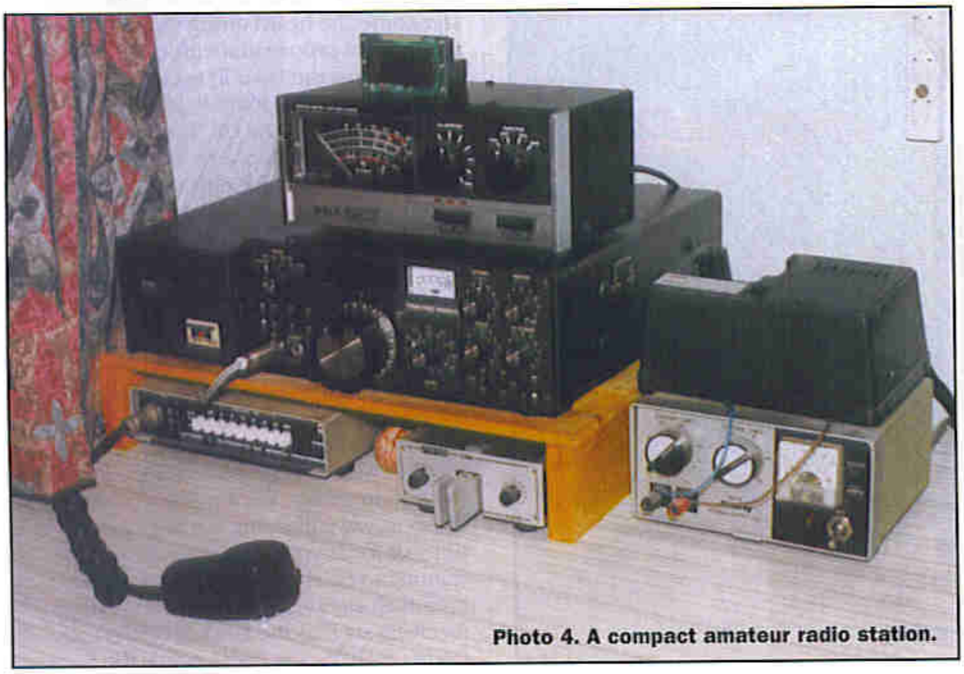


Photo 4. A compact amateur radio station.

Citizen's Band (CB)

Citizens band has grown rapidly since it was first launched in the USA. Nowadays, a large number of countries allow CB operation. Surprisingly, many Eastern-bloc countries allowed it before the UK made it legal, and this was before the fall of communism in Eastern Europe.

For the short wave listener, it is possible to listen to them legally in the UK as they are classed as being intended for general reception. Often, there are a number of stations which can be heard. Sometimes, they may be close by, or at other times, they may be quite distant as the signals are arriving via the ionosphere. The frequencies for the UK bands are given in Tables 9 and 10. The original frequencies allocated when CB was first launched in the UK are contained in Table 9. Those now allocated in line with the rest of Europe are contained in Table 10, and are the ones which are preferred.

CB licences are quite easy to obtain. Unlike the amateur licences which need

Channel	Frequency (MHz)
1	27·60125
2	27·61125
3	27·62125
4	27·63125
5	27·64125
6	27·65125
7	27·66125
8	27·67125
9	27·68125
10	27·69125
11	27·70125
12	27·71125
13	27·72125
14	27·73125
15	27·74125
16	27·75125
17	27·76125
18	27·77125
19	27·78125
20	27·79125
21	27·80125
22	27·81125
23	27·82125
24	27·83125
25	27·84125
26	27·85125
27	27·86125
28	27·87125
29	27·88125
30	27·89125
31	27·90125
32	27·91125
33	27·92125
34	27·93125
35	27·94125
36	27·95125
37	27·96125
38	27·97125
39	27·98125
40	27·99125

Table 9. Original UK 27MHz Band Channel Frequencies (MPT1320 (27/81)).

Channel	Frequency (MHz)
1	26·965
2	26·975
3	26·985
4	27·005
5	27·015
6	27·025
7	27·035
8	27·055
9	27·065
10	27·075
11	27·085
12	27·105
13	27·115
14	27·125
15	27·135
16	27·155
17	27·165
18	27·175
19	27·185
20	27·205
21	27·215
22	27·225
23	27·255
24	27·235
25	27·245
26	27·265
27	27·275
28	27·285
29	27·295
30	27·305
31	27·315
32	27·325
33	27·335
34	27·345
35	27·355
36	27·365
37	27·375
38	27·385
39	27·395
40	27·405

Table 10. CEPT and USA 27MHz Band Channel Frequencies (MPT 1333 (PR 27/GB)).

examinations to be passed, a CB licence can be obtained purely by paying a subscription. However, the equipment which is used must be type approved and they must not be modified – see Photo 5. The power levels are also limited. Limits vary slightly from one country to the next, although between 3-5W is normally the maximum. Although this is considerably less than that allowed for amateurs, it is quite sufficient for transmissions across town and often well beyond.

A wide variety of people use CB. From people wanting to talk short distances to chat with friends to lorry drivers wanting to talk to someone in the cab or find out about the road conditions, CB has a lot of people who use the medium. However, it must be said that the number of people using it in the UK is falling.

In other countries it is still widely used. Some try to make long distance contacts. DXing started in the USA soon after the introduction of CB. Although the licence there states that contacts over distances of 150 miles cannot be made, this has not stopped people making these long distance contacts. Sometimes, at the peak of the sunspot cycle, transatlantic contacts have been made, and some stations even exchange QSL cards.

The conditions for CB operation vary from one country to the next, but now many countries are falling more into line with one another to reduce channel congestion. It also means that equipment manufacturers do not have to make different options for different countries. The channels used across Europe fall into line with those used in the USA. In Britain, the original channels are now being phased out, and the new European channels are being used increasingly. As the occupance of channels increases, this does unfortunately make hearing long distance stations more difficult.

Weather Faxes

There is a vast amount of information transmitted each day by meteorological agencies. Many of these transmissions can be received quite legally in the UK because they are intended for general reception. In the UK, much of the output comes from the Meteorological Office in Bracknell.

Information is transmitted in a variety of forms. A number of transmissions are made in RTTY, but most of the really interesting ones are the facsimile or fax transmissions. Those from Bracknell regularly show maps of Europe and the North Atlantic, giving isobars and some show ice flows for various areas of the Atlantic. Many of the maps show the cloud formations, whilst some show the high and low pressure areas, and others give general meteorological information.

The weather transmissions are found throughout the short wave spectrum. A variety of different stations from all over the world put out transmissions intended for ships and other users. This means that whatever the radio propagation conditions, it is possible to pick up at least some indication of what the weather will be.

Many stations have regular frequencies and time schedules. This helps maritime and other regular users who need to know which frequencies are to be used, so they known where to listen. It also helps the short wave listeners. Many stations transmit their schedules. Although it does not help in finding the stations in the first place, it does help afterwards knowing when and where to listen.

The Meteorological office in Bracknell UK transmits on a variety of frequencies, including 2·168, 4·61, 8·04 and 14·436MHz. Other stations also have regular frequencies, and these can be obtained from one of the frequency listings which can be obtained.

Standard Frequency Transmissions

Although they may not appear to be of major interest, there are a number of standard frequency transmissions which can be heard. These stations broadcast a signal which has a very tight control of its frequency. Whilst the very high degree of frequency accuracy may not be of great interest to the short wave listener, they act as a very good indication of propagation conditions. A number of these stations can be heard around from the world, each giving their callsigns at regular intervals so that they can be identified.

One of the most famous of these standard frequency transmissions comes from WWV located at Fort Collins, Colorado. It also has a sister station located in Hawaii with the callsign WWVH. Dependent upon the propagation conditions, these stations can sometimes be heard giving the time every minute and propagation information at 15 minutes past the hour in speech.

Another station, RWM in Russia, can often be heard in the UK. It transmits 4kHz below the exact Megahertz frequencies on 4·996, 9·996, and 14·996kHz to alleviate interference with stations on 5, 10, and 15MHz. So if you hear these stations, do not think that the calibration on the receiver is 4kHz out!

Equipment

The first requirement for a short wave listener is obviously a receiver! There is naturally a wide variety, and the type of receiver which is chosen will depend upon the requirements. For anyone wanting to try short wave listening out for the first time, or for anyone travelling abroad and wanting to be able to listen to short wave broadcast stations, the 'World Band' type receivers such as the Lowe SRX50 (Stock Code CP24B) – see Photo 6 – or the Sony

Photo 5. A CB transceiver (Maplin Stock Code YE53H).

ICF-SW55 (Stock Code CP23A) is a good buy. These sets offer excellent value for money and enable good performance to be combined with portability. They also offer digital tuning, and this means that the exact frequency of reception is displayed, or can be entered into the set via a keypad. This makes tuning to the correct frequency very easy whereas with the older analogue portable short wave sets, the dials became very cramped and it was almost impossible to tune to the correct station without spending a lot of time searching for the correct spot. The other advantage of a set like this is that it also covers the VHF FM band.

Although the 'World Band' sets are ideal for many listeners, those wanting to take the hobby up more seriously may want a proper communications set. These receivers offer much greater flexibility, more features and a better performance. Naturally, they are more expensive, but people could do much worse than invest in a Lowe HF150 (Stock Code CM23A), shown in Photo 7. These sets offer excellent value for money, and have scored well against competitors at higher prices.

Aerials are very important. Although 'World Band' sets include a telescopic aerial, communications sets do not have an aerial.

Photo 7. A communications receiver (Maplin stock No CM23A).

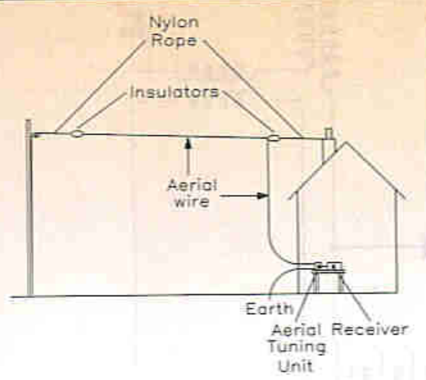


Figure 5. An end fed wire installation.

Instead, they require an aerial external to the set. For many listeners, a long wire or more correctly, an end fed wire like that shown in Figure 5, is an ideal solution. It should be used in conjunction with an aerial tuning unit to ensure the best performance. With the tuner unit, it can be tuned to resonance and can be used over a wide range of frequencies.

To be able to receive data transmissions, it is necessary to have an add-on unit. These units come in different forms and can be used to receive a variety of different transmissions dependent upon the unit. Most of them interface to a PC to display or decode and display the information. Before buying one of these, it is necessary to decide exactly what transmissions you want to receive. Different units receive different types of transmission, although the more expensive units are usually able to resolve most of them.

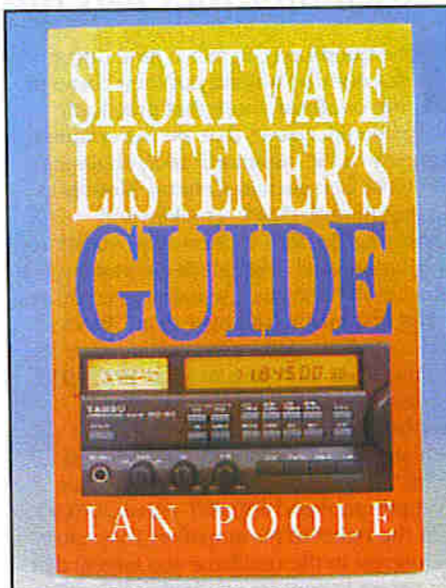


Photo 8. Newnes Short Wave Listener's Guide.

Photo 6. A world band receiver (Maplin Stock Code CP24B).

Books

This can only be a very short introduction to what is a fascinating hobby. Not only is there the excitement of hearing stations from all over the world, but there is also the interest of looking at the latest technology and learning about it. There is also the added fascination of learning from the variety of transmissions made from all over the world. From broadcast to radio amateurs, and from press releases to weather maps and much more, there is a whole world of interest for anyone wanting to take up the hobby of short wave listening.

For anyone wanting to read more about the hobby, Ian Poole has just had his latest title published. Called Newnes Short Wave Listener's Guide and published by Butterworth Heinemann, it is a fascinating introduction to this hobby.

See our book offer on page 75 of this magazine.

WHAT'S IN A NAME

PART 3

Back to Basics: The Oscillator

by Greg Grant

We've all seen the television commercial, the one for a popular brand of mayonnaise: "Without a conductor, there is no symphony . . . etc. . . ." It's the same in communications engineering. No oscillator, nothing to engineer or communicate. So, who invented the oscillator and why didn't he put his name to it?

The question is, in fact, a little unfair. It's not that no-one put their name to the oscillator, more that practically everyone did. Names that are the common currency of the communication engineer's speech in fact, such as Colpitts, Meissner, Hartley, Round, Pierce, Franklin and Armstrong. So, let's rephrase the question: who, among this distinguished company, first came up with the idea? Actually, none of them.

The first man to discover that a Triode valve could be used as an oscillator was its inventor, Lee de Forest, around 1911-1912. However, he shortly got involved in telephone repeater design and, having built and tested a repeater circuit based on his valve on the local telephone lines, promptly accepted $50,000 – some £10,000 – for the rights to his amplifier. Thereafter, his interest in the oscillator was largely that of a patent litigant, as we shall see shortly.

The Vintage Years – 1913-1915

There are, as we all know, good and bad years for wine. If we were to apply the same criteria to oscillators, the period 1913 to 1915 would have to be rated vintage years, as is borne out by the patent applications. The first in the field was the Austrian engineer Alexander Meissner, who applied for a patent for his circuit on 9th April, 1913.

Born in Vienna, Meissner studied at the city's engineering college, graduating with a Doctor of Science degree in 1902. Five years later, he joined the Telefunken Company in Berlin, where he worked on improving the antennas used in longwave communication, new amplifier designs and, of course, the oscillatory circuit which bears his name. This is shown in Figure 1.

By 1911, he'd become involved in the earliest work on what would later be termed Avionics, or Aviation Electronics. He designed the first rotary radio beacon to aid airship navigation, an equipment that would later become known as the Telefunken Compass.

Two years later, he became the first radio engineer to amplify high frequency radio signals by using negative feedback (NFB), in a valve circuit. His arrangement, although crude, did make the receivers of the day that bit more sensitive than they'd been up to that time.

His oscillator was not a success, due to the Wehnelt cathode in the valve he was using burning out after only a few minutes operation. The power output too was nothing to get greatly excited about, although it did enable him to achieve communication over some 36km with the circuit. From 1928 onwards, he was a professor at Berlin's Technical University.

The news that Meissner had succeeded in generating continuous oscillations had been brought to Britain by the Marconi engineer, C. S. Franklin, who'd been on a visit to Germany at this time. He and another Marconi engineer, H. J. Round, were themselves working on the design of oscillators and were close to finalising their ideas.

Naturally, neither they nor Meissner were aware that, across the Atlantic, Edwin Armstrong was also close to realising the same goal, as were Edwin Colpitts and Ralph Hartley.

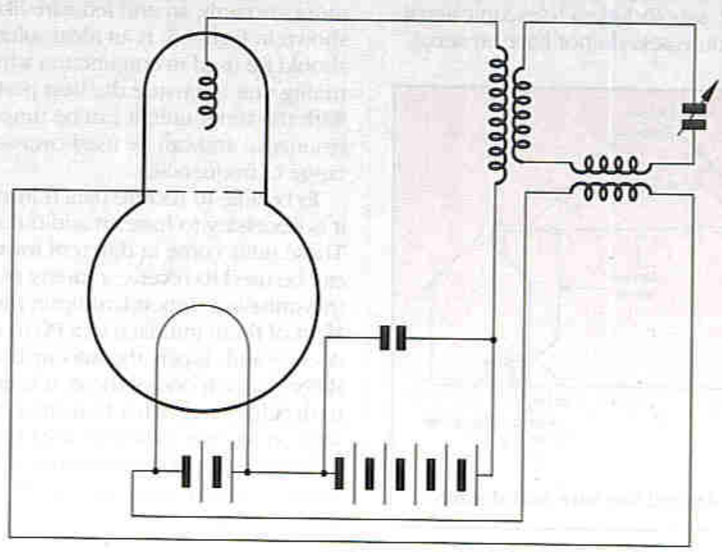


Figure 1. Meissner's oscillatory circuit of 1913. The unusual valve symbol denotes a Leiben-Reisz tube.

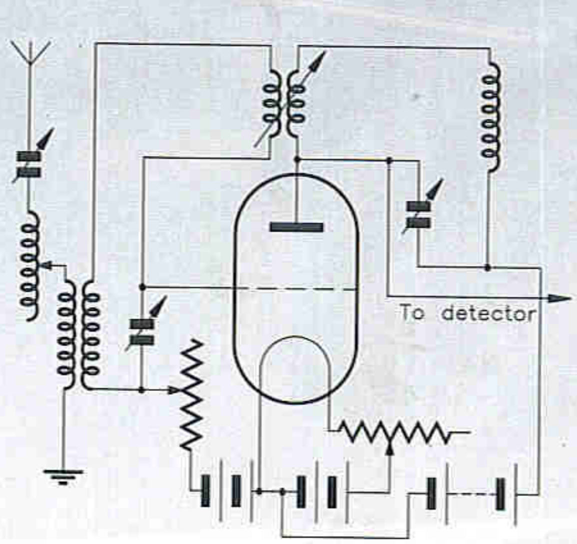


Figure 2. Franklin's oscillator circuit of 1913.

Thus, in the relatively short space of 21 months or so, no less than half a dozen oscillatory circuits appeared, many of which would not only advance communications engineering, but also the financial well-being of patent lawyers!

Charles Samuel Franklin

Meissner's patent was followed by that of Franklin, which dates from June, 1913. Although Figure 2 shows an amplifier circuit with negative feedback, the patent made it quite clear that the originator knew the circuit would oscillate.

Charles Samuel Franklin, the youngest of 13 children, was born in 1879 and suffered poor health for most of his formative years. Nevertheless, he completed his engineering training at Finsbury Technical College under Professor Silvanus Thompson, the author of the groundbreaking Calculus Made Easy, one of the earliest attempts to put calculus at the service of electrical technicians.

Joining the Marconi Company in 1899, Franklin worked in South Africa during the Boer War and later demonstrated the company's products in Russia before coming to the attention of Marconi himself, who made him one of his assistants.

This was the turning point in a career which culminated in Franklin becoming Chief of Independent Research. Franklin's first patent, the Variable Capacitor, dated from 1902 and would be followed by a further 64, among which was his Master Oscillator, Ganged Tuning, the Coaxial Cable and Variable Coupling.

Slightly built, diffident and modest, Charles Franklin remained a dedicated 'Marconi Man' until his retirement in 1937.

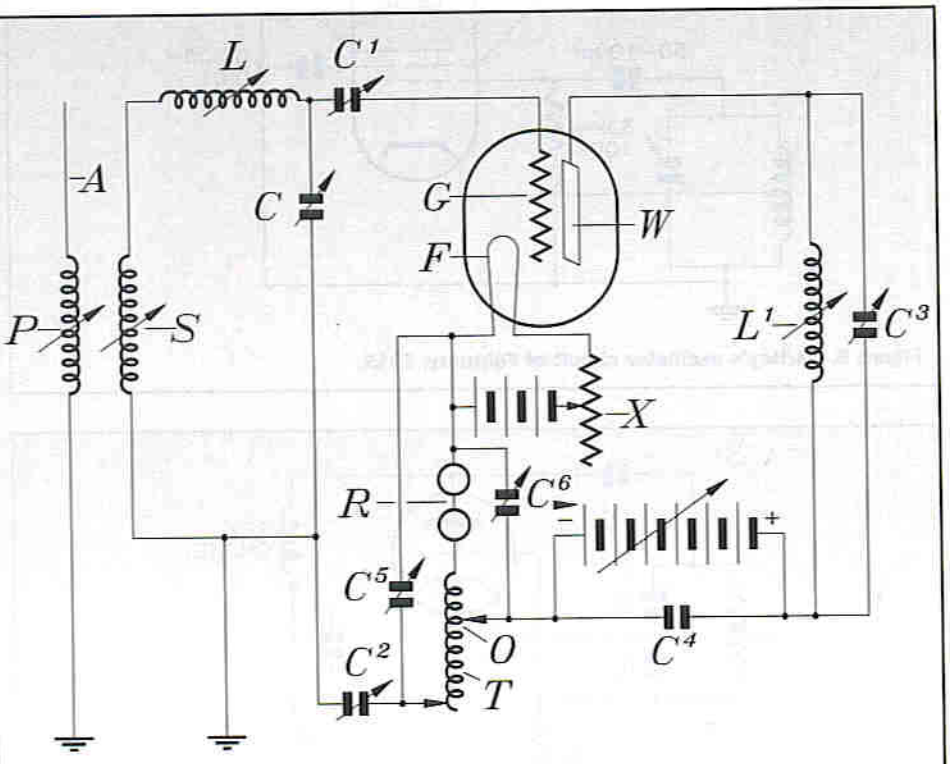


Figure 3. Armstrong's 'Regenerative' circuit of 1913.

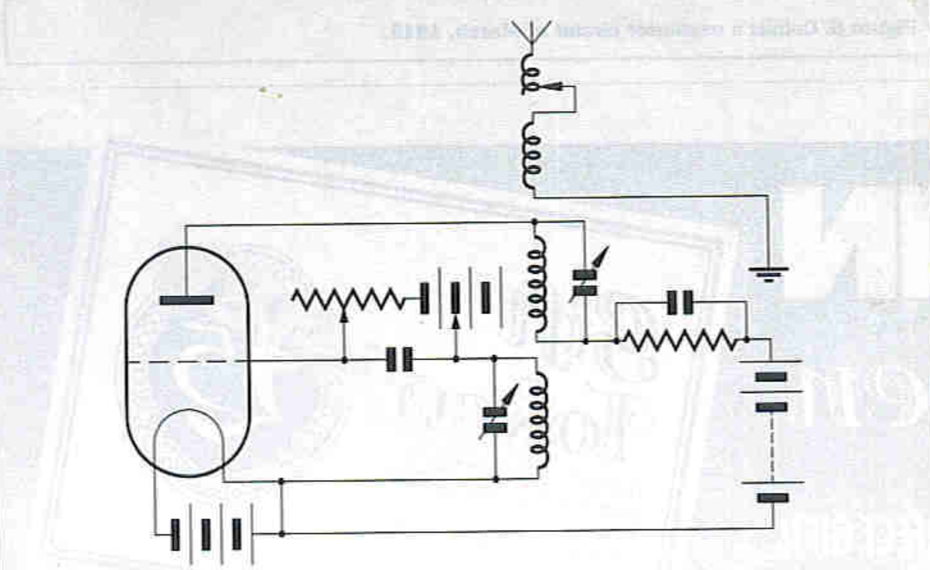


Figure 4. Henry Round's oscillator circuit of May, 1914.

Edwin Howard Armstrong

Four months after Franklin's British patent, the American inventor, Edwin Howard Armstrong, announced his oscillatory circuit. Figure 3, with its strange representation of a triode valve, is taken from the patent application.

A mere 22 years old and a recent graduate of Columbia University, where he'd studied under Professor Michael Pupin, the inventor of the Loading Coil, Armstrong would prove to be one of the most innovative of all the radio pioneers and – possibly – the first communications engineering millionaire.

Apart from the Regenerative circuit as he termed his oscillator, he also invented the Superheterodyne, or 'Superhet' system of reception, an idea of such originality that it remains, to this day, the basis of all radio receivers. Finally, in 1933, he made another major invention: Frequency Modulation, or FM, broadcasting.

However, shortly after inventing his oscillator, he clashed with de Forest over who actually invented the triode-based oscillator circuit. This acrimonious legal punch-up continued for an astonishing 20 years, the American Supreme Court, no less, finally judging de Forest as having primacy, in 1934.

Armstrong had similar problems with his invention of FM. From 1948 onwards, he was involved in litigation with the Radio Corporation of America (RCA) and 20 other smaller manufacturers. By 1954, this inventive genius had enough of litigation, courts – Supreme or otherwise – and patent lawyers. At the end of January, he threw himself from a window of his 13th floor New York apartment.

He did, however, have the last word. Just before taking his own life, he gave his alma mater, Columbia, $50,000 to underwrite research into the success or failure of the law in judging complex technical matters.

Henry Joseph Round

In May 1914, yet another oscillatory patent was granted, once more, in Britain. The engineer behind the design was another 'Marconi Man,' Franklin's colleague, friend and occasional rival, Henry Joseph Round.

Having graduated with first class honours from the Royal College of Science, Round joined the Marconi Company in 1902. He stayed with the company until 1931, when he retired to set up in business as a consultant. Six years later, however, he returned to Marconi as an adviser, remaining as such until his death.

Apart from his oscillator, shown in Figure 4, this cheerful, forthright extrovert developed a Gramophone Recording system, Amplifiers, a Public Address system, the 'Straight Eight' receiver, a number of antenna systems and – perhaps his most famous achievement – the Tetrode valve.

Throughout his long and most productive life, this holder of both the British Military Cross and the prestigious American Armstrong Medal, filed no less than 117 patents. He took out his last one in 1962 when in his 81st year, and he remained active, curious and innovative until his death in 1966.

Ralph Hartley

On February 10th 1915, another American patent announced yet another oscillatory circuit, one developed by Ralph Hartley, at that time supervising the development of radio receivers for the Bell System's radiotelephone trials.

After graduation from the University of Utah in 1909, Hartley won a Rhodes scholarship to Oxford, where he graduated with a BA in 1912, and a BSc in the following year. On returning to America, he joined Western Electric Laboratories, where he developed the circuit that bears his name.

In the 1920s, Hartley became interested in voice transmission and telephone repeaters, initially at Western Electric then continuing with Bell Laboratories after their foundation in 1927.

His outstanding contribution to communications engineering, however, was in Information Theory. He was the first investigator to develop a law linking time to bandwidth and information, which he published as early as 1926, with a more detailed exposition appearing two years later, some 20 years before Shannon and Weaver's more renowned work.

Another prolific inventor, Ralph Hartley held some 72 patents on his retirement from the Bell Laboratories in 1950. He lived for another 20 years, long enough to witness the myriad developments which sprang from his originations.

Edwin Colpitts

In March 1915, Edwin Colpitts received a patent for his oscillatory circuit, an early example of which is illustrated in Figure 6.

A Canadian by birth and upbringing, Colpitts graduated with a first class honours degree from Mount Allison University New Brunswick, to which he shortly afterwards added another from Harvard. In 1897, he completed a Master's degree and remained at Harvard as a member of the physics faculty until, in the century's final year, he joined the Bell Telephone Company.

For the next two decades, Edwin Colpitts concentrated on improving the circuits and equipment of the emerging profession of communications engineering. Among his many contributions were the Push-Pull Amplifier of November 1912, high frequency and Line current measuring instruments and further development of the Loading Coil.

