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connection, Richard Grodzik's compact battery-powered eprom
programmer programs a basic 2kB eprom in two seconds.
**High-Performance Addressing Advances Passive Matrix Colour**

Hitachi Europe has introduced new products based on a new passive matrix colour LCD technology which provides major advances over existing passive matrix colour-STN displays, especially in response times and contrast ratios. The SX3 family of LCDs ranges from 12.1 inches to 15.5 inches in display size, have S-VGA or XGA resolution with conventional or LVDS interfacing.

The new technology, called High-Performance-Addressing (HPA), is aimed primarily at the notebook, mega-notebook and desktop PC markets.

The HPS display family includes initially three products: the SX31S003 12.1-inch SVGA with a conventional interface; the SX33S001 13-inch XGA with an LVDS interface, and, notably, the SX39X, a 15.5-inch XGA with an LVDS interface. A fourth device, the SX39001 15.5-inch XGA panel with a conventional interface, follows shortly.

HPA allows passive matrix technology to be used in applications such as multimedia which were previously forced to use more expensive active matrix displays. The enhanced high-addressing provides response times of 150ms (twice the speed of conventional C-STN) and contrast ratios of 50:1, a significant improvement over existing STN technology. In future, response times of 80ms are expected.

In general, HPA gives response speeds closer to TFT (thin film transistor), a higher contrast ratio and less crosstalk and shadowing. The cost is expected to fall to approximately 60 percent of the equivalent TFT display size.

The more information please contact Vince Pitt. Hitachi Europe Ltd., Whitebrook Park, Lower Cookham Road, Maidenhead, Berks SL6 8YA. Tel 1628 585163, fax 01628 585160.

The following table compares HPA with conventional Colour-STN and TFT displays:

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**National Vintage Communications Fair**

The National Vintage Communications Fair is coming round again. The next Fair will be on Sunday 10th May in Hall 11, the National Exhibition Centre (NEC), near the M6 motorway, Birmingham, from 10.00am to 4pm.

The Vintage Communications Fair is a collectors fair for antique radio, with rare and collectable examples of radios, TVs, gramophones, valve kits and "all manner of electrical and mechanical antiques and collectables". The Fair is now held twice a year, usually in May and October, and expects over 300 specialist dealers from the UK, the Continent and the USA. Help and advice are on hand from representatives from collectors clubs, societies and specialist magazines.

Entrance is £5 and includes a copy of The Sound and Vision Yearbook's Collectors' Guide. Anyone who wants to book stand space or requires other details should contact Sunrise Press, Spice House, 13 Belmont Road, Exeter, Devon EX1 2HF (sending an SAE) or tel. 01392 411565.
Part of the DTI's Information Society Initiative Programme for Business is the ISCA or Information Society Creativity Awards. Twenty British companies have been awarded financial support from a £1 million pound DTT programme to help turn innovative digital ideas into market leaders.

The twenty 1998 winners include:

Ransom Publishing were awarded £25,000 for The History of Life, a multimedia CD-rom with hybrid web access, which covers biological evolution and competing theories of life, creation and biodiversity, and can simulate evolution (visually) on the computer in a number of different environments, to give a better understanding of evolutionary theories. Contact: Lucy Eldridge 01491 613711.

The Barfield Group Ltd. were awarded £25,000 for a hybrid CD-rom package encouraging UK companies to take advantage of business opportunities in Russia. It includes photos, maps, sound and video clips and a searchable database. Contact: Paul Wilsencroft 0181 447 1000.

SMS Multimedia were awarded £45,000 for The Rotary Coping with Life series, multimedia programs that tackle problems facing young people, such as bullying, crime, stress of family breakdown. Contact: Colin Sawyer 01670 813470.

IIP were awarded £25,000 for The Palace of Amnesia, conceived by David Thorpe, author of How the World Works, which "marries human psychospace and computer cyberspace with art, music and humour in the quest for identity and nature". Contact: Dr Will Howard 0171 288 1833.

Ground Bass Productions were awarded £12,275 for a CD-rom allowing any paper-using company to investigate interactive multimedia as an alternative way of producing the "interactive brochure" to promote companies. Contact: Dolly Sanders 0171 285 1833.

JVM Creative were awarded £47,213 for What Are You Like, providing teenage girls with information and entertainment on CD-rom. Contact John Worth 01273 488282.

The Mersey Television Company Ltd. were awarded £45,000 for From Script to Screen, a hybrid CD-rom providing a behind-the-scenes look at television drama production. Contact Andrew Corrie 0151 722 9122.

Cambridge Training and Development Ltd. were awarded £49,980 for ReadingWrite, an application to give UK schools an approach to reading and writing using the National Grid for Learning. Contact Martin Good 01223 582582.

Realise Ltd. were awarded £25,000 for The Knowledge Pool, an interactive web tool combining the benefits of newsgroups and on-line communities. Contact Richard Ashrowan 0131 538 7344.

Lightspeed Online were awarded £12,480 for Ariadne, which allows for secure transmission of sensitive information for the legal and financial professions. Contact Paul Stokes 01222 235760.

Arq Ltd. were awarded £25,000 for Vision, a professional journal for managers and decision makers on the subject of sustainable development and the environment. Contact Nick Hart-Williams 01225 312391.

Datacuture were awarded £21,934 for The 24-Hour Box Office to enable independent theatres and other venues to sell tickets at any time using touch-tone phones or kiosks. Contact Jonathan Hyams, 01908 232404.

Kenneth Mason Publications Ltd were awarded £49,459 for Research Exploitation, a program to match British inventions with manufacturers ready to develop them. Contact Piers Mason 01243 777977.

WHF Chester Ltd. were awarded £25,000 for a prototype for use in forensic reconstruction using a digitally animated presentation of evidence based on accurate interpretation of data. Contact Kevin Horswood, 01244 348480.

Lightwork Design Ltd. were awarded £50,000 for 'LightWorks StyleMaker project to create "artist's renderings" directly from 3-D data. Contact Stuart Green, 0114 266 8404.

Notting Hill Publishing were awarded £50,000 for Dancer DNA Professional which uses evolutionary theory and 3D graphics to evolve animations to music in real time. Contact 0171 937 6003.

Formance were awarded £21,010 for 4.I.D., a hybrid CD-rom/Internet/intranet digital image archiving system operating in three-dimensional space. Contact Alison Murray 0171 729 8808.

Active Adventure Ltd. were awarded £20,075 for Discovering the National Parks, a CD-rom that allows PC users to examine information and images of National Parks interactively. Contact: J M Collins 01928 731 791.

Continuum ID were awarded £21,276 for F.CAD, an information and design assistance tool for small furniture designers and manufacturers. Contact Roland Whitehead 01403 271888.

AND Software Ltd. were awarded £25,000 for ProDesk, an application for designers of microcontroller products to speed design and evaluation, particularly appearance. Contact Valerie Thorn 01922 814655.

The ISCA are sponsored by Sun Microsystems, Macromedia, Demon Internet, Yahoo, The Electronic Telegraph and Computer Arts. "The ISCA give small and medium sized UK businesses the creative freedom to develop new media-based products," said Robert Youngjohns, MD of Sun Microsystems.

The Information Society Initiative Infoline can be contacted on 0345 152000. The ISI website is on http://www.sis.gov.uk
**DIY EMC Test Facility in Sussex**

Crowborough-based company Feedback Instruments has made its in-house EMC facility available for hire for EMC (electromagnetic compatibility) testing on a DIY basis, either as a pre-compliance measure or for self-certification.

Feedback describe the facility as a fully-equipped screened room completely lined with rf absorber and suitable for both emissions testing and radiation immunity testing. For emissions testing, the room is equipped with a combination of antenna, preselector, spectrum analyser and appropriate software. The immunity system consists of an antenna, an RF generator, an amplifier, a field probe and GPIB software for automatic field levelling. Other measurements of transients and static discharge can be carried out using readily available systems.

The room has been designed and equipped to be suitable for use by electronics engineers who are not necessarily RF specialists. Feedbacks representatives make the point that ease of use is important and that days can be lost during new product development if EMC tests are inconsistent. “Our facility has been designed for the greatest possible consistency of results and cost-effective EMC testing”, says Mike Christieson, the Development Manager. At time of writing prices are £540 per day, £280 per half day, ex VAT. For more information, contact Feedback Instruments Ltd., Park Road, Crowborough, East Sussex TN6 20R. Tel 01892 653322 fax 01892 663719. Web WWW.fdbk.com email feedback@fdbk.demon.co.uk

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**Maplin and CB Radio Representatives Co-Endorse**

Maplin Electronics has signed a corporate membership deal with the UK’s leading CB radio organisation, the British Citizens Band Confederation (BCBC).

The BCBC, newly formed in 1997, represents the needs of licensed CB radio users, manufacturers and retailers in the UK. The organisation is recognised by the Radiocommunications Agency, who are responsible for all regulation of CB and other radio use in the UK, including the frequencies in use, modes of transmission and technical manufacturing guidelines and regulations.

Purchasers buying CB radio equipment from Maplin will receive information about the BCBC and CB licensing information.

For further information on the BCBC and Maplin’s product range and store locations, call 01702 554002 or refer to your current Maplin catalogue.

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**8051 Simulator Can Capture Complete Chip State**

A new 8051 simulator running under Windows 95 and Windows NT 4.0 has been released by Crossware Products, a UK-based embedded tools developer. The software creates a virtual 8051 microcontroller on a PC, and provides full source-level debugging facilities without the need for any 8051 hardware.

The software provides full simulation of interrupts, serial port and timers, with graphic displays to show the activity of these on-chip peripherals. Views of memory, registers and disassembled instructions allow observation and control at the microcontroller level. Multiple watch windows show the values of local and global C variables, and context-coloured windows allow debugging at source code level.

A unique feature of this simulator is its State Capture facility: one click will capture the complete state of the microcontroller under simulation, including memory contents, register values and program counter. At a later time, the programmer can restore this state and the simulator will reconfigure itself exactly as it was when the state was captured. The programmer can re-start the simulation from this restored state.

Since multiple states can be captured, the state capture facility provides a means of taking giant steps both forwards and backwards through previously executed code without needing to re-execute all the instructions between each point.

Data sheets and a fully working evaluation package can be obtained from the Crossware website at http://www.crossware.com

For more information contact Crossware Products, St John’s Innovation Centre, Cowley Road, Cambridge CB4 4WS. Tel 01223 421263 fax 01223 421006.
Joint Development for Digital Imaging ICs

New ICs are being developed to integrate Iomega Corporation’s interface for its latest disk drive family, clik!, into Atmel Corporation’s devices. Iomega’s clik! is expected to be the first true "digital film" that can compete on both price and image quality with conventional film. Various of Atmel’s future digital camera products will have the clik! interface standard integrated. The drive is designed to meet the storage needs of digital imaging with portable equipment, so that data can be passed from portable image-gathering equipment (cameras and any portable peripherals) back to a main computer for handing.

The plan behind clik! is a family of high-capacity removable storage media using Iomega’s mobile technology platform, a hand-held (micro) device. It is a planned move to bring greater levels of removable data storage to portable digital equipment, including digital cameras, handheld computers, personal organisers and cellular smart phones.

The standard clik! drive is a portable, low-cost external drive that can be used with a wide range of digital portable and desktop equipment and is small enough to fit into a shirt pocket (and, unlike some cheaper mobile data recording solutions, will not leak ink onto the shiny, A miniature, low-power version of the same drive will be available to original equipment manufacturers (OEMs) to build into equipment from digital cameras to palmtop computers.

Clik! 40-megabyte removable disks are about half the size of a credit card and can store approximately 40 high-quality (“megapixel”) digital photographs or around 400 10-page Word documents.

Currently digital camera users can only take a few high-resolution photographs before they must download their images from the camera to a computer. Removable storage drives like clik! free the photographer from having to constantly return to the computer. A 40-megabyte removable disk is expected to retail for about $9.95 in the USA, so we might expect a price of about £10 when it comes to the UK. The drives as described are reusable.


Wide-Ranging Stepper Materials Catalogue

Parker Hannifin Electromechanical has produced a 72-page catalogue detailing one of the largest ranges of stepper products in the world. The catalogue covers 10 different stepper families, and has full information on compatible motors, controllers and support software. Most applications are catered for: Parker stepper systems are available in torque ratings from 0.5N (Newton) m to 13Nm, drive resolutions from 200 to 50,800 steps per revolution, and speeds up to 3000 rpm.

As well as the ranges of packaged and rack-mount full and half step and ministepping systems, the catalogue has details of Parker’s new-generation Zeta advanced microstepping system drives. Incorporating new technology known as active damping and electronic viscosity (patents pending), the drives provide very fast acceleration and settling times, and offer resolutions up to 50,800 steps per revolution.

Every stepper family includes a version with a built-in indexer with capabilities ranging from point to point positioning through to complex continuous path applications. The catalogue also has a range of stand-alone and PC-based indexers for single- and multi-axis applications, together with powerful software support tools running under LabView or Windows.

For more information contact Sharon Beale, Customer Services, Parker Hannifin Plc., Electromechanical Division - Digiplan, Balena Close, Poole, Dorset VH17 7DX. Tel 01202 669000. Email sales@digiplan.com
COLOUR CCTV VIDEO CAMERAS, BIDS NEW AND CASED, FROM £99. Works with most modern video's, TV's, composite monitors, video grabber cards. Pal, tv-p-p, composite, 760mm, 1/3" CDD, 4mm F2.8, 500x500, bis, 12v, mounting bracket, auto shutter, 1000x1000x1800m, 3 months warranty, 1 off £19.95, 10 or more £99.90 + £8.95 CIRCUIT PACKS Puts together 25 circuit diagram covering user, PW radios, project types etc. Pack: Pack4 £4.99, 1. SMOKE ALARMS Large mains powered, made by the famous Comp. Kit, easy to fit right first time, low power pack £4.99. CONVERT YOUR TV INTO A VGA MONITOR FOR £25. Converts a old TV into a basic VGA screen. Complete with built in plug and good quality lead. Ideal for small domestic upgrade. Supplied in kit form for home assembly. SALE PRICE £9.95 Ref SAIN 15 Watt FM TRANSMITTER £99 with model kit. Complete with rear panel. £4.99 Ref SW3. HUASHA SEACOAL AGED BATTERIES 12v 15Ah at £99.90 and below spec £99.95 & 12v 5 Ah for £99.90 ELECTRIC CAR WINDOW DE-ICERS Complete with cable plug etc. SALE PRICE JUST £9.99 Ref SARI AUTO SUNCHARGER 150x200mm solar panel with diode and 3-way switch with a piggy back plug. £2.99 Ref. SARI 12V SOLAR POWER LAB SPECIAL. You get 2' 2" x 1' 3" solar cell, 4 LED's, 8 rear LED's, 1 x 12v high output battery charger £19.95 Ref SARI. SOLAR DICIC CHARGERS £7.99 Ref SARI. GIANT HOT AIR BALLOON Kit! Suitable for the above camera, enables the camera to be used in total darkness. £19.99 Ref SARI. CIVILIAN MATE 2 WATT FM TRANSMITTER KIT £39.90 Each unit has two gallium Arsenide injection lasers. 1 x 5 watt, 2 x 4 watt and 1 x 3 watt. £19.90 Ref. SARI. CHIEFTAIN TANK DOUBLE LASERS 9 WATT=3 WATT+LASER OPTICS Could be adapted for laser lens, long range communications etc. Also suitable for laser/infra-red torches, 9 watts or 3 watts. £19.90 Ref SARI. BEEF SOYBEAN FUSEHOLDER For our established customers. £99.90 Ref. SARI. ULTRASONIC BLASTER PLANS £19.90 Ref SARI. INFRARED ZENON VARIABLE STROBES FOR CCTV and GCHQ/MI5 coverers everything from secret government frequencies, to the sky, viruses, medical analysis etc £99.99 Ref SARI. IR LAMP KIT Suitable for the above camera, enables the camera to be used in total darkness. £59.99 Ref SARI. GPS ANTENNA PLANS £79.99 Ref SARI. HYDROPONICS CATALOGUE hydroponics catalogue £19.90 Ref SARI. ROYAL ZENON VHF HIGH POWER FM TRANSMITTER KIT £39.90 Ref SARI. TRIPLE WATT FM TRANSMITTER KIT £39.90 Ref SARI. Food and Electronic Absence. In a limited edition, our high power fm transmitter is set at 500w... £39.99 Ref SARI. IR LAMP KIT Suitable for the above camera, enables the camera to be used in total darkness. £19.99 Ref SARI.
Advanced display screen technologies are becoming cheaper and better all the time. It may not be long before they cause the conventional cathode ray tube to face out. Andrew Armstrong looks at some of the current contenders.

Part One: Liquid crystals; amorphous transistors on glass, and Plasma Discharge Panels (PDPs).

The demise of the trusted and familiar cathode ray tube (CRT) as the main means of displaying video and TV has been predicted for a number of years, but to date none of the many flat screen display technologies have proved good or economic enough to make a significant impression. Today, the main applications for flat screen displays are ones for which a CRT would be quite unsuitable, and therefore for which the extra cost or reduced performance of a flat screen display is not a barrier.

You may wonder why CRTs cannot be made thinner and lighter to compete with true flat displays. After all, they give better picture quality at a lower cost than flat-panel alternatives. CRTs have been slimmed down a good deal over the years, but there is a point at which the problems to be overcome increase so much that it is not economic to proceed.

For example: look at figure 1, showing beam deflection. The beam is deflected by means of a magnetic field. If the deflection is truly proportional to the current in the deflection coil - which may not be the case, since different trajectories cause the electron beam to spend a different amount of time in the field - then the deflection of the beam across the screen will be disproportional. It will instead be proportional to the tangent of the deflection angle, which is not at all a linear relationship as the angle becomes large. This effect causes picture geometry errors which must be corrected with more circuitry. Figure 2 shows the form of an uncorrected picture. It stretches further at the corners, because that is where the path length of the electron beam is longest, as it must be when you consider the three dimensional properties of the deflection system.

