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ELECTRONICS TODAY INTERNATIONAL

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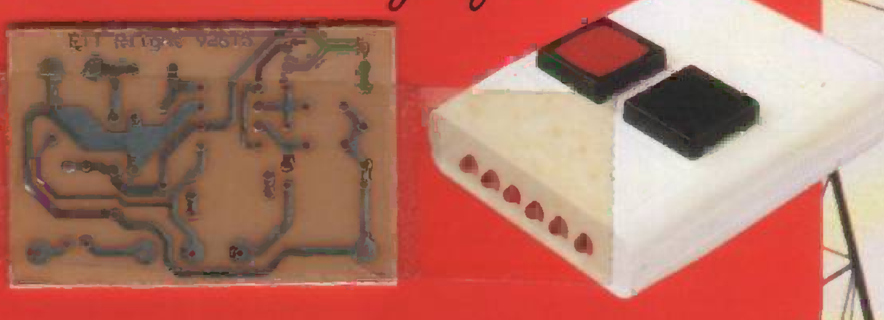

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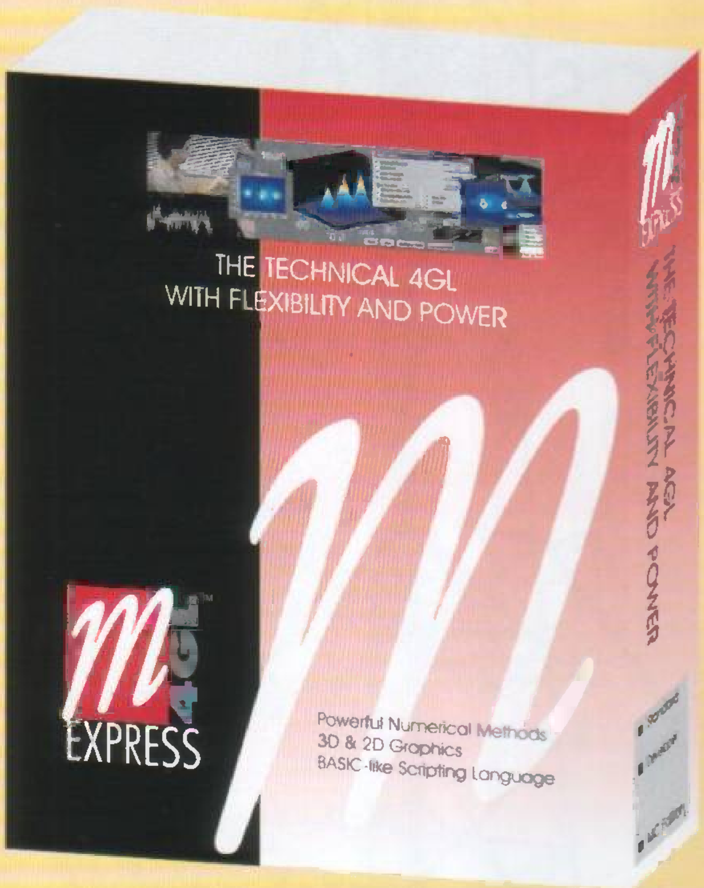

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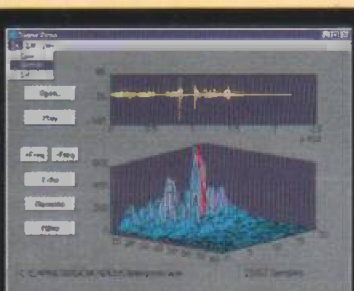

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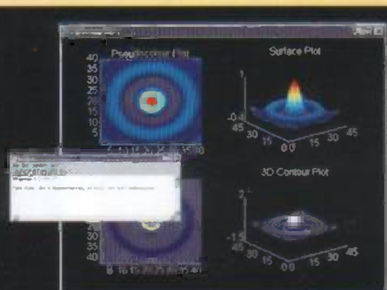

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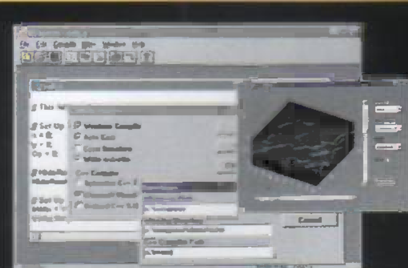

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QUICKROUTE SYSTEMS

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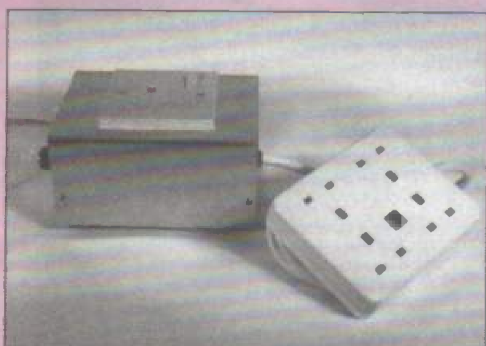
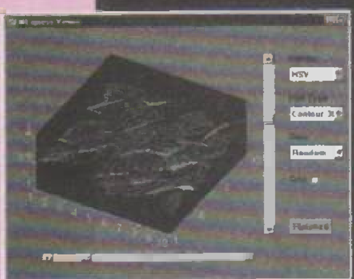


Regulars

ETI ELECTRONICS TODAY INTERNATIONAL News...

MExpress 1.1 for Windows



CAD designers Quickroute Systems have released a new numerical calculation and graphics program, MExpress 1.1, driven by their newly developed scripting language, which they describe as "Think of it as "Basic" for engineers and scientists".

The Basic programming language appealed to programmers because it was relatively easy to learn, use and read. Quickroute identified the need, in this age of increasingly complex programming languages, for a language with the interactive ease of use of Basic, but the extensive and powerful 32-bit functionality of a modern scientific and engineering development tool.

MExpress scripting language has over 250 built-in functions covering areas from solving simultaneous equations and signal processing to advanced 2-D and 3-D plotting and creation of user interfaces. By typing commands at a prompt, MExpress can be used as a "supercharged programming calculator". Data can be loaded, process and plotted or rendered into another visual form by calling on the powerful built-in functions.

Once the basic commands have been mastered, the user can move on to creating script files (similar to batch files) and functions that can be added to the program's own library of functions. Finally, complete applications, with buttons, sliders, multiple windows, menus and so on can be created, and users of the Developers Edition can compile these functions into a Win32s executable file, which can be distributed free of royalties.

Samples of functions within MExpress include: ACos, Angle, ATan, ATan2, ATanh, ExOr, Log, Log10, Remainder, Sign (basic maths); ExportASCII, ExportImage, ExportMEXP, Fileseek, ImportASCII (file support); Difference, Integrate, IsText, IsVector, SortMatrix (matrix functions); BarPlot, Histogram, LogYPlot2d, Plot3d, StairsPlot (general plots) Axes, Axis, Menu, Patch, Window (graphics primitives) Animate, Capture, GetSetWindow, Grid, Multiplot, MakeContours, Title, WClear (graphics support); CaptureSize; Hidden; PrintWindow (graphics utilities); Condition, PolyChar, PolyCurve, Rank (equation solving); Correlate; Identify, RandNorm (special matrices); ColAdd, ColCumMult, GetMinindex, Median, Skew (statistical fucntions); Else, End, Function, Global, Return (structure); Date, Delay, FuncEvaluate, Help, Remove, SetDebug, SPrintF, Type, Whatis, Whereis (system commands) - there are over 250 functions in all.

The RRP for MExpress is £99 (standard edition), or £299 (developers edition), exclusive of VAT, with a 30-day money back guarantee (terms from Quickroute on request). The Developers Edition requires a C++ compiler, which can by Symantec C++ 7.2, Microsoft Visual C++ 2.0, or Borland C++ 5.0. QUickroute Systems are developing the software actively, and plan extra updates and new features regularly, as well as links to other popular mathematical and engineering packages.

For more information, contact Quickroute Systems Ltd., Regent Hosue, Heaton Lane, Stockport SK4 1BS UK. Tel 0161 476 0202 Fax 1061 476 0505 WWW http://www.quickroute.co.uk

RadCom/CdRom

The Radio Society of Great Britain (RSGB) is to issue its monthly magazine RadCom (Radio Communication) as an annual on CD-ROM for the first time. The disc will contain the 12 monthly issue of the 100-page journal for 1996, plus all the year's issues of the beginners' magazine DiY Radio. Using Adobe Acrobat software (the Windows version is also supplied on the CD) it is possible to view the pages on a suitable PC, Mac or Unix-based computer in the same format as they appear on the printed page.

In this form the reader can VIEW all words and illustrations; SEARCH for any word or phrase; JUMP quickly from the contents page to each article; PRINT any page or article and store the 1996 publications neatly.

The disc contains 12 editions of RadCom volume 72 (1996); the annual index of RadCom; 6 editions of DiY Radio volume 6 (1996) and Adobe Acrobat Reader 2.1 for Windows. The recommended system requirements are 486 or Pentium personal computer with a CD-rom drive and 4 MB of spare hard disk space; Windows 3.1 or above with 4MB of ram, Windos 95 with 8MB of ram or Windows NT 3.5.1 or above with 16MB of ram. RadCom 96 can be read on other computers, such as Mac, Unix or DOS models with the appropriate version of Adobe Acrobat Reader, which is downloadable from Adobe Systems Incorporated Website at http://wwwladobe.com.

RadCom 96 costs £18.80 to non-members and £15.99 to members of the RSGB. Contact the RSGB at Lambda House, Cranborne Rd., Potters Bar, Herts EN6 3JE tel 01708 659015 for further information, or visit their Website at http://www.rsgb.org/books/bookmenu.htm.