It's for his oscillator, however, that he's renowned, because his circuit, along with Hartley's, has been the mainstay of communications engineering almost since its inception. Today, although transistorised and their stability assured by the use of quartz crystals, they remain instantly recognisable in any communications circuit.

The Quartz Crystal Oscillator

In fact, the coming of the quartz crystal would establish a level of stability hitherto only dreamed of. Yet, the properties of this fairly common, unglamorous rock had been known for some time. So, who came up with the idea of using it in an oscillatory circuit? Watch this space! ELECTRONICS

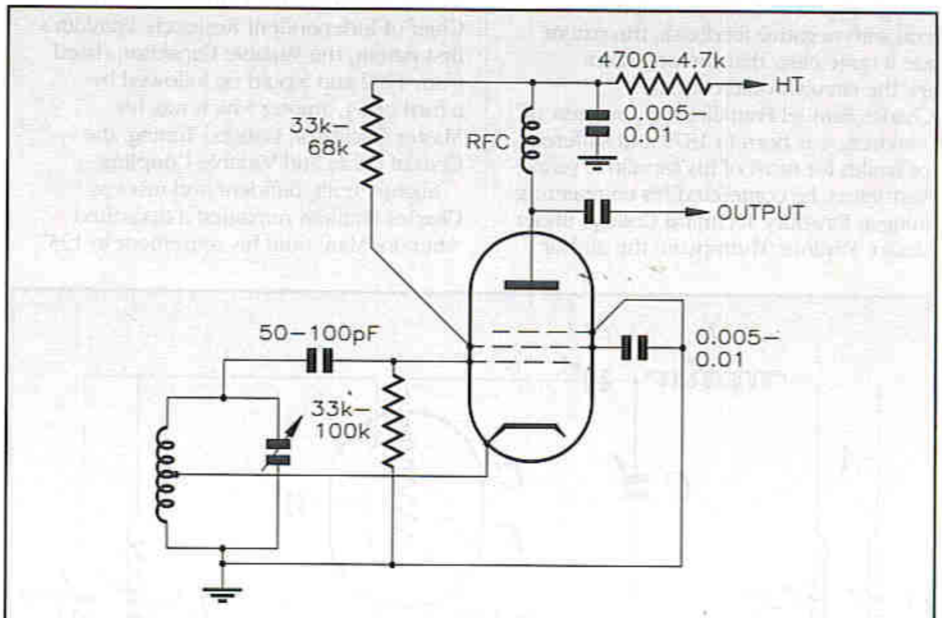


Figure 5. Hartley's oscillator circuit of February, 1915.

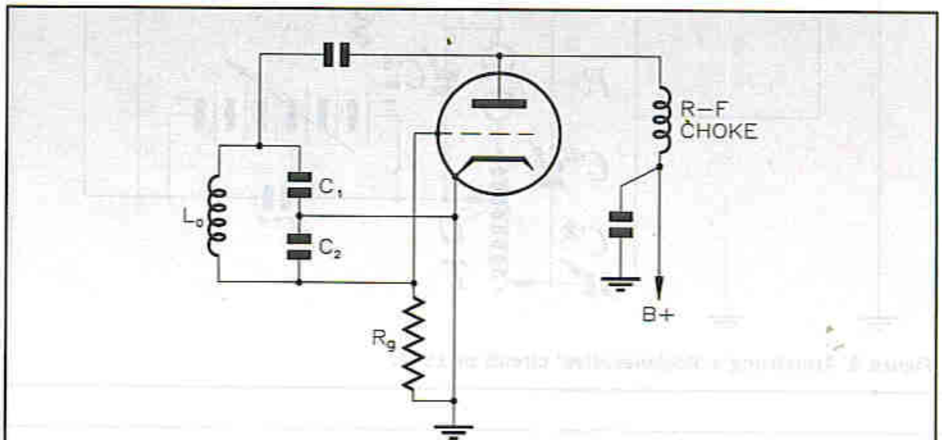


Figure 6. Colpitt's oscillator circuit of March, 1915.

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.

April 1997

8 April. Construction/Night on the Air, Bromsgrove Amateur Radio Society. Tel: (01527) 542266.

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

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

14 to 17 April. Tenth International Conference on Antennas and Propagation, Heriot-Watt University, Edinburgh. Tel: (0171) 344 5478.

19 April 1997. Exhibition of early Marconi apparatus to celebrate international Marconi day at the Wireless Museum, Puckpool Park, Seaview, I.O.W. Tel: (01983) 567665.

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

25 April. Top Band Direction Finding Competition, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

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 & 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.

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.

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

What's On?

Intel Boss Warns European Leaders Of Technology Deficit

Intel president and CEO, Dr. Andy Grove, in his opening plenary session speech at the World Economic Forum in Davos, Switzerland, advised European government and business leaders to take advantage of their existing infrastructure and substantial investments in information technology (IT) as a competitive tool in the race towards globalisation. He said that without significant national programs and incentives towards increased utilisation of existing technology, IT investments alone would not be enough to maintain competitiveness with emerging markets.

Dr. Grove further warned European leaders that the consequences of not adopting and encouraging the use of PC-based technology as a fundamental part of business and education could leave future generations of Europeans with a technology deficit.

Using Intel as an example, Grove demonstrated how a global $20 billion business uses PC-based electronic communications to give it a competitive advantage. Intel has invested $450 million in its C-based digital communications infrastructure, has 42,000 PCs for its 48,500 employees who send over a million e-mail messages per day.

Dr. Grove said, "In modern business, speed is the difference between success and failure – speed of decision making, speed in meeting customer needs, speed in delivering products when and where the market needs them – these are some of the critical factors required to win globally."

Also in his speech, Dr. Grove described the Internet as a Strategic Inflection Point – a point in the life cycle of an industry which is undergoing fundamental change. He argued that the Internet will radically change and create new industries from today's telecommunications, media and services industries. Such radical changes create opportunities for businesses and economies which can operate in these new industries.

Indeed, these changes are already taking place throughout the world and Europe has the opportunity to be a global leader, given its current IT investment and infrastructure. A specific example Grove cited was that the Internet provides a direct link to consumers for advertisers of goods and services without having to go through an intermediary like television or print media.

Grove asserted that Europe's communications infrastructure is an advantage but he balanced this with data showing the growing gap in Europe's use of technology compared to the US and emerging markets in Asia. "The data shows that Europe, while rich in infrastructure and PC consumption, is relatively poor in terms of technology utilisation. Over the long term, Western Europe is forecasted to lag behind emerging markets in the deployment and utilisation of PC technology", he concluded.

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

Inaugural Meeting of European ISPs Airs Key Issues for Internet Future

Over 200 European Internet and Online Service Providers, from the largest to the smallest, met for the first time in Cannes, France over the period 7th to 8th February to discuss the commercial, legal and technological issues that will shape the Internet to the year 2000 and beyond. This event, the first of its kind, was organised by US Robotics, and has laid the foundation for the next ISP summit meeting in 1998.

The summit was a forum in which ISPs could communicate and share experiences with their European peers. It also presented US Robotics' views on future Internet access strategies, including emergent technologies such as ADSL, ATM, Wireless and cable access.

Mike Valiant of US Robotics Network Systems Division, told Electronics and Beyond, "The Internet and on-line world is growing and diversifying at an explosive rate. The summit meeting brought technology vendors and ISPs together to identify future challenges, and to present ways of meeting and resolving them. The summit's success underlines the need for this type of communication, which is why we are already making plans for next year's meeting."

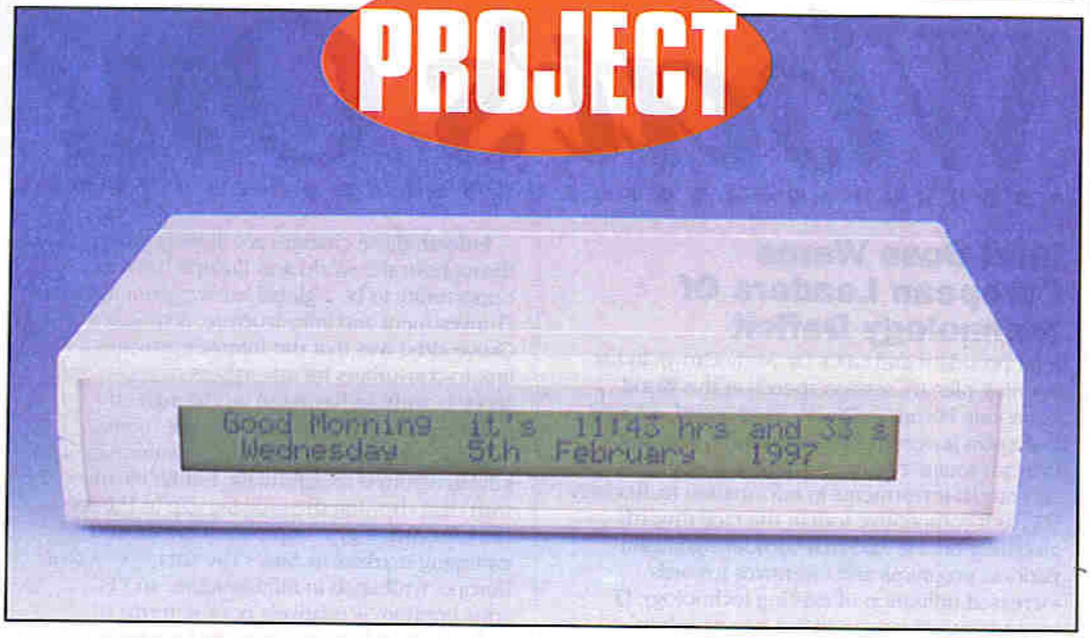
Participants attending the summit included leading ISPs and technology companies, such as Microsoft, the Gartner Group, UUNET Pipex, Telewest, Unisys, Siemens, Grolier Interactive, and the Dutch ISP Society. ISPs from 10 European countries and beyond attended the summit.

US Robotics has already spurred the growth of the Internet with the announcement last October of a modem technology which doubles the speed at which data can be downloaded from the Internet over ordinary telephone lines.

New statistics from the company estimate 70% of Internet subscribers worldwide will have access to the Web through ISPs that support its new x2 technology.

For further details, check: **http://www.usr.co.uk.** Contact US Robotics, Tel: (01734) 228200.

PROJECT



PUTTING PICS TO WORK

PART 2

MSF Clock Project

by Dr. Mike Roberts

This is an ideal project for the PIC microcontroller. You can read this as an example of the PIC's capability or just build it as a project using the PIC demonstration board described in Part 1 and a pre-programmed PIC.

SPECIFICATION

Input:	MSF data as positive-going pulses
Output:	40×2-line LCD Character Display Module Serial data for link to a PC
Example display:	Good Morning it's 11:29hrs and 23s Sunday 10th March 1996
PIC Software:	Error-checking both on parity bits and that the data is feasible (e.g., not 40th January), taking into account normal leap years. Automatic switching to internal timebase when signal is lost.
PC Software:	Emulation of the character display module on screen. Option to update the PC date and time. Compatible with DOS, Windows 3.1 and Windows 95.

Raw data is taken from an MSF receiver. There are many receiver options to choose from. The simplest one is described here. The time and date is displayed on an LCD character display module and also sent out as serial data to a PC. The computing performed by the PIC is extensive. It has far more error checking than the 'BASIC' program listed in Issue 47 of Electronics. I ran up against the 1,024 instruction maximum for the PIC16C71 and had to go through a couple of rounds of code rationalisation to fit everything in. I am not going to list the complete code as it runs to some 27 pages of A4! However, I will describe the logic flow and a couple of useful subroutines.

Development History

My first MSF clock was a standard kit, using a Z80 microprocessor to drive 6 × 7-segment displays. I later used my own Z80 single-board computer to take data from this system and display the time on a 6-digit LCD and the data as text on an LCD Character Display Module. Then I moved to putting all the data to a Character Display Module, this time using my Z80 to do all the processing, starting with the raw data from the MSF receiver.

At about this time, I bought the PICSTART B1 kit, as I wanted to design a speed control for electric powered model aircraft. Later, I wondered if the 760 lines of code in my Z80 SBC, (with its powerful instruction set) would squeeze into the 1,024-instruction capability of the PIC16C71 with its reduced instruction set. To my delight, it did. This gives an idea of the small loss in code efficiency moving from other 8-bit microprocessors to PICs. Initially, I did not include the serial data output facility. It was this addition that required some fine-tuning of the code.

Some readers might be asking "how difficult is it to write code for PICs?" My background before attacking Z80s and PICs was having done some BASIC and FORTRAN 20 years ago. This or similar, plus time spent understanding the register and memory structure of PICs, forms a good basis. The PIC reduced instruction set is quick to learn and you soon develop tricks to get solutions to the problems you wish to solve. Also, the Microchip

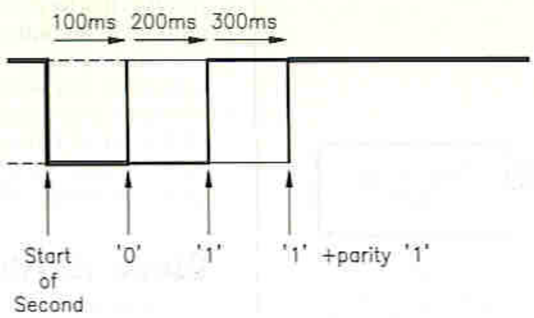


Figure 1. MSF code.

Application Notes are full of excellent examples.

MSF Signal

The time signal is transmitted from Rugby on a 60kHz carrier. A data set is transmitted every minute at a rate of 1 bit per second. The data is read by measuring the length of the interruptions of the carrier. A break of 100ms represents a '0', 200ms represents a '1' and 300ms represents a '1' with a parity of '1' (see Figure 1). The data includes the date and time information in a Binary Coded Decimal (BCD) form but excluding data bits, which will always be zero. For example, the 'tens' digit for the day of the month can only be 1, 2 or 3. Hence, the data transmission for the 'tens' digit for the day of the month only uses two bits. The full data sequence is shown in Table 1. The data finishes with a sequence '01111110'. This is unique, as BCD plus the shortened BCD used here cannot have six '1's in a row. Hence, the end of data can be found by looking for this sequence. Parity information is added to the '1's in this end of data sequence.

The flow diagram for the clock is shown in Figure 2. This is the code that is implemented every 10ms. I have excluded the startup sequence, which is essentially the code described in Part 1.

Second		Information
0	Fast code, same data but quicker!	
1-16	Difference between British Standard and Universal time (not used here)	
17	80	Year (0-99)
18	40	
19	20	
20	10	
21	8	
22	4	
23	2	
24	1	
25	10	Month (1-12)
26	8	
27	4	
28	2	
29	1	
30	20	Day of Month (1-31)
31	10	
32	8	
33	4	
34	2	
35	1	
36	4	Day of Week (0-6, 0=Sunday)
37	2	
38	1	
39	20	Hour (0-23)
40	10	
41	8	
42	4	
43	2	
44	1	
45	40	Minute (0-59)
46	20	
47	10	
48	8	
49	4	
50	2	
51	1	
52	0	Start of framing pattern
53	1	
54	1	Parity – year
55	1	Parity – day and month
56	1	Parity – day of week
57	1	Parity – hour and minute
58	1	
59	0	End of framing pattern

Table 1. Full MSF data sequence.

Clock Software

There is a software counter which is incremented every time the routine is run. When this reaches 100, it is reset to 0. This counter is used both to measure the duration of the data coming in and to trigger seconds, which in turn trigger minutes, hours, etc.

Counts of 8-14 are accepted as a data '0', 18-24 as a '1' and 28-34 as a '1' with parity '1'. Any reading outside these ranges is treated as an error and is discarded. These ranges have been selected to accept data from the MSF receiver module described here. I have built 3 other receivers, including both of the Maplin designs. These all gave similar or better pulses (i.e., closer to 10, 20, 30ms).

When the clock is first powered up, it displays 'Waiting for data XX' rather than 'Good Morning it's...'. XX is the duration of the last pulse received in hundredths of a second. This feature is very useful to check that the MSF receiver is working and producing pulses of the required widths.

The parity check adds up the '1's in the corresponding data (e.g., hours and minutes) and the appropriate parity bit and checks that the sum is odd.

The check on the validity checks that the minute is 0-59, the hour is 0-23, the day is 0-6, the month is 1-12, the day of the month is in the range for that month (including checking for leap years) and the year is 0-99.

When the clock increments time using its own internal timebase, it takes all the above into account. It indicates that it is on its own timebase by putting a '.' before the 's' at the end of line 1 of the display module.

The incrementing of seconds always uses the internal timebase, synchronised to the end of the last good data set.

Driving text for the display is fairly straightforward. The logic for deciding whether to put a 'st' or a 'nd' or a 'rd' or a 'th' after the day of the month took a little thought. My first attempt produced '13rd', much to the amusement of my family.

There is a fair amount of text data to be handled. In Part 1, I showed how to send 'Hello Fred' to a display module. This required 2 instructions per character. With larger amounts of text and where the text changes (e.g., 'Monday', 'Tuesday', etc.), it is more code efficient to use a 'Table Read', which uses only one instruction per character over the code needed to read the table. This is described in detail in the Microchip Application Notes.

Displaying a binary number as text needs a little thought.

```
        ; Subroutine to convert from BCD to binary
        ; Start with w holding 2 digit BCD
        ; Finish with w holding binary equivalent
BCDBIN  movwf temp          ;store in temp
        swapf temp,w        ;swap nibbles to W
        andlw h'0F'         ;w holds top BCD
        movwf temp2         ;temp2 =top BCD
        bcf STATUS,C        ;clear carry
        rlf temp2,W         ;w= 2xtop BCD
        movwf temp2         ;temp2=2xtop BCD
        rlf temp2,F
        rlf temp2,F         ;temp2=8xtop BCD
        addwf temp2,F       ;temp2=10x top BCD
        movf temp,W         ;w=original BCD
        andlw h'0F'         ;select bottom nibble
        addwf temp2,W       ;w=bottom nibble +
        ;10 x top nibble
        return

        ; Subroutine to convert binary to BCD
        ; Start with w holding binary number
        ; Finish with most sig. digit in msd
        ; and least sig. digit in lsd
BINBCD  clrf msd
        movwf lsd
gtenth  movlw d'10'
        subwf lsd,W         ;w=lsd-10
        btfss STATUS,C      ;skip if + or zero
        return
        movwf lsd           ;lsd=lsd-10
        incf msd,F
        goto gtenth
```

Listing 1. Subroutines to convert from a 2-digit BCD number to a binary number and vice-versa.

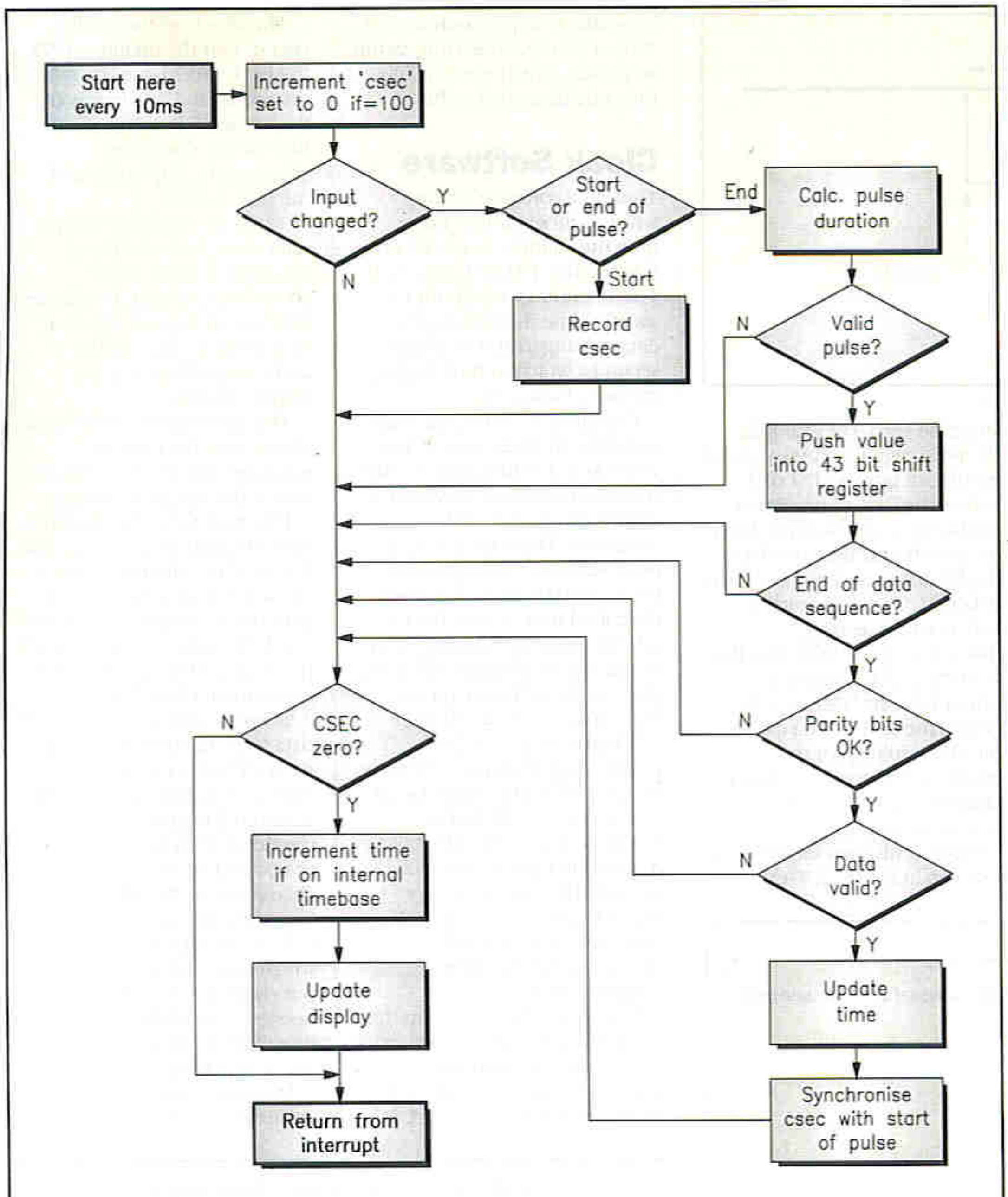


Figure 2. MSF clock flow diagram.

the data transmission. I have handled this by using RA2 as an input to define either '19' or '20'. This can either be connected to a switch or a shorting jumper can be fitted on the pair of pins (one pin is at 0V) and just remove the jumper at the end of 1999.

Clock Hardware

The small size of the PIC demonstration board provides scope for a neat enclosure. However, I did find I needed to search to find the box in the photograph and a display small enough (in height) to fit into it. I also have a smaller version with the display and PCB squeezed into a triangular box cut from plastic cable trunking. This fits between my PC and its keyboard. Choose a box to suit your needs. Please check the location of mounting pillars as well as the external box size.

Receiver

My favourite receiver involved getting a Maplin MSF clock module (the one with hands!), ripping it to pieces and picking the signal off a tiny piece of PCB track inside. Fortunately, you can now get something close to this as a pre-tuned antenna and receiver module. All that is needed is a simple circuit to provide a 3V supply for the module and convert the output to a 5V signal for the PIC. The receiver circuit is shown in Figure 3 and the PCB layout in Figure 4.

It is worth putting the receiver module and associated PCB into a separate box so that the best location can be found. In theory, the best orientation is with the antenna perpendicular to the direction of the transmitter at Rugby. It is probably best placed more than 2m from televisions and PCs.

The time data comes in as BCD. I converted this to binary to make the incrementing of time easier. However, we read numbers as decimal, hence the need for a routine to convert it back to BCD and then to ASCII for the display. Listing 1 gives subroutines to convert from a 2-digit BCD number to a binary number and to do the reverse. Conversion from a single-digit BCD to ASCII is easy. Since the ASCII code for '1' is hex '31', and '2' is hex '32' and so on, all you need is to put the number into 'w' (movf,W) and use 'addlw h'30' '.

The Millennium-conscious amongst you will have noticed the absence of the century in


Photo 1. Remote MSF receiver unit plugged into the back of the MSF clock.

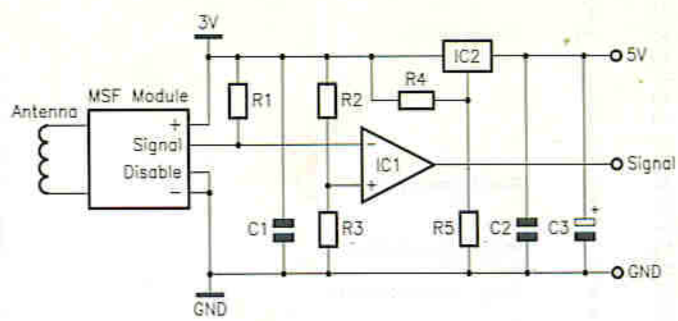


Figure 3. MSF receiver circuit diagram.

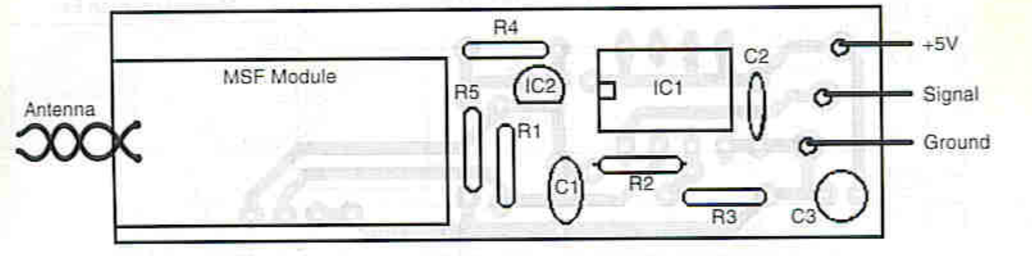


Figure 4. PCB legend and track.

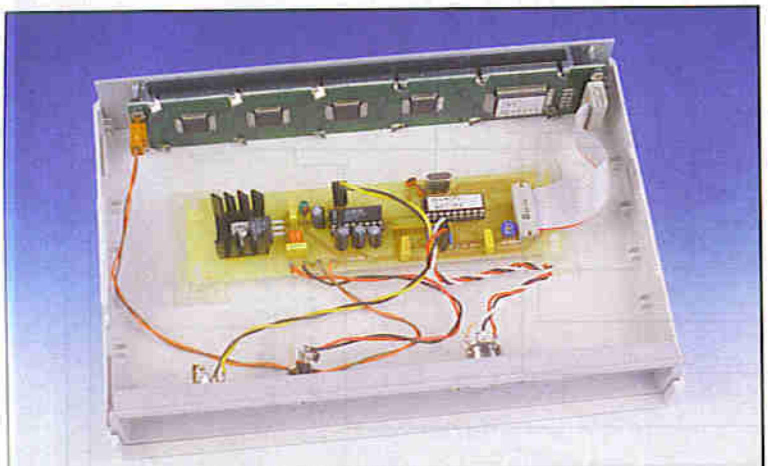


Photo 2. Inside view of the MSF clock.