Clearly, the thinner the CRT for a given screen size, the worse the error will be. Then there are three different colours to be corrected separately so that they all line up - and it is becomes clear why there is a limit to how thin a CRT can be made.

Electron hopping

Until recently, that is. Last year, Philips Research Laboratories demonstrated experimental flat cathode ray tubes, which they called cathode ray panels (CRPs).
The detail of this is shown in figure 4: one entrance hole for electrons is routed to the three separate colour dots.

**Liquid crystals**

Flat displays have been around for years. The first to go public in significant quantities were liquid crystal monochrome displays. In a liquid crystal display, the liquid crystal layer can either rotate or not rotate the polarisation of light passing through it.

With no voltage applied to the display, the liquid crystal molecules line up at the surfaces in a direction determined by the surface finish of the front and back electrodes. When a voltage is applied, the molecules line up (figure 5). Because liquid crystal displays are damaged by direct current, the drive voltage must be an alternating voltage, with front and rear electrodes driven in phase if the pixel is to be un-energised, or in antiphase if it is energised. This is the widely used twisted-nematic type of display.

To convert the change of polarisation to something visible to the human eye, an arrangement such as that shown in figure 6 is used. Here, light cannot pass through the crossed polarisers unless its polarisation is rotated in the liquid crystal cell. If you want to make a vga display panel, you need 640 pixels horizontally and 480 vertically. This, which would be considered a miserable resolution by current standards, needs 640 separately connected vertical strips of electrode, and 480 horizontal strips, in order to address each individual pixel. The interconnection problem is costly to solve, but it can be done, for example, by using elastomeric connectors which press on to metalised contacts on the edge of the display glass (figure 7). The electronics to address this uses surface-mount ics with multiple pins, or ball grid array connections. This is inherently costly to make.

Still, perhaps the major problem of displays like this is how to make the display visible, when each pixel is only addressed for a tiny proportion of the time. The molecules must line up with the voltage rapidly, but settle back to their un-energised position slowly. It is not surprising, therefore, that the response of this type of liquid crystal display to changes in picture content is a bit sluggish.

At some stage in the development of matrixed twisted-nematic displays, techniques for increasing the twist angle were devised, and they became known as Super Twist or STN displays. For a while they looked like going out of use, but improved versions have been developed - see the Hitachi item on the news pages in this issue.

**Amorphous transistors on glass**

Some years ago, three physicists shared the Nobel prize for work on amorphous materials. The first product seen by the public as a result of this fundamental research was the solar-powered calculator. It was found to be possible to make semiconductors using amorphous materials rather than perfect crystals. The material had to have hydrogen added to all the unattached bonds which would otherwise trap charge carriers.

Crystalline semiconductors gave superior performance, but...
even a solar cell of modest efficiency made very cheaply was more suitable to power a calculator than an expensive more efficient crystalline one. It was also possible to make transistors using amorphous semiconductors deposited on glass. This permitted development of the tft (thin film transistor) display, still widely used in notebook computers and portable televisions, where a transistor is used to improve the drive to each pixel.

Referring to figure 8, the circuit on the left here shows that a capacitor is charged to the voltage on the data line when the gate line is energised. The thin film field effect transistor is acting as a sampling switch, and the capacitor holds the sampled voltage until the next time it is addressed.

The performance of liquid crystal displays using this technology is greatly superior to normal stn displays. For a start, the liquid crystal material does not need to be optimised to retain the picture information between scans, so it can be made to respond more quickly. Portable LCD televisions using this type of screen have no visible problems with normal moving tv pictures. However, the delay can be detectable by the eye on some tft computer screens, when the mouse cursor is moved very quickly. To detect it, though, you have to be looking for it. Picture streaking due to crosstalk between pixels in an stn display does not occur on tft displays. Also, because the liquid crystal material is not optimised for one obscure function (slow response) it can be made with a wider viewing angle. The angle is still limited, and it is still necessary to position the screen correctly relative to the viewer, but the problem is eased compared with the typical STN display.

The drawback with tft displays is that there is a lot of electronics for each pixel. Even a single pixel which does not work can be visible, but it is very difficult to manufacture screens with 100% functional pixels. Therefore, quality standards are defined which limit the number of defects in the whole screen area, and further limit the number in the middle area. Even so, many displays do not meet the quality standard and have to be scrapped. This contributes to the relatively high cost of tft displays, particularly large ones with more pixels. Typically, a 1024 x 768-pixel computer display can cost more than a complete machine with a 17-in crt monitor.

As an aside, based on news reports which I read at the time, the means of using thin film transistors was first devised by a British engineer. He was unable to get funding to develop this in Britain or elsewhere in the EU, so the technology was developed in Japan, whose industries have made a good return from it.

Plasma discharge

A number of major Japanese development companies, including Fujitsu, NEC and Panasonic, are working on plasma display panels. These are expensive, and best suited for large area displays, partly due to cost and partly because the pixel size does not fit them well for use in small displays. Large screen televisions using this technology are available in Japan, and will soon be available in the UK.

From the current point of view plasma displays are divided into two categories, those which generate visible light by plasma formation (primary), and those which generate visible light indirectly by plasma formation (secondary). In the second case, ultra violet light may be generated by the plasma, and used to excite a phosphor which emits light at visible frequencies. (This is basically how a fluorescent lamp works.) Plasma is generally referred to as the fourth state of matter, after solid, liquid and gas, and it consists of a mixture of ions and electrons. The best known example of plasma technology is the neon tube. By applying high voltage to cause a current flow in the gas, the outer electrons are stripped from the nucleus. The charged particles migrate to the pole with the opposing charge and collide with other electrons on the way, raising their energy level. When the electron returns to the normal lower energy level, the excess energy is emitted as a
 photon.

Depending on the mixture of inert gases and their pressure, the photon may or may not be in the visible range. With primary displays, the emission is in the visible range as red or orange.

A plasma display panel (PDP) is made up of pixels which are actually tiny neon tubes. Presented in a simplified manner, there is a matrix of electrodes in a space between two glass plates, and the space is filled with inert gas.

The crossovers are the pixels. To illuminate a pixel, a voltage sufficient to ionise the gas is applied between the two electrodes. The colours are produced by the light emission of specific phosphor compounds for the spectral ranges red, green and blue in response to ultra violet emitted by the plasma. The electrodes are protected from erosion by the plasma by a magnesium oxide layer.

The phosphor, of course, cannot be behind a protective layer. In order to protect it from damage a special electrode pattern is used (figure 9). The "surface discharge" is between two adjacent bus electrodes, and does not come into contact with the phosphor.

Figure 7: matrixing of a STN display - crosstalk to adjacent pixels is possible

Figure 10 shows the differentiation of the different colours. The only purpose of the addressing electrode is to initialise the cell. The pixel always consists of three sub-units (sub-pixels). The sub-pixels always contain the red, green and blue phosphors. Every individual sub-pixel can be initialised by the address circuitry. The X and Y bus lines lie horizontally and always activate a complete row. However, the X bus lines can be individually selected, which is necessary for the initialising process. The Y bus lines have a common connection. The bus lines coming from right and left are interfaced.

A major advantage lies in the fact that the picture information is presented as a whole, and not line by line as in a cathode ray tube, so that the characteristic CRT flicker does not occur. Expect variations from all the major manufacturers. For example, Panasonic show a flat bottomed U cross section, with slanting sides near the top, and coated with phosphor almost to the top. Panasonic are part of Matsushita, who announced the world's first 26- and 40-inch colour PDPs in Japan back in 1995, and began marketing their TH-26PD1 PlasmaView (16.77 million displayable colours) in early 1996. Even as we write, Panasonic are planning a 42-inch plasma television for release in the UK later this year. Fujitsu's 42-inch plasma display was demonstrated in televisions from Philips and Grundig at the Cebit-Home Exhibition in March, and the 5-cm thick PDS4203 has just been announced in the UK (priced £7,800 + vat). It may be exaggerating a bit at this stage to think of flat screens as "CRT busters", but it is likely that they will take over from cathode ray tube televisions sooner than expected.

NEC claim an interesting improvement on the colour rendering, and reduced reflections from their plasma displays, by using colour filter for red, green, and blue, which they call "capsulated colour filters", built into the glass front pane as a series of stripes.

The first destination for these television displays will be for home theatres, where at present people use projection televisions. It is in this price area that they will be compete at first. When manufacturing experience has been gained, and sales at higher prices have paid for some of the development costs, then we shall see plasma panels making inroads on the cathode ray tubes' territory.

The physics of the full colour AC plasma display

In general, a plasma display consists of a large number of separate cells which contain at least two electrodes and a...
or can be carried in a pocket. Works with all types of portable cellular phones.

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In the vacuum inside the inverted bulb like container the vanes spin around, which creates a lower pressure inside the container. This difference in pressure causes the gas to flow from the high pressure side to the low pressure side.

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17 WATT 12V SOLAR PANEL A solar panel designed to give a nominal 12V. The solar cells are assembled with a high quality resin material and a protective cover. The panel is mounted on a tempered glass panel and a protective cover. The cells are protected against weather conditions in the cloudless environment.

The power output of the panel is 17 watts and it operates on any 12V battery. The panel is ideal for use in remote locations where there is no access to the mains supply. In the event of any current flowing through the panel, the fuse will open. The panel is fitted with a 15 metre cable and a plug for easy connection.

DOCUMENT SCANNER PINHOLE CAMERA MODULE WITH AUDIO?

CAT SCARER Photographic unit which can be used to take pictures of cats. It contains a small camera and a battery pack. The camera is triggered by the presence of a cat.

The Nightspy is light and hand held, or can be mounted on a standard drill. It is powered by four AA batteries, a battery pack is included.

The Nightspy is a small, lightweight and portable unit. It is ideal for use in remote locations where there is no access to the mains supply.

GALAGO NIGHT VISION £139

Open up a new world of adventure with a pair of Nightmares. The Nightmares are a unique combination of optical and electronic equipment, designed to eliminate over exposure, and infrared illuminator loaded in dark areas. These units are ideal for use in remote locations where there is no access to the mains supply.

17 WATT SOLAR PANEL An additional solar panel can be added to give a total power output of 34 watts. The solar panel is designed to give a nominal 12V. The solar cells are assembled with a high quality resin material and a protective cover. The panel is mounted on a tempered glass panel and a protective cover. The cells are protected against weather conditions in the cloudless environment.

SATELLITE NAVIGATION £19

The GPS 38 is a lightweight, portable unit. It is ideal for use in remote locations where there is no access to the mains supply.

The GPS 38 is a lightweight, portable unit. It is ideal for use in remote locations where there is no access to the mains supply.

DIFFERENTIAL THERMOSTAT KIT An electronic self assembly kit designed for use in solar heating systems. Heat recovery systems etc. The principles of the kit is that it has two temperature sensors which are placed on the items to be measured (typically a solar panel and a water storage tank). The controller then activates or deactivates the item depending on the temperature of the water.

The Nightspy is a small, lightweight and portable unit. It is ideal for use in remote locations where there is no access to the mains supply.

A solar panel designed to give a nominal 12V. The solar cells are assembled with a high quality resin material and a protective cover. The panel is mounted on a tempered glass panel and a protective cover. The cells are protected against weather conditions in the cloudless environment.

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compound of several inert gases (neon, argon and/or xenon). By applying several hundred volts to the electrodes the inert gas will, as a result of the impact ionisation, assume a plasma state. The result will be a mixture of electrons and ions which, depending on their charge, will flow to one or other of the electrodes.

As a result there will be collisions which are capable of increasing the energy level of the electrons still remaining in the ions. After some time, these will revert to their normal energy level and will emit the absorbed energy as light. Depending both on the inert gas compound and on the pressure of the gas, the emission will be within the range of visible wavelengths or within the range of UV wavelengths. UV is used in colour plasma displays.

Ionisation can be induced by DC or AC, using slightly different electrode arrangements. In the case of the DC display, the electrodes are embedded in the plasma cell and trigger the plasma formation directly. This creates a simple type of signal and reduces the expenditure on electronics. On the other hand, high voltages have to be generated and the electrodes will be exposed directly to the plasma which leads to their earlier destruction.

If the electrodes are protected, for example, by an MgO coating, and a dielectric medium is incorporated, then the coupling to the gas is capacitive and an AC drive is needed. The electrodes are no longer exposed and have a longer functional life. The disadvantage is that the signal for the triggering voltage is more complex. This technology does, however, offer a further advantage: once the capacitor voltage has been attained it can be utilised to add to the subsequent triggering voltage. In this way the triggering voltage can be reduced to about 180 volts, as against 360 volts in a DC display, simplifying the semiconductor driver circuitry.

The triggering of an AC plasma display occurs basically in three phases, as illustrated in the waveform diagram of figure 11. The first phase is the addressing or initialising phase. During this phase all the cells which are to become active in the following frame will be preloaded. Cells which are not preloaded will remain dark. The addressing process is completed cell by cell. Current will flow through all the address conductors to cells which have to become active. Then a pulse on bus conductor X1 will cause the
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Figure 10: A cross section through the structure of all AC Colour Plasma Displays (PDPs).

Figure 11: The waveform diagram shows the three-phase triggering of an AC plasma display: (1) cell-by-cell addressing and initialising of active cells for the next frame; (2) stop/display phase during which the build-up of voltage impulses on alternate sides creates the number of light impulses corresponding to the luminance level; (3) extinction phase during which all the cells revert to a neutral state for the next subframe.

ETI wishes to thank the following in particular for data and background material for both parts of this article: Frank Cornell of JDK (Fujitsu Electronic Devices); Joanne Korosi, MMD and Storm Communications (Pioneer); Blitz and Jonathan Dominic (NEC), Ruth Lloyd (Matsushita/Panasonic); Linda Kandy (Mitsubishi); K van Berkel (Philips Research Laboratories); James Veligman (Brookhaven National Laboratory); Danielle Leach of The Weber Group (Cambridge Display Technologies); Roger Bassett (GEC Alsthorn Engineering Research Centre) - and a number of other people who kindly assisted us.
Serial AVR

Microcontroller Programmer

Robin Abbott extends his experience built up with PIC programmers to a programmer for the new fast, in-circuit reprogrammable AVR microcontrollers.

It cannot have escaped the attention of most readers of this magazine that a large number of projects now make use of microcontrollers. The controller which has been used to greatest effect has been the Microchip PIC. Microcontrollers in general include a wide variety of devices offering a variety of capabilities at different prices and in different package sizes. A recent arrival to the microcontroller scene is the AVR series from Atmel. These devices have been hard to obtain until recently, because they have only been in production for a little while. However they are now becoming increasingly available to the amateur and educational market. All the devices have flash eeprom program memory, and can therefore be reprogrammed in circuit, and re-used without the need for an ultra-violet eraser.

Regular readers of this magazine remember that I have programmed two programmers for the PIC series of controllers over the past three years. About 1000 of these programmers have been built by ETI readers. I decided to base a new AVR programmer on a similar circuit, but to improve the circuit on the basis of lessons learned by constructors of the PIC programmers. Throughout this article I shall make frequent comparisons between the AVR and the PICs, because I believe that currently most constructors who will use the AVR probably already have experience with the PIC. The large amount of source material available for beginners to PIC microcontrollers makes it a better starting point than the AVR. This situation may change as the AVR devices gain in popularity and use.

The AVR microcontroller

Currently there are only four devices readily available in the Atmel AVR series: two devices in 20-pin packages, and two devices in 32- or 44-pin packages. The pinouts of these devices are shown in figure 1.

Like the PIC, the AVR has a Harvard architecture - the program memory is separate from the data memory, enabling the next instruction to be fetched whilst the previous instruction is being executed. Program memory varies in size from 512 words in the 1200 device, to 4096 words in the 8515 device. Each program word is 16 bits in length, enabling most instructions to fit within a single word.

Figure 1: pinouts of the currently available AVR devices

There are 32 general purpose registers, each of which has similar capabilities to the W register in the PIC, and therefore a large number of operations can be performed on and between working registers without having to go to other memory. There are 64 configuration registers which control the ports and peripheral devices of the AVR. The three larger devices all have internal static ram which is up to 512 bytes in length in the 8515. Finally all devices have an eeprom data area which is between 64 and 512 bytes in length.

The 4144 and 8515 devices have the capability to fit external...
device on average four times faster than a PIC operating at the second per clock megahertz. In simple terms this makes the execute most instructions in a single clock cycle. Thus its data ram - or any external peripheral devices which operate on a wide variety of instructions, addressing modes, and the large stack which does not allow data to be saved. In addition, the popped, and has far deeper call nesting than the PIC's fixed memory. The AVR has a traditional stack with a stack pointer difficulty of using paging bits to access different areas of data is easier to use than the PIC. The AVR does not have the same clock frequency. When coupled with the AVR's 32 general-purpose register area on the AVR allow algorithms to be developed with greater ease.

The most impressive feature of the AVR is its ability to execute most instructions in a single clock cycle. Thus its throughput approaches one MIPS (million instructions per second) per clock megahertz. In simple terms this makes the device on average four times faster than a PIC operating at the same clock frequency. When coupled with the AVR's 32 working registers, this makes the AVR performance notably faster than a PIC in some applications.

In my opinion the AVR architecture and assembler language is easier to use than the PIC. The AVR does not have the difficulty of using paging bits to access different areas of data memory. The AVR has a traditional stack with a stack pointer operating in SRAM which allows data to be pushed and popped, and has far deeper call nesting than the PICs fixed stack which does not allow data to be saved. In addition, the wide variety of instructions, addressing modes, and the large general-purpose register area on the AVR allow algorithms to be developed with greater ease.

<table>
<thead>
<tr>
<th>PROGRAMMER PL1</th>
<th>9-WAY FEMALE</th>
<th>9-WAY MALE</th>
<th>25-WAY FEMALE</th>
<th>25-WAY MALE</th>
</tr>
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<tr>
<td>2</td>
<td>3</td>
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<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
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</table>

Figure 3: the AVR Programmer circuit diagram

Figure 4: the serial cable from programmer to host PC connections

data ram - or any external peripheral devices which operate on a standard 8-bit microprocessor data bus. This allows the devices, to be used at the heart of far more complex systems than simpler microcontrollers.