Young Radio Amateur of the Year 1997 - Countdown for Nominations

The Radiocommunications Agency together with the Radio Society of Great Britain (RSGB) have announced the Young Amateur of the Year Award 1997.

The annual Award is open to anyone under 18 who has an interest in radio. Candidates do not need to be radio licence holders, but the following activities will be taken into account:

- DIY radio construction
- Radio operation
- Community Service (such as helping the disabled or assisting in emergency communications)
- Encouraging others (for instance, through the Novice Licence scheme)
- School projects

The prize, awarded for the most outstanding achievement between 1 August 1996 and 31 July 1997, will be awarded by the Radiocommunications Agency and presented at the RSGB's HF Convention in September 1997. All entrants will receive a copy of the RSGB's amateur radio log book. The winner will receive a £300 cash prize from the Agency, while the runner-up will receive a £50 cash prize from the agency and amateur radio equipment from the RSGB. Both will be invited to visit the Agency's Radio Monitoring Station at Baldock, Herts.

The Award is open to any resident of the UK, channel Islands or the Isle of Man who has not reached his or her 18th birthday by the closing date for applications, which is 31 July 1997. Entries must be nominated by an adult sponsor, who however does not have to be a radio licence holder.

The Award hopes to generate interest in amateur radio and to encourage people to become involved. Launched in 1988 as part of the RSGB's Project Year (Youth into Electronics via Amateur Radio) initiative, the Award has been supported by the Radiocommunications Agency, and led directly to the Novice Licence Scheme, aimed primarily at young people.

Applications should be sent to: The Young Amateur of the Year Award, Radio Society of Great Britain, Lambda House, Cranborne Road, Potters Bar Herts EN6 3JE. Tel 01707 659015.

New RISC microcontroller has single-cycle execution

The Atmel Corporation has developed the semiconductor industry's first "true" 8-bit RISC microcontroller with an enhanced architecture tuned for high-level languages such as C. The AVR design gives high performance for low power, and "true" single-cycle instruction execution (without clock division). The AVR RISCK is based on a Harvard architecture with an enhanced RISC data path. Atmel state that where most CISCs execute instructions in 8 to 20 clock cycles and RISC-like micros may use clock division to mimic single-cycle execution, the AVR architecture offers "true" single-cycle execution allowing a throughput performance 10 times faster than any other 8-bit micro operating from the same frequency. Owing to the relation between power consumption and frequency, the AVR can function at a clock frequency 10 times lower and achieve the same performance, giving a design tradeoff between high performance and power consumption.

The AVR incorporates 32 fast-access registers all simultaneously available, which help the C developer to develop very compact coding, as data does not have to be shifted between the accumulator and the main memory consecutively.

The first chips to arrive will be the AT90S100 (20 pins, 1K Flash memory, 32 registers and 64 bytes eeprom), ATS90S2312 (20 pins with 2K Flash, 32 registers, 64 bytes Sram and 128 bytes eeprom) and the AT90S8414 (40 pions, 8K Flash, 32 registers, 256 bytes Sram and 256 bytes eeprom).

The AVR has the potential to become a popular microcontroller with small-scale designers and serious hobbyists as well as industrial users. It is described as being able to execute many instructions in a single clock cycle, owing partly to the 32 working registers to carry out operations, and some complex instruction set commands to improve flexibility. The low power consumption makes it suitable for battery operated products. Current consumption of 1.5mA @ 4MHz, 400 uA, and it features low power idle and power down mode under 1uA consumption which can be woken up by an external interrupt. The device is aimed at being programmed in C, which allows quicker development than machine code. The AVR is scaleable, allowing code and clock-cycle compatibility for 8-bit and 16-bit implementations.

Atmel also provide a low cost development kit ATM3165. Distributors include Abacus Polar and G D Teknic. For more information contact Jimmy Tse at Technical Publicity Tel 01582 450054.

Mini-drill gets more power

The popular Minicraft MB1000 Hobby Kit hardware and drilling kit has been uprated - the MB1000 drill now has a more powerful motor and upgraded transformer, giving it twice the power of its predecessor. The list price remains unchanged at £44.99. The starter kit contains a lightweight (4oz) pencil-grip drill, plug-in power supply, and 20 versatile accessories in a robust carrying case. Minicraft's catalogue and stockist list can be obtained from Minicraft, Units 1&2, Enterprise City, Meadowfield Av., Spennymoor, Co. Durham DL16 6FJ. Tel 01388 420535.

Student Enterprise Placements

Launching the Shell Technology Enterprise Programme (STEP) for 1997, Science and Technology Minister Ian Taylor said: "Small businesses must be receptive to new technologies and to the skills of young people who can apply them commercially, and to the need to invest in both." STEP encourages undergraduates to experience the workings of small firms, and of getting small firms to realise the value of employing trained people. Small and medium UK firms employ over 70 percent of the UK workforce, and a recent DTI study showed that better-than-average business performance is strongly related to the employment of highly skilled people and to levels of investment in Research and Development.

STEP, inaugurated by Shell in 1986, is the UK's foremost placement for undergraduates. Penultimate year undergraduates are places in small and medium sized enterprises (SMEs) for 8 weeks during the summer vacation to work on projects identified by the companies. Each graduate receives an allowance, the cost of which is shared equally between the host company and a national or local sponsor, including the DTI. The area of national coverage has been extended steadily over the last 5 years.

Enquiries about STEP can be directed to the DTI on 1071 215 5000.

ETI News...

ELECTRONICS TODAY INTERNATIONAL

Apprenticeships wanted in the Luton area

The University of Luton, in conjunction with Bedfordshire TEC, the NCVQ, Business Link Bedfordshire and BTEC has launched its own Graduate Apprenticeship Scheme of small and medium-sized businesses to provide a level of supervision and training for up to two years. Research shows that SMEs in this area provide 35 percent of employment opportunities, and have a relatively high number of unfilled vacancies. The University is seeking businesses to participate by offering Graduate Placements to recent graduates working towards a relevant NVQ.

For more information contact J. Graham-Wilson on: 01582 743718.

Shorts

The three-hour workshop on designing Coils, Transformers and Inductors via the Internet will take place at the 1997 Annual Coil Winding, Insulation and Electrical Manufacturing Conference at The Messe, Berlin, Germany 10 - 12 June 1997, Europe's largest exhibition for electro-magnetic coil winding, electrical insulation, electrical manufacturing and motor/transformer repair. The workshop will be presented by leading expert Mr. Hadzi-Ratibor of Switzerland. Contact CWI/EME Inc., P O Box 936, Parkstone, Poole, Dorset BH12 3HB UK. Tel 01202 743 906

OVERSEAS READERS

To call UK telephone numbers, replace the initial 0 with your local overseas access code plus the digits 44.

Eprom emulator with 3.3V option

Scanlon Design Inc. has added the E1 eprom emulator to its range of E4 series eprom emulators. These with emulate 1 megabit (E1) and 4 megabit (E4) eproms. Both series have the same features, which include error checking and correction while downloading, low power cmos design, fast loading through a PC printer port, an 85 ns access time standard, with 35 ns optional; DOS-based PC software tools; compact size in a rigid case; power-off backup circuit and 28- and 32-pin dip eprom adapters included (with PLCC adapters as optional).

All JEDEC 28- and 32-pin eproms and flash eproms from 8k x 8 to 128k x 8 (E1) and to 512 x 8 (E4). Options include 3.3V operation, opto-isolated download cable, target adapters for PLCC packages and x16-bit 40-pin eproms and older 24-pin eproms.

The E1/4 software features include reading of binary, Intel, Motorola S and Tektronix file formats, mapping of source files anywhere in the target address space independent of eprom size and base address and full Screen and Command line mode; Users Guide and free upgrades.

The E1-85ns costs US$199 and the E4-85ns US$249 ex stock. Further information from Scanlon Design Inc., 5224 Blowers St., Halifax, NS Canada B3J 1J7. Tel +1 (902) 425 3938 Web.isisnet.com/oceana/SDI email 71303.1435@COMPUSERVE.COM.

MODSMODSMODSMODSMODSMODS

Where chips are hard to get hold of, it is worth making enquiries to suppliers that supply second user and salvage hardware. An informer recommends Greenweld Electronic Components Tel. 01703 236363.

Stag launches lower-price hand-held programmer

The Stag P301 from Stag Programmers, an international producer of silicon programmers, reached the lowest price achieved for full featured hald-held/portable programmers. At £350 the Stag P301 undercuts comparable hand-held programmers without reducing its functionality, and includes Windows and DOS software for full remote control from PC. It is also the first hand-held/portable programmer to facilitate wireless communication with a host PC via an integral infra-red IrDA interface, as well as an RS323 port as standard.

The Stag P301 provides programming support for up to 32-bit structures based on 8-bit devices through a single wide blade socket allowing 8, 24, 28 and 32 pin DIP packages with 0.3 in or 0.6 in pitch. Devices supported include eproms, eeproms, serial eeproms and Flash/cmos proms, with adapters for PLCC, TSOP and SOIC devices. The device support library is fully updatable. the standard 1Mbit (128k) of ram is expandable to 4 Mbit (512k) or 8 Mbit (1 Mbyte). 8, 16, or 32-bit structures are supported, and automatically handled by Stag's unique 'Interlace 2' method of splitting and shuffling data without the intervention of the user.

For more information contact Stag programmers Ltd. Telephone: 01707 332 148 Fax: 01707 371 503.

The Giants and the INVISIBLE INVADERS

The danger to human health posed by massive power transmission lines has already attracted debate, but the real peril may be invisible enemies - natural radon gas, and tiny particles concentrated in strong electric fields. Douglas Clarkson investigates the research so far.