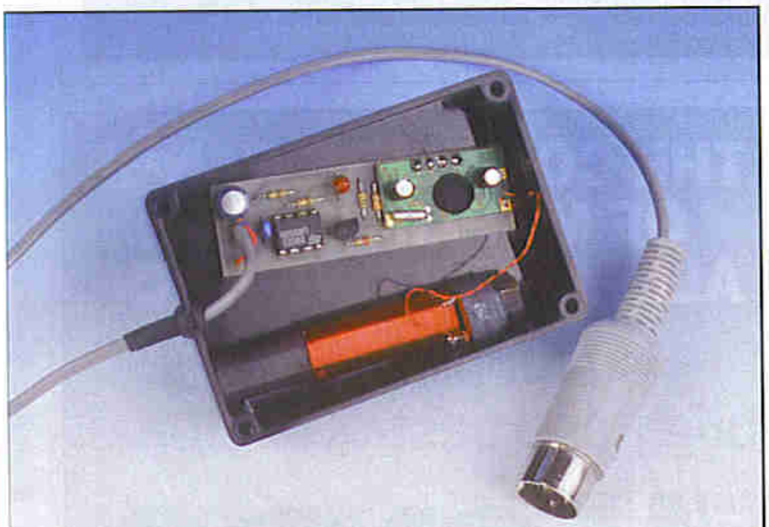


Photo 3. Inside view of the receiver unit.

Photo 4. D-type connector lead used to link the MSF clock to a PC's serial port.

Construction is quite straightforward. I usually add components in the order of their height! The module is mounted to the main PCB via 4 wire links.

Serial Link and PC Software

The cable connections for the serial link were described in Part 1. The PC software which picks up the serial data is a Microsoft Visual Basic (DOS) program which can be run in DOS, Windows 3.1 and Windows 95. It uses COM2 to receive the data. The display on the PC is a copy of the display in the character display module. The only difference is that the background colour is green if the clock has just received a good data set or yellow if it is working on its own timebase. A button marked 'Update' can be operated by a mouse or by pressing 'enter' to update the PC's internal clock and calendar. The program is available from the author with the routines mentioned in Part 1. To load the program (msf_clk.exe), just copy it into the appropriate directory and if in Windows, click and drag it from File Manager onto the appropriate desktop group. There is an icon (msf_clk.ico) if you want to use it. Connect up the serial lead and power up the clock before running msf_clk.exe.

Recommended Reading

Microchip Embedded Control Handbook, Application Note AN548 Implementing Table Read and Table Write.
Order Code AD28F.

Printed Circuit Boards, PIC and PC Clock Program

The following are available from the author (prices include postage):

Development/Clock PCB	£7.50
Receiver Module PCB	£5.00
Programmed PIC for MSF Clock	£12.50
Disc with PC clock program and example code from Part 1 (note this does not include the PIC MSF Clock source code)	£3.00

Dr Mike Roberts, 4 Thames Avenue, Guisborough, Cleveland TS14 8AD.

MSF CLOCK PARTS LIST

PIC CIRCUIT BOARD AND SERIAL LINK

See Part 1 for parts list. Note the crystal is 3·2768MHz (FY86T) and C11 & 12 are 12pF (WX45Y). C12 is omitted if C13 (optional) is fitted.

MSF RECEIVER

RESISTORS: All Miniature 0·125W 5% Carbon Film

R1	100kΩ	1	(M100K)
R2,3	10kΩ	2	(M10K)
R4	220Ω	1	(M220R)
R5	330Ω	1	(M330R)

CAPACITORS

C1	1μF 35V Tantalum Bead	1	(WW60Q)
C2	0·1μF Resin-dipped Ceramic	1	(RA49D)
C3	33μF 16V Radial Electrolytic	1	(AU00A)

SEMICONDUCTORS

IC1	LM358N	1	(UJ34M)
IC2	LM317LZ	1	(AV26D)

MISCELLANEOUS

LCD Character Display Module	1	(DK64U)
or Backlit Version	1	(DK67X)
MSF Receiver Module	1	(MK68Y)
MSF Antenna	1	(MK72P)
Box for Receiver	1	(LL12N)
Printed Circuit Board	1	* See Text *
Disc with PC Clock Program	1	* See Text *

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

The above items are not available as a kit from Maplin Electronics.

ELECTRONICS CORRIGENDA

March 1997/Issue 111

IMPORTANT SAFETY NOTICE

Air Your Views **Page 21**

Mains Isolation Box

L. C. Thomas of Gerrards Cross, Bucks, has brought to our attention that the circuit diagram accompanying the Star Letter (Mains Isolation Box) contains a number of errors, some of which have serious safety implications. They include:

1. The purpose of S2 as described and its wiring do not make sense. In order for the 4mm output socket voltages 6 to 11 to work, both the high and low circuits must be powered simultaneously.

2. S4 either puts a short across the 240V supply or shorts out half the primary of T3. In the latter case, T3 would rapidly overheat because of the shorted turns. Whether, or how quickly, this would blow the mains fuse would depend on its rating, which is not specified, and the quality of T3.

3. The secondary of T1 is marked as 120-0-120 and 48V. If a transformer of the former type were used, the voltage at the 13A output socket would be about 1,200V.

4. The primary of T3 is marked L & N and 120-0-120. A distinction should be made between what may be marked on the transformer and what is applied to it. The centre tap will certainly not be at 0V.

5. The 48V output on the 4mm socket will not work since S3b tag 6 is not connected.

6. There is no mention of the need to wire the transformers in the correct phase nor of S3 being a break-before-make switch. The life of the LEDs is likely to be limited since both are subject to a reverse voltage in excess of the typical maximum rating. Such a failure could lead the user to believe the unit is off when it is in fact still powered.

7. Of great concern is the provision of three outlets, 240V on a 13A socket, a 3-pin socket for 110V (or is it 120V) and the 4mm sockets. It is absolutely essential that only one piece of equipment is powered from an isolating transformer at a time. If two live-chassis radios were plugged in, the voltage between the chassis could be 240V – an extremely dangerous situation with possibly fatal consequences. As stated, the unit could be modified to suit the users' requirements, so the 3-pin 110V socket might be changed to a second 13A socket and wired for 240V, making the above action even more likely.

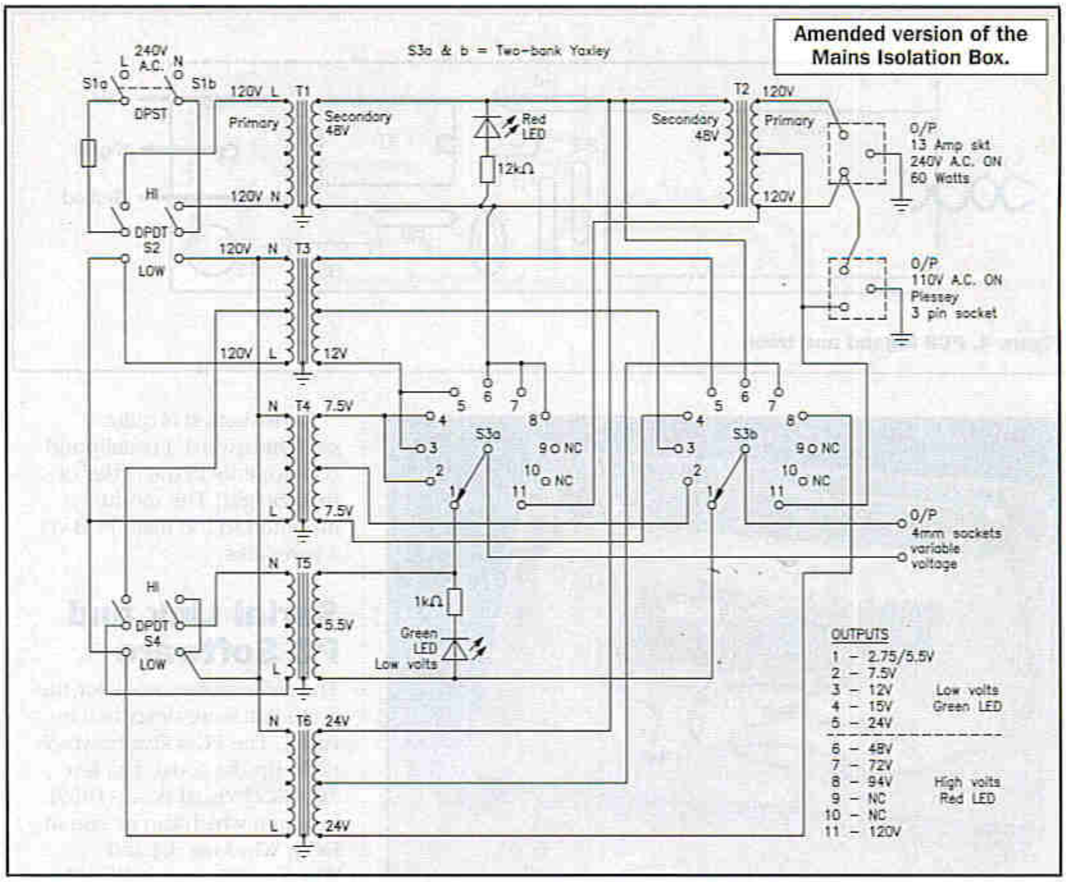
8. The earthing requirements for such a device are far from simple.

Regarding point 1, the wiring to tab 6 of S3b was omitted. It should be connected to the secondary windings of T1 and T2 as shown.

Regarding point 2, there was an unfortunate misprint in the wiring to transformer T5 – please see revised wiring in the diagram shown. No fuse rating was specified by the originator of the circuit which will in any case depend on the power rating of the transformers.

The revised diagram also addresses points 3 & 4, in that misleading details regarding voltages at the transformers have been moved or deleted.

Regarding points 6 to 8, we would like to reiterate the use of break-before-make switches throughout the circuit and the need to wire the transformers in the correct phase, i.e. the same throughout, plus the advice on only operating one piece of equipment from the circuit at a time. For reliability, the LEDs could be replaced by neon lamps with series resistors (220kΩ approximately) connected across the primary windings of transformers T1 and T5. If in doubt as to use of the circuit and suitable earth wiring, consult a qualified electrician.



Amended version of the Mains Isolation Box.

Centronic 24-line Input/Output Card Part 2, Issue 112, page 15.
The Gremlins crept into Figures 6A and 6B whereby no interconnections appeared. We will remedy this in the next issue

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Maplin Magazines Dec '87 to Feb '94, plus projects books 2 & 3. Offers to: P. Palmer, 3 Crown St., Oxford OX4 1QG. Tel: (01865) 725901 (eves).

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B8A Series Valves Wanted, one set; UCH42, UF41, UBC41, UL41, UY41. Mr. F. Nuttall, daytime Tel: (01227) 368514.

Spectrum 128K +3 Computer, also disk drive and printer. Frank Cosgrove, 59 Fenton Road, Bournemouth BH6 5BS. Tel: (01202) 432973.

HERO 2000 Wanted in working order. HERO 1 considered. Tel: (01243) 774285. E-mail: mjb@arunet.co.uk

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.

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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.

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.

Model Railway Enthusiast? How about joining 'MERG', the Model Electronic Railway Group. For more details contact: Paul King (Honorary Secretary), 25 Fir Tree Way, Hassocks, West Sussex BN6 8BU.

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

Science At Your Fingertips. 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 9WX.

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 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.

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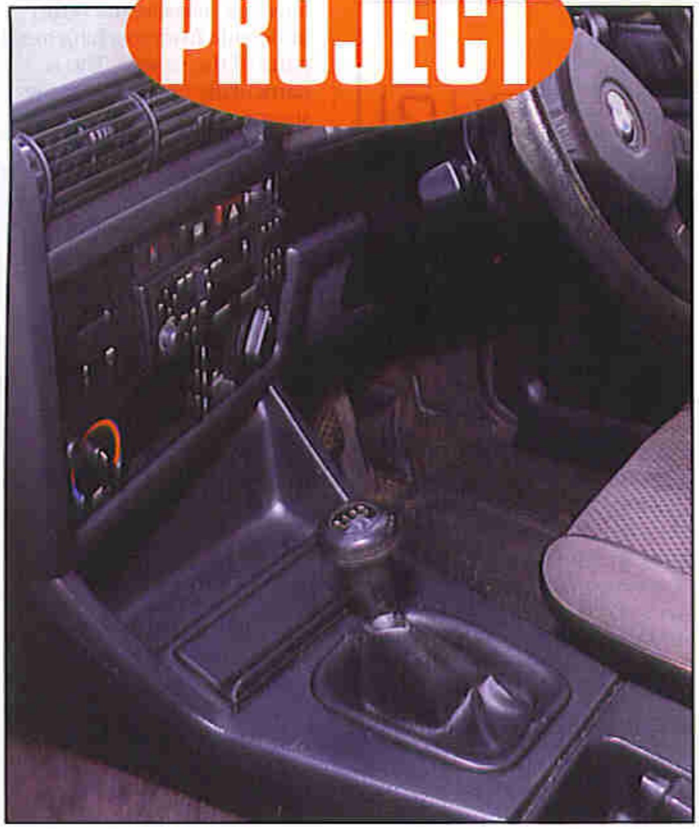
PROJECT



Gearshift INDICATOR

Design and Text by Maurice Hunt

This project is a useful add-on feature to any vehicle having a manual gearchange – an easily read LED digital display readout to automatically indicate the current gear selected, as fitted in many race/rally cars. Ideal for forgetful drivers, who having been in one gear for a long while, can't remember which gear to grab when the next junction approaches and end up frantically fishing around the gearbox for the right cog.

SPECIFICATION

Operating voltage:	7-25V DC (12V nominal from car battery)	
Operating current:	51mA@14V Standby (gearbox in neutral, display off)	
	64mA@14V Activated (in gear, display on)	
PCB dimensions:	Sensor board:	101 × 140mm
(As on prototype)	Logic board:	64 × 33mm
	Display board:	40 × 20mm

The Gearshift Indicator is particularly beneficial in modern vehicles with five-speed gearboxes, some of which have closely-spaced gearshift 'gates' making it difficult to tell at a glance which gear is selected. Judging which gear you're in from the pitch of the engine can be tricky too, owing to the quietness of most modern vehicles – and if the stereo is on, it may be drown out any remaining audible clues.

The project could also have its uses in learner driver/training vehicles, to enable the instructor to easily keep track of which gear the trainee driver has selected and thus be able to give advice about their choice and its appropriateness to the driving situation.

The Gearshift Indicator is also a marvellous boon for back-seat drivers, and looks impressive to passengers!

The project is straightforward to install, with only two connections required (for an ignition-controlled power supply) to the vehicle electrical system and little in the way of mechanical attachment needed. The project can be easily adapted for use in other applications where the position of an object or objects needs to be indicated, since the Hall sensors and actuator magnets could be mounted almost anywhere. For example, the circuit could be used on a bicycle with derailleur gears to show which gear it's in, or which door/gate/window is open in a building, or as an indicator to show which lever has been pulled, etc.

Circuit Description

Refer to Figures 1 & 2, showing the block and circuit diagrams, respectively, of the Gearshift Indicator. Five UGN3503U Hall sensors, H1-5, are used to detect the position of the gearstick within its 'gate'; their output voltage changes slightly when a magnetic field is brought close to them. Without a magnet being close, their output remains at around half the supply voltage (in this case, half of 5V = 2·5V), but with a magnet nearby, this goes up or down by up to around 0·1V, depending on the strength of the magnet and its pole. What is required is for each Hall sensor output voltage to rise slightly when the actuator magnet is brought close.

The sensors have a frequency response of flat to 23kHz, so the circuit wouldn't be caught out by even the quickest gearchange, and can handle 'unlimited' magnetic flux density (i.e., strong magnets) without damage.

The small change in voltage from each sensor (only one of which will be activated at any time) is 'conditioned' and made into a definite logic change by means of the non-inverting hex (6 per chip) buffers in IC1, which act as a form of Schmitt trigger, with a positive-going trigger voltage conveniently similar to that of an activated Hall sensor (at just

FEATURES

- Hall sensors for contactless magnetic actuation
- Independent sensor sensitivity adjustment
- Wide operating voltage
- Fast response

APPLICATIONS

- Any vehicle with 4- or 5-speed manual gearbox
- Remote object position identification

PROJECT RATING 2

Important Safety Warning

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

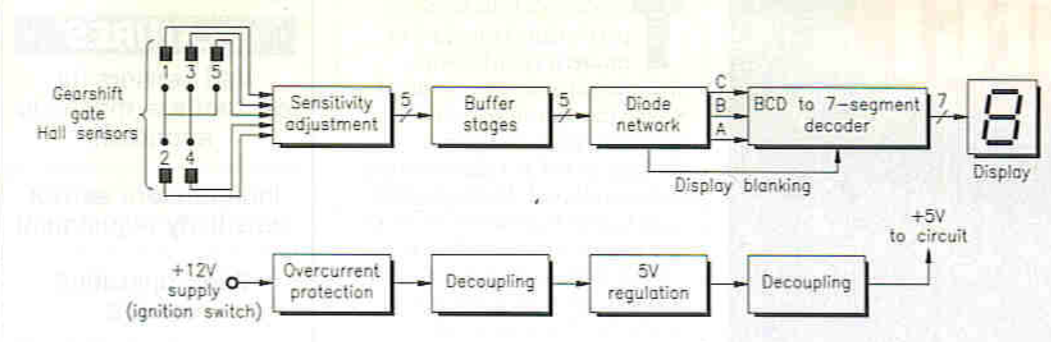


Figure 1. Block diagram.

over 2·5V). Note that one of the six buffers is unused, since only five gear positions need to be indicated in the majority of modern vehicles (although the circuit could be easily adapted to show 6 gears if required).

Preset potentiometers VR1-5 provide biasing to act as a 'helping hand' to trip each buffer into giving a high output. Being adjustable, they enable the sensitivity of each sensor to be altered independently of the others. This is useful, as in some instances (i.e. with some gearshift patterns), the actuator magnet may be needed to activate one sensor from a comparatively large distance (e.g., 1in. away), while the same magnet passes very close (e.g., within a few mm) to a neighbouring sensor. The potentiometers therefore allow 'fine-tuning' of the circuit to suit installation in a particular vehicle. In tests, the Hall sensors could detect the magnet from several inches away with the sensitivity set to maximum.

The outputs from the five buffers are further buffered with transistors TR1-5 used in common collector configuration to act as current amplifiers, since it was found that the outputs of the hex buffers got bogged down when demanded to directly drive the logic stage formed from diodes D1-9.

The diode network performs twin tasks. Firstly, it causes the display blanking to be disabled whenever a Hall sensor is activated; normally, the display is blanked (switched off) to save power. Secondly, the logic translates the five sensor channels into the correct binary code for the 4511BE BCD to 7-segment converter chip, IC2, to further translate into the appropriate numeral on the 7-segment LED display. The coding required is shown in Table 1.

Power for the circuit is taken from the vehicle's 12V supply, using the ignition controlled live feed (so it is only powered up when the ignition is switched on). This is then regulated down to a steady 5V DC using the 7805 regulator, IC3. Note that the Hall sensors H1-5 have a maximum voltage rating of 8V, with a normal operating voltage of 4·5-6V.

Supply decoupling is taken care of by capacitors C1 & C2 (high frequency) and C3 & C4 (low frequency).

Note that the above describes the circuit suitable for a 5-speed vehicle; if fitting the project to a 4-speed vehicle, the fifth Hall sensor (H5) and associated components (VR5, R5, TR5, D5, 8 & 9) can be omitted.

Construction

The prototype (shown in the photographs) was constructed on three PCBs – display board, logic board and the sensor board. The display board is very compact to make it easy to find space for it on the dashboard. Note that the boards were purposely made single-sided, with no holes drilled through to the underside; this was to make for simpler installation in a vehicle, without the problem of having to insulate the board underside from touching metal parts of the vehicle. This is particularly necessary for the sensor board, which needs to be mounted on top of the transmission tunnel at the base of the gearstick. With a totally flat board underside, simple self-adhesive pads or strong double-sided tape can be used to secure the board in place, thus obviating the need for complicated mounting brackets, fixings, etc. However, you need to remember to allow adequate 'pad sizes' so that the components can be mounted onto the board – and the leads of the components will need to be pre-bent prior to fitting.

It is advisable before making the sensor PCB, to inspect the gearshift gate of the vehicle into which the project is to be installed, firstly, to find out how large the board can be (the aim is to hide it from view), and secondly, to take a note of the pattern and distance between each slot in the gate (and where the gearstick is positioned in each gear), so that the Hall sensors can be fitted in a corresponding layout on the sensor PCB. As long as the Hall sensors are located in approximately the right positions, they can be altered as necessary by manipulating their leads, which should be left

Sensor Channel Activated & Displayed Numeral	BCD Input to IC2 C	B	A
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1

Note: BCD Input D is not required, hence is held low (logic 0).

Table 1. Diode network inputs and outputs.

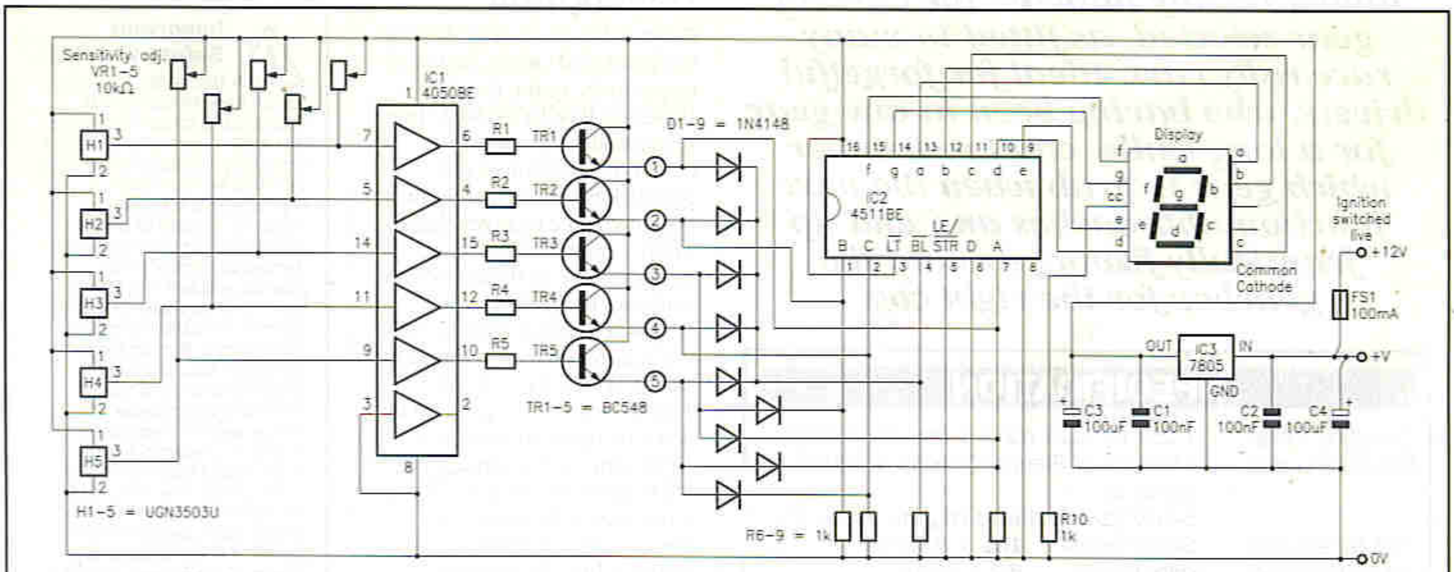
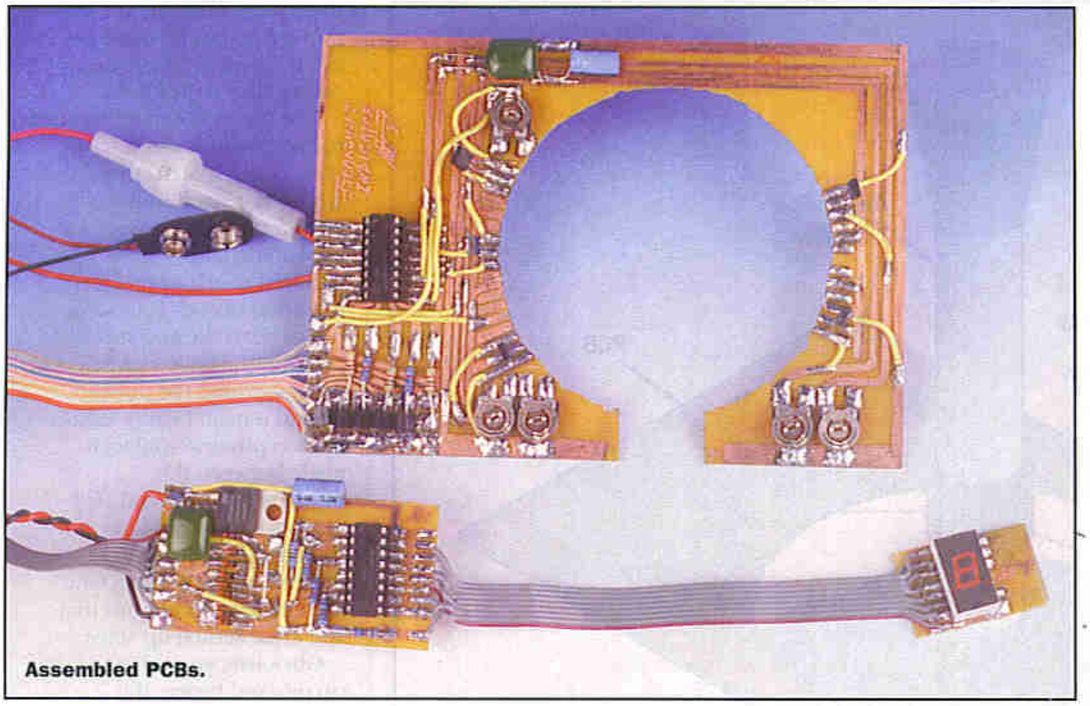


Figure 2. Circuit diagram.



Assembled PCBs.

approximately 0·5in. long, as shown in the photographs. The positions of the magnets and sensitivity of each sensor can also be altered to allow a generous scope of overall adjustment to get the project to suit the vehicle.

The sensitivity adjustment potentiometers VR1-5 were mounted on the sensor board, and are of the horizontal variety, to enable easy access for 'tuning in' of the sensors to the vehicle's gearshift pattern.