Figure 2 shows a comparison of the capabilities and features of the AVR devices together with the PIC16C84, and the

ELECTRONICS TODAY INTERNATIONAL 18
The AVR Programmer

This AVR programmer has the following features:

- The programmer is battery powered.
- It operates on the serial ports of a standard PC running Windows 3.1, '95, or NT.
- It automatically detects activity on the serial ports to wake itself up, so it needs no on/off switch.
- The programmer uses a zero insertion-force socket, and is capable of programming any of the currently available AVR devices.
- The programmer reads the device type from the AVR to allow the correct programming parameters to be used, and ensuring the correct hex file is used to program the device. It is also capable of detecting empty sockets or incorrectly inserted devices.
- It is compatible with Atmel's AVR assembler and simulator.

Experience has proved that the earlier programmers were easy to construct, but users had most difficulty with the serial interface. For this reason the AVR programmer offers an additional light emitting diode to show activity on the serial interface. In addition I have included more notes on the use and debugging of the serial interface in this article to assist constructors.

The host software on the PC has also been considerably improved on the basis of comments made by constructors of the PIC programmers. It now offers toolbars and multiple edit windows, each of which allows users to edit hex files within the programmer, and increased status information to show exactly what processes have been undertaken with the programmer.

Programming the AVR

The AVR devices are all programmed in similar fashion. Both the program memory and the internal reeprom memory may be programmed by this project. The AVR is an easier device to program than the PIC microcontroller, because the AVR has much greater commonality among the devices in the range, whereas the PICs have at least four different programming algorithms, and the
<table>
<thead>
<tr>
<th>LETTER</th>
<th>PARAMETERS</th>
<th>RETURN</th>
<th>DETAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
<td>K</td>
<td>PROGRAMMER OK, WAKE UP</td>
</tr>
<tr>
<td>B</td>
<td>AD&lt;sub&gt;L&lt;/sub&gt;, AD&lt;sub&gt;H&lt;/sub&gt;</td>
<td>256 BYTES</td>
<td>READ 256 BYTES FROM AVR AT SUPPLIED ADDRESS</td>
</tr>
<tr>
<td>C</td>
<td>SET CURRENT PROGRAMMING ADDRESS</td>
<td>K</td>
<td>SET INTERNAL ADDRESS</td>
</tr>
<tr>
<td>D</td>
<td>B&lt;sub&gt;0&lt;/sub&gt;...B&lt;sub&gt;7&lt;/sub&gt;, CS</td>
<td>K</td>
<td>PROGRAM 8 WORDS AT CURRENT LOCATION. INCREMENT LOCATION BY 8. CS IS THE CHECKSUM (FORMED BY ADDING THE 16 BYTES FORMING THE 8 WORD, AND TAKING THE LOWER 8 BITS OF THE RESULT)</td>
</tr>
<tr>
<td>E</td>
<td>AD&lt;sub&gt;H'&lt;/sub&gt;, AD&lt;sub&gt;L&lt;/sub&gt;</td>
<td>16 BYTES</td>
<td>READ 16 BYTES OF EEPROM AT SUPPLIED ADDRESS</td>
</tr>
<tr>
<td>F</td>
<td>B&lt;sub&gt;0&lt;/sub&gt;...B&lt;sub&gt;7&lt;/sub&gt;, CS</td>
<td>K</td>
<td>PROGRAM 8 BYTES AT CURRENT LOCATION. INCREMENT LOCATION BY 8. CS IS THE CHECKSUM.</td>
</tr>
<tr>
<td>G</td>
<td>B&lt;sub&gt;0&lt;/sub&gt;</td>
<td>K</td>
<td>WRITE LOCK BYTE</td>
</tr>
<tr>
<td>H</td>
<td>AD</td>
<td>N, K</td>
<td>READ DEVICE CODE AT ADDRESS AD</td>
</tr>
<tr>
<td>I</td>
<td>N, B&lt;sub&gt;0&lt;/sub&gt;, B&lt;sub&gt;1&lt;/sub&gt;...B&lt;sub&gt;7&lt;/sub&gt;</td>
<td>K</td>
<td>WRITE N BYTES TO DEVICE ON SPI BUS</td>
</tr>
<tr>
<td>J</td>
<td>-</td>
<td>1 BYTE, K</td>
<td>READ ONE BYTE FROM DEVICE ON SPI BUS</td>
</tr>
<tr>
<td>K</td>
<td>0 OR 1</td>
<td>K</td>
<td>TURN POWER ON OR OFF</td>
</tr>
<tr>
<td>L</td>
<td>AD&lt;sub&gt;L&lt;/sub&gt;, AD&lt;sub&gt;H&lt;/sub&gt;</td>
<td>CS&lt;sub&gt;L&lt;/sub&gt;, CS&lt;sub&gt;H&lt;/sub&gt;, K</td>
<td>RETURN CHECKSUM OF 256 WORDS FROM THE DEVICE, START AT SUPPLIED ADDRESS USING C COMMAND</td>
</tr>
<tr>
<td>M</td>
<td>AD&lt;sub&gt;L&lt;/sub&gt;, AD&lt;sub&gt;H&lt;/sub&gt;</td>
<td>0, 1, K</td>
<td>BLANK CHECK</td>
</tr>
<tr>
<td>N</td>
<td>-</td>
<td>K</td>
<td>ERASE ENTIRE EEPROM</td>
</tr>
</tbody>
</table>

**KEY:**
- **K** LETTER K, RETURNED TO ACKNOWLEDGE COMMAND COMPLETE
- **B, B<sub>N</sub>** A SINGLE BYTE
- **B<sub>n</sub>L, B<sub>n</sub>H** A WORD SENT, LOW BYTE THEN HIGH BYTE
- **AD<sub>L</sub>, AD<sub>H</sub>** 16 BIT ADDRESS SENT LOW BYTE THEN HIGH BYTE

Figure 7: the interface commands for the AVR programmer

Differences in programming configuration fuses across the range can make a universal programmer for PICs quite hard to design.

Like the PIC, the AVR can be programmed in either serial mode through an SPI port, or in parallel mode. The serial mode is slightly more limited than the parallel mode, because it does not allow the internal resistor/capacitor oscillator to be selected. This programmer uses a serial mode because it has a lower requirement on for pins than the parallel mode, and more easily allows all devices to be programmed in a single socket. Although this limits the oscillator type to external crystal, this is not seen as a major problem, because the AVR devices are likely to be used in projects requiring a more powerful microcontroller, for which a crystal oscillator is more appropriate. The other minor disadvantage with a serial programmer such as this one is that programming takes longer than in a parallel mode, and again for a low-cost programmer which is not intended for production runs.
this is not seen to be a serious disadvantage.

Unlike the PIC the AVR does not require a high voltage for programming the eeprom, and therefore only a single power supply is required, which allows a simple programmer such as this one to operate from a battery supply.

The circuit

Figure 3 is the circuit diagram of the programmer (the component layout is shown near the Parts List at the end of the article). The programmer is connected to a standard serial port of a PC on which the host software runs under Windows. Although it is easier to design an interface to a PC using a parallel port, I have always found it harder in practice to use this port, because most PCs have only one parallel port, and because parallel cables and connectors are bulky and difficult to use. In addition to this a serial interface will operate over longer cable runs than a parallel interface.

The serial interface is based on the low-cost, simple, but effective design which has been seen on projects in this, and other magazines. This type of interface derives a negative voltage for the transmission by the programmer to the PC from the receiver data line from the PC. R4 and D1 charge capacitor C1 to around -6V whenever the Receive line is below ground, which is the resting state of the RS232 interface. The 330R resistor is chosen to load the receive line at about two-thirds of the maximum allowable input impedance for an RS232 serial interface. C1 buffers the input signal and inverts it driving the PIC directly. The Transmit signal switches either to +6V, or is pulled down to the voltage on C1 when there is no transmitted signal.

The serial interface is efficient for use when there is a low requirement for duplex data exchange, it is not effective when there is a requirement for a large amount of data to be transmitted and received simultaneously. For that type of application a device such as the MAX232 should be used.

The main control of the programmer is achieved with a PIC.

(like many of us, I had the PIC programmer to start with, and not an AVR programmer, otherwise I would have tried to use an AVR here.) The power consumption of the AVR during programming is only a few milliamps, and this allows the AVR to be powered from the PIC during programming, reducing the requirement for an external switch transistor for the power supply to the AVR. The PIC may be any of the 18-pin devices with a 1k by 14-bit word size. 31 to 40 of the large socket.

The programmer is quite easy to construct as there are relatively few components. A PCB has been designed for the programmer, although this is not essential, and the programmer could be constructed on Veroboard quite easily. There are two links on the board. Insert these first, and follow with the 18-pin dil socket for the PIC. All the resistors are inserted vertically. Insert the resistors and the ic socket next, followed by the crystal resonator, capacitors and transistors and light emitting diodes, noting that the green LED is the one towards the left of the board. The LEDs are inserted with the flat on the case towards the bottom of the board, the diode D1 is inserted with the black band towards the top of the board.

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Complete the programmer with the serial socket and the ZIF Socket. On the prototype the ZIF socket was plugged into a 40-pin dip ic socket, although it may be mounted directly on the board. As the ZIF socket is quite expensive, it is possible to use a 40-pin dip socket with a 20-pin dip socket mounted alongside. Pins 1 to 10 of the 20-pin socket connect to pins 1 to 10 of the large socket, and pins 11 to 20 of the smaller socket connect to pins 31 to 40 of the large socket.

Battery clips are available for three AA size cells, with a PP3 style connector. The power supply may be connected to Veroboard, and a standard PP3 battery with connectors wired directly to the pins. Check all of the joints and solder connections on the board, insert the programmed PIC, and the programmer is ready for test.

When the programmer has been fully tested and is proved operational the battery clip can be glued underneath the circuit board with silicone rubber sealant, the entire programmer now sits on the battery case.

Testing the programmer

The programmer must be connected to a PC using a standard serial cable terminating in a 9-pin D plug. The wiring of this cable is shown in figure 4. There are two LEDs on the board. The red LED illuminates when power is applied to the AVR in the socket. The green LED illuminates whenever data is received or is transmitted by the PIC, and flashes briefly approximately once every second when the programmer serial interface is idle.
It is likely that the programmer will operate immediately, so it may be connected to the PC directly. The host software on the PC may be installed as described in the instructions which accompany the program disks. When the host software is initially executed, it will attempt to find the programmer. It may find the programmer immediately, in which case it may be used directly. If the programmer is connected to a serial port which is not serial port number one, then use the Module/Communications menu option to select the correct communications port, at which point the host program will attempt find the programmer and report back when it is found. Use a serial port rate of 9600bps.

If the programmer does not work straight away, then follow this procedure:

Testing the programmer and PIC oscillator: Press the reset button, and the green LED should flash once every second for approximately 10 seconds. The LED will then be extinguished as the PIC enters sleep mode. Repeat this test with a multimeter inserted in series with the battery pack, and check that the power consumption in sleep mode is less than fifty micro amps.

Checking the serial port: Plug in the serial cable. Check the voltage on pin 3 of the connector underneath the board, it should be around -10V, the voltage on pin 2 should be around -6V. Remove the cable and use a crocodile clip to short pins 2 and 3 on the cable. Start a terminal emulator program on the PC, and set the emulator to operate at 9600bps, no flow control. A suitable program is hyper-terminal supplied by Windows '95, the serial port set-up dialog box may be found under File/Properties for this program. Check that as you press keys the characters are echoed. If not there is a fault in the cable or the serial card. If keys are received then power down the programmer and remove the PIC, short pins 2 and 6 of the PIC socket, power up the programmer and check again that characters are echoed. If not then there is a fault in the serial circuitry.

Testing the transmit/receive lines from the PIC to the PC: With the terminal emulator in use insert the PIC and power up the programmer. Press the reset button, a "K" character should be received by the PC. Now press the 'Z' key on the PC, the green LED should flash in sympathy, and "F" characters will be transmitted back to the PC, the programmer's indication that it has received data which it does not understand.

If the programmer still does not work, then there is either an error with the PIC, or the installation of the host software is incorrect.

**Using the programmer**

Either the Atmel Assembler, or the Forest Electronics AVRDE assembler/simulator may be used for this programmer. Set the options in the AVR assembler to assemble to Intel Intellec 8/MDS format - this type of file usually ends in a .HEX extension.

The host PC software is accompanied by instructions on its use in a help file. The host software window is illustrated in figure 5. The 40-pin devices are programmed with pin 1 towards the top of the board, the 20-pin devices are placed in the socket towards the top of the socket, again with pin 1 towards the top of the board.

AVR devices should never be removed or inserted while the red LED is illuminated. If multiple devices are connected to the same serial port, then unless full switching is employed it is advisable to remove the programmer when not in use, or it will be repeatedly woken up by received characters.

The AVR devices have a program memory reprogramming lifetime which is quoted at approximately 1000 cycles - in practice devices operating at normal voltages should achieve much better performance than this, and it is unlikely that this lifetime will be exceeded.

The AVR has a lock byte which prevents the device from being read when set, this is to prevent copying of the internal program. Unlike the newer OTP PIC devices this byte may be set and reset at will, allowing protected devices to rewritten although they may not be read.

**In circuit programming**

The AVR programmer the capability to program devices which are already in-circuit. A typical circuit diagram for programming in-circuit is shown in figure 6. Note that the power is gained from the application circuit - and it is advisable to power the programmer from the same 5V supply as the application. Note that the application has a crystal which must be of greater than 1MHz in frequency. If the circuit has a lower crystal frequency then it must...
be arranged to supply a clock from the XTAL pin of the programmer, which overrides the application clock — this is likely to be very difficult to arrange in practice and is not recommended.

The lead from the programmer to the application has five wires, one for the reset pin, 3 for the SPI bus, and one for ground. The connection to the programmer should be made by using a 20-pin DIL header on an IDC cable. In the application these pins may need to be isolated by resistors as shown in the figure if the application circuit attempts to drive the pins driven by the programmer. These resistors should be greater than 1k to limit the current drawn from the output pins of the programmer. Mount the resistors close to the AVR to reduce the effect of capacitance on signal timing if this is likely to affect the application. Keep the cable to the programmer as short as possible.

Finally note that the application circuit should be able to operate without damage for short periods with the AVR controller reset and its pins in the high impedance state (this will occur whenever the programmer is connected and powered up).

The serial communications protocol

The interface to the programmer on the serial port is quite straightforward. It is reasonably easy to write an application in Basic to control the programmer from the PC for special purposes. For example the original PIC programmer was used by one small manufacturer to test PICs on manufactured circuit boards on a production line by running a verify algorithm on each circuit board as it passed the test machine.

There are a total of 14 commands available to operate with the programmer from the PC. Each command starts with a capital letter, from letter A to letter N. The commands are shown in figure 7. Most commands are fairly self-explanatory, the key to the table is shown in the Figure. Before undertaking any operation with the AVR it is necessary to turn the power to the AVR on, this is achieved with the K command followed by a 1 character. The commands required can then be executed, and after operations are complete, the power may be turned off with a K followed by a 0. Note that the red LED will always illuminate while power is connected to the AVR.

To wake the programmer from sleep mode, the A command should be used, this will wake the PIC on an interrupt, and force it to reset itself, the first action undertaken will be to return a K character to the PC. If the PIC is already awake, then a K character will be returned in response to an A command anyway. Once the programmer has been woken up, then all the commands required should be executed with a maximum gap between them of about eight seconds to prevent the programmer returning into sleep mode.

The only commands which are of special note are the commands to send a number of bytes to the AVR on the SPI bus, and the command to read one byte from the device on the SPI bus. These commands may be used for the future devices to implement currently undocumented commands.

Please note that any locked device will require the entireeprom to be erased before any operation will be successfully executed, apart from determining the device code.

AVR development tools and further information

Atmel have a CD describing the complete range of AVR products including data sheets and an assembler/simulator. If you use this CD, make sure that the Include files are dated the 4th of July 1997, or later as earlier Include files were in error.

The entire Atmel AVR product range is described on the Atmel web site which includes assemblers, simulators, and data sheets for the range. The web site is at: http://www.atmel.com/. Follow the link to the products page.

Forest Electronic Developments can supply the programmed PIC (see below), and also sell a Windows based integrated Assembler/Simulator, they can also supply the AT90S1200 and AT90S8515 devices. The programmed PIC for the project and the Windows 3.1/95/NT host software is available on 31/2" disk. The programmed device and software is £12.00, please add £3.00 for post, packing and handling. Forest Electronics can also supply a complete kit for the AVR programmer for £40.00.

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**ELECTRONICS TODAY INTERNATIONAL**

24
Some people never seem to get the message. In a recent survey, hardly anyone knew what the temperature inside a domestic fridge should be. Some of them should have known better - they were chefs, housewives, shopkeepers and members of the food processing industry.

What's the answer?

For the very few of you who do have temporarily forgotten the answer, the maximum temperature inside a fridge should be 5 degreesC. Some say that between 2 degreesC and 4 degreesC is better. Above 5 degreesC, potentially dangerous bacteria multiply rapidly and can cause food poisoning. Having the temperature set too high is a major cause of trouble, because people assume that food kept in a fridge is safe, unless it is obviously decaying. However, if the temperature is too low, some foods become very stiff to handle. This fridge thermometer will measure temperatures over the range 0 degreesC to 10 degreesC. Apart from measuring fridge temperatures, it could also be put to other uses such as checking that temperatures outdoors are not low enough to kill sensitive plants.

The fridge thermometer is built in a small plastic box with an analogue (pointer-on-scale) meter fitted on top. There is a centre-off switch for the on-off and battery checking functions. The sensor protrudes from the front. In the prototype, the meter scale reads degrees Celsius: zero corresponds to zero degreesC and full-scale deflection to about 10 degreesC. The scale is reasonably linear with each 5uA equivalent to about 1 degree. However, these figures will depend partly on the meter being used.