The balance of safety in society has a historical perspective. Safety cannot be introduced until risk is demonstrated. The understanding of contaminated water supplies revealed the way cholera was spread, but also led to schemes for safe piped water. In respect of electric and magnetic fields, present safety guidelines indicate that general levels of present public and occupational exposure are believed to be adequately safe.

Groups such as the National Radiological Protection Board (NRPB) have issued reports reflecting the current consensus of research into the safety aspect of electromagnetic fields. The initial report published in 1992, with supplementary updates in 1994, and has emphasised the need to follow up with more research - but the emphasis is on a vast swath of research indicating no link between electromagnetic radiation and cancer. The initial Doll report of 1992 has, in fact, 436 references.

It could be, however, that the potential risk from electromagnetic fields is multifaceted. Several factors which, in isolation, exhibit low or negligible levels of risk may act to present a significantly higher risk when their effects are combined. This is one suggested train of thought from Professor Henshaw of Bristol University, and will be a main theme of this article.

Human society has what we might call a careless relationship with risks. It will seek to research to the nth degree for a possible risk link with factor x in society, but live comparatively comfortably with several thousand deaths per year in the form of road accidents, household accidents, accidental and self-inflicted medical poisonings, pneumonia ... and so on. It is also hesitant to take seriously a considerable body of evidence of the risks of radon gas - present in the environment as a 'natural' radioactive element. In fact an in depth look at radon - how it enters the human body and how this can possibly be influenced by electric fields - is a key part of this article.

Table 1: Definitions of electromagnetic fields up to top of the microwave range of frequencies

Group	Subgroup	Frequency range
Microwaves	Extra High Frequency	300 GHz - 30 GHz
Microwaves	Super High Frequency	30 GHz - 3 GHz
Microwaves	Ultra High Frequency	3 GHz - 300 MHz
Radio frequency	Very High Frequency	300 MHz - 30 MHz
Radio frequency	High Frequency	30 MHz - 3 MHz
Radio frequency	Medium Frequency	3 MHz - 300 kHz
Radio frequency	Low Frequency	300 kHz - 30 kHz
Radio frequency	Very Low Frequency	30 kHz - 3 kHz
Voice Frequency		3 kHz - 300 Hz
Extremely Low Frequency		300 Hz - 30 Hz
Static fields sub-ELF		30 Hz - 0 Hz

A range of terms is used for electromagnetic fields. Table 1 summarises the main definitions.

The area with a high profile at present is the Extremely Low Frequency area between 300 Hz, and 30 Hz - the 50 Hz and 60 Hz of mains power transmission. Also, the area of mobile phones in the UHF band is attracting increasing interest on account of the very rapid increase in use and the correspondingly rapidly rising exposure to it.

Before introducing details of how safe man-made forms of pollution such as overhead power lines actually are, it is appropriate to look at an ever-present natural agent which carries a known and entirely measurable level of risk.

Living with radon

Although radon-222 has been well known for several decades in relation to its presence in the domestic and workplace environment, the absolute level of risk from all mechanisms of interaction has not yet been exactly quantified, though it is known to be a significant risk to the population at large. Scientific interest in Sweden during the 1950s was only taken up more generally in other countries during the 1980s.

The risk to people from exposure to radon is giving rise to increased anxiety, with active programmes to reduce the exposure of vulnerable households. This problem is largely caused by the leakage of radon from rocks such as granite into homes built above the bedrock, where the gas is inhaled so that alpha particles are emitted in the lungs.

Figure 1 indicates the decay chain of radon-222. This gas, being a noble gas in the same series as argon and krypton, is chemically unreactive. It has a half life of 3.82 days, so that significant amounts of the gas can migrate from the deeper layers of the earth. When mixed with the atmosphere, levels are generally low, but in enclosed spaces levels can rise above the action level of 200 Bq/m3. (1 Bequerel is the rate of one disintegration per second.)

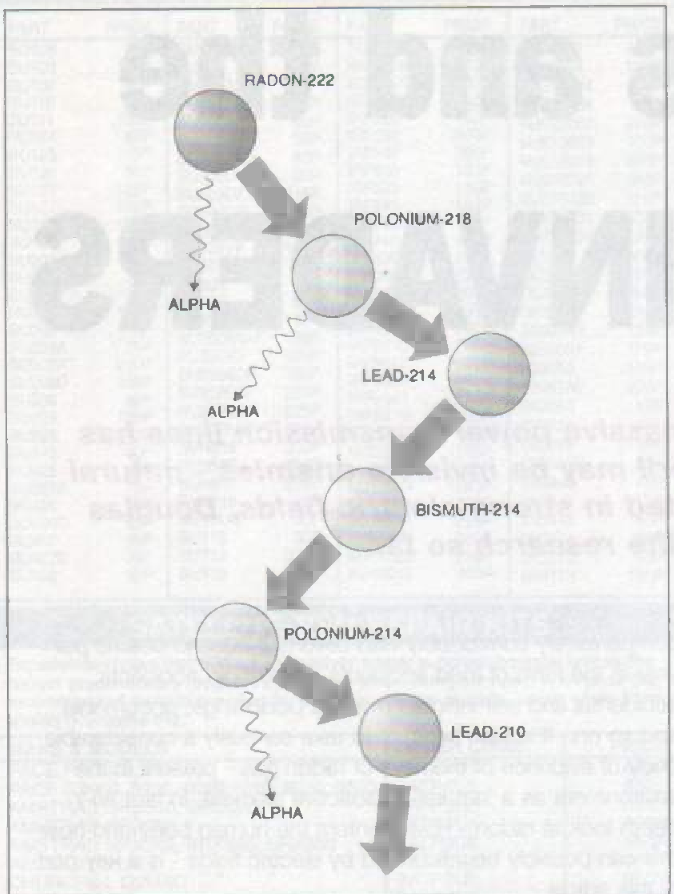


Figure 1: Decay chain of Radon-222. (Courtesy NRPB)

Table 2 summarises the sources of exposure of the UK population to ionising radiation. Within this analysis, some 15 percent is man-made, and 85 percent is of natural origin. This table confirms that - on average - the most likely form of radiation exposure to the general public will be from radon-222.

Table 2: Summary of sources of radiation exposure to the UK population. (Courtesy NRPB)

Source	% of Total	Origin
Radon gas (from ground)	50	natural
Gamma rays (from ground and buildings)	14	natural
Food and drink	11.5	natural
Cosmic rays	10.0	natural
Medical (mainly X-rays)	14	artificial
Occupational	0.3	artificial
Fallout	0.2	artificial
Products	less than 0.1	artificial
Nuclear discharges	less than 0.1	artificial

Table 3: Summary of UK Radon testing (Courtesy NRPB)

Country	No. of tests	Average	
England	260,000	21	22,000
Scotland	3,900	16	120
Wales	5,200	20	220
N. Ireland	11,000	19	390
Total UK	280,000	20	22,800

Figure 2: Variability of Radon-222 in the environment (Courtesy NRPB)

Radon in the UK

Domestic radon surveys in the UK now provide a useful picture of radon levels in the UK. An initial set of 2000 homes - one for every postcode - was published in 1988. Additional data from targeted areas Increased this total to 15,000 by the beginning of 1990. By the end of 1996, over 300,000 UK houses had been tested, with summary data indicated in table 3.

Table 3: It is estimated that there are as many as100,000 homes in the UK at levels above the 200 Bq/m3 action level. Radon detectors use polyallyl diglycal carbonate (Trademark CR-39). This material is also used as an optical plastic for spectacle lenses.

The average level of radon outdoors is around four Bq/m3 - so it makes sense to get plenty of fresh air. As a specific agent In the atmosphere, there is a considerable variability in its appearance with season and time of day. Levels vary considerably, while mechanisms include atmospheric pressure, temperature, wind speed and house ventilation. Measuring for a day or even a week could give uncharacteristic results as indicated in figure 2.

Relative risks of radon

In studies of workers with known high levels of industrial exposure, principally miners exposed to radon-222, from a total population of 62,000 an observed total of 2600 deaths were recorded from lung cancer compared with an expected total of 750. Such studies confirm radon as the causative agent, and with figures indicating statistically significant values for exposure less than that corresponding to lifetime exposure at the UK action level of 200 Bq/m3.

Figure 3 summarises how the NRPB has estimated the risk of lung cancer from lifetime exposure to radon in the home. The barometer of risk relates, in this example, to accidental death in the home of 7 in 1000. At the action level of 200 Bq/m3 for lifetime exposure, an individual would be four times more likely to die from lung cancer induced by radon than from a household accident.

The Department of Health COMPARE 4th Report indicated that as much as 14 percent of childhood leukaemia can be attributed to natural background alpha particle radiation, with 5 percent derived from radon at an assumed exposure of 20 Bq/m3, and 9 percent from other alpha particle emitters, principally Po-218, which is itself a daughter product of radon. It is surprising that such statistics are not more widely circulated to the public.

Previously it had been thought that the mechanism of exposure to radon did not involve any dose to red bone marrow or to the foetus. It has only been through a

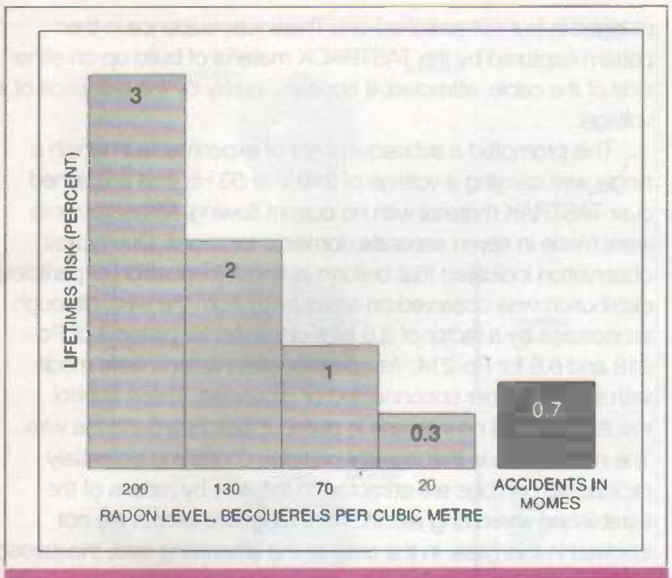


Figure 3 : Estimation by NRPB of relative risk of exposure to Radon at varying exposure levels. (Courtesy NRPB)

reassessment of dose mechanisms involving fat cells in red bone marrow that the link with radon has been highlighted.