Assembly of the components can be done in the usual order of ascending component size/height, taking care to correctly orientate the polarised components – semiconductors and electrolytic capacitors. Anti-static precautions should be taken when handling the CMOS components (Hall sensors H1-5 and ICs 1 & 2). It is advisable to use DIL holders for ICs 1 & 2 to allow easy replacement, should it ever be required. Note that ICs 1 & 2 should be left out of their sockets until after the preliminary testing stage.

Note that the ribbon cable needs to be 8-way for the wiring to the display board, and only 7-way for the wiring to the sensor board. The ribbon wire lengths will depend on the distance between the gearstick area and the dashboard, and on how far away the display board has to be mounted from the logic board. It is worthwhile using header plugs and sockets to make for easy separation of the boards, to facilitate easier installation. However, the ribbon cables could be soldered directly to the boards if you prefer.

Having assembled the boards, check carefully for errors, solder whiskers, bridges and dry joints, then clean excess flux away using a suitable solvent.

Testing

Having assembled the boards, you will need to obtain suitable magnets to activate the Hall sensors. For the prototype, magnets were extracted from two small DC motors (ideal for attaching to the gearstick, since they have a curved profile). If using ex-motor magnets, you ideally need a pair of identical type, i.e., with the appropriate pole on the convex side (outside of the curve), hence the need to take two motors apart to obtain such a pair – most motors will have two magnets with opposite poles. The appropriate pole depends on which way round you fit the Hall sensors in relation to the magnets. If you only have one sacrificial motor available from which magnets could be taken, the upper row of Hall sensors (for gears 1, 3 & 5) could be fitted one way round on the PCB, with the lower row (for gears 2 and 4) fitted the opposite way round. In summary, a bit of experimentation will be necessary to find the best combination of Hall sensor and magnet pole/orientation.

You could instead use bar magnets (e.g. FX71N), but they are more tricky to attach to the gearstick and more than two may be needed to activate all the sensors through each of the gears.

Preliminary testing of the circuit entails powering it up while ICs 1 & 2 are left out of their sockets. Using a multimeter with its '–' lead connected to the 0V rail, check that 5V DC is at the output of the regulator IC3, the supply lead of each of the Hall sensors H1-5, and the Vcc pins of ICs 1 & 2 (pins 1 and 16, respectively).

If all is well, disconnect the power supply and insert ICs 1 & 2 into their sockets, observing orientation and anti-static precautions. Re-connect the supply and observe the display, whose segments should remain unlit. If it is showing a number, the sensitivity adjustment potentiometers will need to be 'backed off' until the display goes blank. Next, bring a magnet close to each of the Hall sensors in turn, which should cause the display to indicate a number relevant to the sensor activated (again, some adjustment of the potentiometers will be needed until each sensor activation causes the correct numeral to be displayed). You may need to reverse the magnet's pole (turn it around!) to get the sensors to react. Removal of the magnet should cause the display to revert to its blanked state.

Note that if more than one sensor is activated at a time, in some cases, the displayed number will be a summation of the outputs, e.g., if sensors 3 and 4 are activated, the number '7' will be displayed. However, for the project's main application, with a positively defined vehicle gearshift, the layout of the sensors will be

Close-up of the sensor board installed around the base of the car's gearstick, showing the actuator magnets attached to the gearstick.

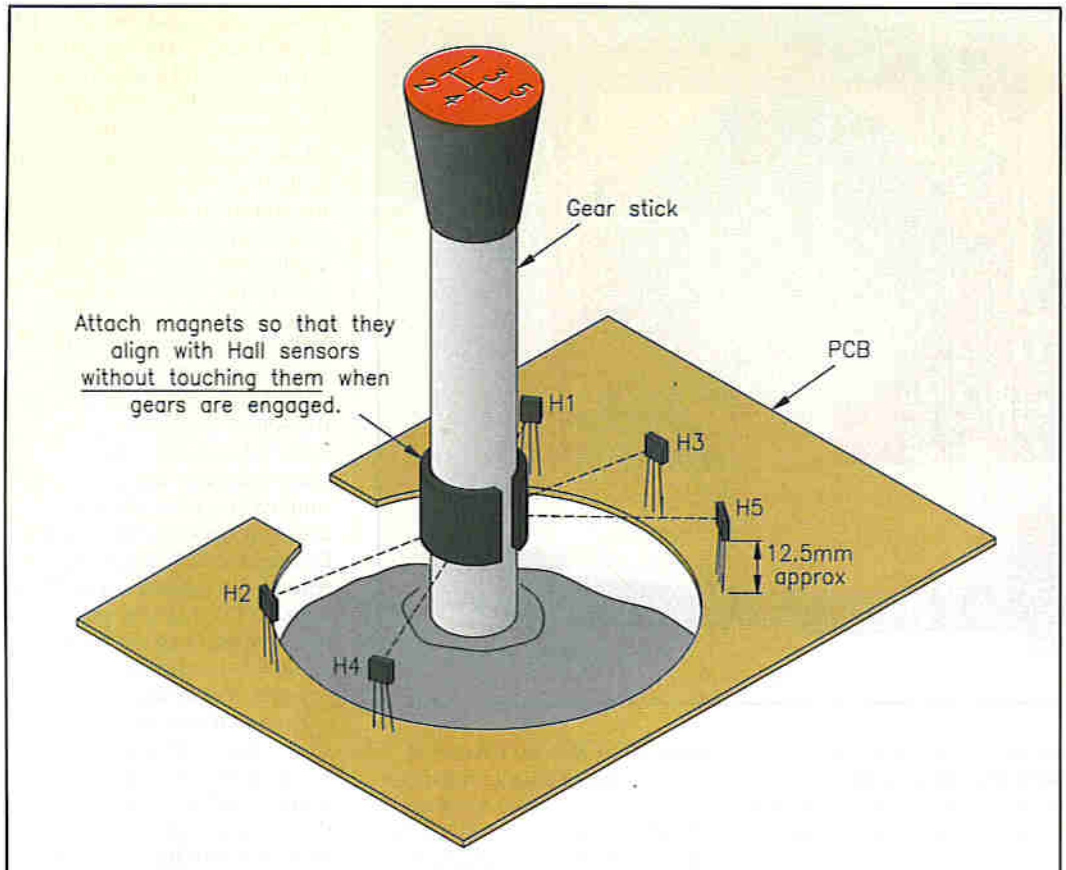


Figure 3. Layout of the magnets in relation to the Hall sensors

such that only one will be activated at any time, so this characteristic won't be a problem if the sensitivity is set correctly.

If the project works as expected 'on the bench', it can be installed into the vehicle. Please read the safety warning printed in this article BEFORE starting the installation.

Installation

Refer to Figure 3, showing how to fit the sensor board and actuator magnets in place. If your initial measurements for a suitable sensor board size were correct, there shouldn't be any problem in fitting the sensor board into the vehicle neatly and preferably, out of view. The prototype was fitted into a 1984 BMW 3-series, which has an easily-removed gearstick gaiter, allowing the sensor board to be slipped in around the base of the gearstick within the centre console, so that with the gaiter replaced, it is hidden from view.

The sensor board can be held in place using strong double-sided tape or self-adhesive pads to stick its smooth underside to the transmission tunnel, or brackets could be made up for a more rigid fixing. The display needs to be mounted in a suitable position on the dashboard so that it is easily readable, but shielded from bright sunlight (which will make it difficult to read). The logic board can be mounted in any suitable position behind the dashboard, and can be fitted into a small plastic box if required.

A connection needs to be made between an ignition-controlled live point on the vehicle (e.g. accessory terminal of the ignition switch) and the '+V' supply rail on the circuit. An in-line fuseholder should be fitted in this live feed, as close to the take-off point as possible, and fitted with a fuse of the specified rating. The ground (0V) connection can be made to any suitable metal area on the car's chassis (assuming the vehicle is wired negative-earth as most are).

An additional switch could be fitted in the supply rail to enable the project to be switched on and off if required. Alternatively, the circuit could be powered from the cigar lighter socket, observing correct polarity. Note that the voltage regulator may need to be fitted with a suitable heatsink, depending on the power supply voltage and the mounting position of the main logic board within the vehicle – check how warm the regulator gets following several minutes' use to ascertain whether a heatsink is required.

The ribbon interconnecting cable and power supply cables can be hidden from view, but make sure that they won't be chafed through by keeping them away from sharp edges, moving parts, etc. Cable ties can be used to secure the cables tidily in position.

The magnets can be attached to the gearstick using strong tape, or suitable adhesive, once appropriate positions have been found for them – some experimentation will be required to achieve reliable actuation of each Hall sensor in response to the gearstick position (including reverse and neutral, where the display should remain blank). Ensure that no physical contact is made between the magnets/gearstick and Hall sensors even during forceful gearchanges. Blu-tack is recommended for attaching the magnets during this trial-and-error setting up stage.

Obviously, you will need the circuit (and hence, the ignition) switched on while setting up the sensors/magnets, and each gear will have to be selected in turn. It goes without saying that the vehicle's engine need not (indeed, *should not*) be running while this procedure is being carried out!

The final test is to drive the vehicle as you normally would and check that the display reliably informs you of the gear selected, and that the display turns off with the gearbox in neutral/reverse or with the ignition switched off.

GEARSHIFT INDICATOR PARTS LIST

RESISTORS: All 1% 0·6W Metal Film (Unless Stated)			
R1-10 1kΩ		10	(M1K)
VR1-5	10kΩ Horizontal Preset Potentiometer	5	(UH03D)
CAPACITORS			
C1,2	100nF Mylar Film	2	(WW21X)
C3,4	100µF 35V Radial Electrolytic	2	(AT59P)
SEMICONDUCTORS			
D1-9	1N4148 Silicon Diode	9	(QL80B)
TR1-5	BC548 n-p-n Transistor	5	(QB73Q)
H1-5	UGN3503U Ratiometric Linear Hall Effect Sensor	5	(GX09K)
IC1	4050BE Hex Non-inverting Buffer	1	(QX22Y)
IC2	4511BE BCD to 7-segment Decoder	1	(QX31J)
IC3	L7805CV 5V 1A Voltage Regulator	1	(QL31J)
DISP	0·3in. Common Cathode LED 7-segment Display	1	(FR38R)
MISCELLANEOUS			
	16-pin DIL Holders	2	(BL19V)
	PCBs	3	
	10-way Ribbon Cable * See Text *	As Req.	(XR06G)
	8-way PCB-mounted Header Plug	As Req.	(YW13P)
	8-way Latch Socket Housing	As Req.	(YW23A)
	Actuator Magnets * See Text *	2	(FX71N)
	Car In-line Fuseholder	1	(DR79L)
	100mA 1¼in. Fuse	1	(WR08J)
	100mm Cable Tie	As Req.	(BF91Y)

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

The above items are not available as a kit.

Audio Basics
PART 1

Design by Ray Marston

Ray Marston looks at audio-system basic principles in this special feature article.

Audio Signals

An audio signal is a waveform with a fundamental frequency that falls within the range 16Hz to 20kHz, which is the recognised span of human hearing. The audio signal may be acoustic (a sound wave) or electric (a voltage or current). Figure 1 shows some important features of the audio spectrum. Thus, the human voice generates acoustic waves within the range 100Hz to 4·5kHz, human hearing has a sensitivity peak at about 3·5kHz, and most music waveforms fall within the spectrum 50Hz to 16kHz.

Humans with unimpaired hearing have an aural response curve that varies with frequency, loudness, and with age. Figure 2 shows typical response curves for 18 to 25 year olds, at both 'very low' and 'moderate to loud' sound levels. The aural response falls off sharply (typically at a 10-14dB/octave rate) below 200Hz, and drops dramatically at frequencies above 16kHz.

Above the age of 25 years, the ear's relative sensitivity to signal frequencies greater than 500Hz falls off (when compared to a typical 25 year old) in proportion to both frequency and the age of the listener, in the basic manner shown in Figure 3. Thus, to hear a 10kHz signal with the same clarity as a 25 year old, a listener needs to give the signal 5dB of boost at the age of 30, 11dB at the age of 40, 20dB at 50, 35dB at the age of 60, and a hefty 55dB at the age of 70.

Audio Systems

An audio system is one which enables an acoustic audio signal to be conveyed from a source point to a destination point by artificial means. Prior to the invention of electronic amplifying devices, all short-range audio systems consisted of simple mechanical devices such as megaphones, hearing horns, or speaking tubes, and the most widely used long-range systems were the telephone and the hand-cranked gramophone.

All modern electronic audio systems consist of the basic elements shown in Figure 4. At the source end of the system, the sound is picked up by a microphone (an acoustic-to-electric transducer) and the resulting electrical output signal is passed to an electronic processing circuit, where the signal may be amplified and/or filtered, etc., before being applied to the system's communication medium, which usually takes the form of a tape, a disc (record), a CD, a length of cable, or some form of wireless link.

At the destination end of the system, the basic audio signal is extracted from the communication medium via a suitable detector/converter circuit and is then changed back to its original form via another signal processing circuit. The resulting audio signal is then passed through a power amplifier before being connected to an electric-to-acoustic transducer such as a loudspeaker or headphone, which converts the signal back into its original audible form.

Audio System Fidelity

In audio system jargon, 'fidelity' is a rough measure of the ability of a system (or major sub-system) to reproduce an accurate copy of an original audio input signal, and is expressed in terms of either 'Hi-Fi', 'Medium-Fi', or 'Low-Fi'. A system's 'Fi' requirement depends on the specific application, as shown in Table 1 and indicated by the following notes:

- A Hi-Fi system is one that gives a good to superb quality of sound reproduction over the full audio frequency spectrum. A Hi-Fi performance is required in all good music reproduction systems. Most sophisticated modern home entertainment audio units give a Hi-Fi performance.
- A Medium-Fi system is one that gives a moderate to good quality of sound reproduction, over most or all of the audio frequency spectrum. Such a performance is adequate for use in portable radios and portable cassette or CD players, and in Karaoke units, etc. Most such units do in fact give a Medium-Fi performance.
- A Low-Fi system is one that gives a poor to moderate quality of sound reproduction, or responds well to only a restricted part of the audio frequency spectrum, but gives a performance that enables voice messages to be reproduced without significant loss of intelligibility. Most loud-hailers, public address systems, intercoms, and mobile phones give a Low-Fi performance.

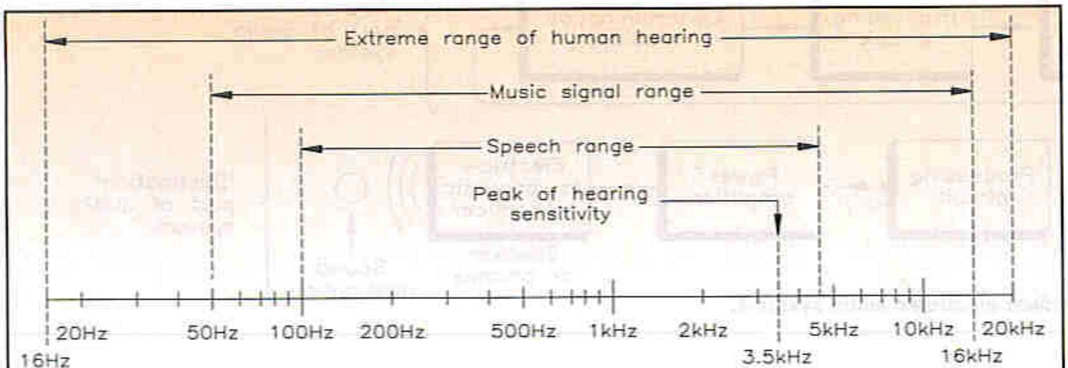


Figure 1. Important features of the audio spectrum.

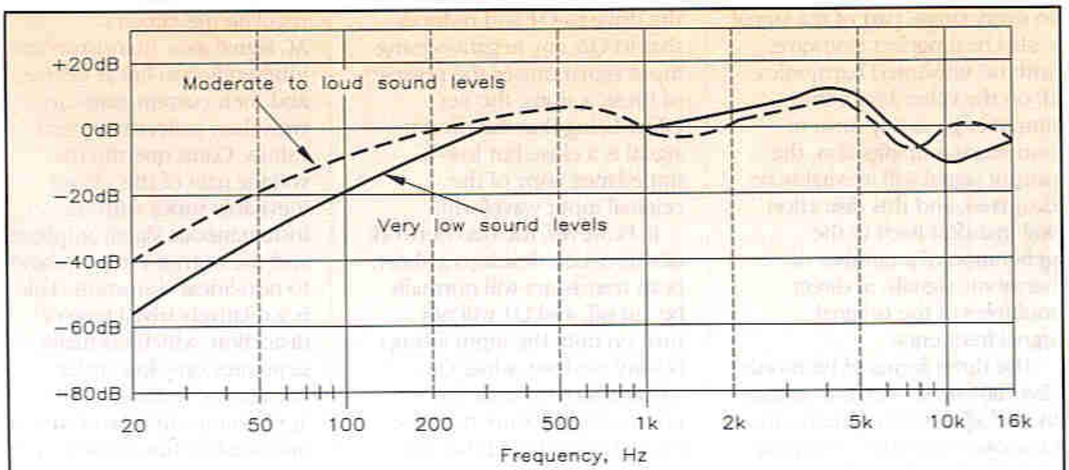


Figure 2. Typical aural frequency responce curves for healthy 18 to 25 year olds.

Type of Unit	'Fi' Type	Notes
Sophisticated home entertainment unit	Hi-Fi	High-performance stereo unit
Portable radio	Medium-Fi	Typically operate over the 20Hz-12kHz audio spectrum and have very simple controls
Portable cassette/CD unit	Medium-Fi	Typically operate over the 20Hz-12kHz audio spectrum and have very simple controls
Simple Karaoke unit	Medium-Fi	Typically operate over the 20Hz-12kHz audio spectrum and have very simple controls
Loud-hailer	Low-Fi	Operate mainly over the 100Hz-4·5kHz speech frequency spectrum
Public Address system	Low-Fi	Operate mainly over the 100Hz-4·5kHz speech frequency spectrum
Intercom	Low-Fi	Operate mainly over the 100Hz-4·5kHz speech frequency spectrum
Mobile phone	Low-Fi	Operate mainly over the 100Hz-4·5kHz speech frequency spectrum

Table 1. Examples of fidelity ('Fi') requirements of eight popular audio units.

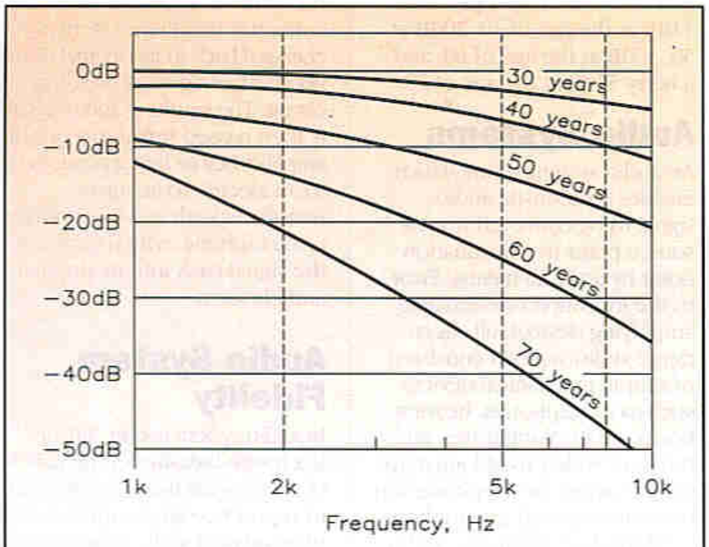


Figure 3. The ear's relative sensitivity to signal frequencies above 500Hz deteriorates with age, typically in the manner shown here.

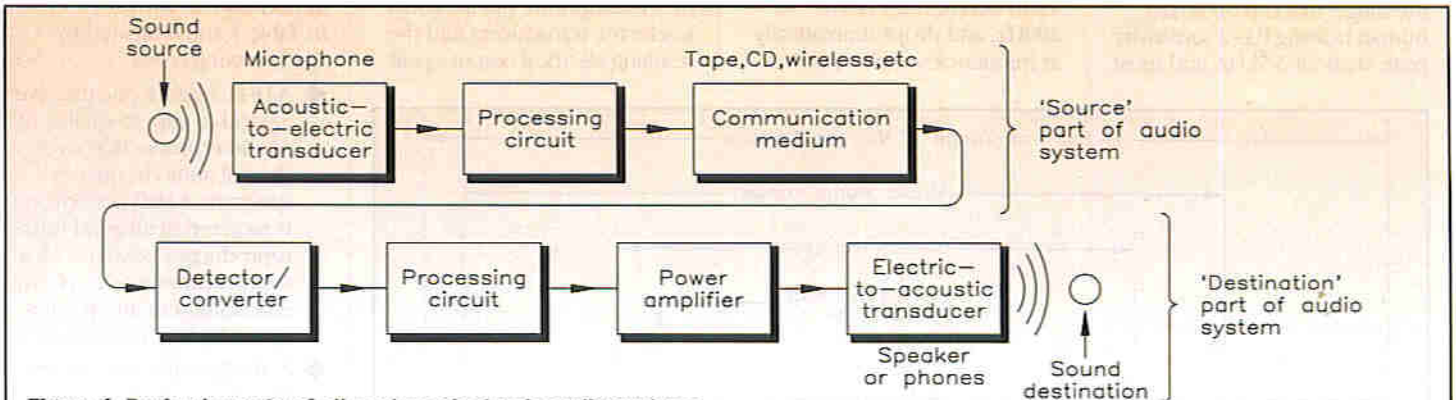


Figure 4. Basic elements of all modern electronic audio systems.

'Harmonic' Signal Distortion

The prime aim of any audio system is to convey an acoustic audio signal from a source point to a destination point (the listener's ears) without undue loss of fidelity. Any loss of fidelity that occurs along the way can only be ascribed to changes in the signal's waveform, and such changes are called distortion. These are several basic forms of distortion, most of which can be classified as either a harmonic or a frequency response type of distortion.

If a perfect sinewave signal is applied to the input of an amplifier, the output signal will – if the amplifier is perfectly linear and gives exactly the same amount of amplification to every single part of the signal – also be a perfect sinewave, with no unwanted harmonics. If, on the other hand, the amplifier gives any form of non-linear amplification, the output signal will inevitably be distorted, and this distortion will manifest itself in the generation of a number of harmonic signals, at direct multiples of the original signal frequency.

The three forms of harmonic distortion most often encountered in analogue audio systems are crossover distortion, 'clipping' distortion, and simple non-linear distortion, and examples of these are shown in Figures 6 to 8, using triangle-shaped input signals for clarity.

Figure 5 shows an example of crossover distortion caused by a defectively biased complementary emitter follower output stage of the basic type used in most power amplifier ICs. In this type of circuit, R1 & R2 act as a potential divider that sets the bases of Q1 & Q2 at a mean half-supply voltage value, and the bias unit applies a voltage of (typically) about 1·2V between the two bases, so that each transistor is slightly biased on when no input signal is applied. Under this condition, the mean charge in the load-driving electrolytic output capacitor tends to hold the emitters of both transistors close to the half-supply voltage value, and any positive-going input signal thus increases the drive to Q1 and reduces that to Q2; any negative-going input signal causes the reverse of these actions, the net effect being that the output signal is a close but low-impedance copy of the original input waveform.

If, however, the bias network of this circuit develops a short, both transistors will normally be cut off, and Q1 will not turn on until the input swings 600mV positive, while Q2 will not turn on until the input swings 600mV negative, the net effect being that the circuit effectively removes the central 1·2V 'slice' of the output waveform, as shown in the diagram, as a consequence of this 'crossover' defect. This type of distortion is highly undesirable, and generates many harmonic signals.

Figure 6 shows an example of 'clipping' distortion caused by over-driving a simple common-emitter transistor amplifier. The output of this type of amplifier is an amplified and inverted version of the input signal, but if (as shown) the input signal is too large, its larger positive parts will drive the transistor to saturation, causing the loss of the lower parts of the output signal, and its larger negative parts will drive the transistor to cut-off, causing the loss of the upper parts of the output signal. 'Clipping' distortion is highly undesirable, and generates many harmonic signals.

Figure 7 shows an example of simple non-linear distortion caused by operating a common-emitter transistor amplifier with insufficient signal negative feedback. Note in this circuit, that biasing network R1-R2 is decoupled by C1 and thus provides DC negative feedback but not AC (signal) negative feedback, which is normally used to regulate the circuit's AC signal gain. Transistors are inherently non-linear devices, and their current gain varies with their collector current values. Consequently, the voltage gain of this circuit inevitably varies with the instantaneous signal amplitude, and the output is thus subject to non-linear distortion. This is a relatively trivial type of distortion, which normally generates only low-order harmonics. In most applications, the distortion is undesirable, but in some special applications, it can be used to the advantage of the end-user.

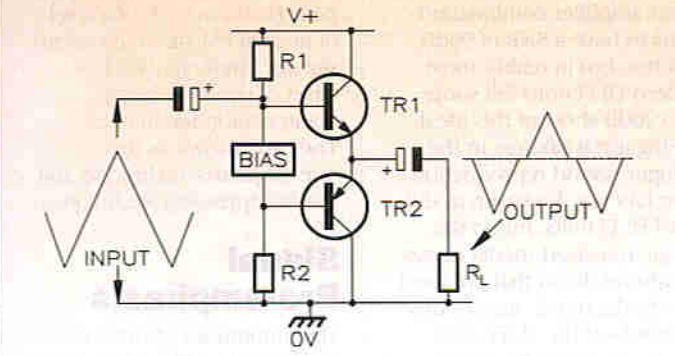


Figure 5. Example of crossover distortion on a defectively biased complementary emitter follower output stage.

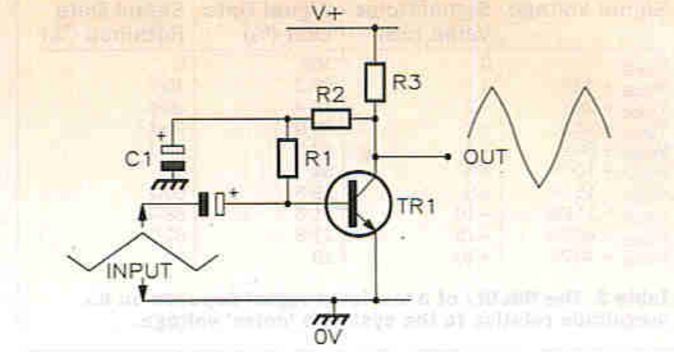


Figure 7. Example of simple non-linear distortion in a common-emitter amplifier.