Some readers might prefer to label the scale with coloured segments, like red for "too high" (say above 4 degrees), green for "correct temperature" (between 2 and 4 degrees) and blue for "too cold" (less than 2 degrees).

Making the test

To use the fridge thermometer, operate the battery check function first. Press the switch to the "test" position. The pointer go to full scale if the battery is in good condition. Now move the switch to "temp" and place the unit in the fridge. After about 30 minutes take a reading with the unit still inside. Due to the thermal inertia of the sensor, it will take a second or two for it to warm up significantly, so take the reading fairly quickly.

If the temperature falls outside the ideal range, the thermostat should be adjusted accordingly and the fridge left for an hour or two to let the temperature stabilise. You can then recheck it and adjust as necessary. The fridge thermometer should always be used during a period of hot weather. Fridge thermostats are not always good at maintaining a constant temperature; when the outside temperature is warm in summer cold in winter, it can affect the fridge accordingly. The thermometer will soon show how the temperature rises if the door is left open too long, opened and closed excessively or not shut completely. Children take note!

You will need a good quality thermometer with which to calibrate the circuit at the end of construction. The best is a standard mercury laboratory type with a resolution of one degree or less. You could probably borrow one from a local school with, perhaps, a payment to charity. An alternative is to use a digital thermometer.

How it works

The circuit for the Fridge Thermometer is in figure 1. S1 is double-pole biased with centre off. It is biased because in one of the on, the lever will spring back to off when released. This is used for the battery check function ("test"). In the other on position, the lever will remain at on until switched off. This is used for the temperature measurement ("temp"). When the switch is set to "temp" or "test", pole b directs current from the 9V battery to the input of IC1, a 5V regulator. This will maintain a steady voltage for the circuit until the battery gives less than about 7V. The circuit only requires about 4mA so, in occasional use, an alkaline PP3 battery should last for at least a year. C1 and C2 are necessary for stable operation of the regulator.

Suppose S1 is set to "temp". The temperature sensor consists of a miniature bead thermistor, TH1, whose resistance falls as the
The thermistor and three other resistors (RV1, R1 and R2) are connected as a Wheatstone Bridge. This has not been drawn in the traditional diamond-shape, as this confuses many people. The negative terminal of the microammeter, ME1, is connected to the junction of RV1 and TH1 and the positive terminal to the junction of R1 and R2. Preset RV2 works with Si in “test” to do the battery-check. Ignore this part for the moment.

Fixed resistors R1 and R2 are connected in series across the 5V supply to form a potential divider. The voltage between the OV line and the junction between these resistors (that is, the meter positive terminal) will be approximately 3.75V with the values shown. RV1 and TH1 make a further potential divider. Via RV1, the voltage across the thermistor can be adjusted to 3.75V at 0 degreesC; in that case, the voltage at each side of the meter will be equal; no current will flow, and the reading will be zero. The Wheatstone bridge is then “balanced”.

Unsteady bridge
When the temperature sensed by the thermistor rises, its resistance falls and so does the voltage across it. The voltage at the left of the meter is now less than at the right. Current flows through the meter from the positive to the negative terminal (from higher to lower voltage). If the temperature falls below zero, the voltage across TH1 will exceed 3.75V and current will flow through the meter from negative to positive. The pointer will then try to move to the left, but this is of no consequence here.

Often, a Wheatstone bridge is only used in its balanced state where no current flows through the meter. The voltage of the supply is then unimportant. However, when it is unbalanced a complex arrangement of resistors (including the resistance of the meter itself) comes into play to determine the current flowing through the meter. The reading then depends on the supply voltage. Without IC1 to provide a stable supply, the reading would change as the battery aged.

Battery test
The battery-check works as follows: with Si at “test”, current flows through the meter from the R1/R2 potential divider via S1 pole a and RV2 to the OV line. The preset will be adjusted so that the pointer reaches full-scale deflection for a 5V supply. When the battery voltage falls below about 7V, the regulator is unable to maintain a 5V output and the pointer fails to reach full scale.

Construction
The on-off and “test”/“temp” functions were combined in a single centre-off switch in the prototype. This was neat and avoided the need for two switches. Some constructors may prefer to use separate switches (depending on what is available). The PCB is mounted on the rear of the meter itself (copper track side outwards) using the meter’s terminal posts and the small fixings supplied with it.

Drill the holes in the PCB for meter attachment (do not mount the meter yet). Solder the terminal block and all other components in position. The terminal block will be used to connect the thermistor and is essential for two reasons: firstly, it will make it easy to site it remotely for calibration at the end. Secondly, when the thermistor is attached to the PCB, the terminal block avoids the need to solder it. This is significant, as the heat of the soldering iron would permanently alter its operating characteristics. If the specified voltage regulator is used, it will be soldered with its rounded face towards the right-hand edge of the PCB. Note, however, that certain similar devices appear to have their input and output pins interchanged. If necessary, check the supplier’s data. Wire up the switch (if it is the specified type, follow figure 3) and connect the PP3-type battery snap. Adjust RV1 to approximately mid-track position and RV2 fully anti-clockwise (as viewed from the left hand edge of the PCB).

Testing
Mount the meter on the PCB. The terminal marked “+” must be connected to the pad leading to R1 and R2, or the pointer will try to move in the wrong direction.

Connect the thermistor to the terminal block. Connect the battery and Si to “temp”. The pointer will probably deflect - possibly off-scale. This will not harm the meter. Adjust RV1 until the reading is zero. Now warm the thermistor between your fingers - the pointer should move to the right. Move the switch lever to the “test” position. The meter will give a deflection of less than full-scale if RV2 was left adjusted as described. Rotate RV2 sliding contact until full-scale deflection is reached. Switch
The thermometer must now be set up to read the correct temperatures. If the switch springs back to off while in "test" rather than "temp", reverse the relevant wires on S1 pole a.

**Calibration**

You will need (in addition to the thermometer), a small drinking glass with some cooking oil in it and access to a freezer (or the freezing compartment of the fridge). You will also need an assistant! Do not use water instead of cooking oil. Water would freeze at 0 degreesC. Also, water conducts electricity and if the thermistor leads were dipped in it, there would be an apparent reduction in resistance. Using a small piece of screw terminal block or other reliable method, connect the thermistor to a short piece of twin wire and the other end of the wire to the terminal block on the PCB.

Remove the oil from the freezer and immerse the thermistor fully. If necessary, wait until it has become more fluid. Keeping the oil well stirred, watch the temperature and when it reaches about minus 2 degreesC, switch the unit to "temp". Keep stirring and when the temperature reaches 0 degrees, adjust RV1 until the pointer reads zero. At each two-degree increment, record the reading. Put the oil back in the freezer and repeat the process, making small adjustments as necessary.

Carefully remove the front cover of the meter by gently prising it up from the body. With the aid of tracing paper or by careful measurement, make a new scale to stick on top of the existing one. Take great care to avoid damage to the pointer while doing this. Attach the new scale and replace the cover, taking care to engage the peg on the adjustment screw with the fork in the meter movement. Do a spot check at 4 degreesC to ensure that the scale is correctly placed.

Remove the wires from the terminal block and attach the thermistor. The thermistor must be the same one used for calibration, to avoid differences between individual units of the same type. Detach the PCB and drill the lid of the box to mount the meter. The best way to cut the large hole is to drill a circle of small ones, push out the centre, and then file the edge smooth. This need not be very neat, as the meter will cover it up. Mount the meter and re-attach the PCB to it. Measure the position of the thermistor and drill a hole in the side to accommodate it. Bend the thermistor wires so that its body will pass through the hole when the case is assembled.

The thermistor should protrude by a few millimetres. Secure the battery to the side of the box using an adhesive fixing pad or small bracket. Attach the lid of the box, checking for trapped wires.

**Using the thermometer**

When switched on, the fridge thermometer will give an off-scale reading until the temperature has fallen below about 10 degreesC. This will not harm it. It is essential to leave the unit inside the fridge long enough for it to reach the true temperature. This will take at least 30 minutes, because the temperature sensed by the thermistor is affected by the box until it has cooled down. Make a final check on the fridge to compare the reading of the new unit with that of the laboratory thermometer to make sure that they correspond and that nothing has been disturbed during assembly.

But don't forget, when you are using your fridge, that all food has its use-by date, and it can be unsafe to keep food for too long, even under ideal storage conditions. Always follow the manufacturers' instructions.
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Ups and downs

Of the two new noise reduction techniques used by this system, downward expansion is probably the easiest to understand. It is when the programme material is quiet that background noise tends to be most noticeable and objectionable. One way to reduce the noise is to reduce the volume on quiet passages. Simply turning back the volume control will give the required noise reduction, but it will also reduce the volume during crescendos. Downwards expansion gives the best of both worlds by maintaining high volume levels when the music is loud, but the required reduction in volume when music is quieter. Figure 1 shows the expansion characteristic used in this application. At the 0dB level there is unity voltage gain through the unit, and even with the input at -20dB there are only minor losses through the circuit. At lower levels the losses become increasingly significant, reaching some 15dB when the input signal is at -70dB. This gives 15dB of downward expansion, which, as one would expect, contributes 15dB to the system's noise reduction.

There is an obvious problem with any form of volume expansion technique, which is simply that it alters the dynamic levels of the original programme material. What were originally quite subtle changes in the dynamics could easily become exaggerated and completely over the top. This will certainly happen if more than a modest amount of expansion is used, and 15dB probably represents the maximum amount that can be applied without any undue effects.

Although the dynamic levels are being altered, bear in mind that sound engineers often apply a certain amount of compression when music is recorded or broadcast. This becomes necessary when the
dynamic range of the programme material exceeds the "headroom" of the recording or broadcasting system. Low level signals have to be boosted slightly so that they do not drop down below the noise level. Downward expansion counteracts this process, and more or less restores the dynamic levels. The original dynamic levels can never be precisely restored, because the compression characteristic is unknown, and is unlikely to complement precisely the expansion characteristic used here. However, with some programme sources a small amount of volume expansion gives more realistic dynamics, and music that has more impact.

A cut above
Combating noise using dynamic lowpass filtering relies on the fact that high level signals tend to mask noise. When the volume is low, the noise is all too obvious, but at medium to high volumes it becomes inaudible. In many respects human hearing is very precise, but quiet sounds can not be heard through much louder sounds, especially where the two sounds are similar.

Most readers will probably be aware that applying lowpass filtering can reduce "hiss". This is easily demonstrated by backing off the treble control when listening to any programme material that has a high hiss level. The measured decrease in the noise might not be very great, but the perceived reduction is usually quite significant.

The difference in the perceived and measured noise levels is due to the way human hearing operates, particularly the fact that high frequencies tend to stand out. Signal-to-noise measurements are often weighted using a special filter, which massages the results so that they match our sensitivity to noise.

Simply applying some top-cut filtering will give an improved signal-to-noise ratio, but it will also reduce the treble content in the signal. The brass section, violins, and many instruments will sound rather dull and lacking in sparkle. Crescendos tend to sound "muddy" and lack impact. Dynamic lowpass filtering provides the noise reduction, but it minimises the amount of treble loss. With low signal levels the full amount of treble cut is applied, but as the signal level is increased, the cut-off frequency of the filter is raised. At the highest signal levels the cut-off frequency is made so high that the filtering is effectively removed, and audio frequency signals are left unaffected. There is no noise reduction at high signal levels, but this does not matter because the noise is not audible at these levels anyway. Maximum noise reduction is applied to low level signals, which is where the noise is most noticeable.

Although one might expect the varying amount of filtering would be all too obvious, in practice it is not noticeable provided a few conditions are met. It is apparently important to control the amount of filtering by altering the cut-off frequency. Using a fixed cut-off frequency and altering the severity of the filtering will not give "transparent" results. It is also essential that the filter responds more readily to high frequency sounds than it does to low and middle frequency signals, because the high frequency noise is masked more efficiently by high frequency signals than by lower frequency signals. If a strong low frequency sound was to lift the filtering, the increased noise would not be properly masked, and it would be clearly heard to increase, producing the aptly named "breathing" effect. Finally, the changes in the cut-off frequency of the filter must be implemented very rapidly so that the unit responds quickly to changes in the dynamic levels. If the filtering does not respond rapidly to sudden falls in volume, short bursts of hiss will be heard, again giving rise to "breathing" effects.

Over the threshold
For the system to work properly it is essential that the filtering and expansion start to operate at the correct threshold level. If the
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sensitivity is too low, the full amount of expansion will not be obtained, and the filtering will not be completely lifted at high volume. If the sensitivity is set too high the full expansion will be produced over a relatively small dynamic range, and the filtering will be lifted at middle volumes, either giving less than the maximum noise reduction, or else making the changes in dynamic level and filtering fairly obvious. Either way results leave a lot to be desired, and the programme material would probably sound better without any processing!

Most noise reduction systems of this type require you to select the optimum threshold level carefully, and where necessary readjust the threshold level to suit different programme material. For example, with very noisy signals you may need to use a high threshold level, even if this means that the full amount of expansion is not obtained; and the lowpass filtering is never fully lifted. Otherwise there can be problems with breathing effects, and the action of the system can become apparent to the listener. This unit does not require manual setting of the threshold level, because the circuit includes stages that analyse the input signal and set the most appropriate threshold level. This reduces the play value somewhat, but is more convenient as you can switch from one source to another without having to worry about any manual adjustments to the unit. It automatically adjusts itself to suit the signal source, whether that source is a slightly noisy FM receiver or an old and hissy cassette tape.

**System operation**

A noise reduction system of this type can either process stereo signals using separate circuits for each channel, or the filter and expander circuits can be controlled by a sort of averaged signal derived from both channels. The discrete approach is probably the more common one, but in this case the two stereo channels are controlled in unison. Each method has its advantages and drawbacks, but in practice both systems can be made to work well. Figure 2 shows the block diagram for this noise reduction system. This actually shows a slightly simplified version of the system, but it includes all the main circuit blocks.

The two stereo channels are fed through identical signal processing stages, each consisting of a voltage controlled filter (VCF), a voltage controlled attenuator (VCA), and an output buffer stage. As one would expect, the VCF provides the dynamic filtering and the VCA produces the downward expansion. The rest of the unit supplies these stages with a control voltage that provides the required changes in the filtering and attenuation. A mixer stage combines the two input signals, and it is from this signal that the both the VCA and the VCF control voltages are derived. It is probably best to start with the generation of the VCF control voltage. This is produced by first feeding the signal through a highpass filter. As explained previously, the cut-off frequency of the filter must respond to the high frequency components in the input signal, and largely ignore low frequency signals that will not mask the noise very well. This three-stage highpass filter ensures that even the strongest of low frequency signals will not lift the filtering. The filtered signal is fed to a peak level detector. This stage full-wave rectifies the input signal and produces a positive DC output voltage that is equal to the peak (positive or negative) input level. This voltage could be used to control the VCF but, as pointed out previously, the circuit has a threshold detector that automatically adjusts the sensitivity of the side-chain circuit to suit the input signal.
The primary purpose of the threshold detector circuit is to discover the noise level. The input amplitude needed to provide full expansion and lift the filtering is then scaled to this level. This circuit seems to be quite involved, but it is basically just detecting the minimum input level, which occurs during gaps in the main signal when only noise is present. It is high frequency "hiss" type noise that is of primary importance here, and it is for this reason that the threshold detector is driven via the highpass filter circuit. Feeding the outputs of the threshold detector and the peak detector to a differential amplifier produces the control voltage for the VCF. With a high output potential from the threshold detector, the output from the peak detector must also be high before a positive output signal is obtained from the differential amplifier and the cut-off frequency of the filter is increased. Basically the same method of operation is used for the side-chain that drives the control input of the VCA. The only difference is that no highpass filtering is used ahead of the peak detector in the VCA section of the circuit. The threshold detector is common to the VCF and VCA control circuits.

Circuit operation

Figure 3 shows the full circuit diagram for the stereo noise reduction unit. The circuit is extremely simple due to the use of a specialised integrated circuit, the SSM2000 from Analogue Devices. The only other semiconductor in the circuit is IC2, which is an operational amplifier used as a supply splitter. The half supply potential produced at its output provides a pseudo central supply rail, which is used to bias some of the internal circuits of IC1. The two VCFs are single pole (6dB per octave) circuits that have C5 and C6 as the filter capacitors. These set the minimum cut-off frequency at approximately 3kHz. A lower cut-off frequency would give greater noise reduction, but the affect on the wanted signal would be too great. With strong input signals the cut-off frequency is taken above the 20kHz upper limit of the audio range.

Pin 9 is the output of the mixer stage in the side-chain, and this feeds the peak detector for the VCA via coupling capacitor C9. The VCFs peak detector is driven via a passive three-stage highpass filter comprising C10 - R1, C11 - R2, and C12 plus the input impedance of IC1. C7 and C8 are the smoothing capacitors in the VCF and VCA peak detectors. C13 is part of the automatic threshold detection circuit. There are several pins of IC1 which serve no purpose in normal use, but the control input at pin 16 is very useful. With SW1 closed this input is taken low, and the unit then functions normally. When SW1 is open, pin 16 of IC1 is taken high by R3, which removes both the expansion and the dynamic filtering. This provides an easy way of switching out the noise reduction. The current consumption of the circuit is about 10 to 12 milliamps from a 9 to 12 volt supply. A small (PP3) size nine volt battery is just about adequate to power the unit, but a higher capacity battery would be preferable if the unit will receive a great deal of use. Obviously a 12-volt mains power supply unit can be used if preferred, but the supply must have a low output noise level.
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Contact Information

Tel: 0191 2514363 Fax 0191 2522296 Email: sales@esr.co.uk http://www.esr.co.uk

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This makes it necessary to use a regulated supply, even though the circuit does not actually need a well-regulated supply. The circuit has been designed to be very tolerant and self-adjusting to any reasonable input signal level around normal hi-fi line level.