Table 4: Indicates the present range of estimates for dose to the bone marrow for inhalation of radon in the air in the UK for an average concentration of 20 Bq/m^3(Courtesy NRPB)

Reference	Dose in micro Sv/year
Peterman and Perkins (1988)	16
Richardson et al (1991)	90
Harley and Robbins (1992)	26
Allen et al (1995)	60 - 160

Table 4: Present range of estimates for dose to the bone marrow due to inhalation of atmospheric radon in the UK for average concentration of 20 Bq/m3. The relative risk estimates therefore range over an order of magnitude! (Courtesy NRPB)

The NRPB have already written to offer a free radon test to households in areas of the UK which are most likely to have high radon levels. There is also an indication that other polluting agents in the environment could be subject to such large variations. Monitoring of atmospheric pollution is much more expensive. While Radon can be measured using single mass production detectors, measurements relating to pollution are more difficult to establish, with the result that much smaller sets of data are available.

Aerosol deposition in lungs

Over the years a significant amount of work has been undertaken in order to understand the way in which aerosol-bound agents such as radon-222 are deposited in the human body, with principal attention directed to the lungs. While research has largely related to the incidence of lung cancer in uranium mine workers and associated industries, the mechanism of aerosol ingestion would generally apply for a wide range of chemical pollutants and microbiological agents.

One of the key aspects relates to aerosol size distribution. In mine observations, particles are invariably silica based and less than a micron across. Where diesel fumes are generated, particle sizes can be around 200 nm. Domestic aerosols are typically 100 nm, although the size of such aerosols may be reduced by devices such as electric motors, open flames and electric heaters. It is quite evident that little is generally known about the aerosol species in many types of modern living environment. It is apparent, however, that the nature of such aerosols plays a key part in determining the rate of uptake of many environmental pollutants that enter the body via the respiratory system or from contact with the skin.

Cigarette smoke produces an aerosol diameter of about 300 nm. As such, it is assumed that the dangerous chemicals in such particles originate at source from the tobacco smoke - a serious enough problem. Little is known, however, about the potential of such particles to interact with other chemical agents in the environment.

Radon-222 initially exists as an atom of about 1 nanometer diameter. The lone atom will tend to attract a cluster of water or other molecules, depending on the local environment. These particles are described as the 'unattached fraction', and generally tend to become attached to the local, ambient aerosol particles, the characteristics of which are determined by prevailing atmospheric conditions.

In very clean air conditions, where all the larger aerosol particles have largely been removed, the unattached fraction can be several times higher. In conditions of typical equilibrium, it is the longer lived Po-218 daughter product which exists in the unattached fraction, with Po-214 only forming about 10% of this fraction. There is generally increased uptake of aerosols at higher rates of breathing.

Where this is associated with carcinogenesis of lung tissue, studies of radon-derived tumour cells indicate that these cells originate typically around 30 microns from the exposed surface. This relates to the localisation of energy deposited in tissue from the generation of an alpha particle on the trapped radon daughter product. It is now known, however, that radon gas can also pass into the red cells of the bone marrow and do damage there.

Aerosol particles of less than 200 nm tend to deposit due to diffusional processes - it is their own independent velocity relative to the air that makes them contact surfaces. For larger sized particles, they will tend to deposit due to impaction processes - they physically collide with lung surfaces as they are propelled along by moving air.

Electric fields revisited

The number of reports and papers that have been conducted on the safety of electromagnetic fields is legion. The primary aspect of investigation has been in relation to overhead power lines, and in particular the influence of alternating magnetic field lines on the human body. One of the basic problems with such investigations was the absence of any clearly understood mechanism that would give rise to any significant adverse effect in the population. It was almost as if, because there is no known causative mechanism, so no definite cause can be detected.

While interest has conventionally been directed towards the magnetic field effects of power line transmissions, there has been a re-examination recently of the effects of electric fields, primarily to assess how they might interact with substances present in the atmosphere.

The nature of fields

Figure 4 indicates typical values of electric fields for a range of high voltage transmission lines which typically carry a pair of transmission lines about the mid plane of such systems. The fields rise until directly over a live conductor and then begin to fall off with distance. While the magnetic field will vary with seasonal and daily current load, the electric field is essentially constant. The minimum height of a high tension voltage line is 7.6 m at mid span.

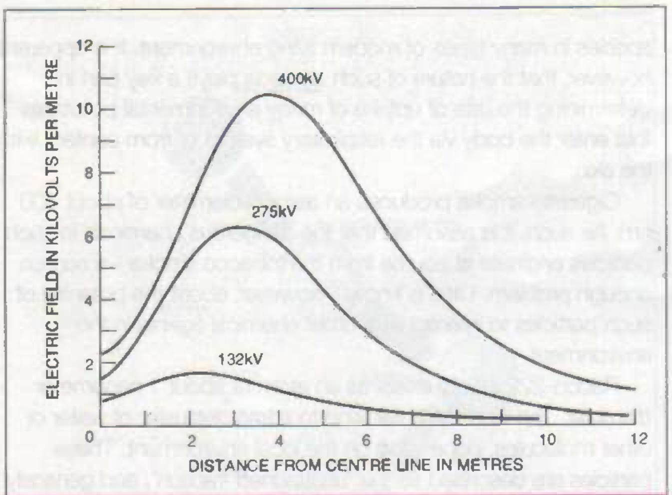


Figure 4: Typical values of electric field for a range of high voltage transmission lines which typically carry a pair of transmission lines about the mid plane of such systems. (Courtesy NRPB)

The actual height of the cables above ground can, however, be influenced by prevailing weather conditions or the loading of the cables - as the temperature of the cables rises significantly, it will cause the cable to lengthen and sag. There may be some variation in associated ground-level electric fields, depending on the amount of sag.

In the domestic environment, electric fields can be in the range 10 to 250 V/m with values in the range 1 to 10 V/m typical of interior of modern houses. Higher field values could possibly be established in the vicinity of sub stations where voltage levels are transformed down.

The Bristol Connection

It was, however, investigations carried out by a team of scientists at Bristol University led by Professor Dennis Henshaw of the Physics Department that has led to identifying one possible mechanism linking exposure to electromagnetic fields and certain types of cancer.

The researchers, however, are quite clear in identifying their work as a pointer for much more extensive work. Their research as such does not prove that power lines give rise to increased incidence of cancer. The subject area is understandably a very emotive one, but certainly one that now requires clarification through new lines of research.

The new appreciation of a possible link relates to the known ability of electric fields to attract our old friends the aerosol particles, suspended in the atmosphere. The work at Bristol has largely been related to demonstrating that electric fields can increase the concentration of radon daughter nuclei. The increased localisation of such nuclei can readily be measured by observing tracks left on a specialist alpha particle sensitive material called TASTRAK. Individual tracks are typically 30 microns in size and 15 microns in width. The plastic is etched in hot concentrated sodium hydroxide for around five hours to reveal the deposited tracks.

The new observations

It is now appreciated, however, that electric fields can increase the density of aerosol particles, some of which could be radioactive. Some experiments to verify this result are certainly elementary in the extreme - in an initial experiment, the mains lead of a hair drier was positioned over a sheet of TASTRAK material in an environment with a radon background level of 200 B/m3 for six days. The wires of the power connection were at mains voltage, though no current was delivered (that is, the hair drying was plugged in but not switched on). There was evidence in the pattern captured by the TASTRACK material of build up on either side of the cable, attracted, it appears, purely by the presence of a voltage.

This prompted a subsequent set of experiments in which a single wire carrying a voltage of 240 V at 50 Hz was positioned over TASTRAK material with no current flowing. Measurements were made in seven separate domestic locations. One typical observation indicated that uniform plateout [deposition of particles] distribution was observed on areas away from the wire, although an increase by a factor of 3.6 was observed for plateout of Po-218 and 6.8 for Po-214. As controls, observations were made with the wire either unconnected or grounded. These control results indicated no increase in plateout factors around the wire. The mechanism is that aerosol particles containing potentially radioactive particles are attracted to the wire by means of the established alternating electric field. Magnetic effects are not involved in this case. In the case of the alternating field, the aerosol particles can be considered to move at the mains frequency, with the smaller aerosol particles moving at the greatest amplitude.

In observations with applied DC potentials, there is a very significant increase when significant negative voltages, around -100 V, are applied to a surface. This indicates that some particles have a positive charge. Surfaces at a high positive potential will tend to repel such particles, and indeed a reduced plateout density is generally observed.

In modern offices, static charges are easily acquired from walking over nylon carpets, working with photocopiers and IT equipment in general. Surface voltage can rise as high as 10 kV and with local fields exceeding 50 kV/m close to the face. Thus high negative voltages could be anticipated as increasing considerably the plateout rate of airborne Radon daughter products.

Such experiments, however, indicate factors which relate to specific types of TASTRAK material. It is known that plateout density increases a great deal in the vicinity of a fingerprint on TASTRAK material. This would indicate that the plateout characteristics of human skin and associated tissues of the airways and lungs could further increase plateout rates on those surfaces. What polarity is the charge on your PC?