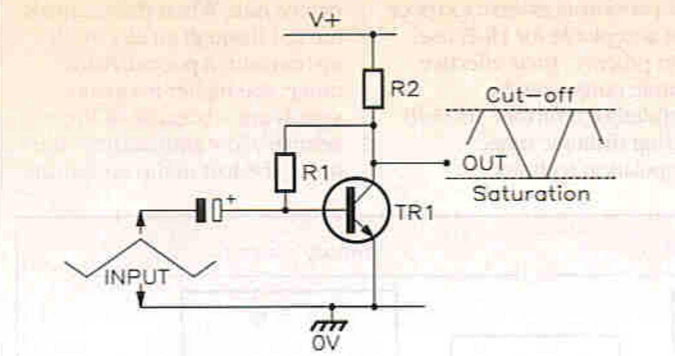


Figure 6. Example of 'clipping' distortion caused by over-driving an amplifier stage.

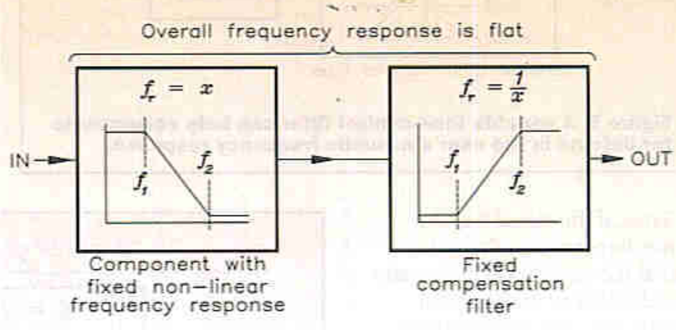


Figure 8. Frequency response non-linearity in one part of a circuit can be countered with a matching compensation filter, to give a flat overall frequency response.

'Frequency Response' Distortion

The other basic form of distortion is the frequency response type, in which the effective voltage gain or attenuation of a circuit or system element varies with the applied frequency. The most obvious example of this kind of distortion is the human listener who sits at the money-paying end of the audio-system processing chain, and who (as shown in Figures 2 and 3) has an upper-frequency acoustic response that declines steeply with the passing of the years. Electro-mechanical devices such as microphones, loudspeakers and pickups also have a non-linear frequency response.

Modern active filter circuits can be designed to give virtually any desired frequency response, and can easily be used to counteract response defects that occur in any part of an audio system. Figures 9 and 10 illustrate the basic principle. Thus, Figure 8 shows how a component or device that has a fixed non-linear frequency response of 'x' can be used in conjunction with a fixed compensation filter with a response of '1/x' (the exact inverse of 'x') to give a flat overall frequency response.

Figure 9 shows how a variable tone-control filter can be used to help compensate for frequency response defects or variations in the acoustic path that exists between the output stage of a power amplifier and the sound-perception mechanism of the audio listener, i.e., in the loudspeaker, the room acoustics, or in the listener's hearing. The filter shown in the diagram is a simple type in which bass and treble can each be boosted or cut by up to 20dB (i.e., by a 10:1 ratio), but in practice, most modern tone-control filters also give similar control of the mid-band response. Thus, if the bass and midband controls are both set to maximum cut and the volume level is boosted by 20dB, the treble response can be effectively boosted by up to 40dB (i.e., by a 100:1 ratio).

'Noise' and Dynamic Range

If the input terminal of an audio power amplifier is shorted to ground, so that zero input signal is applied to the unit, and the volume control is then wound up to maximum, a distinct 'hissing' sound will be heard from the unit's loudspeaker. The signal responsible for this sound is generated by the equipment itself, takes the form of a mixture of tones of randomly generated frequency and amplitude, and is known simply as 'noise'. If the rms amplitude of the noise signal is measured on an analogue meter, its rms value will be found to be reasonably constant even though its instantaneous value varies wildly from moment-to-moment. If an external variable-amplitude signal is now applied to the amplifier, it will produce no useful output until its rms amplitude significantly exceeds that of the noise signal, which effectively swamps all lesser signals. The unit's 'noise' signal value thus determines the minimum signal level that can be usefully handled by the equipment.

All electronic amplifiers and items such as microphones, tapes, discs, and CDs generate noise, and thus have finite 'minimum signal' handing limits. They also have intrinsic 'maximum signal' handling limits, beyond which any applied signal will become too distorted to have a practical value. In amplifiers, this limit is reached at the onset of signal clipping or some other form of severe distortion, and in tapes, it occurs when the tape nears magnetic saturation.

An electronic item's maximum-to-minimum signal handling ratio or absolute maximum dynamic operating range is thus determined by the relative ratio of its 'maximum signal' to 'noise level' values, and is known as its signal-to-noise ratio or SNR, and is defined by the formula:

$$\text{SNR} = \frac{\text{maximum signal volts}}{\text{noise volts}}$$

Thus, if an amplifier can handle a maximum input of 1,000mV and generates 1mV of noise, it has a 1,000:1 or 60dB SNR.

Note at this point, that in audio systems, the input signal is usually a music/speech one that contains data in the form of complex audio patterns that can be subliminally interpreted by the listener's brain, and that the brain can still interpret these patterns even if a substantial portion of the original data is lost, i.e., if the signal is corrupted. Consequently, the practical value of such a signal depends on its magnitude relative to that of the system's 'noise' signal, in the manner shown in Table 2.

Signal Voltage	Signal/Noise Value (dB)	Signal Data Lost (%)	Signal Data Retained (%)
V_{NOISE}	0	100	0
V_{NOISE} + 12%	+1	89·3	10·7
V_{NOISE} + 26%	+2	79·4	20·6
V_{NOISE} + 41%	+3	70·9	29·1
V_{NOISE} + 58%	+4	63·3	36·7
V_{NOISE} + 100%	+6	50	50
V_{NOISE} + 151%	+8	39·8	60·2
V_{NOISE} + 216%	+10	31·6	68·4
V_{NOISE} + 462%	+15	17·8	82·2
V_{NOISE} + 900%	+20	10	90

Table 2. The fidelity of a low-level signal depends on its magnitude relative to the system's 'noise' voltage.

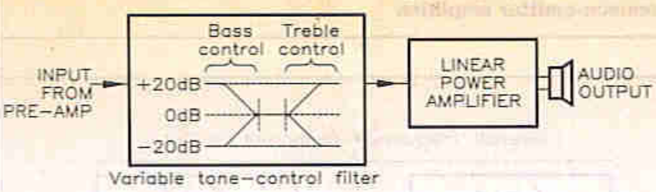


Figure 9. A variable tone-control filter can help compensate for defects in the user's acoustic frequency response.

Thus, if the signal has the same amplitude as the noise signal (i.e., the signal/noise ratio equals 0dB) all of the signal data is lost, and the signal has zero practical value. The signal only achieves some slight practical value when its amplitude is double that of the noise (i.e., at +6dB), at which point, 50% of its original data is retained, and begins to attain real value only when its amplitude rises to +10dB (about treble the noise value), at which point, almost 70% of the original data is retained. The signal quality attains a reasonable 'Hi-Fi' standard only when its value rises to +20dB (ten times the noise value), at which point, 90% of the signal data is retained. Consequently, in modern analogue audio systems, the following general empirical rules apply to the definition of a system's dynamic range:

(1). Absolute maximum dynamic range = SNR value.

(2). Absolute maximum useful dynamic range = SNR minus 6dB.

(3). Normal 'Mid-Fi' dynamic range = SNR minus 10dB.

(4). Normal 'Hi-Fi' dynamic range = SNR minus 20dB.

Dynamic Range Manipulation

It is generally agreed that large orchestras are capable of generating sound levels – from the softest to the loudest values – over a 70dB (3,162:1) dynamic range. To reproduce this sound range with really good fidelity, a Hi-Fi preamplifier and power amplifier combination needs to have a SNR of 90dB or better, but in reality, most modern Hi-Fi units fall some 10 to 20dB short of this ideal. The biggest weakness in the analogue sound reproduction chain lays not, however, in the actual Hi-Fi units, but in the storage/transport media (tapes and phono discs) that are used to carry the music signals into the inputs of the Hi-Fi units.

Typically, modern cassette tapes and stereo phonograph discs have SNRs of 55dB and 58dB, respectively, and thus have basic Hi-Fi dynamic ranges of only 35 and 38dB. Superficially, these performances seem too poor to be acceptable for Hi-Fi use, but in practice, their effective dynamic ranges can be expanded by a further 10-15dB by using dynamic range manipulation techniques, thus bringing their final replay performances up to the level of normal FM stereo broadcast signals. There are two basic types of dynamic range manipulation technique. They are known as the 'pre-emphasis' technique, and the 'compression' technique.

Signal Pre-emphasis

The amplitudes of most music and voice signals are dominated by bass frequencies, with the amplitudes of the higher 'treble' frequency signals – which are mainly harmonics of the bass signals – falling off at a 6dB/octave rate. When these signals are fed through an electronic system with a poor dynamic range, the higher-frequency signals are – because of their relatively low amplitudes – the first to be lost in the underlying 'mush' of system noise, and the resulting audio output sounds flat and unpleasant. Figure 10 shows how this problem can be partially overcome in tape or disc recording systems by feeding the input signals to the media via a treble-boosting pre-emphasis filter during the 'recording' stage, and then restoring the signals to their original form via a matching treble-cutting de-emphasis filter during the 'replay' stage.

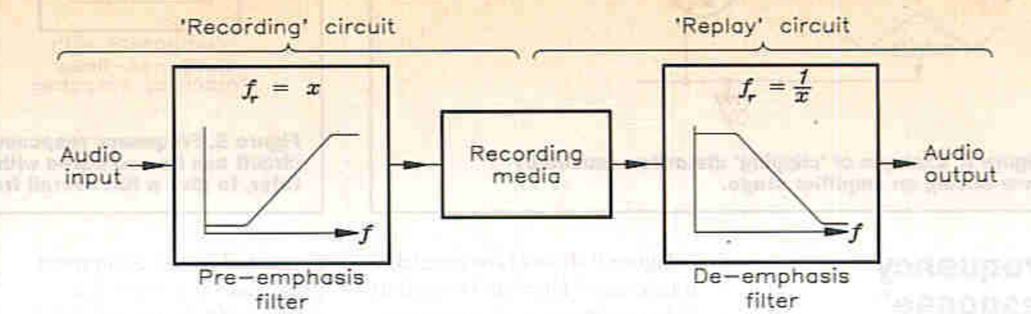


Figure 10. Basic 'pre-emphasis' method of dynamic range manipulation.

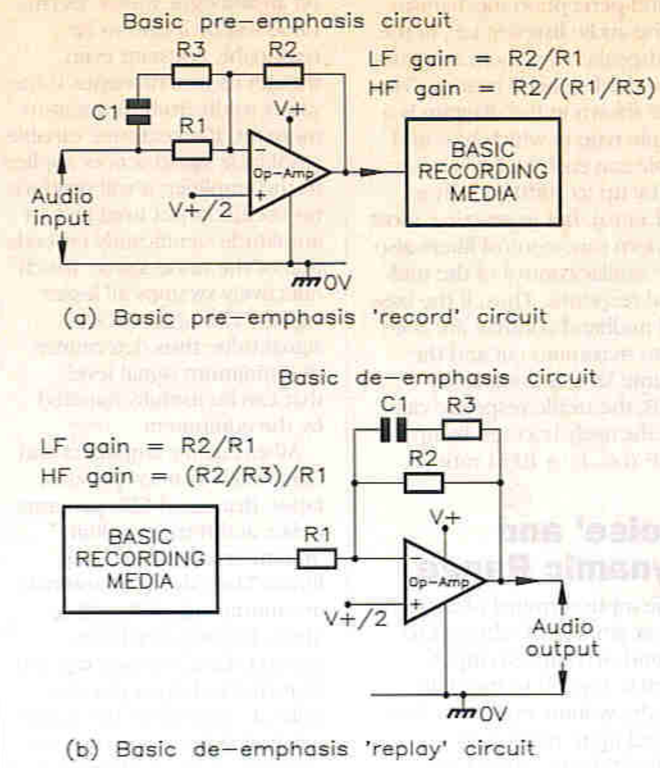


Figure 11. Basic pre-emphasis (treble-boost) and de-emphasis (treble-cut) filter circuits.

Figure 11 shows the basic forms of the pre-emphasis and de-emphasis filters, which in this case, have treble boost or cut slopes of 6dB/octave but have their maximum boost or cut limited to about 20dB by their resistance values and have their turnover frequency (usually about 800Hz) set via C1. Circuits of this type can improve the effective dynamic ranges of various media by about 12dB, and are often used in conjunction with other compensatory filters, as in the case of the RIAA phonograph system and with various tape/cassette playing systems. ELECTRONICS

REVIEW

LF (30kHz – 300kHz)
Includes:
Rugby time signal (60kHz)
LORAN navigation system (100kHz)
LW broadcast band (153kHz – 288kHz)
MF (300kHz – 3MHz)
Includes:
Aircraft beacons (300/400kHz)
MW broadcast band (531kHz – 1,602kHz)
Cordless phones (c. 1·6MHz)
160m 'top' amateur band (1·81MHz – 2MHz)
HF (3MHz – 30MHz)
Includes:
80m amateur band (3·5MHz – 3·8MHz)
40m amateur band (7MHz – 7·1MHz)
Voice of America (9·76MHz)
Voice of Russia (11·63MHz)
Radio Nederland (13·7MHz)
20m amateur band (14MHz – 14·35MHz)
BBC World Service (15·07MHz)

Table 1. Some frequencies that can be received by Target.

AKD HF3 Target COMMUNICATIONS RECEIVER

Reviewed by Martin Pipe BSc (Hons.) AMISTC

If you want to get into the fascinating world of short wave listening (SWL), there has traditionally been three paths – buy a second-hand communications receiver, purchase one of the specialised portable radios available (these are typically Japanese, the Sony models being a good example) or build a simple kit (normally a direct-conversion design). It can be difficult to obtain components and service information for second-hand communications receivers – often available at rallies – when they go wrong, although the amateur community is often quick to help (many amateurs are, incidentally, on the Internet and will answer queries on the relevant rec.radio.amateur.x newsgroups). Performance of these older models isn't, in most cases, up to the standards of newer communications receivers. The majority of current models, from the likes of Yaesu, Kenwood, Icom and AOR, tend to be – at £400 upwards – too expensive for the HF newcomer.

Those Far Eastern portable radios normally give reasonable coverage of the HF bands, but tend to be operated from keypads, and aren't particularly user-friendly as far as 'serious' listening goes. They are normally designed for travellers, and also include features like VHF FM stereo reception and gimmicks like world clocks. These sets don't come cheap, particularly the ones with the VFO (variable frequency oscillator) and special filters needed for SSB (single sideband) reception. It's also worth pointing out that the cheaper models can give truly appalling HF performance. Kit building is not as common as it used to be, and messing around with piles of components and a soldering iron may be off-putting to those new to radio listening. What's more, none of those beginners' kits are general coverage, the vast majority covering specific amateur bands (such as the 40m or 80m bands).

Fortunately, there's now another option – from British company AKD, an outfit famous for its 70cm/2m amateur transceivers and TVI (television interference) filters. For £160, you can buy the HF3 receiver, which is being marketed as the Target. It's available by mail-order from amateur radio dealers such as Waters and Stanton or from AKD direct. Your money buys you a stripped-down microprocessor-controlled communications receiver that contains all of the essentials. These include general 30kHz to 30MHz coverage (for reception of all HF amateur bands and a wide range of broadcast signals), SSB or AM demodulation, a decent tuning system with LCD frequency and signal strength readout, and a well-designed user interface. There's no narrowband FM mode, so you won't be able to receive 27MHz CB transmissions – but that's no real loss (you might be able to pick them up in AM mode, however, by tuning off-frequency; this is known as slope detection).

In terms of internal configuration, the Target is a dual-conversion superhet. The first IF is 45MHz, while the second is 455kHz. A block diagram of the receiver is given in Figure 1. A look inside the radio reveals that construction is of an excellent

TARGET SPECIFICATIONS

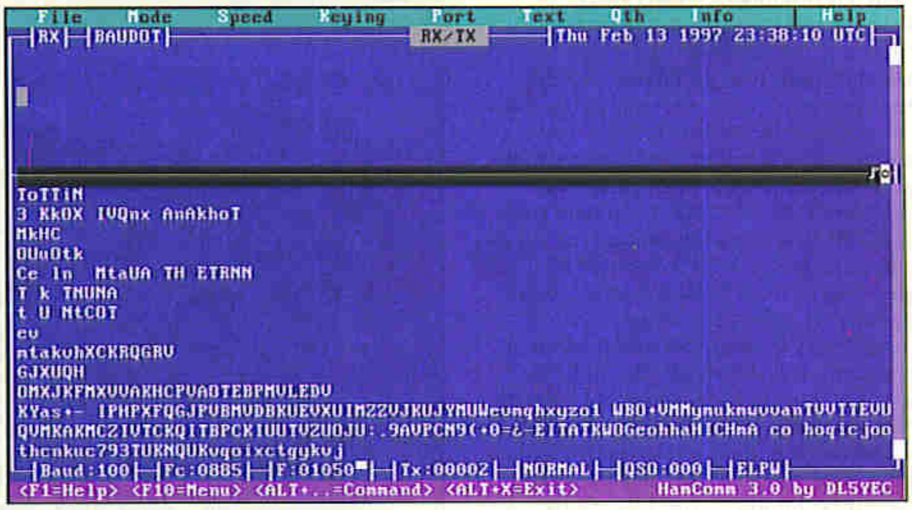
Frequency range:	30kHz to 30MHz
Frequency Tolerance:	100Hz
Synthesiser:	1kHz steps
Clarifier:	800kHz
Bandwidth:	6kHz (AM), 3·8kHz (SSB)
Sensitivity:	1V
Audio output:	2W
Aerial input impedance:	70Ω
Tuning control:	4 rates; 10kHz/rev, 100kHz/rev, 1MHz/rev, 10MHz/rev
Power supply:	12V DC @ 300mA, regulated
Reception modes:	USB/LSB/AM
1st IF:	45MHz (with crystal filter)
2nd IF:	455kHz (with ceramic filters)

standard. For example, the circuit boards are high-quality double-sided fibreglass types, and the most sensitive areas of the RF circuitry are hidden in a screening can. Externally, the Target has roughly the same dimensions as a car radio or 2m mobile rig, and is attractively – yet simply – finished. To the left of the control panel are the rotary on/off/volume and clarifier (fine and SSB tuning) controls; to the right is a large weighted tuning knob with finger recess. In between is a large and readable LCD that provides frequency (4 digits below 10MHz, 5 digits above) readout and a 10 point signal strength meter, which is calibrated on the 'S' scale. Unfortunately, the display is not backlit, which may be a minor irritation during those interesting late-night listening sessions.

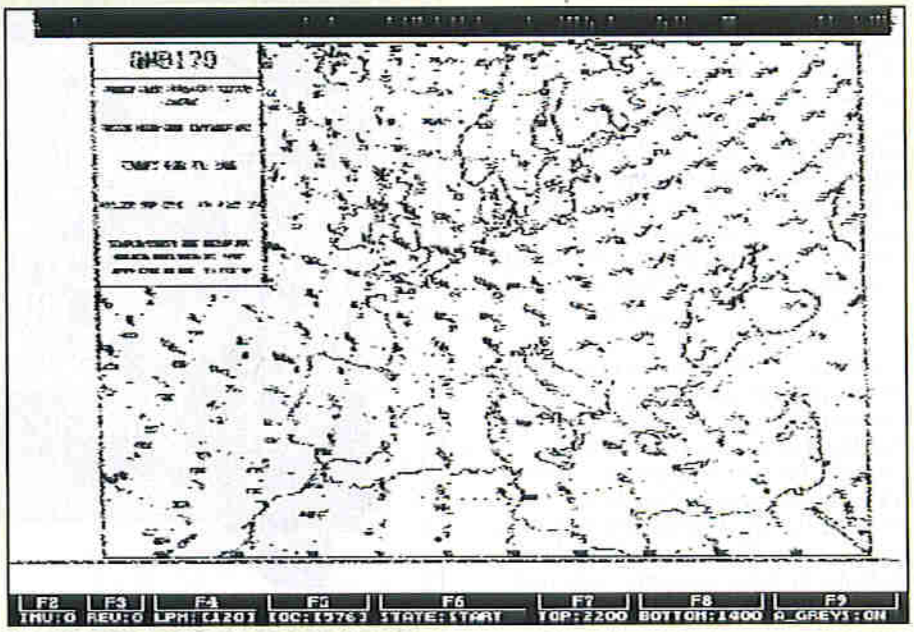
Underneath the display are four push-buttons. The first pair cycle up or down between the modulation modes. The second pair of buttons allow a single frequency, and the corresponding modulation mode, to be stored (in a non-volatile memory) and recalled at any time. Whenever you turn the receiver on, it reverts to the frequency last stored in the memory. Sensibly, the loudspeaker is located on the top of the receiver. Round the back of the receiver is a 3·5mm headphone socket, a phono aerial socket (with switchable attenuator to prevent overloading from nearby powerful transmitters) and a DC input socket. The Target runs from a regulated 12V 300mA supply, and a power supply unit is provided. The receiver could also be powered from a car battery, making it useful for mobile operation.

Also supplied with the Target is a 10m wire aerial and a manual that also serves as an introductory guide to shortwave listening. It talks in basic terms about radio and propagation, and also lists some frequencies, notably those of broadcast stations such as the BBC World Service, Voice of America and so on. The length of the aerial is very much a compromise, and is really only included to get you started – purpose-designed aerials will provide better performance. The manual explains how the aerial can be 'strung up' in the garden. It recommends that if it's to be located some distance from the receiver, then it should be connected via TV coax – this is also a good idea if the radio is being used near computer equipment. The aerial, which terminates in a phono plug, also has a ground wire that allows the receiver to be earthed if necessary. The Target is designed to be very much a 'plug in and use' solution (an ideal birthday or Christmas present, perhaps?).

Using the Target is simplicity itself. The tuning knob is used to reach the desired frequency – unlike some of those portable radios, there's no interstation muting as you sweep the band, allowing you to scan for new stations. Inside the receiver, the tuning knob becomes a notched cylinder, which lies in the optical path of an optoisolator. As the knob rotates, this arrangement generates a pulse train, which is fed to the microcontroller (a PIC chip, by the look of it), and thence to the frequency synthesiser, which works in adequate 1kHz steps. There are four tuning rates; the one selected depends on the rate at which you turn the knob. The slowest is 10kHz per revolution, while the fastest is 10MHz per revolution. This simple but effective solution allows quick tuning without the need for a bandswitch (it also keeps the manufacturing costs down). In SSB mode, the clarifier adjusts the VFO (variable frequency oscillator) that's used to regenerate the carrier suppressed during the transmission stage. In AM mode, the clarifier control is used as a fine tuning adjustment with an 800Hz range.



HamComm RTTY display info is also transmitted on HF bands but often encrypted.



Some landbased stations also transmit weather faxes to ships. They can be intercepted on land.

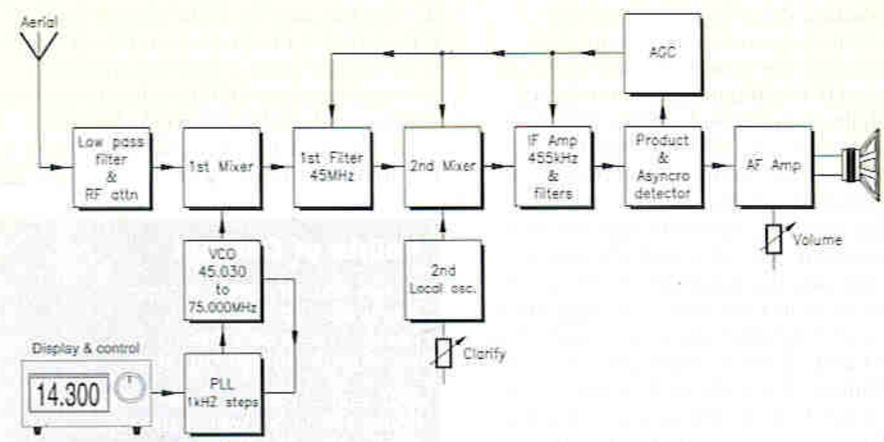


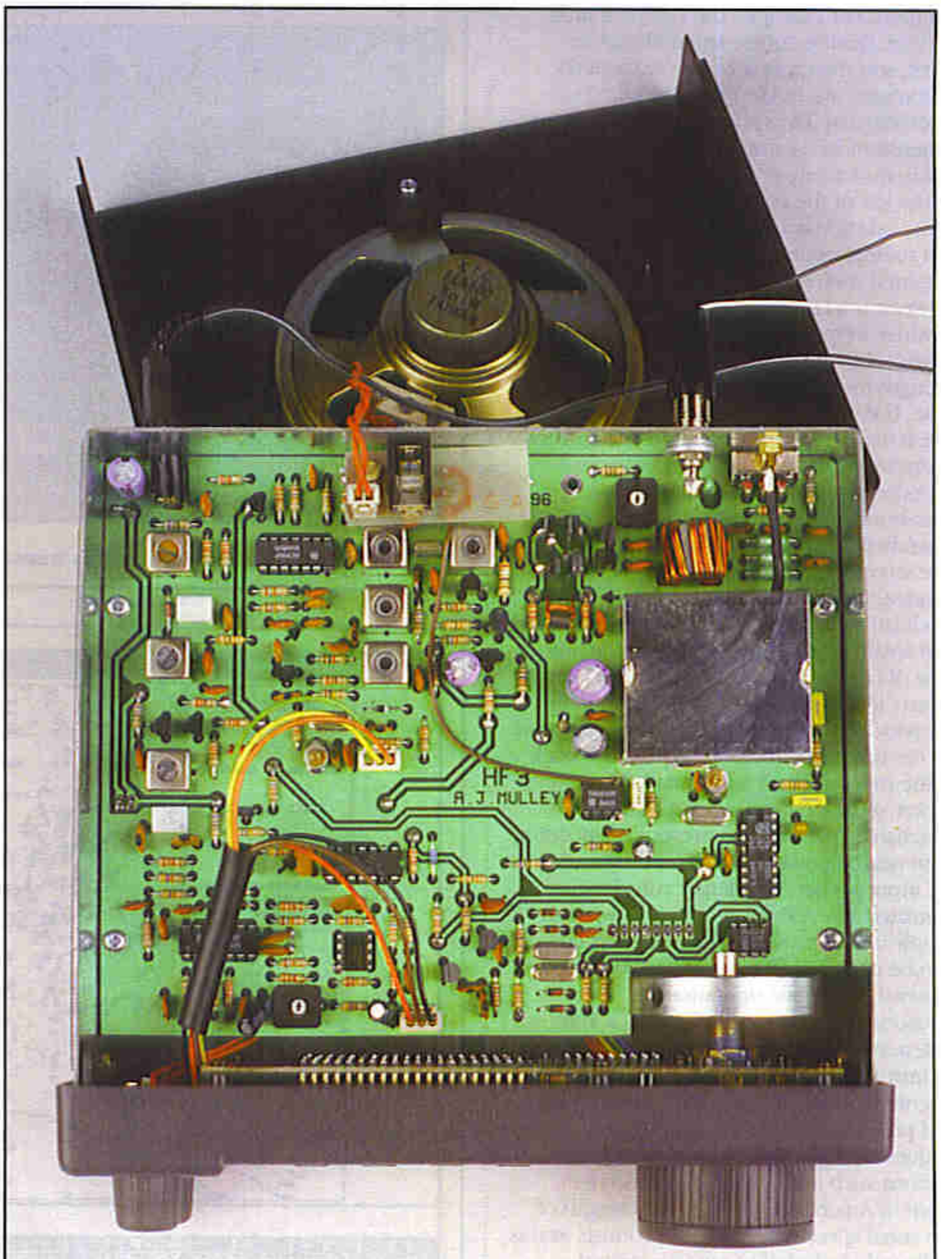
Figure 1. Block diagram of the AKD Target receiver.