Construction

Stripboard construction is well suited to a simple circuit of this type, and a suitable layout is shown in figure 4 (component side) and figure 5 (copper side). The board measures 37 holes by 29 copper strips. Construction of the circuit board follows along the normal lines and offers little out of the ordinary. The SW1/2000 is not a MOS device, but as it is a fairly expensive component it should be fitted in a holder as a matter of course. It has a rather unusual encapsulation, which is a 24-way DIL plastic type having 0.3-inch (7.62 millimetre) row spacing. 24-pin integrated circuits exist in at least three different forms, with row spacings of 0.3, 0.4, and 0.6 inches. In most component catalogues only the 0.6 inch version of 24-pin DIL holders are listed. The easiest solution is to fit ordinary 16 and 8-pin holders on the board, butted together to effectively form a 24-pin holder. This works well provided the holders are of the same make and type. This method is unlikely to give usable results if the holders are of different heights.

The component layout is designed to suit plastic foil capacitors having 7.5mm or 0.3 inch lead spacing, and it could be difficult to fit other types into the layout. The electrolytic capacitors must be high quality components such as aluminum electrolytics. Tantalum bead capacitors are also suitable. Be careful not to omit any of the link-wires, including the small link just below C5. The longer link-wires must either be pulled taut, or fitted with PVC sleeving to ensure that there are no accidental short circuits. Any medium-sized case should comfortably accommodate this project. As the circuit never has more than unity voltage gain there are no problems with stray feedback, and "anything goes" when designing the general layout of the unit. Phono sockets are specified for the input and output connectors, and these match the sockets used on most domestic hi-fi and video equipment. Obviously these can be changed to any type of audio connector that fits in better with your particular set-up. The sockets are mounted on the front panel of the prototype, but it would probably be more practical to fit them on the rear panel.

The hard wiring is very simple and is shown in figure 6. This is used in conjunction with figure 4 (i.e point "A" in figure 4 connects to point "A" in figure 6). As the circuit only handles high level signals, it is not particularly sensitive to stray pickup of hum and other electrical noise, and it is not essential to use any screened leads. However, it must be wired into the hi-fi system (or whatever) using good quality screened leads.

Testing and use

When using this unit, remember that it is a single-ended noise reduction unit only used during playback. It connects between the signal source and the input of the power amplifier. If it is only required with (say) a cassette deck, simply connect the outputs of the deck to the inputs of the noise reduction unit, and the outputs of the noise reduction unit to the inputs of the power amplifier. Matters are more involved if the unit is to be used with all the signal sources. It should then connect between the outputs of the preamplifier and the inputs of the power amplifier. This is easy enough if the pre- and power amplifiers are separate units, but might not be possible if they are combined into one unit. Some combination pre- and power amplifiers have the necessary input and output sockets marked as such. Many others have them in the form of a tape monitor facility that can be switched in and out. Connecting the unit between the tape input and output sockets enables it to be switched in and out using the tape monitor switch.

The effect of the unit should be very obvious on any hissy signal that covers a wide dynamic range. Switching SW1 on and off during quiet passages should produce a large change in the hiss level. There is relatively little to be gained if the signal source already has a low noise level, and the effect of the unit will then be much less obvious. When using the unit with a cassette deck, it is best to switch off the Dolby B decoding of the deck when playing Dolby encoded cassettes. The dynamic filtering of the noise reduction unit will not provide highly accurate decoding, but it provides a reasonable imitation of a Dolby B decoder. In the chip manufacturer's words, it "effectively decodes Dolby B encoded sources." Using the unit in addition to Dolby B decoding provides a great deal of noise reduction, but the sound might be rather muddy at low signal levels, and the double dose of dynamic filtering may produce very apparent changes in the treble content of the reproduced sound.

### PARTS LIST

**Resistors**

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<td>R2</td>
<td>1k</td>
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<tr>
<td>R3</td>
<td>3k3</td>
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<td>R4, R5</td>
<td>39k</td>
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**Capacitors**

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<td>C1, C7</td>
<td>1u 50V radial elect</td>
</tr>
<tr>
<td>C3, C4, C14, C15</td>
<td>10u 25V radial elect</td>
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<tr>
<td>C5, C8</td>
<td>1n polyester</td>
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<tr>
<td>C6, C9</td>
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<td>220n polyester</td>
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**Semiconductors**

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<td>IC1</td>
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<td>IC2</td>
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**Miscellaneous**

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<td>Phono sockets</td>
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<tr>
<td>SW1, SW2</td>
<td>SPST miniature toggle</td>
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<tr>
<td>B1</td>
<td>9 volt (see text)</td>
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Plastic or metal case, 0.1-inch pitch stripboard having 37 holes by 29 copper strips, 8-pin holder, 24-pin DIL holder (see text), battery connector, wire, solder, etc.
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A UHF MODEL RADIO CONTROL SYSTEM

UHF radio can be more effective for model control than the old 27MHz band ever was. Geoff Pike GI0GDP decided to try it from scratch and was pleased with the results.

About a year ago, I realised that making a UHF radio control system should not pose any major problems, given the ease of component availability and new techniques in construction.

I made a start, and initially no unforeseen problems were encountered. A first prototype was made and tested in about three months. The design as presented here took a bit longer to finalise, and should not be regarded as the ultimate development of the design, but rather as a basis for others to improve.

A constructor with average experience and some knowledge of radio control should be able to get this going without too many problems, but this project does require the use of an oscilloscope, digital frequency meter, and a diode probe to measure RF. Those of you who are not into UHF radio may be a little puzzled by the things that are done at these frequencies, however, as long as you do it the way it's described, then you should have minimum problems with it.

The system is suitable for all forms of model, land, sea, and air. It will drive normal servos, and the only departures from VHF radio control are the particular attention needed to the installation of the receiver antenna, and the non-standard use of a 9.6-volt receiver (Rx) nicad pack. This is because of the demands made by the Rx local oscillator (lo). However this in practice will not cause any great weight problems in most models.

A model radio control licence no longer exists. However, the UHF allocation is always changing with respect to power. The current situation, which can be confirmed by ringing the Radiocommunications Agency (RA) low power section on 0171 215 2150 ext. 2058, is as follows:

1) 458.5 MHz to 458.8 MHz 1mW
2) 458.8 MHz to 459.5 MHz 100 mW eRp

Obviously, the second allocation will be used for models or anything needing some distance between the transmitter and the receiver. This gives some 0.7 MHz of space, which would in theory give 28 channels spaced at 25 kHz.

Model radio control articles have been published in the past in both ETI and dedicated modelling magazines and books. Some of the ideas contained in this design as already...
standard. I found Paul Newell's book *Radio Control: A Handbook of Theory and Practice* (Radio Modeller Books Ltd., 1981) on radio control useful, especially for the data slicer comparator used in the rx decoder. It is not in print at the moment, but you may find it in libraries.

**The circuit**

**The transmitter**

The transmitter is in two parts, the transmitter itself and the encoder. Both parts are shown in the circuit diagram in figure 1.

The transmitter follows fairly common practice in model radio control, accepting plug in third overtone crystals and running from a 9.6V nicad pack. The overtone oscillator Q5 is stabilised by the crystal X1, and the frequency is set by adjusting L1. The oscillator is frequency modulated via a varicap diode, D12. This changes the resonant frequency of L1 slightly. The signal is passed to the next stage for frequency doubling (Q6), and then on to Q7, where it is multiplied by three. The total multiplication before the output stage is six times the marked crystal frequency. Final amplification is provided by Q8 and Q9 in parallel. The output of this stage is matched into the helical filter HF1 by L8 and VC5. Harmonic suppression is also provided by this two-chamber filter. The signal at this point is about 250-350 mW, and is then passed to the antenna by either direct connection to the pcb (preferred method) or by a short length of miniature 50R coax cable RG174/U. Stable oscillator performance is helped by the regulated 7V5 supply from the voltage regulator IC6.

The encoder is of the linear ramp type, which was previously available as a dedicated ic for the job. However, here the task is carried out using discrete ics (IC1 - 4) and associated components.

The control stick pots RV4 - RV10 provide a voltage which is dependent on their position. These voltages are fed to the
multiplexer, IC1, and are commutated in turn as the address changes from the 7-stage ripple counter IC2.

Considering one channel at a time, at neutral, a stick pot wiper voltage will be approximately 3.75V. This would be presented to op amp IC3a's inverting input. This would allow the integrating capacitor C9 to charge up to this value before IC3b, a comparator, would change state. This would then cause the 555 monostable to produce a short pulse of about 250 us, causing the 7-stage ripple counter to advance and present the next pot wiper voltage to the MUX input and in turn to the op amp IC3a. This would also cause C9 to discharge via D7. The process would start over again, and C9 would linearly charge via Q2 in a time related to the voltage on the selected stick pot.

This process is repeated until the eighth count, when something completely different occurs. Pin 15 of the MUX will select the preset RV1 (sync) and, with the gating of D1, D2 and D3 will cause Q1 to divert Q2's base current. This will mean that C9 will take longer to charge up. This allows a sync pause of up to 20ms to be generated if needed. This has not always been possible with this type of linear ramp encoder.

The process is regenerative. Adjustment of RV2 changes the value of constant current in Q2, which in turn sets the neutral pulse widths. These are typically 1.5 ms in duration. Time constant R18/C14 will control the inter-pulse gap, which is typically 250 us; RV1 sets the...
The complete system is fed from a stabilised 7.5V supply rail provided by IC5, the voltage regulator. SMD (surface mount device) type capacitors C1-C8 decouple the rf from the control pot wipers. RF entering an encoder is a real pain, but this design seems to have high immunity against this. Please use the chip capacitors here.

As typically four channels will be used (that is, two control sticks), all unused inputs to IC1 must be connected to the vref point marked "x". The clock signal from the 555 not only advances the 7-stage counter IC2, but is also the modulating signal. This is fed to the bi-directional current device 03/04, an n-channel and p-channel fet (field effect transistor). This ensures approximately equal and near-linear shaping of the pulse edges before they are applied to the varicap diode D12 via R25.

The edge delay is about 100 us on both the rising and falling edges. This shaping is needed to limit the transmitter signal width. RV3 is used to set the overall deviation to +/- 3.5 kHz.

The component layout for the main transmitter board is shown in figure 2, and the encoder board is shown in figure 3.

The receiver (figure 4) is split into two boards, the receiver front end/mixer/LO (figure 5), and the separate pcb with the NBFM decoder and digital processing and decoding (figure 6). The receiver front end consists of an rf pre-amplifier Q1 ahead of a bipolar mixer Q2. Initial selectivity is given by Li/VCl.

Ahead of Q1, this signal is passed to the helical filter HF1, which gives some degree of protection from image signals at 21.4 MHz from the desired signal. After mixing with the lo signal, the difference is selected by T1 at 10.7 MHz and then passed to the nbfm IF amp and demodulator.

The lo signal is generated by a third overtone crystal oscillator, and is multiplied by 6 via Q4 and Q5. Stabilisation is provided by two methods, IC4 supplies Q3 and Q4 with a regulated 7.5V rail, and afc is applied to D2, a varicap, from the discriminator output of IC1.
The IF signal at 10.7 MHz is applied to IC1 via a ceramic 50 kHz wide filter. All IF amplification is done at 455 kHz, and the main selectivity is afforded by ceramic filter FL2. None of the squelch or noise amp stages are used for this design. T2 forms the quadrature detector coil and controls the level of the demodulated signal output on pin 10. IC1 is not particularly prone to noise on its supply lines, however it is fed by a capacitor multiplier Q6, and only loses about 0.5V in the process, but effects excellent supply line decoupling from a potentially noisy environment.

AFC is conditioned by R10/C17, and is biased to mid rail (about 2V) using R11/R31. The overall shift is about 2.5 -3 kHz. The recovered signal is de-emphasised in the network R9/C18. This is applied to a data slicer formed by a comparator IC2. This takes a fixed percentage of the incoming signal as its reference at pin 3. It is smoothed by R14/C23, and the working point established by R15. This arrangement allows direct connection, and will ensure excellent data retrieval under all signal conditions because the threshold level of the comparator is not fixed, but is referenced to it. The reconstructed encoder waveform appears at pin 7 and is connected to the clock input of the octal counter IC3. This signal also drives a diode pump D1/C21 and during the sync pause of 8ms +/- R12 will cause C21 to charge up to a level that exceeds the trigger threshold, resetting the counter ready for the next data stream.

The eighth count on pin 10 is connected back to the clock enable so as to disable the counter when no Tx signal is present, preventing servo chatter.

In the second part of this article in the next issue I will describe the construction, casing and antenna of the UHF Radio Controller.
7-channel UHF Transmitter

Resistors
All 0.25W 5 percent
R1-R8 56k
R9 10k
R10, R11 22k
R12, R21 4.7k
R13, R14 47k
R15 33k (select on test)
R16 820R
R17, R28 100R
R18 82k
R19 560R
R20, R23, R31, R32, R35-36 1kR
R22 3k3
R24 470R
R25 18k
R26 330R
R27 6R2
R28 100R
R29, R34 22R
R30, R33 680R
R32 5k6
R37 560R temporary for test only
R38, R39 5k6 temporary for test only
RV1 10k vertical
RV2 4.7k horizontal
RV3 4.7k horizontal
RV4-10 5-50k linear control stick pots

Capacitors
C1-C8 1nF surface mounts mounted on track side.
C9 100uF polyester
C10, C11 2u2 10V tantalum
C12 100uF 10V radial electrolytic
C13, C24, C28, C30, C34 10nF ceramic
C14 3900pF polyester
C15 22nF disc ceramic
C16, C18-19, C23, C31-93, C35 1nF disc
C17 200pF ceramic
C18, C24, C50, C51 10pF ceramic plate
C21 2pF ceramic plate
C22 5pF ceramic plate
C25 2pF ceramic plate, off board between L2 and L3
C26, C27 10uF 16V electrolytic
C28, C30, C34 10nF ceramic plate
C29 1pF ceramic plate
VC1-VC4 10pF Mullard yellow film trimmers (Cirkit)
VC5 5pF ceramic

Inductors and Others
L1 S18 green with ferrite core (Cirkit)
L2, L3 3 turns 22SWG silver wire 1/8th inch ID space wound
L4 Half-turn 'loop' 1 inch of 20SWG wire
L5 On PCB
L6 Long resistor tail from R32, about 3/8th inch
L7 3 turns 22SWG 3/32-in ID space wound
L8 Spare resistor tail mounted about 1/8th inch above PCB
HF1 252MX-1551A helical filter
X1 Third overtone HC25/u (from Quartzlab Marketing (OSL) Ltd. - see below). For 459.5MHz this will be 76.5833 MHz, which is just above the limit of 75 MHz, that the third overtones are normally made to. However, they will make this frequency on request.

7-channel UHF Receiver

Resistors
R1, R6, R18, R26 100R 0.25 watt
R2, R3 68k
R4, R16 10k
R5 120k
R7, R24 330R
R8 56k
R9, R22 3.3k
R10 1k5
R11 100k
R12 2k7
R13, R14, R28 27k
R15 1M
R17 100 - 150k s.o.t. to ensure reliable resetting of the counter
R19, R20, R25, R27 10R
R21 4.7k
R23 470R
R29 680R
R30 22R

Capacitors
C1, C7, C8, C11-13 1nF disc ceramic
C2, C3, C4 47pF ceramic plate
C5, C33 4p7 ceramic plate
C6, C20, C22, C24, C30, C31, C34, C35, C37, C38 1nF disc ceramic
C9, C10 56pF ceramic plate
C14 150pF ceramic plate
C15, C16, C19 47uF 6V3 mini radial electrolytic
C17 680nF polyester
C18 22nF Mylar/polyester
C21 47nF Mylar/polyester
C22 1u10V tantalum ceramic
C23, C27 10p ceramic plate
C26 20p ceramic plate
C29 5p6 ceramic plate
C32 8p2 ceramic plate
C33 2p2 ceramic plate
C36 4p7 ceramic plate
VC1 200p ceramic plate
VC2 10pF Mullard yellow film trimmers (Cirkit)
VC4 5pF ceramic (Cirkit)
**Semiconductors**

<table>
<thead>
<tr>
<th>IC1</th>
<th>ULN3859 or MC3359, or without AFC</th>
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<tbody>
<tr>
<td>IC2</td>
<td>LM311</td>
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<tr>
<td>IC3</td>
<td>MC4022</td>
</tr>
<tr>
<td>IC4</td>
<td>78L05</td>
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<tr>
<td>Q1,Q2,Q4,Q5</td>
<td>BFR91 (Cirkit)</td>
</tr>
<tr>
<td>Q3</td>
<td>2N5179/BF9Y90 (Cirkit/Farnell)</td>
</tr>
<tr>
<td>Q6</td>
<td>BC547(Cirkit)</td>
</tr>
<tr>
<td>D1</td>
<td>1N4148</td>
</tr>
<tr>
<td>D2</td>
<td>BB104 (Cirkit)</td>
</tr>
<tr>
<td>D3</td>
<td>2V7 zener</td>
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</table>

**Inductors and others**

| L1   | 1.25-in 20SWG silver wire        |
| L2   | 516 series coil green with ferrite core (Cirkit) |
| L3, L4 | 3 turns 22SWG 1/8 Inch ID space wound |
| L5   | Half-turn loop from 0.75-in long 22SWG silver wire |
| X1   | 11.155 MHz stock crystal (Cirkit) |
| X2   | To suit frequency: for 459.500 MHz this is 74.800 MHz 3rd overtone (QSL Ltd.) |
| FL1  | 50kHz scan filter 10.7 MHz ceramic (Maplin) |
| FL2  | 20kHz 455kHz ceramic filter CFU 455D (Cirkit) |
| T1   | 118AC 30099R 10.7 MHz IF transformer (Cirkit) |
| T2   | LMC 4100A 455 kHz-transformer (Cirkit) |

**HF1**

252MX-1551A helical filter (Cirkit)

**Case**

Made from 1-mm plastic card glued with cyano-acrylate adhesive

Custom crystals can be obtained from Quartzlab Marketing Ltd., PO Box 19, Erith, Kent DA8 1LH. Tel. 01322 330830. They need to know the frequency required for self-build equipment, or the make and model number for commercial equipment.