Explaining the effect: aerosols on the move

In the example in figure 5, a radon daughter product in an aerosol particle has no charge. When placed in a uniform electric field the particle becomes polarised, but because the field is uniform the particle experiences no net attraction. If, however, the field is non-uniform, as is the case with the field of a high voltage wire, then the particle will be alternately polarised by the changing field but always experience a force towards the direction of increasing field gradient. So in the vicinity of the wire the particle will always feel an attractive force as indicated in figure 5. Also when a stream of water is passed along a conductor energised at 2 kV at 50 Hz, it is attracted to the conductor as indicated in figure 6.

It is estimated that a particular ultra-fine particle would experience an excess drift of 2 to 5 microns for an electric field of 1 V/m - a field that would be induced in the vicinity of a body cavity by an external field of 10 kV/m. This could have a role in altering deposition patterns within the human body. Where the ultra-fine fraction is exposed to high electric fields of the order of 10 kV/m, aerosol particles could drift 2 to 5 cms in a half 50 Hz cycle. Direct fields can also act to produce significant movement of aerosol particles in ultra-fine mode.

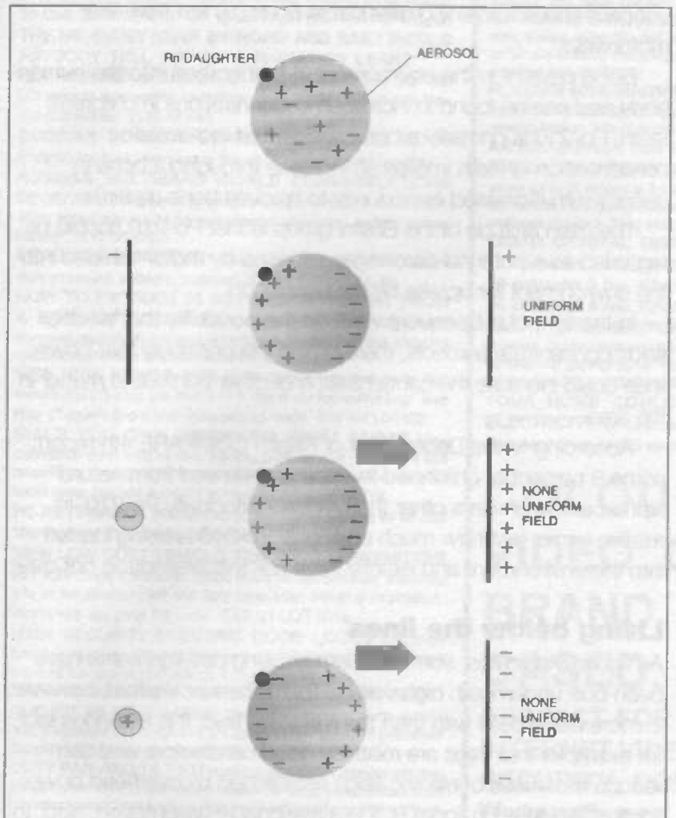


Figure 5: Mechanism of attraction of polarised aerosol particles in a non-uniform electric field

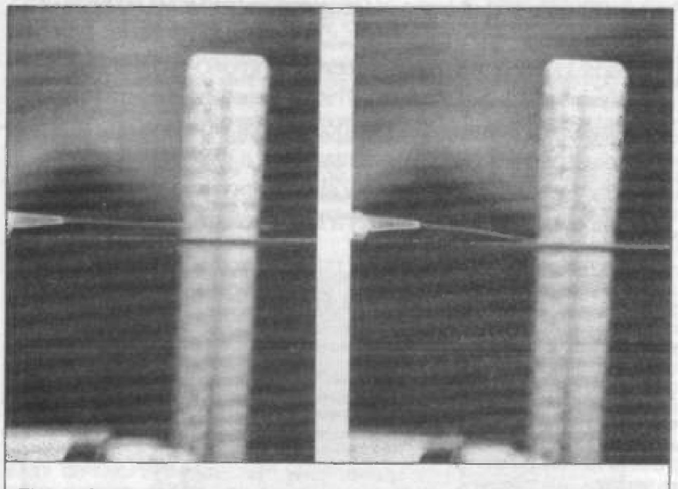


Figure 6: Attraction of water to conductor energised at 2 kV at 50 Hz. (Courtesy Department of Physics, University of Bristol)

In connection with increased deposition due to alternating E fields, the more commonly occurring so-called 'attached fraction' is aerosols of mean particle size around 0.15 micron. Only about 20% of these particles are actually retained in the lungs. Because these particles are relatively heavy, the presence of even high field strengths is unlikely to increase their tendency for enhanced deposition in the lungs.

The remaining 'ultra-fine fraction' is much more readily absorbed. Although making up only around 10% of the number of aerosol particles, almost all such particles are retained in the human body, distributed between the tip of the nose, nasal passages and lungs in general. It is possible that the presence of alternating electric fields could act to change the relative distribution of where such particles are deposited. This could tend to deposit particles sooner, before they penetrate deep into the lungs.

The wide world of aerosols

The involvement of electric fields in the distribution and uptake of environmental pollutants is an interesting development, which focuses attention on much broader health risk issues. The demonstration of the ability of alternating electric fields to cause aerosol particles containing radon daughter products is in a way using the high detectability of alpha particles to prove the effect.

The principle thus demonstrated is relevant to a broad spectrum of problems relating to atmospheric pollution. For instance, conditions of stagnant air polluted with chemical agents, aerosol particles containing molecules of pollutants, plus radon and its daughter products, may well be attracted to the wires of the transmission lines.

In an increasing range of research, the nature and action of atmospheric aerosols is seen as having key importance for their associated effects. One group at the University of Lund in Sweden, headed by Dr. Erik Swieticki, has developed a system known as the tandem Differential Mobility Analyser. This system (TDMA) is used to measure the hydroscopic behaviour of atmospheric aerosols. In atmospheric conditions of stable or changing humidity, aerosols exhibit a range of growth behaviours.

Aerosols from the sea

Interest in aerosols comes form surprising directions. It is recognised, for example, that the action of the wind on the sea and the waves on the sea shore releases sea salt aerosols into the atmosphere. These aerosols are considered to have an important influence on the generation of the nucleation particles that cause the formation of clouds. They may also interact generally with environmental pollutants in ways still to be determined. Instruments to monitor aerosol production are currently in space aboard satellites GOMF - (ERS-2) and AVHRR (NOAA).

It is a curious sight, when northerly gale force winds are blowing, to stand on a high point of land on the North Wales coast and observe a band of white mist as wind-blown spray advances several miles inland. This is an example of finite distribution of particles onto the land from the most radioactive sea in the world.

Aerosols - the unresearched

While extensive investigations have taken place into the unhappy lot of the uranium miner, where there is a perceived risk of lung cancer, surprisingly little work has been done on the distribution of the type and size of aerosol particles in domestic environments.

Such work, however, does give a fair assessment of the problems of estimating the actual dose that individuals receive from exposure to radon in homes and workplaces. This is largely determined by the pattern of aerosol distribution. However, there are still gaps in our knowledge of the nature of alteration of aerosol behaviour by industrial pollution (including vehicle exhausts) and also the nature of alteration of aerosol characteristics in the home and workplace environments.

Could it be, for example, that so-called 'sick building syndrome' could be influenced by the nature and type of aerosols within such buildings, and do they act as an agent for the uptake of other pollutants? Also to be considered are the variety of pollutants that may be carried, and their interactions when they are absorbed in the lungs.

Of course, a collection of aerosol particles in the air must be considered as a complex population which demonstrates at any one time an equilibrium of states. A dynamic interchange of components between surfaces would be expected, especially of the unattached fraction, since this is more mobile. Also, the superposition of electric fields with associated rapid movement of such particles will tend to cause increased mixing of particles, since they will be travelling in the same direction (assuming neutral charges) but at varying speeds depending on their mass. Could power lines therefore act as a catalyst for enhancing the production of a wider range of chemicals? If you stand under high voltage lines during damp weather you can hear the crackle and hiss of ozone being formed.

With vehicle pollution set to rise steadily over the next decade, the already severe pollution in some of our major cities has been allowed to assume economic dominance over the health of the people who live there. We clearly do not yet know enough about how pollution could interact with powerline electric fields to take the necessary action to minimise any ill effects.

Aerosols in climate change

It is just dawning on us how aerosols and the agents carried on them can affect our health. The generation of aerosols by man-made processes is now understood to have a significant impact on global warming. It is known now that a sizable fraction of the aerosols in the lower atmosphere are the result of human activities. Research into global warming has triggered extensive fundamental investigation of aerosols.

The persistent haze visible throughout the industrialised regions of the world (and indeed in areas far from industry) is mainly composed of sulphate and organic compounds, largely derived from the combustion of fossil fuels, organic gases and vegetation. While coal combustion emissions have been decreasing in the USA, coal-burning in the Northern hemisphere, has increased over the last 100 years. Although the use of coal has fallen in the UK, this has been more than offset by the rapid industrialisation of developing countries such as China.

Aerosols can be considered to have a role both in the micro and the macro climate. Aerosol particles can either reflect incident sunlight or absorb it, creating pluses and minuses in relation to global warming. The aerosol can also act as a site for subsequent chemical reactions. Most important environmentally is perhaps that of aerosols containing sulphur dioxide acting to deplete stratospheric ozone. These aerosols are largely propelled to the upper atmospheric by volcanic eruptions - thus, a cloud of volcanic dust in the Philippines can become someone's deeper suntan in Hawaii - with all that that implies.