SSB has two modes – LSB (lower sideband) and USB (upper sideband), referring to the sideband that wasn't filtered off prior to transmission. SSB is used to conserve radio spectrum (valuable in these days of crowded HF bands) and transmission power (no modulating signal means no transmitter power). But which mode should be selected? A common rule is that LSB signals are transmitted on frequencies below 10MHz, while SSB signals can be found above 10MHz – there are, however, a few exceptions. It's generally easy to tell a SSB transmission. If the receiver is in AM mode, the audio is extremely distorted, and the signal strength meter fluctuates wildly. During reception, the SSB mode is also used to recover CW (continuous wave) Morse transmissions, which are common on the amateur bands. All of this sounds complex, but in practice, you simply adjust the control until the transmission becomes intelligible.

Two different filters are selected, according to whether AM or SSB is selected. In AM mode, the bandwidth is 6kHz – fine for audio reception. The AM demodulator used is a quasi-synchronous type. With the 2W amplifier and a decent internal speaker, the Target delivers excellent audio quality. General MW and LW broadcast reception, for example, was noticeably better than many transistor radios, despite AKD's claim that the Target is 'optimised for speech'. There was a slight buzz, which was cured by earthing the receiver.

In SSB mode, a 3·8kHz filter is switched in. This is perhaps a little wide, and during some late-night sessions, interference was noticeable. The signals could still be resolved, but it may cause problems with RTTY (radio teletype) and fax decoders such as the PC-based HamComm and JVFax packages. A new 250 version of the Target (which also includes a versatile computer interface) will include a 2·6kHz SSB filter – a better bet. SSB reception is, however good, although tones could sound a little warbled. It's still a lot better – and easier to use – than many portable sets. In terms of sensitivity, the receiver was excellent. Even with the supplied aerial, a wide range of HF broadcast stations and SSB amateur stations from around the world were pulled in. It's easy to see why shortwave listening is still popular, despite the overwhelming attractions of the Internet and its potential for audio broadcasting (streaming). That's not to say that computers aren't connected with radio listening. On some frequencies, weather maps are transmitted to ships from powerful land-based stations. With the appropriate software, such as the popular shareware program, JVFax and Skyview Systems' PC-Fax, it's possible to decode such maps and display them on a PC screen.

JVFax will also generate pictures from slow-scan TV (SSTV) transmissions. In such cases, the audio output from the receiver is fed to the computer's serial port via a simple interface (effectively a Schmitt trigger, based around a 741 op-amp) that converts the audio tones to RS232 levels. The same interface is used with other programs that decode CW and RTTY (radio teletype) signals. One such program is the shareware program Hamcomm – from which the name of the interface is taken. A search on Alta Vista, or another search engine, should point to a Web or FTP site from which such programs can be downloaded.



Internal view HF3 receiver. Note neat layout.

At £160, however, the Target can be considered excellent value for money. Although it doesn't have the features or performance of vastly more expensive communications receivers, it is an ideal starting point for somebody who wishes to get into HF communications, and should hopefully open up the hobby to a greater number of people. With the Target, they will learn what's out there, and develop a practical understanding of radio propagation. It will hopefully get more people involved with amateur radio, although shortwave listening (and the acquisition of SWL cards) is a hobby in its own right. The Target does, of course, have applications among existing Class A and HF novice licensees. They can, for example, check the audio quality from their main rig. The new uprated version of the Target, unveiled at the London Amateur Radio Show in March, is also worthy of consideration. As discussed, it has a more useful SSB filter with a narrower bandwidth. The feature of greatest interest, however, is the computer interface – the radio attaches to a PC's parallel port. The DOS-based software supplied provides a number of useful facilities, including a spectral display (normally the province of top-end communications receivers, such as the Icom IC-756) that may be useful for checking transmitters for harmonics and the like. The software also gives you 500 memories for storing frequencies. Other software features planned include fax and RTTY decoding.

Finally, my thanks go to Waters & Stanton for the loan of equipment.

Points of Contact

Waters and Stanton Electronics, Spa House, 22 Main Road, Hockley, Essex SS5 4QS. Tel: (01702) 206835/204965.

AKD, Unit 5, Parsons Green Estate, Boulton Road, Stevenage, Herts. Tel: (01438) 351710. Web: http://www.kbnet.co.uk/akd.

DEVELOPING APPLICATIONS AROUND THE PIC ARCHITECTURE

PART 7

Advanced Development Techniques

by Stephen Waddington

Last month, we developed a basic flip-flop application based around the PIC microprocessor. Now its time to shift up a gear. Here, Stephen Waddington looks at advanced microprocessor design and development techniques.

While last month's flip-flop application was very simplistic, it served to clearly demonstrate each element of the PIC microprocessor design process. Figure 1 reviews the development cycle for a PIC microprocessor application while Figure 2 reviews the development cycle for the flip-flop application. The flip-flop problem could have been solved using a discrete flip-flop device rather than the PIC16C84, but having taking the time last month to examine each element of the development cycle in detail, we can now begin to look at more complex problems.

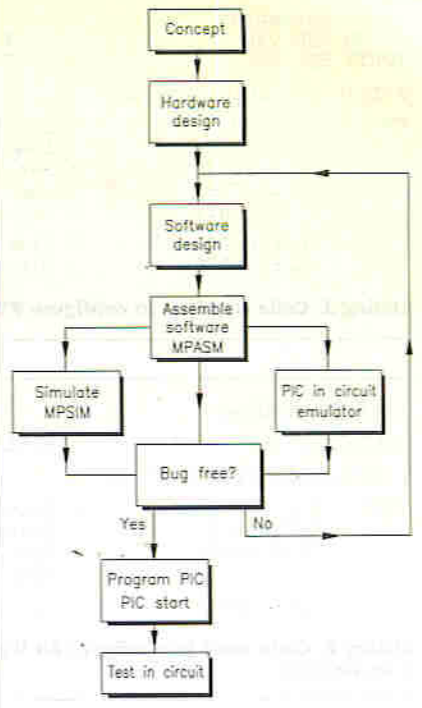


Figure 1. Development cycle for microprocessor application.

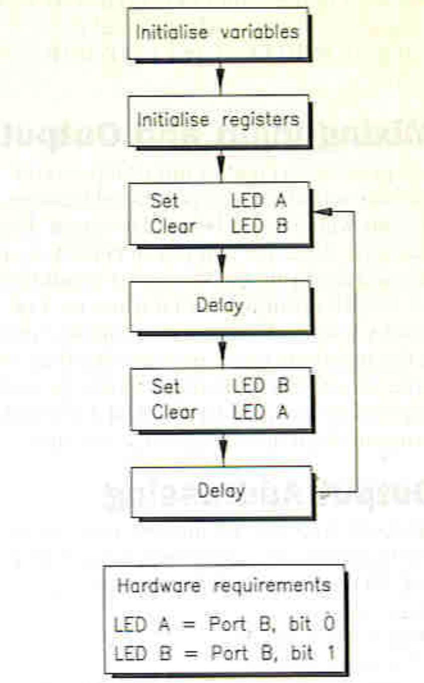


Figure 2. Development cycle for flip-flop application.

Input or Output?

The flip-flop application considered only the output capability of the PIC16C84, and in fact, it used only two of the 13 available output lines. Any of those 13 lines could have been configured as an input. It is precisely this capability that makes the microprocessor such a versatile device. Instead of working through lists of instructions and triggering outputs in a clockwork fashion, the designer is able to create an application which will respond to its external environment.

Input lines can be configured to react to light, temperature, noise or a straightforward switch press. But how is this achieved using the PIC family of microprocessors? You will recall that we have been focusing for the sake practicality, throughout the initial parts of this series at least, on development around the PIC16C84. Later in this feature, we will look at others members of the PIC family, and examine how they compare in terms of hardware and software with the PIC16C84. But for the short term, let's stick with the PIC16C84.

Before we consider either input or output using the PIC16C84, or indeed, any other member of the PIC family, the port control registers must be configured. These are used by the microprocessor to determine whether the port is to be used for input or output. As Figure 3 shows, the PIC16C84 has two ports, PORTA (Register 5) and PORTB (Register 6). PORTA consists of 5 bits, while PORTB has 8 bits.

The TRIS command is used in conjunction with accumulator – the W register – to set the ports for input or output. To set PORTA as an INPUT port, the W register should be set to 1FH (31 decimal), ensuring that each

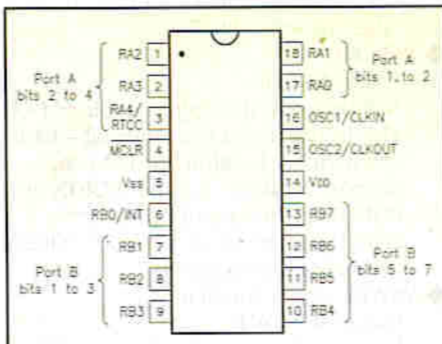


Figure 3. Pin-out diagram for PIC16C84 showing PORTA and PORTB.

```
; Set Variables
PORTA EQU 05H               ; PORTA is register 5
PORTB EQU 06H               ; PORTB is register 6

; Initialisation routine

INIT   ORG 00H              ; Store program at location 00H
       MOVLW 00H            ; Load accumulator with 1FH
       TRIS PORTA           ; Set PORTA as inputs
       MOVLW FFH            ; Load accumulator with 00H
       TRIS PORTB           ; Set PORTB as outputs

       CLRF PORTA           ; Clear PORTA
       CLRF PORTB           ; Clear PORTB
```

Listing 1. Code required to configure PORTA for input and PORTB for output.

```
; Set Variables
PORTA EQU 05H               ; PORTA is register 5

; Initialisation routine

INIT   ORG 00H              ; Store program at location 00H
       MOVLW 03H            ; Load accumulator with 03H
       TRIS PORTA           ; Set bit 0 and bit 1 of PORTA as inputs
                            ; with bits 2, 3 and 4 configured as outputs

       CLRF PORTA           ; Clear PORTA
```

Listing 2. Code used to configure bit 0 and bit 1 of PORTA as inputs, with bits 2, 3 and 4 as outputs.

of the 5 lines of PORTA is set to 1. To set PORTB as an output port, the W register should be set to 00H (0 decimal), ensuring that each of the 8 lines of PORTB is set to 1. Listing 1 shows the code required to configure PORTA for input and PORTB for output.

Mixing Input and Output

It is possible to create a mix of inputs and outputs within a single port by addressing the bits which are to be used for input. For example, if the first two bits of PORTA are to be used for input, the W register should be set to 03H, ensuring that bit 0 and bit 1 of PORTA is set to 1. As no other bits are set to 1, the microprocessor assumes that they are to be used for input. Listing 2 shows the code required to configure bit 0 and bit 1 of PORTA as inputs, with bits 2, 3 and 4 as outputs.

Output Addressing

There are four key instructions that can be used to configure output bits, namely BCF, BSF, MOVWF and MOVLW. Let's review these options:

◆ BCF (Bit Clear F)
  Usage: BCF f,b
  This instruction sets a single bit – bit b – in memory location f to zero. In this instance, memory location f is either PORTA or PORTB. PORTA, bit b takes the value 0 to 5, while for PORTB, bit b takes the value 0 to 7.

◆ BSF (Bit Set F)
  Usage: BSF f,b
  BSF performs the opposite role of BCF. This instruction sets a single bit – bit b – in memory location f to 1. Again, memory location f is either PORTA or PORTB. In the case of PORTA, bit b takes the value 0 to 5, while for PORTB, bit b takes the value 0 to 7.

◆ MOVLW (Move Literal to W)
  Usage: MOVLW k
  In terms of output, this instruction is used as an intermediary to transfer a data value – in this case, k – into the W register to subsequently address the either PORTA or PORTB. In the case of PORTA, k takes the data value 0 to 1FH (0 to 31 decimal), while for PORTB, k takes the value 0 to FFH (0 to 255 decimal).

◆ MOVWF (Move W to f)
  Usage: MOVWF f
  MOVWF moves the data value in the accumulator to memory location f, in this case, either PORTA or PORTB. MOVLW and MOVWF operate together to transfer a value from the accumulator – register W – to memory location f, in this case, PORTA or PORTB.

In general terms, BCF and BSF are used to operate on a single bit since they can address a bit in a single instruction. The combination of MOVLW and MOVWF are used to operate on a number of bits at the same time. In this way, two instructions can be used to address a complete port if necessary.

Input Addressing

A similar set of instructions exists to test input lines, namely BTFSC, BTFSS and MOVLW. These operate as follows:

◆ BTFSC (Bit test, skip if clear)
  Usage: BTFSC f,b
  This instruction tests a single bit – bit b – in memory location f. If bit b in data memory location f is 0, then the next instruction is skipped. In this instance, memory location f is either PORTA or PORTB. PORTA, bit b takes the value 0 to 5, while for PORTB, bit b takes the value 0 to 7.

◆ BTFSS (Bit test, skip if set)
  Usage: BTFSS f,b
  This instruction tests a single bit – bit b – in memory location f. If bit b in data memory location f is 1, then the next instruction is skipped. In this instance, memory location f is either PORTA or PORTB. PORTA, bit b takes the value 0 to 5, while for PORTB, bit b takes the value 0 to 7.

◆ MOVLW (Move Literal to W)
  Usage: MOVLW k
  We've have already seen how this instruction is used in terms of output, as an intermediary to load a data value into the accumulator. In terms of input, MOVLW is used to transfer a data value – in this case, k – from a port into the W register. Once loaded into the W register, the value can be manipulated as required by the particular application.

In general terms, BTFSC and BTFSS are used to test and react to a single bit since they can address a bit in a single instruction. MOVLW is used to operate on a number of bits at the same time, or when the data value of a port needs to be loaded into memory for subsequent manipulation. In this way, two instructions can be used to address a complete port if necessary.

In terms of determining an input value, data is only valid at the moment it is read from a port, since all input ports on the PIC family of microprocessors are non-latching. Also, the MOVLW instruction will read the entire contents of a port into the accumulator. Where a port is used for both input and output, it can prove confusing since the value of any lines used for output must be discounted.

There is an additional issue which needs to be considered when mixing input and output lines on a single port. A port is read at the beginning of an instruction cycle, while a write is executed at the end of an instruction cycle. Code should be written to avoid successive reads and writes to the same port as pin voltages need time to stabilise. The addition of a NOP (null operation) or any other non-port instruction should be used in between a write and a read instruction to eliminate potential error.

Example Input/Output Design

Listing 3 shows an example routine for the PIC16C84 which tests two push button switches and modifies the status of an LED appropriately. Figure 4 shows how the design is implemented in hardware. When Switch A connected to Bit 0 of PORTA (pin 17) is pressed, LEDA, connected to Bit 0 of

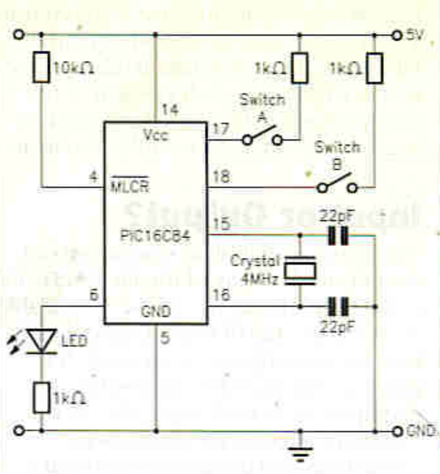
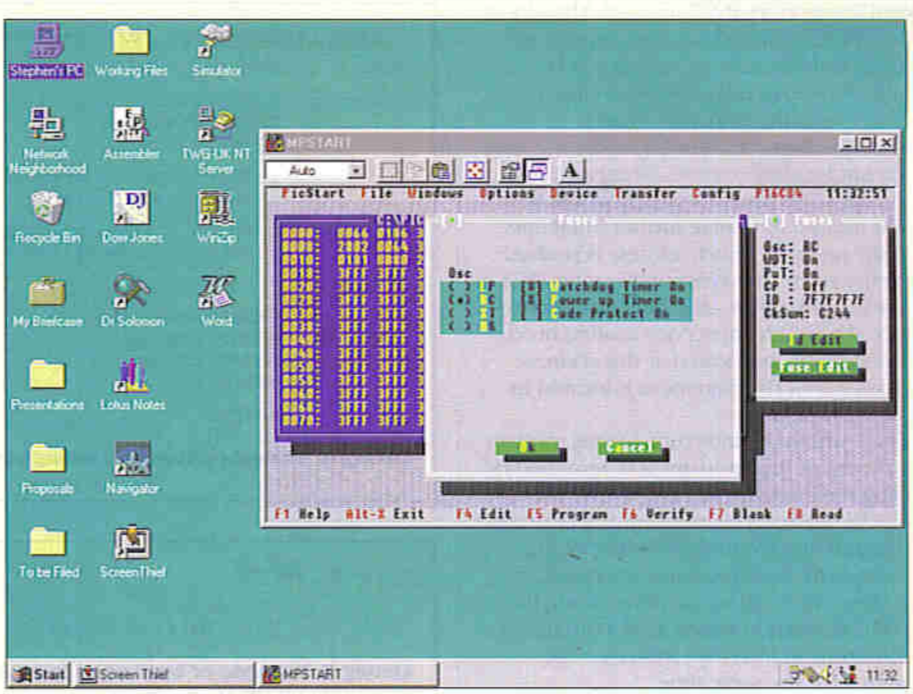


Figure 4. Hardware design for two push button LED I/O example.

PORTB (pin 6) is triggered on. When Switch B connected to Bit 1 of PORTA (pin 18) is pressed, LEDA is turned off. The subsequent operation of Switch A while LED A is on, or Switch B while LEDA is off has no effect on the microprocessor's operation.

The example program makes used of the instructions BTFSS, BSF and BCF. BTFSS is used to test whether Switch A or Switch B has been pressed. In either case, it defaults to the next instruction and loops round the subroutine LEDA_ON or LEDA_OFF. Only when either switch is pressed does it jump to the LOOP instruction and perform the appropriate on or off operation on LEDA (PORTB,BIT 0). BSF is used to turn LEDA on, while BCF is used to turn it off.



Fuse options available to the programmer during device programming using the PICStart programming environment.

Housekeeping

There are a host of housekeeping issues such as interrupt handling, the Watchdog Timer (WDT), Sleep mode, reset vectors and the Real Time Clock Counter (RTCC) which the PIC programmer must bear in mind while developing software for the PIC architecture. Many of these topics have been covered in earlier parts of the series, however, each issue is discussed here in detail from a software perspective.

Interrupts

Interrupts allow the normal flow of a program to be halted by an external mechanism and direct the microprocessor to execute an alternative interrupt code sequence. For example, an interrupt could be used to halt an electronic control system in the case of an emergency, or a less dramatic use might require a data communication line to be stopped when a new packet is received to enable the microprocessor to decode the data.

There are two forms of interrupt, namely hardware and software. A hardware interrupt directly addresses the microprocessor in the same manner as an I/O port address. Beyond, it has the ability to stop the microprocessor and direct an alternative course of action the moment the interrupt is triggered.

A software interrupt is included as a polling loop within a program and is tested each time the microprocessor executes the polling loop. Its key advantage is that the results of its action are entirely predictable in terms of its effects on the STATUS register. The key disadvantage of a software interrupt is that it is only accessible to the outside world when the I/O line used as an interrupt is ported. This type of interrupt is generally used when a microprocessor has no hardware interrupt capability.

Software Interrupts

Implementing a polling loop in software is relatively straightforward. Figure 5 shows a block diagram for a code routine which uses an I/O line configured to act as an input. If an input is detected on the input line, the program jumps to interrupt routine, returning to the main program after the interrupt has been serviced.

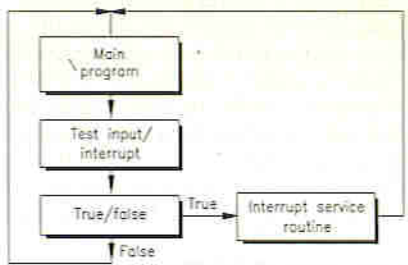


Figure 5. Block diagram of an interrupt polling loop.

```
; Set Variables
PORTA EQU 05H                          ; PORTA is register 5
PORTB EQU 06H                          ; PORTB is register 6
BIT0 EQU 00H                           ; Set variable BIT0
BIT1 EQU 01H                           ; Set variable BIT1
; Initialisation routine
INIT ORG 00H                           ; Store program at location 00H
  MOVLW 00H                            ; Load accumulator with 1FH
  TRIS PORTA                           ; Set PORTA as inputs
  MOVLW FFH                            ; Load accumulator with 00H
  TRIS PORTB                           ; Set PORTB as outputs
  CLRF PORTA                           ; Clear PORTA
  CLRF PORTB                           ; Clear PORTB
; Start of program
LEDAON      BTFSS    PORTA,BIT0        ; Test if Switch A is closed
            GOTO     LEDAON            ; Loop until Switch A is closed
            BSF      PORTB,BIT0        ; If Switch A closed turn on LEDA
LEDAOFF     BTFSS    PORTA,BIT1        ; Test if Switch B is closed
            GOTO     LEDAOFF           ; Loop until Switch B is closed
            BCF      PORTB,BIT0        ; If Switch A closed turn off LEDA
            GOTO     LEDAON            ; Loop back to LEDAON
RESET       GOTO     INIT              ; On RESET goto INIT
            END
```

Listing 3. Example routine for the PIC16C84 which tests two push button switches and modifies the status of an LED.

The PIC16C5x family of PIC microprocessors do not have hardware interrupt capability and so are reliant on software polling. By comparison, the 16Cxx family of PIC devices – including the PIC16C84 – do have hardware interrupt capability, but can also use the polled techniques if required.

As we saw in Part 2 of this series, when we examined the PIC hardware architecture, the PIC16C84 has four sources of interrupt:

- External interrupt from RB0/INT pin.
- TMR0 timer/counter overflow interrupt.
- Change in status on lines 4 to 7 of PORTB.
- End of data EEPROM write (used on during programming EEPROM).

The first three interrupt sources apply across the PIC16Cxx range. Each of these mechanisms will cause an interrupt to the main program flow. INTCON, the interrupt control register, as shown in Figure 6, records individual interrupt requests as flag bits and is used to test the interrupt method. It also contains individual and global interrupt enable bits used. The global interrupt bit (GIE) enables or disables all interrupts. Individual interrupts can be disabled through their corresponding enable bits in the INTCON register.

Listing 4 shows an example of an interrupt handing routine. When an interrupt stops the flow of a program, the GIE is cleared to disable further interrupts and the program return address is pushed onto the stack. The Program Counter (PC) is loaded with 004H – the interrupt service vector. The interrupt service routine need not necessarily be located at this address, providing a GOTO statement is located in its place instead.

Once within the interrupt service routine, the source of the interrupt is determined by polling the interrupt flag bits within the INTCON register. The interrupt flag bits must be cleared in software before re-enabling interrupts to avoid recursive interrupts from the same event. This is achieved using the RETFIE instruction which allows the user to return from an interrupt and re-enable interrupts at the same time.

```
; Example Interrupt Service Routine
ORG        04h                          ; Interrupt address
Interrupt  MOVWF wsave                  ; Preserve accumulator
           SWAPF status,W               ; Preserve zero flag
           MOVWF ssave                  ; Save status register
           ; Interrupt service routine
           ; should sit here
           ; Reset interrupt flags before
           ; returning from interrupt
Endint                                  ; End of Interrupt service routine
           SWAPF ssave,W                ; Restore Status register
           MOVWF status
           SWAPF wsave                  ; Restore W register
           SWAPF wsave,W
           RETFIE                       ; Return from interrupt
```

Listing 4. Example interrupt handing code routine.

```
; Reset Vector
           ORG 000H                 ; Change this value for PIC used
           GOTO INIT                ; Specifies start of program
```

Listing 5. Example of code used to ensure microprocessor commences normal execution on reset.

Watchdog Timer

The Watchdog Timer (WDT) is a type of interrupt used by the PIC microprocessor to prevent itself becoming latched in a loop. This can occur as a result of a bug in the software or an external electrical interference. The WDT provides a heartbeat to the PIC microprocessor. If this heartbeat stops, the microprocessor generates a reset condition.

There are occasions when the WDT is not required, such as when the microprocessor is placed into SLEEP mode. In this instance, if active, the WDT would create a reset condition as soon as it timed-out, waking the microprocessor from its SLEEP condition. For this reason, the WDT can be disabled via its configuration fuse during device programming. Photo 1 shows the fuse options which the programmer is able to configure during programming using the PICStart programming environment.

The WDT has a nominal time out period of 18ms, although this varies with ambient temperature and supply voltage. If longer time-out periods are required, a prescaler with a division ration of up to 1:128 can be assigned to the WDT by addressing the OPTION register, as shown in Figure 7. This enables time-out periods of up to 2·3s (18ms × 128) to be achieved.

The WDT and prescaler are cleared by a SLEEP or CLRWDT command. A CLRWDT command should be included in sections of code where there is a chance that a time period greater that the time-out setting may occur, for example, where an application is waiting for an external input signal.