Control sticks and case are from Micron Mail Order, 24 Brendon Way, Long Eaton, Nottingham, NG10 4JS, tel. 0115 972 3893. This supplier also supplies servos.

Mainline Electronics PO 235 LE2 9SH Tel. 0116 2777648

Maplin: PO Box 3, Rayleigh, Essex SS6 8L. Tel 01702 554161

Cirkit Distribution Ltd., Park Lane, Broxbourne, Hertfordshire EN10 7NQ. Tel 01992 448899

Farnell Electronic Components: Canal Road, Leeds, LS12 2TU. Tel 0113 263 6311

Silver wire can be obtained from Cirkit. Tinned copper wire is also suitable and is cheaper.

(Where a supplier is mentioned alongside a part without further details it indicates that the supplier listed the part recently, not necessarily that they are the sole or main supplier.)

---

**Figure 6:** The component layout of the receiver IF amplifier and NBFM decoder
M1304 200 step stepping motor with wireless (transmit and receive) £2.45

Contact M1304 12V 1.6 A 1.6A contains 12 C-cells with solder tags (the size most commonly used in electronic circuits and allows 5 to 6 bi-monthly tags). It is easy to crack open and was manufactured in 1991.

Boards case 2.50 H2026 3 C-cells with solder tags (the size most commonly used in electronic circuits and allows 5 to 6 bi-monthly tags). It is easy to crack open and was manufactured in 1991.

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Adaptable, affordable - handy circuits for around £5. By Owen Bishop

Audible logic probe

We have described quite a number of logic-based projects in this series so it is high time that we presented a device for checking logic levels. Typically a logic circuit consists of several ICs, each with 14 or 16 pins, and checking involves probing the pins one at a time to confirm that the logic levels there are correct. It is more convenient if you can keep your eyes on the test circuit while you do this, so as to be sure that you are contacting the right pin. It is better not have to watch an LED or a meter at the same time. This is where this audible checker is so appropriate. The logic level is indicated by the pitch of the sound produced. A high note indicates a high logic level and a low note indicates a low level. More later about what it means if the note is neither high nor low.

The basis for this circuit is an IC which occupies a kind of borderland between the digital and analogue worlds, though it is a member of the CMOS 4000 series and so qualifies as a logic IC. The 4046 is usually described as a phase locked loop (PLL) IC. It contains several distinct modules which together are used to build a PLL. PLLs are used for locking on to a digital signal of a particular frequency that has become mixed with other signals of other frequencies or perhaps just a noisy background. PLLs can be used for restoring a badly degraded digital signal to its original square-cut form. One of the useful modules to be found in the 4046 is a voltage-controlled oscillator (VCO), and it is this part that we use in this project. We do not need or use the other parts of the PLL. The basic frequency of the VCO is determined by the value of C1 and R1 (figure 1). If the voltage at the control input (pin 9) is exactly halfway between the two supply rails, the frequency at the VCO output (pin 4) is 1/RC. If the voltage at pin 9 drops to zero, the frequency too drops to zero. If the voltage increases to the full supply voltage, the frequency doubles to 2/RC. With the values given in the figure, the frequency ranges from zero up to about 750Hz.

In this project we need a signal in the audio range when input is 0V. We obtain this by adding a second resistor R2 to produce a frequency offset. The effect depends on the ratio of R2 to R1. In figure 1 the ratio is 82:27, which is approximately 3:1. This raises the zero-input (logic low) frequency from 0Hz to 750/3 = 250Hz (approx). It increases the logic-high frequency by the same amount, that is, from 750Hz to 1kHz.

The signal from the VCO is made audible by using it to switch a small magnetic sounder on and off. C2 is needed to prevent the signal from being fed back to the IC through the power lines. The circuit includes a resistor R4 to reduce the volume of sound. The exact value of this depends on the type of sounder used. There is also a push-button in the audio circuit so that the sound is heard only when we want it. As you will discover, the audio output is a depressingly screeching sound unless the probe is connected to a point which is firmly at a steady high or low logical level. Which brings us to the next topic.

In-between levels

In an ideal logical world all points are either at logic-low or logic-high. In-between values do not exist. Unfortunately, in the real world of projects being tested, there may be several points in the test circuit that are hovering somewhere between the two states. If, for example, the connection to one of the supply terminals of an IC is open-circuit so that the IC is receiving its supply unofficially through another input terminal, we find that the voltages at the inputs and outputs are fairly steady, but at some level between low and high. The tone from the probe is steady, but is intermediate in pitch. The same may occur if there are unintended short-circuits between adjacent terminals. If an input terminal has been left unconnected, it "floats", and its input level varies erratically. The input terminal itself or the output terminal of the same gate produces an...
unpleasant screeching sound.

Oscillation, either intended or accidental, is a cause of apparently intermediate voltage levels. The levels are alternating between true logic low and true logic high but changing so rapidly that a voltmeter applied to the terminal shows a steady intermediate reading. With this probe this may give a two-tone ‘warble’ (can sound like a telephone ringing). If the oscillations are faster, it sounds more like a continuous ‘high’ but not as loud as usual. The loudness depends on the ratio between the time spent high and the time spent low. With a little experience you will soon learn to interpret the sounds and pick out their differences.

Construction
The circuit works on any voltage in the range 3V to 15V (18V is the absolute maximum) and is best driven from the supply of the circuit being tested. It is built on a small rectangle of stripboard (figure 2). We have designed it so that the copper strips run across the width of the board. The board could be housed in a small case with a rigid metal probe at one end and the power leads emerging from the other. The push-button is placed so that the forefinger rests naturally on it as you hold the case in your hand. Then you can easily press the button each time you touch the probe down on a test point.

LS1 is a mini magnetic transducer (not a piezo-transducer) specially intended for PCB mounting. The circuit will also work with a range of miniature loudspeakers if they have a resistance in the range 16 to 64 ohms. Some of these have a diameter of only 2 cm and can be mounted on the board if it is made slightly longer than shown. But do not use a ‘buzzer’ or any other type of sounder that produces its own tone.

We have mounted the push-switch directly in a hole drilled in the board. The switch is connected to wires soldered in the holes marked A and B. Alternatively you could mount the switch on the case and take leads from it to these two points. R4 in our design is a 39-ohm resistor, which reduces the volume of sound to a suitable level. You may find that you need a resistor of different value or perhaps may omit R4 and replace it with a wire link.

The circuit is so simple that it is best constructed and tested in one session. Connection to the power supply on the test piece is by two flexible wires ending in crocodile clips. We have had no trouble with feedback but, if the tone is ‘harsh’ when the probe is touched against the +V or OV supply line, try increasing the value of C2.
Guardian Light

If you lose lighting through a power cut, Terry Balbirnie’s Guardian Light provides an automatic, battery-backed lighting system to see you through.

You have probably noticed emergency lighting systems in shops and other public places. These are essential to allow people to find their way out if the mains supply fails, especially at night. Emergency lighting helps to prevent people panicking and saves lives, especially in a power failure caused by fire.

Lighting the way
This circuit allows you to build a small emergency lighting unit for your own home. The elderly would benefit, as they could sit comfortably until power was restored. It would also be useful in houses with dark passages, especially where there are frequent power cuts. Note that this system is for use only in private homes and other places where no emergency lighting regulations exist.

The emergency lighting system is a unit that can be placed on a shelf and plugged into a nearby mains socket. There is an on-off switch and a neon indicator which confirms that the supply is on. The lamp itself is plugged into a socket and placed in some convenient position.

Making sense
The unit contains a 12V lead-acid battery which is maintained in a fully-charged state while a mains supply exists. It will then power the lamp when there is a power failure. On top of the unit is a hole which allows light to reach a sensor on the circuit panel. This prevents the lamp from coming on if there is already sufficient light in the room.

The bulb could be of the car type of, say, 5W rating. Such a lamp would operate for about 15 hours using the specified battery, and this would suffice for most purposes.

Alternatively, a bulb of lower rating could be used to give a longer operating time. You could also use a small fluorescent light (the 12V caravan or boat type). The nominal 8W variety (which, in practice requires about 1A) would give some 6 hours of operation. Lamps requiring more than 1A (12W) must not be used with this unit. This is chiefly for the sake of the PCB tracks.

If lead-acid batteries are left in a deep discharged state (that is, discharged much below a certain low point) they can suffer permanent damage, despite what the supplier’s data might say. In the present circuit, this is prevented by an audible warning given below a nominal 10V. The lamp will also become noticeably dimmer. The user must then switch it off using the lamp on-off switch on the front panel.

How it works
The circuit for the Guardian Light is in figure 1. The mains supply is connected to transformer T1 primary winding via on-off switch S1 and fuse FS1. LP1 glows while the mains supply is on.

The transformer has two 9V secondary windings which are connected in series to give a nominal 18V ac supply. This is used in conjunction with bridge rectifier REC1 and C1 to provide a smooth dc on-load output of some 18V to 20V. Fuse FS2 provides protection to this part of the circuit.

The supply is applied to the input (pin 1) of ICl, the voltage and current regulator. This provides a fixed voltage output of between 13.5V and 13.8V, which is correct for continuous (“trickle”) charging the type of battery used, and limits the current to what is safe to supply to the circuit. The limit used here is 200mA. C2 and C3 are needed for stable operation of the IC.

At a low point
Disregarding the current-limiting aspect for the moment, the charging current would normally be related to the difference between the supply voltage and that of the battery. Thus, with the battery terminal voltage at the low point of 10V, the difference would be about 3.5V to 3.8V and the current would be relatively high. As the battery charges, its terminal voltage rises, the voltage difference decreases and the charging current falls. When fully charged, the difference between the two voltages is very small and only a “trickle” current of a few milliamps remains. This may be left flowing continuously and serves to keep the battery in good condition by overcoming the small loss of charge which inevitably occurs.

However, the process above is modified because, at the beginning of the charging process when the voltage difference is at a maximum, the current is limited by ICl to a safe working value. This prevents damage to both the battery and power supply. The specified transformer is of the 6VA type and can therefore supply a maximum of 333mA into a resistive load. However, due to the smoothing capacitor, it must be de-rated, hence the chosen current limit of 200mA. During most of the charging cycle, the current will, of course, be much less.
Voltage regulation

R1 connected between IC1 pins 3 and 4 operates with preset pot RV1, connected between pins 2 and 4, to determine the voltage at pin 2. On construction, the preset will be adjusted so that between 13.5V and 13.8V appears at the cathode of D1. Therefore between 14.2V and 14.5V must be provided at pin 2. The voltage difference is necessary to take account of the approximate 0.7V forward voltage drop of the diode.

The pair of resistors R2, connected between IC1 pins 5 and 2, determine the maximum current which can be delivered by the output. The two resistors are connected in parallel to obtain a close match to the value required (2 ohms). The current-limiting aspect of the circuit works as follows: current flows from pin 5, through resistor(s) R2 and develops a small voltage across it. This is sensed by pin 2, and if it exceeds 0.4V, the IC turns the current down to maintain 0.4V. The resistor value required (R) for a given current limit (I) is given by this formula:

\[ R = \frac{0.4}{I} \]

However, the voltage threshold 0.4V is subject to a certain tolerance, as are the resistors. The small resistance of the inter-connecting tracks on the PCB must be taken into account, so the current limit is only a nominal figure.

The voltage difference between IC1 pins 1 and 2

Figure 1: the circuit of the Guardian Light
multiplied by the current flowing gives the power dissipated. This could exceed 2W with a seriously ‘flat’ battery, so the metal tab is bolted to the aluminium case which then acts as a heat sink. Most of the time, the current is quite small and the heat dissipated will be minimal.

The ins and outs
If the mains supply is on, current flows from IC1 pin 2 via diode D1 and fuse FS3 to charge battery B1. The fuse protects against too much current flowing in or out of the battery. In a mains failure, the voltage at IC1 output falls to zero. D1 then prevents any back flow of current from the battery into IC1. If the lamp switch S2 is on, current flows to the circuit section based on the dual op-amp IC3. This contains two independent, identical op-amps, IC3a and IC3b. The top half (IC3a) forms the light-sensing section while the lower one (based on IC3b) is the low-voltage warning indicator.

Look at IC3a and ignore the effect of D2 for the moment. The inverting input, pin 2, receives a voltage equal to half the supply (between about 5V and 7V), due to the potential divider action of R5 and R6. The non-inverting input (pin 3) is also connected to a potential divider made up of preset RV2 and fixed resistor R4 in the upper arm, and the parallel arrangement of light-dependent resistor LDR1 and fixed resistor R3 in the lower one. Ignore the effect of R3 for now. While there is sufficient light reaching LDR1, its resistance will be low and a relatively small voltage will develop across it. Providing this is less than half that of the supply, the voltage at pin 3 will be less than at pin 2, and IC3a output pin 1 will be low. There will be no further effect and relay RLA1 normally-open ("make") contacts will be open with lamp LP2 off. When the light level drops sufficiently, the resistance of LDR1 rises and the voltage across it increases. At a certain point, the conditions at IC3a inputs will reverse with the voltage at pin 3 rising above that at pin 2. The output will then go high, current will flow into Q2 base via resistor R12 and the collector current will cause the relay coil to energise. The normally-open contacts then close and allow current to flow from the supply to the bulb.

D3 bypasses the reverse high-voltage pulse which appears across the relay coil when the current is switched off. Without this, semiconductors in the circuit could be damaged. R10 provides some positive feedback and sharpens the switching action. The operating light level will remain the same with variations in supply voltage (that is, as the battery discharges). This is because the voltage at each op-amp input falls in the same proportion, so the relative conditions remain unchanged.

A bit inhibited
This bulb must not come on while there is a mains supply, and D2 prevents this. While there is a supply at IC1 pin 2, D2 maintains IC3 pin 2 high (supply voltage less 0.7V due to the diode). The voltage here will exceed pin 3 whatever the light level, noting that it is subject to a 0.7V “loss” due to D1 as usual. The op-amp will therefore remain off and so will the lamp. Most LDRs have a very high resistance in total darkness, almost an open circuit - probably much higher than the stated “dark” resistance. R3 is in parallel with the LDR, so the resistance of the two can never be greater than...
the value of R3 (1M). Without R3, the voltage across the LDR in total dark would rise to that of the supply, where it could exceed the voltage at pin 2 and switch on the op amp and the lamp. When more light reaches the LDR, R3 has only a small effect.

**Sound warning**

In the low-voltage warning section, IC3b non-inverting input pin 5 receives a fixed voltage of 5.0V due to the voltage reference ic IC2. R7 allows sufficient current to flow through it to enable it to work. Meanwhile, the inverting input, pin 6, receives a voltage equal to half the supply, due to potential divider R8/R9. When the voltage across B1 exceeds 10V, the voltage at pin 6 exceeds that at pin 5 and the output, pin 7, will be low. This will also be the case when there is a mains supply. If the supply voltage falls below 10V, the voltage at pin 6 will be less than 5V, pin 7 will go high and current will pass through R13 into the base of Q1. Collector current will then flow through the buzzer, sounding it. R11 provides some positive feedback and, as with IC3a, sharpens the switching action.

It is important to switch off the lamp using S2 soon after the warning sounds. If this is not done, the terminal voltage would eventually fall to the point where the relay "drops out". However, this does not happen until it reaches approximately 2V. The battery is likely to suffer some damage unless recharged promptly.

**Battery specification**

The specified battery totally sealed with a nominal capacity of 6.5 amp-hours: it could supply, say, 0.5A for about 13 hours. However, with a bulb of very low rating it will last longer. A larger capacity battery would be more expensive, bulky and probably unnecessary. Note that a battery designed for cyclic use (repeated charging and discharging) will last longer than the ordinary kind. However, the type designed for "float" operation will work well providing the lamp does not discharge it to the low point too often.

The buzzer should be loud while drawing only a small current. The prototype uses a pulsed-tone type (see the parts list). This has the usual red (positive) and black (negative) wires plus three others in green orange and yellow. If the green and orange wires are connected together it emits a pulsed tone (this was the mode I used). If the green and yellow are joined, it gives a two-tone sound. If they are left unconnected, it gives a continuous tone.

**Construction**

The PCB of the Guardian Light is single sided (see figure 2 for the component layout). Start by drilling the four mounting holes, and those for the components as indicated. Solder the relay, ic socket and fuseholders FS2 and FS3 into place. Add C1 taking care with polarity, then the other capacitors and resistors including the preset and LDR. Add the diodes, bridge rectifier, transistors and voltage reference device taking care over their orientation. The voltage reference ic has one flat side which should face towards IC3. Only two of its pins are connected. Solder IC1 in position as shown in the photograph. Make sure that the metal tab slightly overhangs the edge of the PCB to enable it to be bolted to the metal case later.

Solder pieces of different-coloured stranded wire to the points labelled "battery", "18V ac in", "S2" and "lamp". Add spade connectors to the battery wires. Adjust RV1 and RV2 to approximately mid-track position.

**Boxing up**

Important: The enclosure for this project must be made of metal and should be large enough to allow a gap of at least 50mm between the transformer and battery. This is because the transformer becomes quite hot when delivering the maximum current. The life of the battery will be significantly reduced if its temperature is allowed to rise above 30 degreesC.

Insulate the battery tags using PVC tape if this has not already been done. This is necessary because lead-acid batteries can deliver a very large current if short-circuited. This can cause wires to become red hot and result in burns and fire as well as damage to the battery.