The estimate for the current increase in absorbed energy from the sun due to greenhouse gases corresponds to a net increase of 2.5 watts/square metre. The net effect of man-made aerosols from industrialisation is considered to correspond to a net loss of -1.3 watts/square metre, though the uncertainty of the latter result is considerable. This estimation of global warming now involves two opposing factors, each with their own limits of uncertainty.

The greenhouse gas effects are always in operation, like extra layers of insulation keeping the heat in Earth's atmosphere. The aerosol effect, however, only operates during daylight hours on incoming solar radiation. There are, however, regional variations in the distribution of such aerosols which in turn introduce regional variations in the climate change models. Also, while such aerosols may give the appearance of being helpful by reducing global warming, fine aerosol particles, as we have seen, endanger health and introduce damaging ecological effects. Further polluting the air is not the answer to global warming.

Polonium-210 in children's teeth

As described previously, Po-210 is an alpha particle emitter daughter product of radon-222. Professor Henshaw's group has recently identified this element as occuring in increased concentrations in the vicinity of motorways, with increased concentrations remaining detectable up to 10 km from the motorways.

Being present in the environment, it is absorbed into the human body and can be found in increased concentrations in children's teeth. Po-210 is primarily a bone seeker and increased concentration in teeth implies an increase throughout bone in general with increased opportunity to irradiate bone marrow.

The main attitude of the Bristol group is that Po-210 should be regarded as a potential carcinogen released by motor vehicles into the environment for uptake by the population.

In the light of subsequent work on the possibility that electric fields concentrate aerosols, there is also the possibility that power lines could increase the concentration of other particulate matter in the area.

According to the Department of Health COMPARE 4th report, some 9 percent of childhood leukaemia is derived from natural alpha particle emitters other than radon - principally Po-210. In relative terms, just how much additional Po-210 is being loaded into the environment and exactly what risk this presents is not clear.

Living below the lines

As figure 7 indicates, some modern housing developments have been built underneath high voltage lines. The electric field, however, is more easily dealt with than the magnetic field. It is a curious fact, for example, that trees are relatively good conductors and can reduce the values of electric fields established by overhead power lines as indicated in figure 8. It is a reasonable assumption, also, to assume that evergreen trees would provide a better year-round protection than deciduous trees. I wonder what Powergen would say to the planting of acres of Douglas Firs below 400 kV power lines.

Perhaps, by a parallel, plants in homes and offices could also modify or reduce electric fields. This is something that could readily be measured. There is also the thought that when we go for a walk in a forest, we are in intimate contact with a well-grounded environment with low or very low electric field gradients present - except, of course, when there is a thunderstorm hovering nearby.

Figure 7: In the crowded modern world, homes are often near to overhead powerlines

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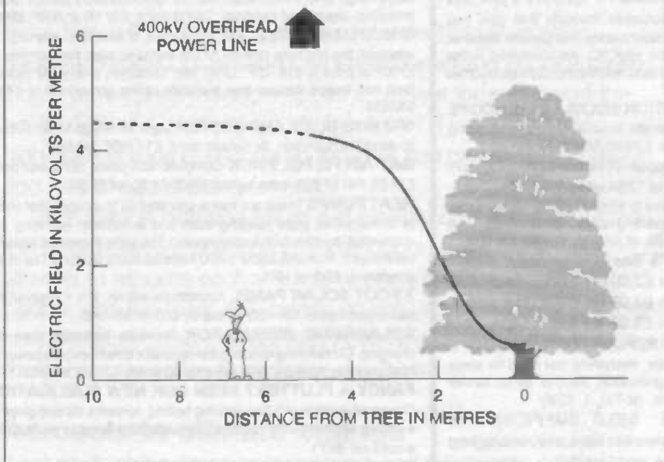

Figure 8: Reduction of electric fields by presence of trees

It should not be beyond the wit of town planners, architects, builders and power utility companies to come up with strategies for minimising electric field values where it is not possible to avoid routing overhead power lines through populated areas.

Postscript

The tentative findings of the Bristol group have been, not surprisingly, strongly dismissed by the NRPB. It is interesting to note, however, that the response was highly specific regarding the inability of electric fields to influence significantly the uptake of radon in homes.

Science, however, is all about measurement. The scientific mind should be capable of developing a system to mimic the respiratory intake rate of radon; for example, by way of a filter system that simulates the respiratory cycle. Comparisons could then be made of deposition rates of radon as a function of base radon levels and values of electric field in the environment. Hey presto - we have real science, not just the restatement of an opinion.

Also, the Bristol group has not exclusively indicated radon and its daughter products as the problem. There are numerous pollutants in the modern industrial environment - ones indeed beyond the remit of the NRPB to measure.

Mobile Phone Technology

The world is currently undergoing a rapid expansion of mobile phone technology. Already there have been some specific anxieties about the use of this equipment items, and research is being undertaken to identify potential problems.

There appears to be a belief that base-station antennae present no risk, because the broadcast levels are so low. More interest is being directed at handsets, because they can concentrate radio frequency energy over small areas of the human body.

Typically, analogue phones operate at around 900 MHz, and digital phones between 1800 MHz and 2000 MHz. Based on Planck's law, where the photon of radiation energy is given by the product of Planck's constant and the frequency of the radiation, the energy of a quantum of frequency 1000 MHz is 6.63 x 10(LITTLE HAT)-25 J - equivalent to around 4 micro electron volts. Thus the energy of these quanta is considered too small to affect chemical reactions in cells directly.

In the USA, a set of safety standards are in force for base station antennae which relate to a plane wave power density of 1.2 mW/cm2 for PCS phones between 1800-2200 MHz, and 0.57 mW/cm2 for cellular phones between 860-900 MHz. The International Commission on Non-Ionising Radiation Protection (ICNIRP) provides similar but slightly more restrictive limits. (A level of 1 mW/cm2 is equivalent to 10 W/m2.)

The setting of "safe" limits is essentially based on the assumption that the biological effect of radio waves depends only on the role of energy absorption, which is not considered to vary significantly between 1 MHz and 10,000 MHz.

These limits were set by determining a threshold for detectable thermal absorption effects and then introducing safety margins for occupational exposure, with further margins for continuous exposure for the general public. This has resulted in "safe" levels for the public being set at only a few per cent of levels where potentially hazardous biological effects have actually been observed. Thus, at ground level below a base station, a power density of the order of 0.02 mw/cm2 may be produced, though levels will typically be much less than this in practice.

Problems tend not to occur with isolated base stations, but rather when they are located on rooftops where access is required by maintenance staff for other activities. In some circumstances this will lead to roofs being designated control areas.

The interaction of the human body with electromagnetic fields is complex. Between 3 MHz and 3 GHz a "body resonance" region is established, where the nature of any exchange of energy is influenced by the relative geometry of the human body. For example, energy is absorbed more efficiently by people when their height is about half a wavelength of the incident radiation. For a tall person this would correspond to a frequency of around 80 MHz. At higher frequencies, however, resonances are more local. The NRPB have developed a model to anticipate how, for example, the head will resonate when presented with radiation above 600 MHz. Simulations show that relative hot spots may be presented in the area of the mid brain. These "hot spots", however, are only relative, and with reference to likely already low levels of exposure - for example from mobile phones.

Several studies to re-assess the safety of mobile phones are currently being undertaken, with a major one within the EEC. These studies are very much "work in progress".

Official UK viewpoint: electromagnetic field safety

Studies of time-varying fields such as those developed under powerlines indicate that values above 12 kV/m can typically be sensed by the public, with some 5 percent being able to detect much lower field values between 3 to 5 kV/m. This indicates the variability of response in individuals. As for mutagenic effects in animal studies, no effect has been observed - even at field values up to 20 kV/m. One theory that high values of electric fields can suppress melatonin levels which may influence the immune response has apparently not been validated.

At frequencies above 100 kHz the limitation to exposure is derived from Specific Absorption Rate (SAR) levels. Depending on human activity, the thermal load associated with activity can vary from 1 W/Kg (resting) through 2.5 W/kg (light manual work) to 6 W/kg for heavy manual work. Setting a whole body level of energy absorption of 0.4 W/kg SAR from absorbed incident radiation is therefore a relatively small additional burden on the body's thermal regulation. Thus, jumping into a hot bath is probably more than the equivalent of walking right up to a mobile phone base station. Above 10 GHz, however, the SAR approach breaks down as energy becomes principally absorbed on the body's surface.

Figure 9 indicates the investigation levels for electric fields between 0 to 300 GHz and with specific SAR restrictions indicated. Thus these "'investigation" levels - note the careful choice of term - are primarily derived from considerations relating to physical comfort and/or heating effects associated with absorption. No other mechanisms are considered.