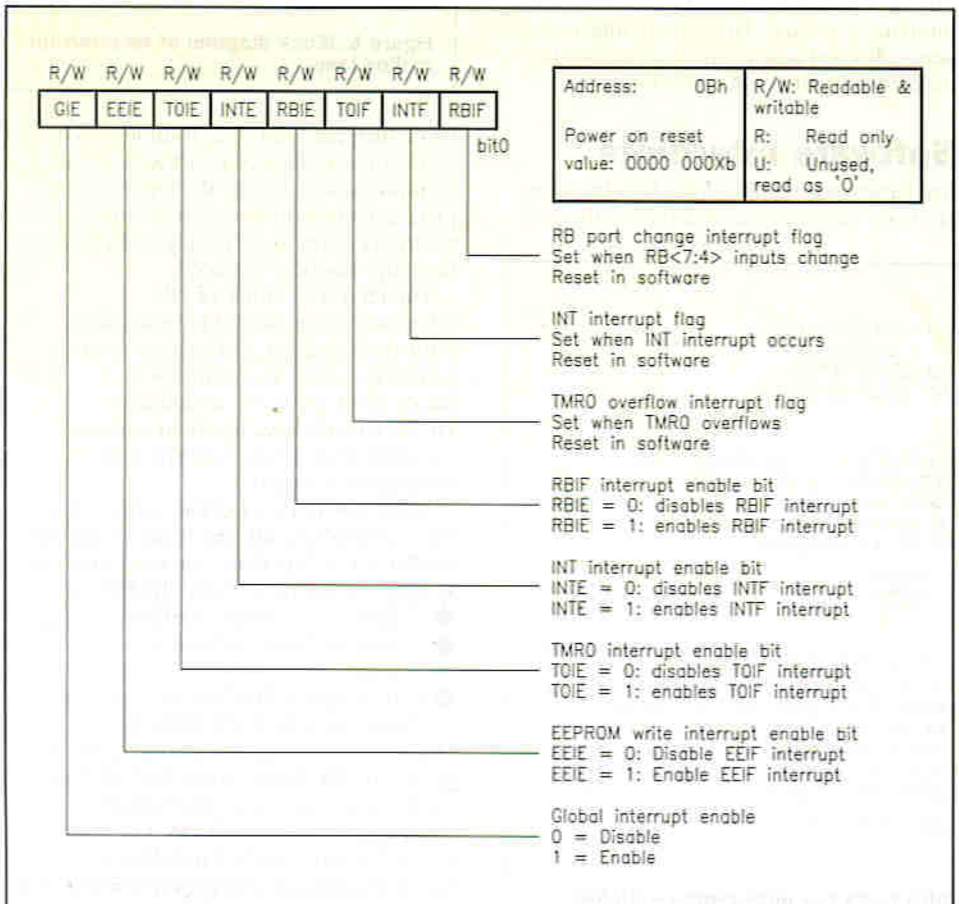


Figure 6. INTCON register records individual interrupt requests as flag bits.

Reset

After a reset has occurred, the PIC microprocessor sets the PC to a preset address value which varies from device to device. The PIC16C84 – like all the PIC16Cxx series – uses 000H as its reset vector. The reset vector of other devices in the PIC family is shown in Table 1. Listing 5 shows two lines of code used to ensure that the microprocessor recommences normal execution of the program on reset. The reset vector of the device being used should be substituted for that shown, which assumes the code written for the PIC16C84.

When a reset condition is generated, two bits within the STATUS register indicate the cause of the event. These bits are the Time Out ($\overline{TO}$) and Power Down ($\overline{PD}$) bits, as shown in Table 2, alongside a summary of events which determine their status. By examining these bits immediately after a

PIC Microprocessor	Reset Vector
16C54	1FFH
16C55	1FFH
16C56	3FFH
16C57	7FFH
16C58	7FFH
16Cxx	000H

Table 1. Program Counter (PC) reset addresses for devices within PIC family of microprocessors.

Time Out ($\overline{TO}$) Bit	Power Down ($\overline{PD}$) Bit	Reset Event
0	0	WDT wake-up from SLEEP
0	1	WDT time-out not during SLEEP
1	0	External reset from SLEEP (WDT off)
1	1	Power up

Table 2. Status of Time Out ($\overline{TO}$) and Power Down ($\overline{PD}$) bits versus reset events.

```
; Delay Routine
DELAY MOVLW TIME
  MOVWF COUNT
  CLRF RTCC                  ; Clear RTCC register
LONG BTFSC RTCC,7            ; Test RTCC bit 7 (128 × 256µs = 32·768ms)
  GOTO JUMP                  ; If RTCC bit 7 set goto JUMP
  GOTO LONG                  ; If RTCC bit 7 not set loop until set
JUMP CLRF RTCC               ; If RTCC bit 7 is set clear RTCC
  DECFSZ COUNT,F             ; Decrement COUNT by 1 until reach zero
                             ; (32ms × 8 = 0·256s)
  GOTO LONG                  ; Loop LONG if COUNT not equal to zero
  RETURN                     ; Return to call location
```

Listing 6. Typical code sequence used to generate delay using RTCC.

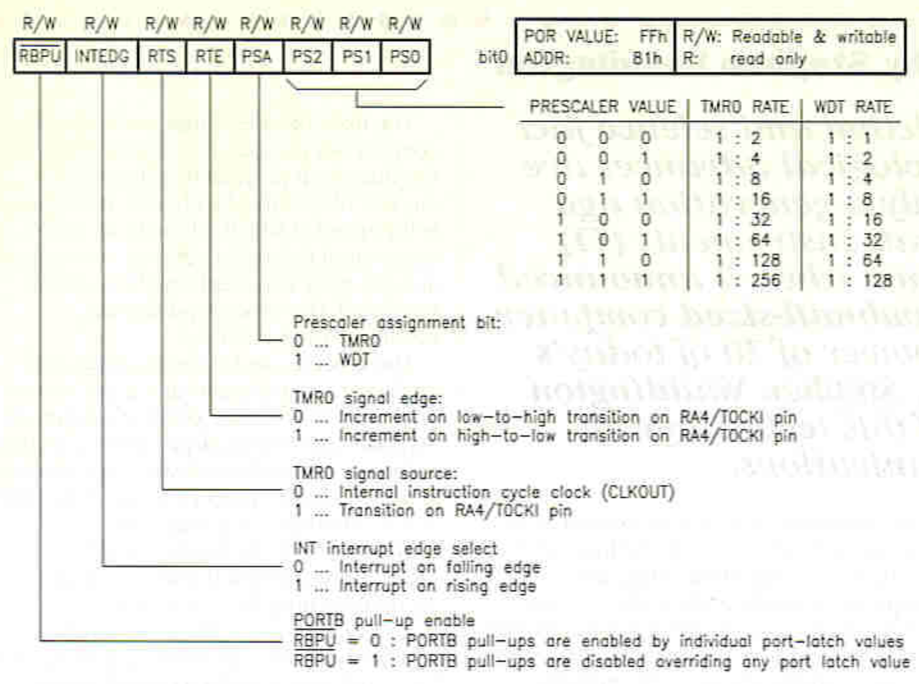


Figure 7. The OPTION register allows a prescaler to be applied to either the WDT or the RTCC.

reset has occurred, the microprocessor can determine how to react.

Sleep or Power Down Mode

The ability to halt all functions of the microprocessor and in effect put it to sleep in order to conserve power has already been discussed in detail in earlier parts of this series. However, the technique is an important one, and is worth reviewing here.

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

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

Wake Up

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

- External reset input on $\overline{MCLR}$ pin
- Watchdog Timer time-out reset (if WDT enabled)
- Interrupt from INT pin change
- Change of status on PORTB

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

When the SLEEP instruction is being executed, the next instruction is pre-fetched. For the device to wake-up through an interrupt event, the corresponding interrupt enable bit must be set (enabled). Wake-up is regardless of the state of the GIE bit. If the GIE bit is clear (disabled), the device continues execution at the instruction after the SLEEP instruction. If the GIE bit is set (enabled), the device executes the instruction after the SLEEP instruction and the branches to the interrupt vector (004h). In cases where the execution of the instruction following SLEEP is not desirable, the user should have a NOP after the SLEEP instruction to cause a delay. The WDT is cleared when the device wakes-up from sleep, regardless of the source of wake-up.

Real Time Clock Counter

The Real Time Clock Counter (RTCC) allows accurate timing or event counting to be carried out during code execution. Listing 6 shows a sequence of code from last month's flip-flop application which was used to generate a delay of 0·256s between the LEDs flashing on and off.

The RTCC takes its timing feed directly from the microprocessor clock. A separate clock could be used on the RTCC pin, but this offers few advantages. Configuration of the RTCC is via the OPTION register as shown in Figure 7. This enables the RTCC to be configured for an internal or external signal and also enables a prescaler to be assigned to the clocking rate to create variable delays.

Next Month

In the final part of this series next month, we'll look at how to select a PIC device for a particular application, advanced features of individual devices within the PIC family such as analogue to digital conversion, and how to go about debugging both hardware and software.

Reading List

The following books 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.

Description	Reference/Order Code	Cost
A Beginners Guide to the Microchip PIC	AD31J	£19.95
PIC Cookbook	DT76H	£19.95
Embedded Control Handbook	AD28F	£9.50
Microchip Databook	AD29G	£9.50

Texas Instruments' Timeline Technology

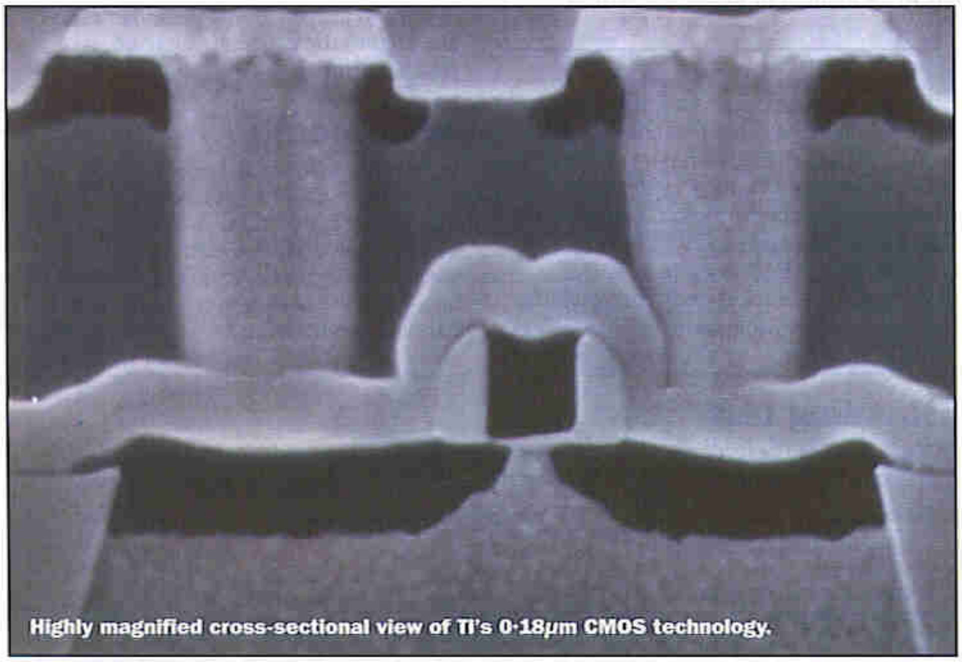
SCIENCE FICTION BECOME SCIENCE FACT

by Stephen Waddington

The line between science fiction and science fact continues to blur as technological advances are making possible what only a generation ago seemed pure fantasy. Texas Instruments (TI) underscored that phenomenon when it announced the capability to build a thumbnail-sized computer chip with the processing power of 20 of today's personal computers. Here, Stephen Waddington examines the impact of this technology on modern communications.

Every day, the equivalent of over 300 million pages of text are sent over the Internet globally. Yet to many, those pages creep along at snails pace, getting bumped and stalled by network collisions and collapses. Demand for bandwidth – and speed – far exceeds supply.

As consumers rush to gain Internet access, the question remains – will the Internet ever live up to the hype of providing an unlimited supply of information at the snap of your fingers? It's looking doubtful. But the answer lies in the vehicle that delivers the Internet to homes and businesses – the network.



Highly magnified cross-sectional view of TI's 0·18μm CMOS technology.

The mass of wires, plugs and boxes that connect our computers to the network and the Internet is plagued by a determined amount of available bandwidth. Bandwidth is the speed at which information can be transmitted through a network. As demand and use grow exponentially, the available bandwidth decreases exponentially, resulting in a slow service.

These needs can be met incrementally by design improvements at the modem or system level. However, order of magnitude improvements in network performance and size reduction are possible only with improvements at the chip level – integrating more bandwidth and functionality on a single chip.

This vision of chip-level capabilities is delivered by the new 0·18μm Timeline Technology from Texas Instruments (TI), as shown in Photo 1. TI's architectural improvements not only enhance performance today, but also provides a comprehensive roadmap for reaching the Gigabit- and Terabit-level performance required by emerging network applications.

New Levels of Performance

This technology allows up to 125 million transistors, each 600 times smaller than the diameter of a human hair, to be manufactured on a single chip, as shown in Photo 2. To put this in perspective, 125 million transistors is equivalent to 20 Pentium processors, the main processing chip in a computer. This scale of technology achieves such high performance that traffic of today's entire Internet could be carried on a switch the size of a can of fizzy drink

"The most exciting device in the network today is the development of network switches that can deliver high bandwidth, and also become smart enough to route information to the appropriate destination across a wide area", said Marc Cetto, director of European Network Business Unit, TI. "Adding this type of bandwidth management capability to network switches will require vastly increased intelligence and performance to be delivered, at a price that can provide consumer network services.

"TI's 0·18μm Timeline Technology is an enabling technology that can provide this bandwidth and bandwidth management. By working closely with our key networking partners, the resulting products will provide in essence unlimited bandwidth to everyone who wants it. The average person working in an office sending and receiving large files with text, graphics and video will see dramatic improvements as the several minutes wait with today's network is eliminated."

This new technology builds upon the advances of the TI ThunderNET architecture, which provides a wide variety of single-chip networking solutions. Together, the 0·18μm and ThunderNET technologies reflect TI's experience and architectural expertise for delivering card- or box-level functionality on a chip.

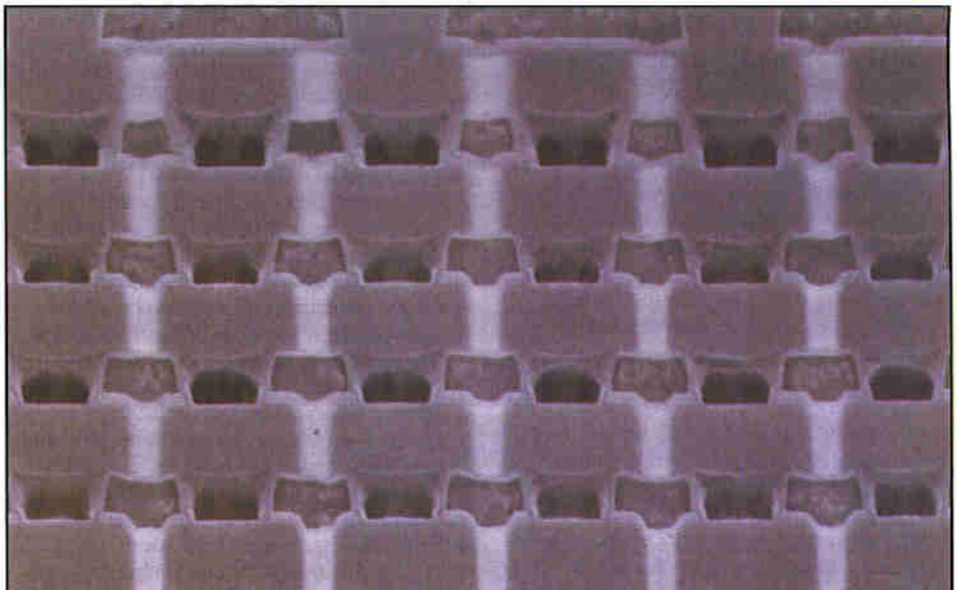


Photo 2. TI's 0·18μm CMOS technology enables up to 125 million transistors on a single chip. The highly magnified picture shows the semiconductor's layers of circuitry.

Design Process

With its ability to pack 125 million transistors on a microchip and to boost performance to several times current levels, TI's Timeline Technology creates unprecedented opportunities to reach the market quickly with new, feature-rich products based on Digital Signal Processing (DSP) cores. The density achieved with TI's 0·18μm technology means that dynamic random access memory (DRAM), static random access memory (SRAM), FLASH memory and read only memory (ROM) can reside on the same chip with DSPs, communications interfaces, analogue-to-digital and digital-to-analogue converters, and other peripherals. The result is a true single-chip solution for many communications, computing and high-performance applications, as shown in Photo 3.

Equally important, the enormous integration capacity achieved with TI's Timeline Technology – more than twice that available with current leading-edge 0·25μm technologies – can slash development cycles by as much as half.

Rather than struggle for solutions that fit within semiconductor limitations, designers can select DSPs and other modules from TI libraries or select their own logic to create a unique proprietary solution. An important part of TI's strategy of providing comprehensive DSP solutions, DSP technology uses industry-standard application-specific integrated circuit (ASIC) design tools to combine DSP cores and peripherals with TI's gate array and standard cell ASIC libraries.

Photo 3. TI's 0·18μm portfolio will enable the design of a new generation of innovative and energy efficient computer, consumer and communications products.

Key Applications

With the TI 0·18μm technology, networking product designers can integrate, within a single chip, all of the functions available today on a full LAN switching system. Fewer components result in simpler design requirements, a smaller system footprint and lower costs. The 0·18μm technology also increases performance through higher integration of switching functions and improves saleability through increased port density.

In addition, the TI 0·18μm technology can be used to create 'router-on-a-chip' products by integrating LAN and wide-area network (WAN) functions. To serve their exploding number of individual subscribers, Internet service providers can benefit from the substantial reductions in equipment footprints enabled by this integration, which can be described as 'access in a drinks can'.

"The most exciting product in the network today is the development of network switches that can deliver high bandwidth, and also become smart enough to route information to the appropriate destination across a wide area", said Cetto. "Adding this type of bandwidth management capability to network switches will require vastly increased intelligence and performance to be delivered, all at small form factor and price points that can provide consumer network services."

Technology Futures

Other improvements in network performance are made possible with this new technology. Gigabit and Terabit networking can be realised in silicon, along with integration of advanced traffic management and flow-control techniques, as well as network management functions.

As development engineers continue to blend routing and switching functions at all levels of the network, the 0·18μm technology will easily enable combined switched network and routing silicon architectures for even greater improvements in network performance. In addition, management information systems (MIS) managers will realise a simplified network infrastructure, seamless adaptation of multiple network protocols and the potential for virtual network management. While the benefits to the user are very real, many of the advances credited to TI's 0·18μm Timeline Technology will appear invisible. Information systems managers, the people responsible for defining, installing and managing office networks, will readily appreciate the significance of taking the equipment in a wiring closet and reducing it to a single, thumbnail-sized chip. The result, whether it be the Internet or your company network, will be unlimited bandwidth and lower costs.

Aside from bandwidth and speed, the most visible benefit to the user will be the reduced cost of network components, such as Internet access through personal computers. Increased functionality will also be added, thanks to the single chip 0·18μm solutions.

These single-chip solutions will negate the need for a fixed point of access. Today, the hardware required to provide Internet access consumes several city blocks. With Timeline Technology, new hand-held devices will be developed, enabling free-moving communication in voice, video and data across cities, states and countries.

"Using this new Timeline Technology, we can increase network performance, increase bandwidth and speed and lower the cost at the same time", said Cetto. "In essence, we will be putting time on your side, where it should be. Timeline Technology will bring us a truly global network, allowing communication with anyone, anytime, anywhere."

Extending the Timeline Architecture

TI is currently conducting several research and testing efforts to extend and validate the Timeline Technology. A joint project involving TI and Stanford University is using the 0·18μm technology to develop Terabit-speed Ethernet switching. The first product to result from the project will be a small, high-bandwidth packet switch with an aggregate 320G-bps for use in a high performance ATM switch, the core of an Internet router or as a fast multiprocessor interconnect.

By employing unique scheduling algorithms for unicast and multicast traffic, the switch will have a maximum throughput of close to 100%. To verify the performance of products based on the Timeline Technology with a wide range of network applications, TI relies on the Network Technology Centre (NTC). The NTC validates standard product and core designs prior to silicon prototyping, enabling customers to bring their products to market faster.

With the 0·18μm Timeline Technology, TI is introducing a new roadmap for product design engineers, one that will enable them to easily reach the next level of high-power networking. This new level will also benefit businesses and individual users, as they enjoy improved performance for their high-demand, networked applications.

Fabrication Capacity

TI has benefited from six new semiconductor fabrication facilities, which have been built since 1989, beginning with TI's Avezzano, Italy, wafer fab constructed with the support of the Italian government. Other fabs include joint ventures in Taiwan with Acer Computer, in Japan with Kobe Steel, in Singapore with Hewlett Packard, Canon and the Singapore Economic Development Board, and in Richardson, Texas (USA) with Hitachi.

Phase II of a new TI-developed wafer fab called DMOS 5, based in Dallas, is complete and will be operational in 1997. Another Dallas wafer fab (DMOS 6), primarily dedicated to DSP production, is under construction, as is Alpha-TI, a joint venture in Thailand. Also available to TI, under a long-term cooperative agreement, will be a percentage of the output from a new semiconductor wafer fabrication facility being built in Korea by Anam Industrial of Korea and US-based Amkor Electronics.

As TI makes investments in semiconductor capacity, it also is focused on realising manufacturing efficiencies in existing wafer fabs. The company has dramatically reduced order fulfilment cycle times – almost cutting them in half on some custom products, and delivering increased value to customers. With an on-time delivery record of 97%, TI is recognised worldwide as the industry benchmark for high-quality, reliable customer service.

Initial design engagements employing the Timeline Technology are currently in progress and TI plans began working with beta customers in the September 1996. Live production is scheduled to begin in 1997.

Further Details

Further details of TI's Timeline technology can be obtained at `http://www.ti.com/sc/docs/schome.htm`, as shown in Photo 4.

Applications

A variety of network technologies and applications can be enhanced by the 0·18μm Timeline Technology. Examples include:

- Super 'switch-on-a-chip' integration for high-performance workgroup and backbone switches with superior scalability.
- 'Router-on-a-chip' integration of LAN and WAN functions in a very small footprint that delivers 'access in a drinks can' for Internet service providers.
- Gigabit and Terabit network functions, including integration of advanced traffic management and flow control techniques to enhance bandwidth delivery across global networks.
- Embedded network intelligence that enables powerful small-office and home-office networks as well as performs remote diagnostics on network equipment.
- Combined switched network and routing silicon architectures for even greater increases in network performance.

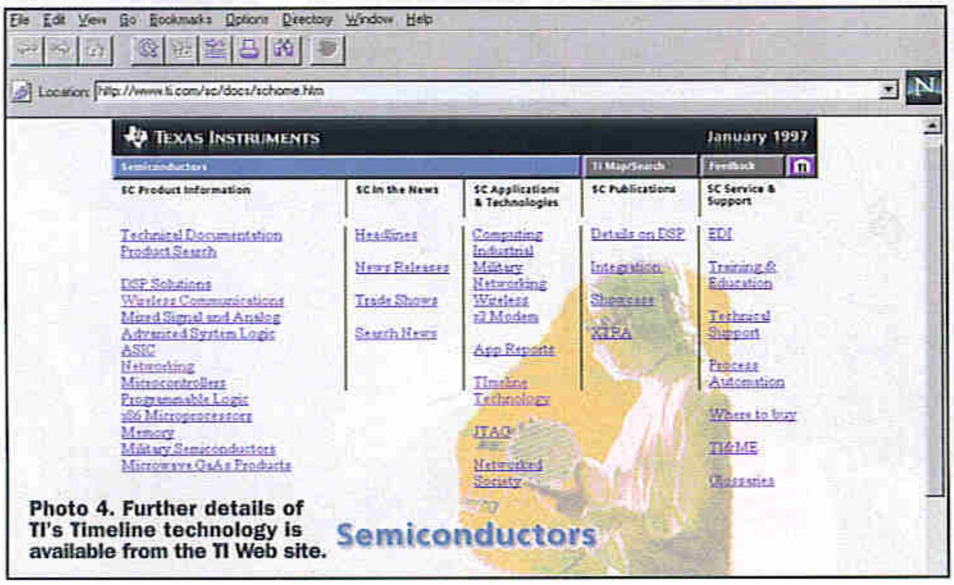
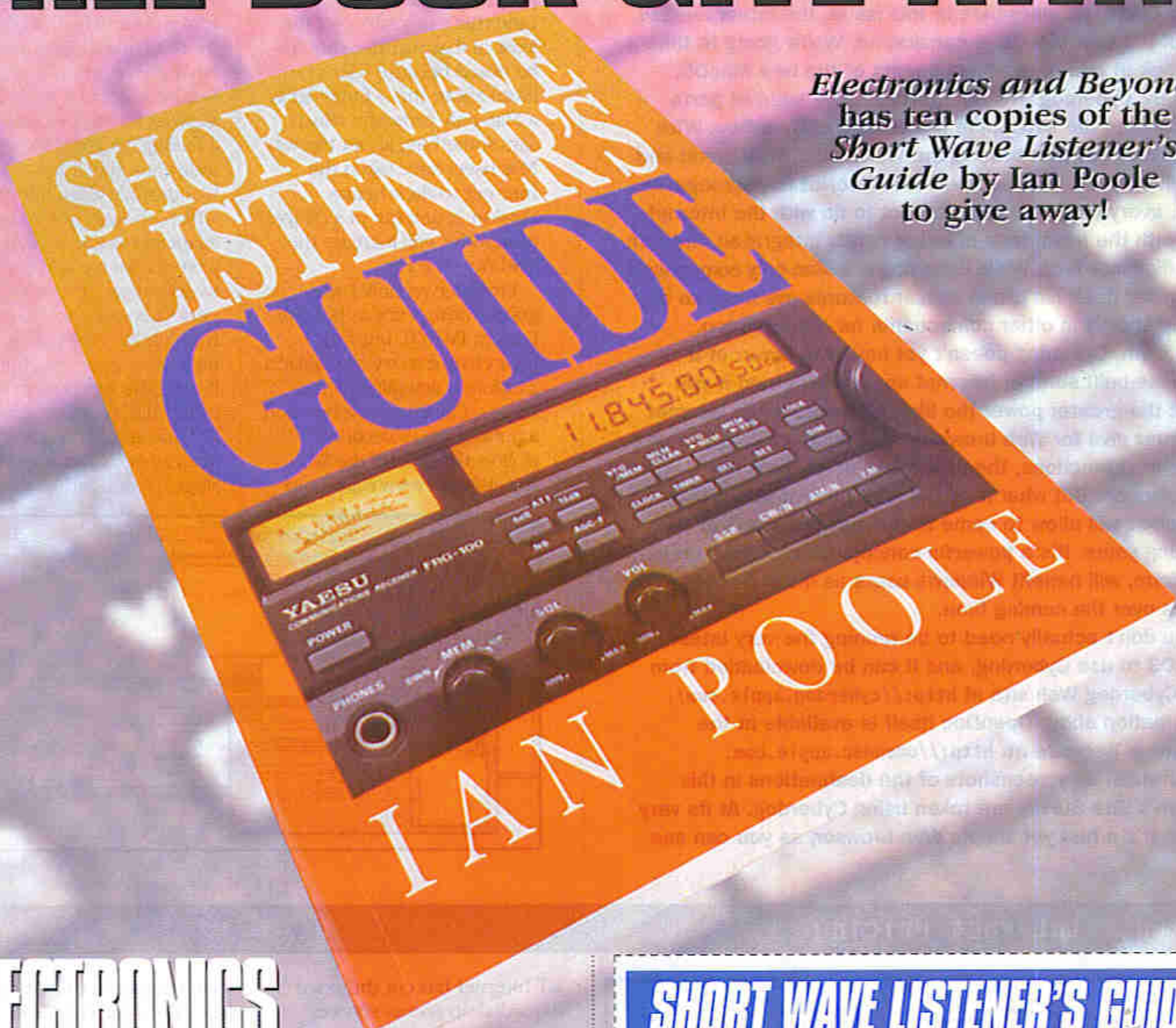


Photo 4. Further details of TI's Timeline technology is available from the TI Web site.