Place the PCB, battery and transformer on the base of the box in their final positions (see photograph). Because the battery is fully sealed, it may be mounted on its side. Make sure that IC1 touches the case so that it can be bolted in position. Mark the PCB and transformer fixing holes and
remove the components. Drill these holes then attach the PCB temporarily using 12.7mm (0.5 in) plastic stand-off insulators on the bolt shanks. Mark the position of the hole in IC1 tab. Remove the PCB again and drill this hole. Make holes in the back panel for the strain relief bush to be used on the mains lead and the power-type socket (which will be used to connect the lamp). Make holes in the front panel for the mains panel fuseholder, neon indicator and for S1 and S2. Make holes also for the buzzer, depending on type. The specified buzzer is loud enough to allow it to be mounted inside the box as shown.

**Feeling the strain**

Solder the buzzer wires to the PCB. If using the specified unit, connect the orange and green wires together (to give a pulsed tone) or as required. Attach the circuit panel again and make sure that all connections on the copper track side of the PCB are clear of the metalwork. Attach IC1 using a small nut and bolt, checking that the pins are not left under any strain. No mounting kit or heat transfer compound is necessary but you should scrape the paint away from the contact area and attach the IC firmly to make good metal-to-metal contact. Attach the buzzer.

Mount the transformer with the solder tag on one of its fixings. Attach the battery on the base of the box using a small bracket. Do not connect it up yet. Attach also the switches, neon indicator and lamp connector socket. Measure the position of the LDR on the PCB and drill a hole of diameter 8mm approximately in the top section of the box to correspond. Note that the LDR should lie about 50mm beneath the hole. This will make its response very directional and will minimise the amount of light reaching it from the lamp being controlled (which is important).

Refer to figure 3 and complete the low-voltage wiring. Note that when wiring up the lamp socket, the outer (sleeve) connection must be connected to the negative "lamp" wire on the PCB (that is, the lower one).

**Mains section**

Now do the internal mains wiring. Use mains-rated wire and follow all relevant safety precautions. In particular, use an insulating cover for the transformer primary tags and a plastic boot on the panel fuseholder. Use fully-insulated spade receptacles on the mains on-off switch, panel fuseholder and neon indicator connections (see photograph).

Make a suitable input lead using 3A three-core wire. Secure it using the strain relief bush leaving a little slack inside the case. Fit a 2A or 3A fuse in the plug if it is of the UK pattern. Hook the earth wire and a further short piece of earth wire through the hole in the solder tag and solder them securely in place. Solder the short piece of wire to the negative (sleeve) connection of the lamp socket.

**Before proceeding, check that it is impossible to touch any mains connections at the transformer primary, fuseholder, neon indicator, on-off switch or anywhere else**

**Finishing off**

Insert the fuses into their holders. Note that fuse FS1 (for the panel fuseholder) must be of the mains high-rupture ceramic type as specified. Do not use a glass fuse here. Insert IC3 into its socket. Since this is a CMOS component, it is vulnerable to damage by static charge. To avoid this, touch...
something which is earthed (such as a water tap) before unpacking it and handling the pins.

Prepare a suitable lead for the lamp and fit the plug. The wire should not be too thin or there will be an excessive voltage drop (especially over a long length) and the bulb will be dim. It seems that suitable bayonet-type holders for small filament lamps are not readily available. You may end up having to solder the wires in position. This is acceptable since the lamp will probably not be on very often and will have a very long life.

Testing
Plug the lamp into the socket. Plug the unit into the mains and switch on. Note that if RV1 has been set to deliver less than 10V to the circuit, the buzzer will sound. It would therefore be wise to cover its hole with some PVC tape until testing is complete! Check that the neon indicator glows. With switch S2 on and with the battery still disconnected, measure the voltage between the battery connectors. Adjust RV1 until it lies between 13.5 and 13.6V (clockwise rotation of the sliding contact increases it). If S2 is off, there will be no load on the system, the forward voltage drop of D1 will be very small and this will result in a figure which is too low in operation. Switch off the mains and connect the negative battery terminal only, taking care over the polarity and observing the precautions to prevent short circuits mentioned earlier. Switch on the mains and measure the charging current to make sure it is below the limit. To do this, set the meter to a suitable current range and connect its leads between the unoccupied battery tag and the free wire. Since the battery is probably well-charged when supplied, the current is likely to be very low. Remove the meter and connect the battery positive wire.

After an hour or so, switch off at the wall socket to simulate mains failure. Shield the lamp so that light from it will not fall on the LDR. Apply a piece of Blu-Tak to the LDR window - the light should come on if this does not work, adjust RV2 clockwise a little and re-try. Switch on the mains and it should go off. RV2 should now be set so that the unit operates with the right amount of light in the room.

Clockwise rotation causes the circuit to switch on at higher current is at a maximum.

With the mains switched off to simulate failure again, allow the bulb to discharge the battery to the low point. Use the voltmeter to monitor the terminal voltage from time to time. At 10V approximately, the buzzer should sound. At this point, re-charge the battery. Check the current again. It should be about 200mA. If it is too high, adjust it by raising the value of R2. Note that the case will become warm, especially at the beginning of the charging cycle when the current is at a maximum.

Normally, the unit will be left in place and forgotten. Remember to switch off the lamp promptly if the warning sounds. Remember also to switch it on again when power has been restored.

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Magnetic Swipe Card Reader

An ISO track 2 card reader with PC-based Turbo Pascal software, by Magnus Pihl

If you've ever wondered what kind of information is written on the magnetic strip on your plastic cards, or want to build a security system around a card reader, this is for you. The applications of this little card reader are many, from simply exploring the technology used with magnetic card swipe readers, to building a full access control for an alarm system or doorlock. The application example given here is for a PC-based system. No PCB is needed.

How cardreaders work

There are several types of card reader: there are swipe readers, motor-driven readers and motor driven readers/writers. Swipe readers are the cheapest, and that is what we will use here. There are actually two types of swipe readers, the swipe readers with a TTL interface or swipe readers with an RS232 interface. The swipe readers with the TTL interface (actually just without RS232 interface) are the cheapest, and cost typically about £20, and - guess what! - that's what I have used in this application.

Omron's manual swipe card reader 3S4YR-HNR-4U is the one used in my prototype. This reads the ISO track 2 on the card. The BPI (bits per inch) can be adjusted manually by a switch inside the reader, and it can easily be rebuilt to read ISO track 1 or ISO track 3. Tracks 1 and 3 written at 120bpi, and ISO track 2 is written at 75bpi. When reading ISO track 2, the BPI switch should be set to 75bpi, the ISO standard for track 2.

A card can have several tracks that can be written on. Cards that follow the ISO standard have three tracks. The most used track is Track 2 is most used, so choose a card reader that can read ISO track 2, like the Omron's 3S4YR-HNR-4U. The connector has nine pins, configured as follows:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N.C.</td>
</tr>
<tr>
<td>2</td>
<td>N.C.</td>
</tr>
<tr>
<td>3</td>
<td>N.C.</td>
</tr>
<tr>
<td>4</td>
<td>RDP</td>
</tr>
<tr>
<td>5</td>
<td>RCP</td>
</tr>
<tr>
<td>6</td>
<td>CLS</td>
</tr>
<tr>
<td>7</td>
<td>CSV</td>
</tr>
<tr>
<td>8</td>
<td>+5V</td>
</tr>
<tr>
<td>9</td>
<td>Ground</td>
</tr>
</tbody>
</table>

In this application I only use RDP, RCP, +5V and Ground. Then, using the PC to read the RCP and RDP signals, and convert them to Ascii, I can read out the information. See figures 1 and 2 to see how the program decodes the data.

You cannot encode (programme) a card with a swipe reader. Encoders cost around £500-£1000, and are always motor-driven.

Construction

I use the PC's games port to interface to the reader. The connector is a 15-pin DSUB connector. Using a four wire shielded cable, connect the reader to the D-SUB connector as follows:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>(RDP) 7</td>
</tr>
<tr>
<td>5</td>
<td>(RCP) 2</td>
</tr>
<tr>
<td>6</td>
<td>(CLS) 14</td>
</tr>
<tr>
<td>8</td>
<td>(+5V) 9</td>
</tr>
<tr>
<td>9</td>
<td>(GND) 4,5,6,12</td>
</tr>
</tbody>
</table>

(Use the cable shield as GND)
The software

Turbo Pascal:

Program CardReader;

Uses Crt;

Const
    gameport=$201;
var
    ch,a:array[1..200] of integer;
    l,i,j,p,x,cn:integer;
    end_flag:integer;

Procedure Parity_check;
Begin
    if (p mod 2 = 0) and (a[i+4]=0)
    then begin writeln('Parity Error');i:=300;end;

    if (p mod 2 <> 0) and (a[i+4]=1)
    then begin writeln('Parity Error');i:=300;end;
End;

Procedure Translate;
Begin
    for i:=1 to 5 do
    Begin
        if a[i]=1 then begin j:=j+1;inc(p); end;
        Repeat Until (Port[gameport] and 32)=0;
        if a[i+1]=1 then begin j:=j+2;inc(p); end;
        if a[i+2]=1 then begin j:=j+4;inc(p); end;
        if a[i+3]=1 then begin j:=j+8;inc(p); end;
        ch[cn]:=j;
        parity_check;
        Repeat Until (Port[gameport] and 16)=0;
        Irc_count;
        End;
        i:=i+5;
        inc(cn);
    End;

Procedure Print;
Begin
    for i:=1 to 40 do
    Begin
        if (Port[gameport] and 32)=0 then
        if ch[i]>10 then write(ch[i]);
        if ch[i]=11 then write('<');
        if ch[i]=13 then write('');
        if ch[i]=15 then begin
            write('>');i:=40;end;
    End;

Procedure Read;
Begin
    wait_start;
    for i:=1 to 200 do
    Begin
        wait_clock;
        a[i]:=(data_input);
        wait_clock_end;
    End;

Procedure LRC_check;
Begin
    for x:=1 to 5 do
    Begin
        if (l[x] mod 2 = 0) and (a[end_flag+x-1]=1)
        then begin writeln('LRC ',x,' Error');
            i:=300; end;
        if (l[x] mod 2 <> 0) and (a[end_flag+x-1]=0)
        then begin writeln('LRC ',x,' Error');
            if ch[cn]=15 then end_flag:=i+5;
            a[i]=1 then inc(l[1]);
            a[i]+1=1 then inc(l[2]);
            a[i+2]=1 then inc(l[3]);
            a[i+3]=1 then inc(l[4]);
            a[i+4]=1 then inc(l[5]);
        end;
    End;

writeln;
writeln("Waiting for card programmed with ISO standard 3554-1976(E)");
writeln("-------------");
Decoding procedure

Cards following the ISO standard are encoded with 5 bits per character, (unless it is alphanumeric, as tracks 1 and 3 are). The first four bits are the actual data and the fifth bit is an even parity check. The last five bits are the longitude redundancy check (LRC). This is how it works:

The ASCII table:

<table>
<thead>
<tr>
<th>ASCII Value</th>
<th>Decimal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>1</td>
</tr>
<tr>
<td>0100</td>
<td>2</td>
</tr>
<tr>
<td>1100</td>
<td>3</td>
</tr>
<tr>
<td>0010</td>
<td>4</td>
</tr>
<tr>
<td>1010</td>
<td>5</td>
</tr>
<tr>
<td>0110</td>
<td>6</td>
</tr>
<tr>
<td>1110</td>
<td>7</td>
</tr>
<tr>
<td>0001</td>
<td>8</td>
</tr>
<tr>
<td>1001</td>
<td>9</td>
</tr>
<tr>
<td>1101</td>
<td>11            = Start sentinel</td>
</tr>
<tr>
<td>1011</td>
<td>13            = Field separator</td>
</tr>
<tr>
<td>1111</td>
<td>15            = End sentinel</td>
</tr>
</tbody>
</table>

The data is written in 5-bit words, always starting with the least significant bit, then two bits more, then the most significant bit, and finally an even-parity check bit. All even ASCII values should end with a zero, and all odd ASCII values should end with a 1 to be accepted by the system as correct data. When all 40 characters are transferred, the last 5-bit word is a longitudinal redundancy check. This is like a parity check, but longitudinal instead, covering all transferred data. Thus it is easy to check that all data was successfully transferred.

1101 0 = 11 = Start sentinel
0001 0 = 8
1010 1 = 5
1000 0 = 1
0110 1 = 6
1001 1 = 9
and so on...

Waiting for card programmed with ISO standard 3554-1976(E)

<8516998749515001 99055142018511111>

ACCOUNT NR    Expires May, 1999
Determined Amateur Designer Seeks Sponsorship for Rocket Development

Daniel Jubb, Britain's youngest participant in the international space race is as we write about to make a bid to put the world's first amateur-built rocket into orbit.

Daniel has been designing, building and launching single- and multi-stage rockets since he was nine. Now aged 13, he is planning to launch his latest rocket, the 14-foot Falcon 7 Mk II in April at the Otterburn Army Field Training Centre in Northumberland, the site of two of his previous launches. The latest rocket is a single-stage, reusable launch vehicle believed to be capable of reaching an altitude of 20,000 feet moving at around 3,000 mph.

The Falcon 7 has an on-board computer guidance and data logging system including components built to Daniel's own design. The details of the system are being kept understandably confidential, but the logging system can process over 200,000 bits of information per second operating at a speed of 19,200 Baud, and can store up to a gigabyte of data. The data will be gathered by sensors throughout the rocket reading information on speed, position, direction and the internal stresses it will undergo during flight. The rocket - prudently - also contains a custom-built radio data link incorporating a modem and transmitter.

The prize of US$ 2 million offered by a private American consortium for the first independent organisation to put a vehicle into orbit has attracted many competitors into the world of rocket technology.

The space race, including among dedicated amateurs and small-rocket researchers & fraught with uncertainty. Recently Starchaser, a two-year, £70,000 rocket project by the University of Salford Space Technology Laboratory, crashed into a firing range on Dartmoor after only 200 feet of climb when the motors failed to ignite in sync. The rocket's developers are setting back down at the drawing board for the next step in their mission to put a low-cost satellite into low earth orbit. Even Stephenson's Rocket started with James Watt's kettle.

Daniel Jubb has had several successful launches and plans to fit the Falcon 7 with a larger motor capable of taking the rocket 20 miles into the stratosphere following his April launch.

Daniel is looking for sponsorship from any company that may be able to provide specialist components or some modest financial support in his bit to break the records.

Anyone who wants to join the project with some sponsorship and wants more details should contact Robin Gregson at Interface PR, Brook House, 70 Spring Gardens, Manchester M2 2EO. Tel 0161 907 3075 fax 0161 907 3080

Major New Award Scheme for Technology Students

Eight of Britain's leading industrial companies have joined forces to sponsor the new Science, Engineering and Technology Student of the Year Awards, with the aim of changing attitudes towards technology education.

Prizes worth more than £40,000 will be presented at a ceremony in June 1998. The awards will cover the range of technology education from civil engineering to biotechnology and computer science. Some of the categories include:

Best Aeronautical Engineering student; best Electronic Engineering student; best Physics student; best Computer and Computer Software student; Best Civil Engineering student, and a number of other categories, as well as the Science, Engineering and Technology Student of the Year.

Awards organiser Malcolm Turner says: "there has been an unspoken assumption that making things is less prestigious than dealing in things. This is not the case in the USA, France or Japan, where technical degrees are among the most sought-after, or Germany, where engineering is considered to be more prestigious than medicine."

The awards can be seen as part of a movement in recent years to raise awareness of the importance of engineering and science in the UK.

Entry forms are being delivered to UK Universities and students must be entered by their lecturers, who must be full-time lecturers at universities within the United Kingdom of Great Britain and Northern Ireland. Lecturers must send a completed application form by not later than 15 May 1998.

For more information contact Turner Meredith Ltd., 13A Lower St. Haslemere, Surrey GU27 2NY. Tel 01428 658588 fax 01428 656155.
50% discount for ETI readers on Kenwood power supplies

Vann Draper is offering over 50% discount to readers of ETI magazine on the PAC range of high quality Kenwood power supplies until May 31st.

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To order simply post the coupon to Vann Draper Electronics Ltd at Unit 5, Premier Works, Canal St, South Wigston, Leicester LE18 2PL. Alternatively tel 0116 2771400, or fax 0116 2773945.

<table>
<thead>
<tr>
<th>Model</th>
<th>Rating</th>
<th>Ripple</th>
<th>Line reg'n</th>
<th>Load reg'n</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAC20-3</td>
<td>0-20V 0-3A</td>
<td>0.5mV rms</td>
<td>4mV</td>
<td>4mV</td>
</tr>
<tr>
<td>PAC30-2</td>
<td>0-30V 0-2A</td>
<td>0.5mV rms</td>
<td>5mV</td>
<td>5mV</td>
</tr>
<tr>
<td>PAC30-3</td>
<td>0-30V 0-3A</td>
<td>0.5mV rms</td>
<td>5mV</td>
<td>5mV</td>
</tr>
<tr>
<td>PAC30-6</td>
<td>0-30V 0-6A</td>
<td>1mV rms</td>
<td>5mV</td>
<td>5mV</td>
</tr>
<tr>
<td>PAC60-1</td>
<td>0-60V 0-1A</td>
<td>1mV rms</td>
<td>8mV</td>
<td>8mV</td>
</tr>
<tr>
<td>PAC60-3</td>
<td>0-60V 0-3A</td>
<td>1mV rms</td>
<td>8mV</td>
<td>8mV</td>
</tr>
</tbody>
</table>

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Signature :
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Richard Grodzik's compact 2k eprom programmer runs from DOS commands and programs in two seconds per eprom

The eprom programmer in this article was designed to program 2k 27C16 eprom in 2 seconds, using a 9600 baud serial PC connection and simple DOS commands. It's a handy small-sized board that can be carried around, runs from a 9-volt PP3 battery. An onboard dc-dc converter generates the programming voltage.