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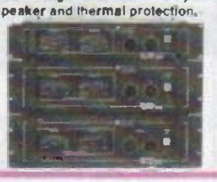

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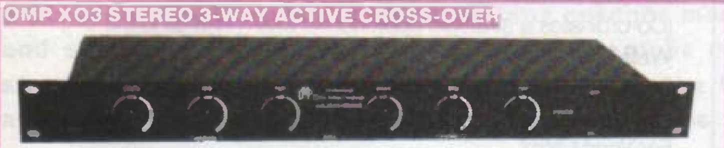

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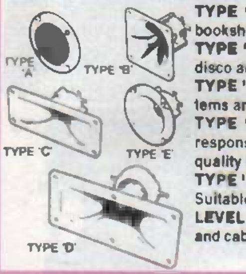

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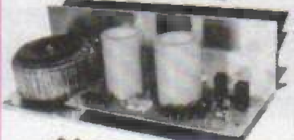

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
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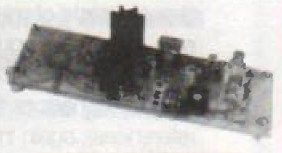

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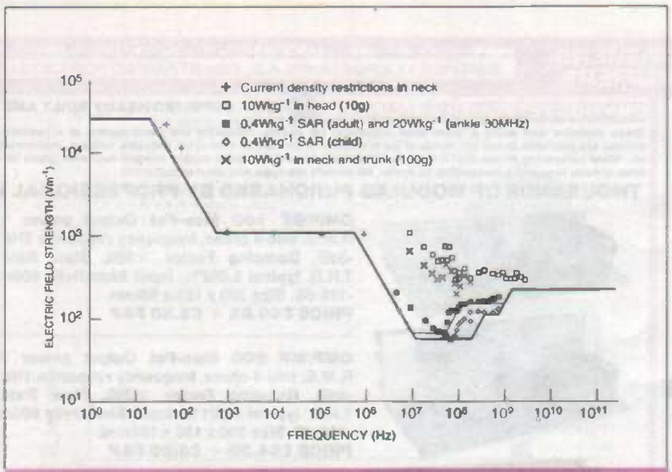

Figure 9: NRPB investigation levels for electric fields between 0 to 300 GHz and with specific SAR restrictions indicated

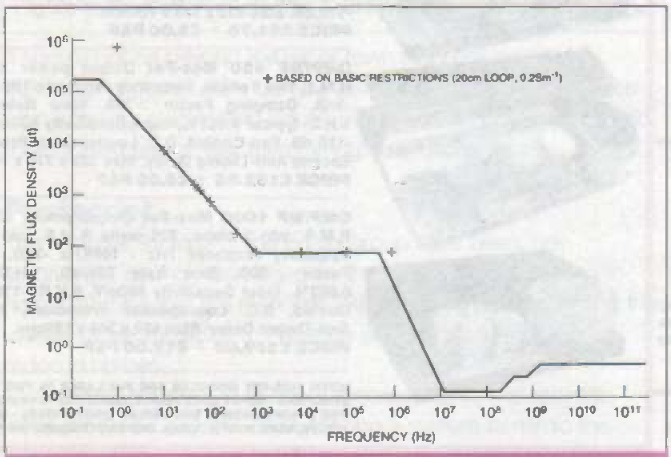

Figure 10: Corresponding investigation levels for magnetic fields (Courtesy NRPB)

Figure 10 indicates corresponding investigation levels for magnetic fields.

Such data provides therefore the framework for "official" responses to "safe" levels of electromagnetic fields. The model of interaction assumed could be described as "single compartment", where no factors other than the fields and the human body are involved. In particular, there is no consideration of, for example, environmental factors as we have discussed above.

A summary

The growing awareness of the possible interaction between electric fields and a wide range of environmental pollutants - both natural and man-made - is in essence a valuable insight into how best to direct new research and re-assess old data. This amounts almost to a re-assessment of the environmental impact of high value electric fields, including the levels of aerosol-bound agents that could be attracted to such fields. Hopefully this more expansive outlook will lead to a more expansive approach to research in which other environmental factors will be addressed. At the same time, the body of existing knowledge relating to radon is already rather daunting - and one that should certainly receive more attention than it gets at present.

It is also obvious that anxiety in any form which leads to stress can also lead to illness. Thus living in the vicinity of powerlines in a stressful state of mind - even though the powerlines may be quite safe - could as a quite separate factor lead to illness.

I am also aware of increasing activity by groups looking at electromagnetic pollution on a holistic level (see my last three references), again increasing the parameters of interaction and reaction to electromagnetic fields far outside the scope of the NRPB documents.

On the plus side, modern instruments are now much more effective for the environmental monitoring studies necessary to research the potential of electric fields to concentrate environmental pollutants.

The significant level of interest in the Bristol work will no doubt encourage other groups to investigate electric fields as interacting with known risks in the environment. Also, while seeking after such effects, known or unknown, the very real risks of radon in the UK require to be given more publicity.

Contact Points

National Radiological Protection Board, Chilton, Didcot, Oxon, OX11 ORQ. Tel 01235 831600 Fax 01235 833891
NRPB Radon Freephone 0800 614529
BRE Radon Hotline 01923 664707
TASL HH Wills Physics Laboratory, Tyndal Avenue, Bristol BS8 1TL. Tel 0117 9260353 Fax 0117 9251723
Powerwatch UK, Orchard House, High Common, Barshaw, Beccles, NR34 8HW. Tel 01502 715637
(Co-ordinates a strategic approach to EMF hazards in the UK)

Web Sites
Subject: Powerlines and Cancer FAQs 4/8
http://www.cs.ruu.nl/wais/html/na-dir/powerlines-cancer-FAQ/part4.html
(extract of sequence of pages from major on-line reference)
Cellular phone antennas and Human Health
http://www.mcw.edu.gcrc/cop/cell-phone-health-FAQ/tic.html

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Geopathic Stress: How earth energies affect our lives, Jane Thurnell-Read, Element, 1995

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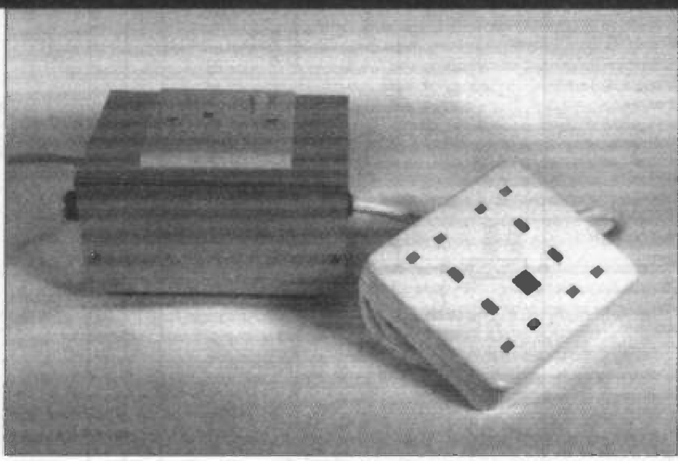


Anyone involved in the world of personal computing cannot have failed to notice that the average PC is a great deal more complex than its equivalent of a few years ago - not just in terms of the basic computer itself, but also in the range of peripherals fitted that we understand to be de rigeur for the well-dressed PC these days. It seems that a PC needs to have a modem, CD-rom drive, printer, sound card and speakers, etc. In order to be considered an entry level machine! No wonder the kids love them.

One slight problem with this proliferation of peripherals is that it often results in a substantial number of mains power outlets being required. Some of the peripheral devices might be in the form of internal expansion cards, but devices such as printers, modems, scanners and powered loudspeakers obviously require their own power source. My PC requires mains outlets for a printer, a digitising tablet, a Zip drive, and a modem. The monitor is powered from a mains outlet on the computer base unit, but this is by no means a universal feature.

Providing mains outlets for all the peripherals is obviously not too difficult, but it is a bit inconvenient when it is time to switch everything on or off. This either seems to involve crawling around on the floor in search of the on/off switch on the mains outlet or the distribution board, or groping around for half a dozen tiny rocker switches concealed on the cases as only computer peripheral manufacturers know how. Life would obviously be a great deal easier if the peripherals were automatically switched on and off in sympathy with the computer.