FREE BOOK GIVE-AWAY



***Electronics and Beyond* has ten copies of the *Short Wave Listener's Guide* by Ian Poole to give away!**

ELECTRONICS and Beyond

The *Short Wave Listener's Guide* by Ian Poole provides a complete practical guide to the fascinating subject of short wave listening (SWL). The book explains exactly what short wave listening is, what equipment is needed to receive signals, setting up and running an SWL station and how to obtain an amateur radio licence. The practicalities of SWL are discussed, from buying new or used equipment, making and installing aerials and enhancing the operation of receivers and aerials with ancillary equipment.

Each topic is clearly explained and illustrated. A description of wave propagation by all modes relevant to the HF bands is given in the chapter on radio waves, and the various transmission types encountered in short wave are detailed: morse, amplitude & frequency modulation, single sideband, data modes including RTTY, packet and amtor, are all covered.

The author is an electronics engineer, currently involved in project management for the development of a large radio system. He is a regular contributor to electronics magazines including *Electronics and Beyond*, and has written several books on amateur radio.

Short Wave Listener's Guide by Ian Poole is published by Newnes, priced at £14.99, softback with 94 illustrations and 192 pages.

Please note that employees of Maplin Electronics PLC, associated companies and family members are not eligible to enter. In addition, multiple entries will be disqualified. The prizes will be awarded to the first ten entries drawn.

SHORT WAVE LISTENER'S GUIDE

Ten lucky* Electronics and Beyond *readers need not pay a penny for a copy of* Satellite Projects Handbook. *The first ten readers whose names are drawn from the Editor's hat(!) on 6th May 1997 will have a copy delivered to their home.

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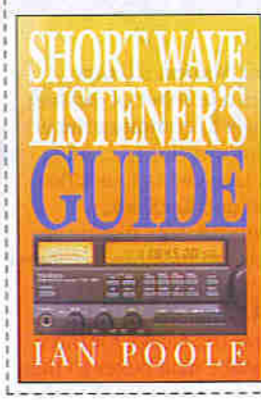

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***Send your entry to Satellite Projects Handbook* Free Book Draw, The Editor, *Electronics and Beyond*, P.O. Box 777, Rayleigh, Essex SS6 8LU.**

ELECTRONICS and Beyond

@Internet

Go Get It, Boy

In *Comment* elsewhere in this issue, the latest release of the new MacOS is considered. We're going to take a look at one of the components of the new MacOS, namely, Cyberdog. It's an Internet-ready suite of parts which uses the new Apple technology of OpenDoc. With Cyberdog, you can browse the World Wide Web, send and receive e-mail, read articles from UseNet newsgroups, in fact, everything you might expect to do with the Internet, but with the advantage of being tightly integrated and with a unified interface. While Cyberdog is a Mac-only component, OpenDoc itself isn't, and similar features are likely to be found shortly in other components for Windows too.

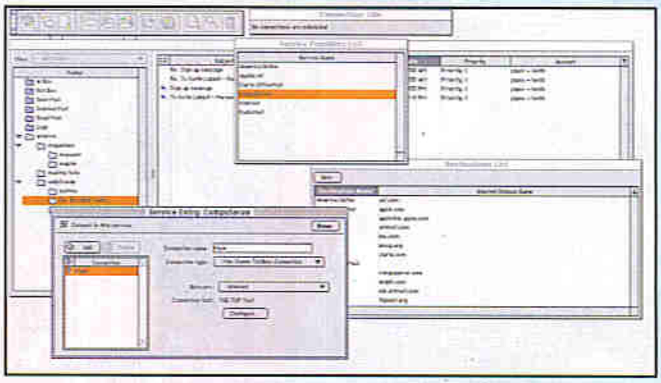
In truth, Cyberdog doesn't yet have the power of a purpose-built suite of Internet applications, and if you want the greater power the likes of Navigator or Internet Explorer give for Web browsing, or Eudora or Em@iler give for e-mail functions, then it'll seem pretty pale by comparison. But what it shows is the latent talent that OpenDoc will allow to come to the surface over the coming years. It's a powerful concept which, being cross-platform, will benefit Windows users as much as Mac users over the coming time.

You don't actually need to be running the very latest MacOS to use Cyberdog, and it can be downloaded from the Cyberdog Web site at `http://cyberdog.apple.com/`. Information about OpenDoc itself is available at the OpenDoc Web site at: `http://opendoc.apple.com`. Meanwhile, all screenshots of the destinations in this month's Site Survey are taken using Cyberdog. At its very least, it's a fast yet simple Web browser, as you can see.

Eudora – Watch Out!

It might surprise some readers to learn that the world's best-selling e-mail program is Claris Em@iler (and that's official!). Not the least of that surprise should be noted because – let's be blunt about this – Em@iler is a Mac-only program, which says something about the way Mac users have taken the Internet to their hearts. Version 2, due out in a couple of months, will increase the lead over the rest.

Em@iler version 1 was good (though not as good as Eudora IMHO), but now's your chance to try out version 2 before it actually hits the streets. Claris has just released a public beta of version 2 (follow the link off the Web site at http://www.claris.com to download it – having said that, it's a 7·5M-byte download, so get the kettle brewing while you do!). It's a 60-day trial version which will give more than a sufficient idea of what the program's about. I've been using it now just for a day as I write this, and I have a feeling it's going to prove indispensable. It has a wonderfully clean interface which, though not quite as adaptable as Eudora's (if you're a bit of a techie and like to tweak things), provides almost perfect control over e-mail. It's ideal for heavy or light e-mail users alike – particularly if you have mailboxes on more than one account, as it lets you send and receive mail from all your accounts with a single phone call.



BT Cuts Internet Pricing

BT Internet has cut the price of its dial-up access service. The new prices – which take effect today – include more than 20% off BT's flat monthly subscription fee, 50% off high-speed ISDN Internet access and an end to the one-off registration charge of £17.03.

The new subscription fee for unlimited use enables customers to access the Internet as much as they want for only £11.75, reduced from £12.77, and for the cost of a local telephone call. Also, BT has halved the cost of its high-speed ISDN Internet unlimited access service from £23.50 to £11.75.

For customers who pay annually, the subscription fee is reduced from £150 to £129.25, giving them a discount equivalent to one month free.

For further details, check: **`http://www.bt.co.uk`.**
Contact: BT Internet,
Tel: (0800) 800 001.

NETCOM Releases NETCOMplete 3.2

NETCOM has announced NETCOMplete 3.2, the latest version of its Internet access solution, which offers a fully licenced and customised version of Netscape Navigator version 3.0.

The NETCOMplete 3.2 software suite includes Netscape Navigator 3.0, the latest version of the world's leading Internet browser. Version 3.0 now includes a number of exciting new ways to communicate and share information, including Live Audio, Live Video, QuickTime support and CoolTalk, a revolutionary tool that turns users computers into a real-time phone using the Internet.

NETCOMplete 3.2 users will also have the facility for three additional e-mail boxes to their dial-up account, as well as the ability to forward mail free of charge through Mail Box administration site on-line. This gives flexibility for NETCOM customers with more than one e-mail address. If users travel abroad, the mail forwarding will mean that their e-mail can easily be sent to an account in the destination country.

In addition, NETCOMplete 3.2 gives users 2M-byte of Web space free with their dial-up account.

NETCOMplete provides a one-stop, easy-to-use Internet solution for a flat rate of £14.95 per month, with no start-up fee and unlimited usage. Customers pay only £5.95 for the first month. Access to NETCOM's service is backed by 24-hour, seven-day-a-week customer support.

For further details, check: **`http://www.netcom.net.uk`.**
Contact: NETCOM,
Tel: (0800) 973001.

Progressive Networks Announces RealVideo

Progressive Networks, creators of RealAudio has launched RealVideo 1.0, the first cross-platform solution for delivering streaming video content over the Internet. The beta version of RealVideo is now available for free by downloading the RealPlayer at http://www.real.com.

Rob Glaser, chairman and CEO, Progressive Networks, told Electronics and Beyond, "Two years ago, Progressive Networks pioneered audio on the web when it introduced Real Audio. Now, two years and thousands of RealAudio sites later, RealVideo moves the web one more step toward becoming a true mass medium. Our RealAudio experience shows us that the market rewards excellence. This means delivering great technology, great content, and broad industry support."

Progressive Networks claim that RealVideo delivers VHS-quality video over 28.8k-bps modems, full-motion-quality video using V56 (56k-bps) and ISDN (56/64k-bps) modems, and near-TV broadcast quality video at LAN rates or 'broadband' speeds.

Web Hosting at US Speeds with 50M-byte Webspace as Standard

UK standards for virtual web servers hosted on small leased lines have resulted in web sites being tortuously slow to download. In the US, nearly all virtual servers are hosted on massive leased lines. NetBenefit is the first UK Internet Service Provider (ISP) to conform to US standards by hosting all its servers on a dedicated T1 (1M-bps line), giving UK customers the fastest service on the market. As a measure of the quality of its leased line, in January, an average of only 1·5% of NetBenefit's bandwidth was utilised.

Larry Bloch, Managing Director at NetBenefit, told Electronics and Beyond, "By providing such a fast, quality service, we have established our position as the largest Internet domain name registrar in Europe, and we are on track to make NetBenefit the largest provider of virtual servers by mid 1997".

Although NetBenefit only introduced its T1 service three months ago, it already hosts over 400 virtual servers. By comparison, Netlink host 2,500 sites on a line half the size. NetBenefit is now providing a quality guarantee that its web site-to-connectivity ratio will never exceed 1,000 web sites per 1M-byte of Internet connectivity. As a standard service, NetBenefit's servers offer 50M-byte of space for £20 per month. The only other provider of 50M-byte servers as standard in the UK, BT WebWorld, currently charge £416 per month.

For further details, check: `http://www.netbenefit.co.uk.`

Contact: NetBenefit,
Tel: (0171) 336 6777.

Pipex And CyberGuard Claim Security First

UUNET PIPEX and CyberGuard have linked up to jointly offer what is expected to be the first UK government-certified security solution for Internet access. UUNET PIPEX customers are now able to safeguard key corporate data to a high level using CyberGuard's comprehensive security solution.

The CyberGuard firewall includes a multi-level security system that resides between an internal network and the Internet. The firewall provides a single, highly secure connection point through which all data must be filtered. CyberGuard's filter is transparent to users and has minimal impact on throughput. It may also be used within intranets.

Unauthorised attempts to communicate with the internal network are blocked and logged, reducing the possibility of data theft or damage to the internal network and allowing the customer to identify the source of the attempted intrusion.

For further details, check: `http://www.uu.net.`

CompuServe Stresses Importance of European Market

Only days after the resignation of its chief executive in February, CompuServe has cut 14% of its workforce through resignations and other voluntary means.

The online service provider is hoping that the cuts will allow it to become profitable enough to allow parent company H&R Block to spin off its remaining 80% stake in CompuServe to shareholders.

In discussing financial results for the company's third fiscal quarter, Frank L. Salizzoni, CompuServe's chairman and acting CEO, stressed Europe's strategic importance for the firm.

"CompuServe is the European market-leader among global online service and Internet companies today", he said. "Our strategy calls for continuing this impressive growth."

Denny Matteucci, president of CompuServe's Interactive Services division, told Electronics and Beyond that CompuServe has nearly doubled its membership in Europe during the past 12 months. "With approximately 900,000 subscribers, we now have a two-fold lead over the next-largest global competitor in Europe."

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

@Internet

New Domains Expected to Relieve Naming Competition

The problem of limited domain names will be alleviated somewhat with an announcement by the International Ad Hoc Committee (IAHC) that seven new top-level domains will be released.

Internet users will have seven new generic Top Level Domains (gTLDs), in addition to the existing ones under which they may register Internet names, when the plan is implemented.

The new gTLDs and the intended fields of use are:

- .firm for businesses, or firms
- .store for businesses offering goods to purchase
- .web for entities emphasising activities related to the web
- .arts for entities emphasising cultural and entertainment activities
- .rec for entities emphasising recreation/entertainment activities
- .info for entities providing information services
- .nom for those wishing individual or personal nomenclature

In addition, up to 28 new registrars will be established to grant registrations for second-level domain names under the new gTLDs.

The new registrars will be selected by lottery from applicants who fulfil specific requirements established by the IAHC. All the new gTLDs will be shared among the new registrars, meaning that each registrar may effect registration of second-level domain names under all the new gTLDs.

It is intended that the three existing gTLDs (.com, .net, and .org) would also be shared upon conclusion of the cooperative agreement between Network Solutions, Inc. (NSI) and the US National Science Foundation (NSF), which allows NSI to act as the registrar for those gTLDs.

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

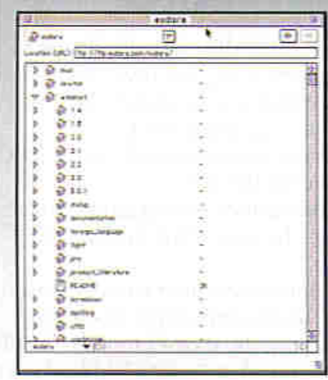
Contact: Internet Society, Tel: +1 703 648 9888.

Site Survey

The month's destinations

Users of Eudora version 3 (Pro and Lite) may be interested to download an upgrade to the program which provides bug fixes and a couple of extra features. It's available for either platform (Windows or Mac) at **ftp://ftp.eudora.com/eudora**, as well as pre-release versions of the program for Newton PDA users (of which there are ever-increasing numbers) to couple to PC or Macs.

Weather watchers can download satellite images from **http://www3.accuwx.com/web/getwx/sat/europe.htm** for an in-depth picture of what's happening on the planet's surface. The screenshot shown is of Europe during the stormy weather of the last week in February. I'm pleased I stayed indoors.



Above: Eudora version 3

Above: Satellite images

Farallon has released a freebie applet which allows a computer user to view the activity on another person's computer anywhere over the world via the Internet. It's a stripped down utility along the same lines (though obviously far less capable) as another of the company's products, Timbuktu Pro, which not only lets you view another computer's activity but lets you control it too. Download Look@Me in several flavours, depending on your operating system, from **http://www.farallon.com/www/look/ldownload.html.**

Below: Look@Me

Readers of this column in the education world (particularly teachers) should check out the National Council for Educational Technology's Web site at **http://www.ncet.org.uk/.** Here, there are details of NCET projects, news, educational CD-ROM reviews (reviewed by teachers who use them!) and much, much more. It's a great starting-point for the use of information technology in schools, and you can pick up several pointers in this area.

Below: NCET site.

ELECTRONICS and Beyond

next issue

Don't miss another great assortment of entertaining and easy-to-make projects and essential electronics information aimed at the novice constructor.

Slow Scan TV Decoder

A simple PIC microcontroller-based interface to receive and decode slow scan television signals, for display on a PC monitor.

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.

Audio Lead Checker

Confirms that your audio system's DIN and jack socket interconnecting cables are properly wired for sound.

History of Disco Lighting

Kevin Hopcroft discusses developments in disco sound-to-light systems since their introduction in the late sixties.

PLUS Cave Radio from Mike Bedford explains a communications system designed for underground use by potholers.

Hi-tech at the Post Office by Alan Simpson describes Project Genesis, an initiative to integrate the P.O.'s computing systems and offer customers additional communications services.

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.

Speaker Crossovers by Robert Saunders discusses the design of Hi-Fi loudspeaker crossover circuits.

Part 2 of Audio Basics from Ray Marston covers fundamental audio system principles.

The final instalment of PIC Programming by Stephen Waddington informs you on selecting PIC microcontrollers appropriate to the application, and how to debug PIC hardware and software.

Surface Mount Technology Today and Tomorrow from Ian Davidson picks and places present and future developments in component miniaturisation.

Martin Pipe reviews the Apple PowerMac 9500/200.

Issue 114 on sale Friday 2nd May

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:

PROJECT RATING 1 — 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.

PROJECT RATING 2 — Easy to build, but not suitable for absolute beginners. Some test gear (e.g. multimeter) may be required, and may also need setting-up or testing.

PROJECT RATING 3 — Average. Some skill in construction or more extensive setting-up required.

PROJECT RATING 4 — Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.

PROJECT RATING 5 — Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

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TECHNOLOGY WATCH

with Martin Pipe

Having all but taken over the desktop computer operating system market with Windows and MS-DOS, Microsoft has now set its sights on the pocket-sized machines that we know variously as PDAs (Personal Digital Assistants), palmtops and electronic organisers – you know, the compelling little gadgets produced by the likes of Casio, Hewlett-Packard, Psion and even Apple. Microsoft would rather we called them hand-held PCs, or HPCs, and last September, it announced a basic hardware specification for the product it hopes will revolutionise the world of pocket (truly personal?) computing. This basic hardware specification is required to run a ROM-based operating system called Windows CE (Compact Edition or Consumer Electronics?).

If it all goes Microsoft's way, then we'll have a universal pocket-sized platform – something that has been sorely missed until now. The lack of standardisation in the PDA industry so far has put software developers off – who wants to write programs that will just work on a single machine? As a result, the range of software available for machines is extremely limited – although highly specialised areas, such as medical data collection, tend to be served reasonably well. This absence of standards has done nothing to keep obsolescence at bay; even now, many regard PDAs as 'toys'. Hardware functions that many would consider essential – such as serial ports – are not universal, making machine upgrades and data backup a pain.

The basic hardware specification that Microsoft casts in stone for would-be HPC-builders centres around an energy-efficient 32-bit RISC processor. Hitachi (SH-3) and NEC (VR4101) seem to be the current choice, although Intel, ARM (ARM7, StrongARM) and Philips (TwoChip PIC) RISC processors, amongst others, will apparently be supported. A processor-specific hardware abstraction layer (HAL) sits between the hardware and operating system, meaning that any application will run on any HPC with the required resources. There is also 4M-byte of ROM, 2M-byte plus of non-volatile RAM, a 480×240 pixel LCD touch screen with stylus and 2-bit greyscale, and a QWERTY keyboard.

In terms of I/O subsystem, Microsoft specifies IrDA-standard infra-red communications, a serial port, a Type II PCMCIA slot and support for .WAV audio. Quite comprehensive, in other words. The Olympia Windows 97 show, in late February, gave many UK visitors the first chance to see the hardware available – although it's been available in the US since last November. Packard Bell's MobilePro was so new, there wasn't a suggested retail price (I would expect this will be around the £500 mark). MobilePro does, however, have 4M-byte of RAM and 8M-byte of ROM (the extra 4M-byte ROM presumably contains CE versions of Microsoft Word and Excel, which are bundled with the device). Battery life is claimed to be 50 hours on a pair of alkaline AA cells. Ah, where would we be without RISC processors? Also on show at Windows 97 was a Casio model. The CE stand certainly seemed to generate a lot of interest.

Windows CE, the operating system designed to work with this hardware, also looks good. Originally codenamed Pegasus, CE is a compact 32-bit multi-tasking, multi-threaded design with an open architecture. In terms of user interface, it's (hardly surprisingly) very similar to Windows 95. The movable toolbar is there, with its 'start' button and clock. The 'Recycle Bin' and 'My Computer' are both present, although the latter has been renamed, perhaps not surprisingly, 'My Handheld PC'. There's a 32-bit TCP/IP stack, meaning that Internet applications can be run. To connect to the Internet, you would use a PCMCIA fax/modem or GSM data card. Microsoft has designed a version of its popular Internet Explorer Web browser for CE. Pocket Internet Explorer doesn't, surprisingly, offer a virtual machine for running Java applets. A shame, since the platform shares many similarities to the network computer. One can only assume that it's down to hardware constraints, such as memory.

Microsoft claims that over 40 leading hardware and software companies have committed to developing products for the HPC platform. At the time of writing, the list of manufacturers that have pledged to produce HPCs include Casio, Hewlett-Packard (Packard-Bell), LG Electronics, NEC, and Philips Electronics. The CE web site (`http://www.microsoft.com/windowsce/default.asp`) offers a search engine that allows you to search for a type of application. Most appear to be quite specialised (anyone for flight planning or fleet management?), although there is an abundance of communications and connectivity packages.

If CE takes off, the major software vendors will presumably port software of more general interest (such as spreadsheets, electronic A-to-Z type guides, word processing, games, etc.) over to CE. For the time being, Microsoft has produced a 'mini' Word, amongst other things. In the States, you can buy street guides for the major cities. Software will be supplied in the form of desktop PC media, and not memory cards. You transfer the programs across from the PC to the HPC via the serial link. This is an approach that keeps media costs down, and frees up the PCMCIA slots for other purposes.

There are development aids available for those who want to design software for CE. These include a NT-based software developer kit (SDK) that can be freely downloaded from Microsoft's Web site. This is a complete emulation environment for building applications, and includes desktop libraries, header files, Windows CE-specific samples, and documentation. Using this SDK, and a standard desktop compiler (such as Microsoft's own Visual C++), it is possible to build, debug and run Windows CE applications on a standard desktop PC. Other tools planned include a cross-compiler (which will eventually ship as a plug-in for Visual C++).

CE isn't just about HPCs – Microsoft has deliberately designed it to be scalable. The company believes that it is suitable for future devices such as credit-card sized 'wallet' computers. There's a possibility that 'CE' might stand for consumer electronics after all. The operating system could, according to its creator, be used to drive next-generation pagers, cellphones, set-top boxes, multimedia consoles and Internet-ready TV sets and phones. Home automation hasn't been ruled out. A common operating system means that all of these devices could talk together from the very beginning; at the very least, the familiar Windows user interface means that consumers would quickly get to grips with their new gadgetry. CE is clearly part of Microsoft's strategy to ensure that it survives in the hotly-anticipated post-PC networked age.

E-mail your comments or suggestions to Martin Pipe at whatnet@cix.compulink.co.uk.

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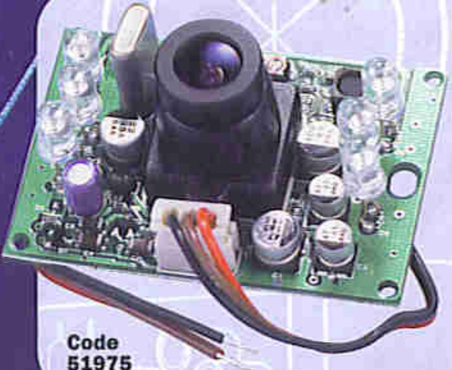

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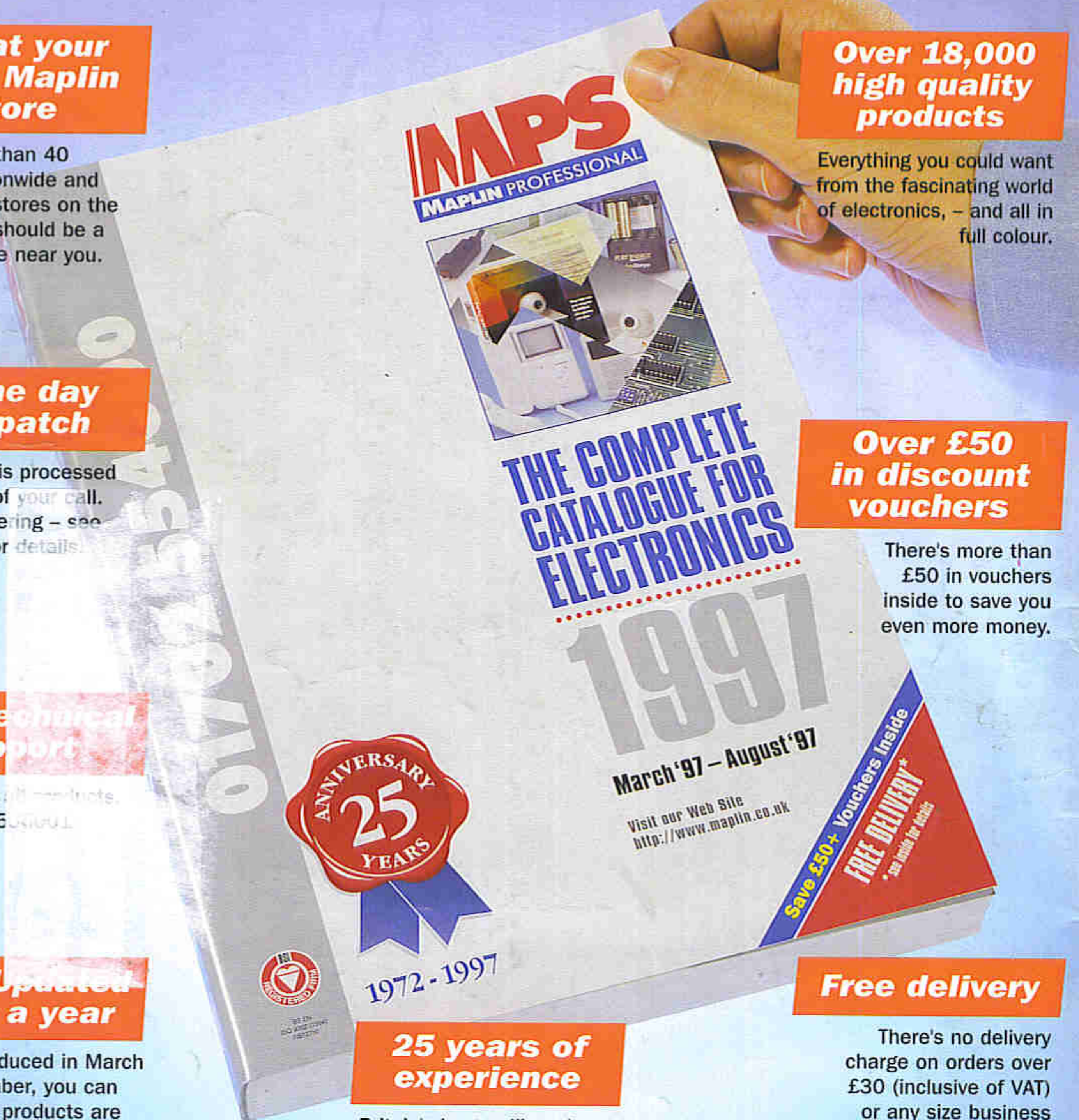

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