The 2k eprom
The 2-kilobyte eprom has been in use for over twenty years and always was a good starting point for eprom-based projects. It is found in countless microprocessor 'trainers' and for a long time has been widely available in the quick-programming 12V75 version, type 2716B0200. This project was designed to answer the need for a quick and simple solution to programming these devices. No software driver is required. Object code is sent from the PC to the Programmer using the simple DOS copy command. The RS232 protocol used for communication between the PC and the Programmer is 9600 baud, 8 data bits, no parity, 2 stop bits. To set up the PC for this protocol, the DOS 'mode' command is invoked:

MODE COM1:96,N,8,2

If the COM2 serial port is to be used, COM2 is substituted for COM1. Then it is a simple matter to send the object code 2048 bytes (0800H) in depth using the DOS copy command, that is:

COPY FILENAME.OBJ COM1/B

A couple of seconds later the eprom is programmed. Multiple eprom programming can be accomplished, as the onboard firmware runs in a continuous loop and is automatically re-configured for each successive eprom. The firmware to drive the Programmer is contained in a PIC, and a pre-programmed PIC is available from the author (see the end of this article).

The eprom
The 27C16B0200 eprom requires a nominal 100 microsecond programming pulse, a Vpp programming voltage of 12V75 and a Vcc supply of 6V2. Since it takes only 2.5 seconds to program the entire eprom, a battery-based voltage source is practical. I was faced with the problem of generating the various voltages from a PP3 9-volt battery. Glancing through the component catalogues revealed a 6V2 regulator (7862), available from Farnell electronics. The 13V dc-dc converter is available mainly from the manufacturers' agents. Two of them do one-off orders (see end of article) This works out a bit more expensive than the big catalogues, but only a pound or so plus the postage.

The main requirement for an eprom programmer is that no voltage is present on the eprom socket when the eprom is inserted or removed. At best, random data would be programmed into the eprom; at worst, the eprom would sustain catastrophic damage. The circuitry associated with transistor BD140 supplies the 6V2 voltage to pin 24 of the eprom socket only when the RA0 line of the PIC is low. Simple transistor action will then drive the PNP transistor into saturation, the emitter/collector junction attaining a near short circuit and thus applying the full 6V2 voltage to the supply pin of the eprom. The NM0513 is also controlled by the RA0 line via a FET (BS170) transistor switch. A low on the gate of the transistor will ensure that the transistor is switched off. The 'open collector' configuration, that is, no load resistor provides a very high impedance (a virtual open circuit) at pin 5 (the control pin) of the dc-dc converter and the full 12V75 is applied to the Vpp pin (21) of the eprom. A high on the RA0 line will drive the BS170 transistor into saturation and will reduce the converter output to 1V5. Simultaneously cutting off the BD140 transistor and isolating the 6V2 supply. A standard 78L05 5-volt regulator supplies both the NM0513 and also the PIC chip and 4040 counter.

The communications link between the PC and the eprom socket is based in the PIC16C54XT/P application specific programmable microcontroller which has been programmed to receive RS232 data at 9600 baud. Since at that speed each bit 'cell' is of 104 microseconds duration, a 2-stop-bit protocol has been chosen to create a 208 microsecond buffer zone between each received data byte. A software delay of 104 microseconds is used during this time for the programming pulse, the remainder used for software overhead and 'waiting time'.

The 'MPSIM' PIC simulator was used to develop the firmware and is especially useful in that precise measurements of software execution can be made to verify that a delay loop is of the required time duration. The 4-MHz crystal of the eprom writer produces a clock cycle time of 1 microsecond. The SC 1 command in the simulator will then show real time events as the software runs. Sure
beats the old method of consulting the manufacturer's data sheet to determine the execution time of each instruction and then calculating the total time required for a software loop. I was always a hundred microseconds out. But beware. Simulating a 1-second delay loop on the simulator takes at least an hour!

The purpose of the 4k7 resistor which grounds the RA1 pin of the PIC is to ensure that the RXD input (RA1) is at a logic-low level (a stop bit) if the communications link is disconnected. As successive serial data bytes are received, the PIC's firmware converts them to an 8-bit parallel data byte and presents them to the data bus of the eprom socket via port lines RBO-RB7. The programming pulse burns the data into the eprom and increments the eprom address counter on the falling edge of the pulse. A simple R-C network resets the 4040 counter on switch-on, clearing all 0 outputs to zero, that is, address 0000H. If a key is pressed inadvertently on the keyboard, the corresponding character will be transmitted from the terminal emulator to the eprom Writer - and the LED will turn on. Re-powering the Writer will re-initialise the system back to zero state. On completion of programming (when 2048 bytes have been received), the LED will go out, permitting the safe removal of the eprom, since all supply voltages to the socket will have been disabled.

Hints
If frequent use of the programmer is anticipated, then the reverse voltage protection diode (D1) may be omitted, extending the useful battery life. The CR circuit associated with the reset pin of the 4040 address counter has a long time constant to ensure that any glitch on line RA2 does not activate the counter on switch on. This was found to be the case with the OTP but not the UV version of the PIC.

The PIC Listing (27C16.LST)

```
0001:     LIST p=16C54
0002:     RXD        EQU 1          :PA1
0003:     STATUS     EQU 3          :STATUS REGISTER
0004:     PORT_A     EQU 5          :PORT A
0005:     PORT_B     EQU 6          :PORT B
0006:     MSB        EQU 7          :PORT A
0007:     COUNTR     EQU 8          :PORT B
0008:     DLYCNT     EQU 9          :BYTE COUNTERS
0009:     BUFFER     EQU 10         :BYTE COUNTERS
0010:     BHIGH      EQU 11         :BYTE COUNTERS
0011:     BAUD_1     EQU .32         :9600 BAUD 1 BIT PERIOD
0012:     BAUD_1ST   EQU .48         :1.5 BITS
0013:     COUNTR     EQU 0BH        :STATUS REGISTER
0014:     DLYCNT     EQU 9          :BYTE COUNTERS
0015:     BUFFER     EQU 0AH        :BYTE COUNTERS
0016:     BHIGH      EQU 0DH        :BYTE COUNTERS
0017:     BAUD_1     EQU .32         :9600 BAUD 1 BIT PERIOD
0018:     BAUD_1ST   EQU .48         :1.5 BITS
0019:     ...
0020:     ...
```
Figure 2: A suggested configuration for accommodating a larger eprom.

Figure 3: The component layout for the 27C16 Eprom Programmer.

```
0000 ORG 0

start

0000-0000 NOP
0001-0000 NOP
0002-092F CALL INIT

EPROM

0003-0C40 MOVWF .64
0004-002C MOVWF BLOW
0005-0C20 MOVWF .32
0006-002D MOVWF BHIGH

CYCLE

0007-0725 BTFS PORT_A,RXD
0008-0A07 GOTO START_BIT

0009-0405 BCF PORT_A,0 ;POWER ON

000A-0C08 MOVWL 8 & DATA BITS
000B-002B MOVWF COUNTR

000C-0929 CALL DELAY1ST ;1.5 BITS DELAY
000D-006A CLRF BUFFER ;CLEAR BUFFER

DELAY

000E-0403 BCF STATUS,0
000F-032A RRF BUFFER
0010-0625 BTFS PORT_A,RXD;
0011-05EA BSF BUFFER,7
0012-0923 CALL DELAY

0000-0000 NOP
0013-02EB DECFSZ COUNTR,1
0014-0A0E GOTO NEXT
0015-0cff MOVWF OFFH;INVERT DATA
0016-018A XORWF BUFFER,0
0017-0026 MOVWF PORT_B ;SEND TO PORT
0018-0545 BSF PORT_A,2 ;CE/PGM HIGH
0019-0923 CALL DELAY ;BURN PERIOD 104 uS
001A-0445 BCF PORT_A,2 ;CE/PGM LOW
001B-02EC DECFSZ BLOW,1
001C-0A07 GOTO CYCLE
001D-0C40 MOVWL .64
001E-002C MOVWF BLOW

001F-02ED DECFSZ BHIGH,1
0020-0A07 GOTO CYCLE
0021-0050 BSF PORT_A,0 ;POWER OFF
0022-0A03 GOTO EPROM

0023-0C20 MOVWL BAUD_I
0024-0029 MOVWF DLVCNT
0025-02ED REOI DECFSZ DLVCNT,1
goto REOI
0026-0A25 clrwdt
0027-0004 retlw 0
0028-0800 retu
```
DELAY1ST

0095: 0029- 0C30  MOVWL BAUD_1ST
0096: 002A- 0029  MOVWF DLYCNT
0097: 002B- 0E9E REDO1ST DECFSZ DLYCNT,1
0098: 002C- 0A2B  goto REDO1ST
0099: 002D- 0004  CLRWDY
0100: 002E- 0900  retlw 0

0101:

0102: INIT

0103: 002F- 0C02  MOVWL 2

0104: 0030- 0005  TRIS PORT_A
  ;RAO OUTPUT 6V2,12V75 CONTROL

0105: 0800  RETLW 0

0106: 0006  TRIS PORT_B ;RBO-RB7 DATA OUTPUT

0107: 0C30  MOVWL BAUD_1ST
0108: 02E9  REDO1ST  DECFSZ DLYCNT.1

0109: 0031- 0000  MOVWL 0

0110: 0032- 0006  TRIS PORT_B ;RB0-RB7 DATA OUTPUT

0111:

0112: 0033- 0CFF  MOVVLW OFFH ;PORT B LINES ALL HIGH

0113: 0034- 0026  MOVWF PORT_B

0114:

0115: 0035- 0445  BCF PORT_A,2 ;PGM/CE LOW

0116: 0036- 0555  BSRF PORT_A,0 ;POWER OFF

0117: 0037- 0565  BCF PORT_A,3 ;BURN MODE

0118:

0119:

0120:

0121: 0038- 080C  RETLW OCH

0122:

0123:

0124: ;

0125: 0000  org 01FFb

0126: 01FF- 0A00  goto start

0127: ;

0128: 0000  END

Cross Reference

27

Symbol  Def.  Value
BAUD_1   0016  00000020
BAUD_1ST  0017  00000030
BHIG     0014  0000000D
BLOW     0013  0000000C
BUFFER   0012  0000000A
COUNTER  0010  0000000B
CYCLE    0037  00000007
DELAY    0085  00000003
DELAY1ST 0094  00000029
DLYCNT   0011  00000009
EPROM    0029  00000003
INIT     0102  00000002F
MSB      0009  00000007
NEXT     0051  0000000E
PORT_A   0007  00000005
PORT_B   0008  00000006
REDO1    0088  00000025
REDO1ST  0097  0000002B

Resistors
R1        22k
R2, R5    4k7
R3        10k
R4        47k
R6        3k9
R7        2k2
R8        56k
R9        1k

Capacitors
C1, C3    10uF
C2, C4    100nF
C5, C6    33pF

Semiconductors
IC1        7862 6.2V regulator (Farnell LM78L62ACZ No. 412-958)
IC2        78L05 5V regulator
IC3        NMF0513S 13V dc-dc converter (see below)
IC4        PIC16C54XT/P (available reprogrammed from the author)
IC5        4040 ripple counter
D1, D2    1N4148
Q1         BS170 fet
Q2         BD140 pnp transistor
LED1      5mA miniature led

Miscellaneous
X1         4MHz crystal
Z1         24-way zif socket
S1         9-way D-type socket
S2/P1      3-way miniature DIN socket and plug
9V battery and connector.

A pre-programmed PIC plus DOS-printable PCB artwork is available, price £17.50 including post and packing, from Mr. R.Grodzik (MICROS) 53 Chelmsford Road Bradford BD3 8QN.

The 27C16 eprom is available from Farnell Electronic Components, part no. 246-712 (200ns) £3.72 plus vat and carriage, or the faster 150ns (246-700) at £3.82 plus VAT and carriage. Farnell Electronic Components, Canal Road, Leeds LS12 2TU Tel 0113 2636311.

The NMF0513S 13V dc-dc converter is available one-off from Campbell Collins Ltd., Boulton Road, Stevenage, Herts SG1 4XQ Tel 01438 369466, price £8.17 plus £2.50 VAT and carriage, or XT Plc, Horseshoe Park, Pangbourne, Berks RG8 7JW Tel 0118 9845515. Price £12.40 inclusive of VAT and carriage.
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Remember classified gets results fast
This month we shall continue with more of the calculations used in developing circuits. Last time we looked at the way in which a panel microammeter of the traditional pointer-on-scale (analog) type could be made to read volts. This time we shall look at how the same type of meter can be re-scaled to read a current range higher than its present full-scale value. For example, how a 0 - 100uA meter could be made to read up to 50mA.

**Scaling up**

Suppose your meter has a 0 - 50uA scale. You are making a battery charger and want the meter to read up to 5 amp. You know from the manufacturer's or supplier's data that the meter has a resistance of 4300 ohms (4.3 kilohms).

The solution is to connect a resistor (called a shunt) in parallel with the meter as shown in figure 1. This resistor has a much lower value than that of the meter so most of the current will flow through it (that is, it will bypass the meter). At full-scale deflection, only 50uA is allowed to flow through the meter while the balance (5A - 50uA) will flow through the shunt. This works out at 4.99995A so, for all practical purposes, we may regard the entire 5A as flowing through the shunt (the error is only 0.001 percent).

Perhaps the easiest way to understand how to calculate the value of the shunt, R, is to find the voltage which exists across the meter when the full-scale current of 50uA flows through it.

Using Ohm's Law and remembering that a current of 50uA (0.00005A) flows through the meter and this has a resistance 4.3k, the voltage across it may be found thus:

\[ V = I \times R = 0.00005 \times 4300 = 0.215V \]

Referring to figure 1 again, it will be seen that since the ends of the shunt are connected to the terminals of the meter, the same voltage (0.215V) must exist across the shunt also.

Ohm's Law is used again - this time to calculate the resistance of the shunt. Remember, the shunt may be regarded as carrying the whole 5A and 0.215V exists across it:

\[ R = \frac{V}{I} = \frac{0.215}{5} = 0.043 \text{ ohms} \]

The problem is finding a resistor having such a low value. Suppliers' catalogues do not list resistors lower than about 0.1 ohm. You could obtain a fairly close value by connecting two 0.1-ohm units in parallel giving 0.05 ohm. However, the error here is about 16 percent and so is not really acceptable. You could "trim" this value and make it a little lower by connecting a relatively high value resistor in parallel with the pair. For example, a parallel arrangement of 0.1, 0.1 and 0.33 ohms gives a very close result - 0.0434 ohms (an error of about 1 percent).

Note: Performing calculation on resistors in parallel was the subject of Practically Speaking in ETI Issue 2 this year.

A further example will make this all clear.

**Example:**

You require a milliammeter scaled 0 - 250mA and you have available a microammeter scaled 0 - 100uA and having a resistance of 3750 ohms.

Referring once again to figure 1, with a total current of 250mA (0.25A) flowing, there will be 100uA passing through the meter. The current in the shunt is then (0.25A - 0.0001A) = 0.2499A. As in the last example, we can regard the whole 250mA as flowing through the shunt. The error is extremely small.

Using Ohm's Law to find the voltage across the meter when 100uA flows through it:

\[ V = I \times R = 0.0001 \times 3750 = 0.375V \]

Applying Ohm's Law again to find the resistance of the shunt and (remembering that 0.375V exists across it):

\[ R = \frac{V}{I} = \frac{0.375}{0.25} = 1.5 \text{ ohms} \]

Fortunately, this value is available "off the shelf".

If the new full-scale deflection is much greater than that of the meter there is no problem in regarding the total current as flowing through the shunt. However, if the new full-scale deflection (fsd) were to be, say, 500uA and the meter had an fsd of 50uA, there would be a considerable error. In this case, you would need to say that 450uA was flowing through the shunt when doing the calculation.

You can make a new scale for the meter by removing the old one, spraying it with matt white paint, and applying the new numbering using dry print lettering.

Note: When making a calculation on resistors in parallel, the resistance of the parallel combination is always less than the lowest resistance used.

**Figure 1:** Using a parallel resistor, in this case 0.27R, to increase the scale of the meter.
Electronic(hr] phobes in the modern world know that a business called Intel makes a processor called the Pentium II, and dimly realise that it is one of the most powerful things that you can find inside a computer. Now that even toasters contain microprocessors, what's new at the other end of the range that concerns DIY designers and builders?

It may not surprise anyone that I am thinking of Microchip, makers of the widely used PIC range of microcontrollers. Looking through the new catalogues, I noticed that, since the last time I looked at the section, an 8-pin PIC-family has appeared. The basic model, PIC12C508, costs around £1 a piece, and can store up to 512 x 12-bit instructions. It has 25 bytes of data ram, and a completely internal 4MHz clock. As a result, 6 pins are available for I/O. It also contains a timer, a watchdog, and it can be programmed in circuit. Perhaps you could connect your toaster to the Internet and have its software upgraded.

The PIC12C508 is probably more than enough to control a toaster, and is suitable for a number of other appliances which would otherwise use complicated cams and switches, hard-wired logic, or a more expensive processor. Of course, the idea of programming it in Java is probably a non-starter, but where you are going to make hundreds or thousands of something, it is probably worth paying for an extra man-day of programming to avoid the need for a more expensive processor in each one.

Microchip have recently announced the PIC12CE673 and PIC12CE674 processors. These are the same except that the '74 can store 2048 bytes of flash memory to store data while in the program state. It can also be programmed in system, and contain a timer plus a watchdog timer.

In addition, four of the six digital I/O pins can double as 8-bit analogue to digital converter inputs. You could do a lot with that.

Two of the basic models are available from both Farrell and RS/Electromall, so they are accessible to constructors. Now, who is going to design a programmer for this tiny PIC, or a project that uses one?

That is an example of an editorial question which may be looking for an editorial answer. ETI now has a page on the World Wide Web. Initially we have posted some of the basic information which is often requested, such as the contents of forthcoming and current issues, publication dates, contact addresses, and some useful electronics links. In future, we expect to add any MODSMODS or updated component supply information for projects, in advance of the next issue reaching the newsstands.

Also under longer term planning is a master project index, going as far back as is practical, notes for contributors, and possibly letters and technical tips. Tell us what you think. One thing we will lack for the foreseeable future is unlikely to be much software on the site, for copyright reasons. The URL is http://www.aaelectron.co.uk/eti/, and the email address is eti@aaelectron.co.uk.

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