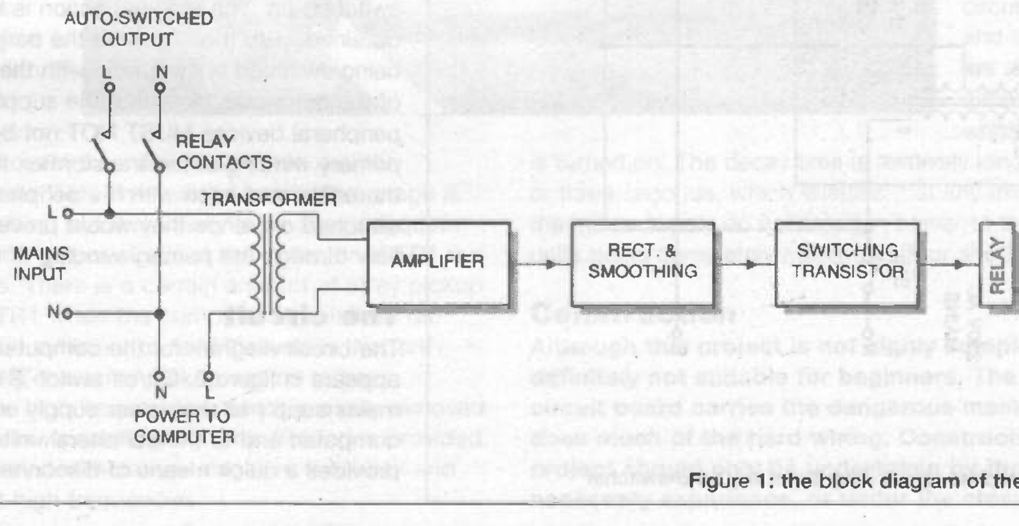


Figure 1: the block diagram of the Auto-switcher

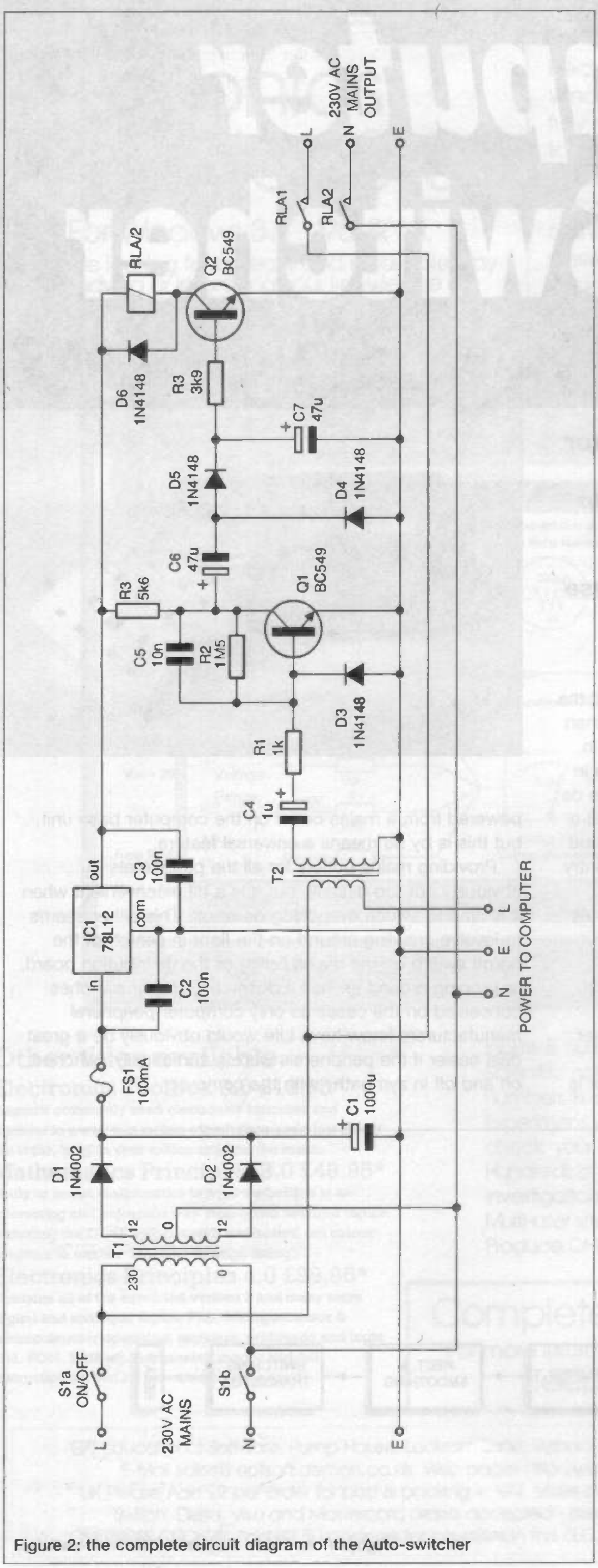


Figure 2: the complete circuit diagram of the Auto-switcher

So, this is the function of the project featured here. It has a mains outlet for the computer plus four outputs for the peripheral devices. When the computer is switched on, the device detects the resultant current flow and switches on the four additional mains outlets. Power to these outlets is automatically switched off again a few seconds after the computer is switched off.

System operation

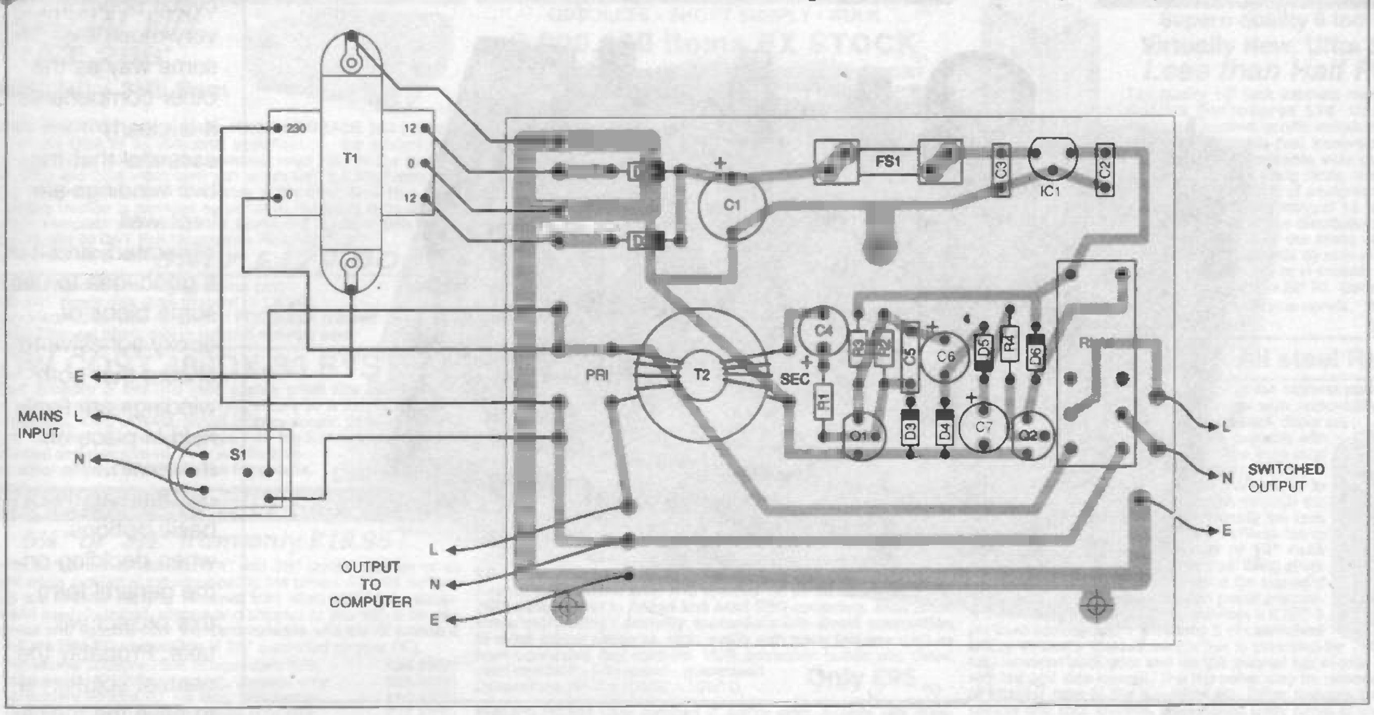
A device of this type is basically quite simple, as will be apparent from the block diagram for the computer auto-switcher (figure1). clearly the unit requires some means of determining whether or not the computer is switched on. The obvious method, and the only one I tried, was to use a transformer in series with the supply to the computer. An alternating current flows through the primary winding of the transformer when the computer is switched on, and this produces an output signal from the secondary winding. When the computer is not switched on, no current flows through the primary winding of the transformer, and there is no output from the secondary winding. The transformer must have a very low secondary impedance so that it produces a voltage drop of no more than a volt or two in the supply to the computer, and the computer can function normally. There is no need for a massive step-up through the transformer, since a small output voltage from the secondary winding is easily amplified to a high enough level to activate a relay.

This amplification is provided in two stages. The first of these stages boosts the 50Hz ac output to the point where it is heavily clipped. The signal is then processed by a simple rectifier and smoothing circuit that produces a strong positive dc output signal. This signal is used to bias a switching transistor into conduction, and the gain of this stage is sufficient to provide control of a low voltage relay. When the relay is activated, a pair of normally open contacts close and connect the mains supply through to the peripheral devices. Of course, the relay is only activated when the computer is turned on, and an output signal is produced from the transformer. If the computer is switched off, no significant output is produced from the transformer or the smoothing circuit, and the relay is not switched on. The required action is therefore obtained, with the supply to the peripheral units being switched in sympathy with the on/off switch of the computer. Note that the supply to the peripheral devices MUST NOT not be taken via the primary winding of the transformer. If this was done the unit would latch with the peripheral devices switched on, since they would provide a current flow through the primary winding of the transformer.

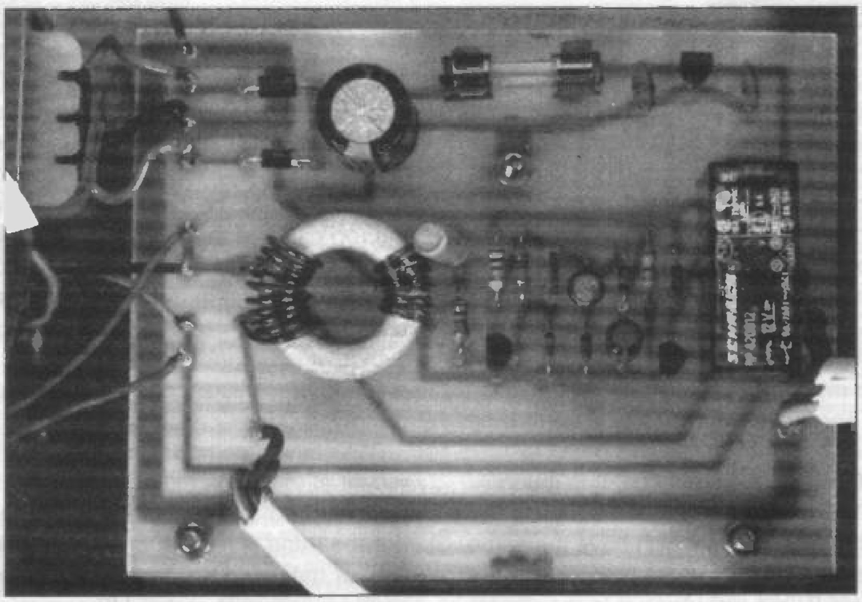
The circuit

The circuit diagram for the computer auto-switcher appears in figure.2. On/off switch S1 controls the mains supply to the power supply unit, the computer, and to the peripheral units. It therefore provides a quick means of disconnecting all circuits

Figure 3: details of the component layout and hard wiring



from the mains supply. T1 is the step-down and isolation transformer in the power supply unit, which is a conventional 12 volt stabilised design. D1 and D2 provide full-wave rectification, and C1 is the smoothing capacitor. IC1 is a small (100 milliamp) voltage regulator, which is more than adequate in this application where the maximum current drain is only about 50 milliamps. Protection against overloads is provided by fuse FS1, and IC1's built-in output current limiting circuit.

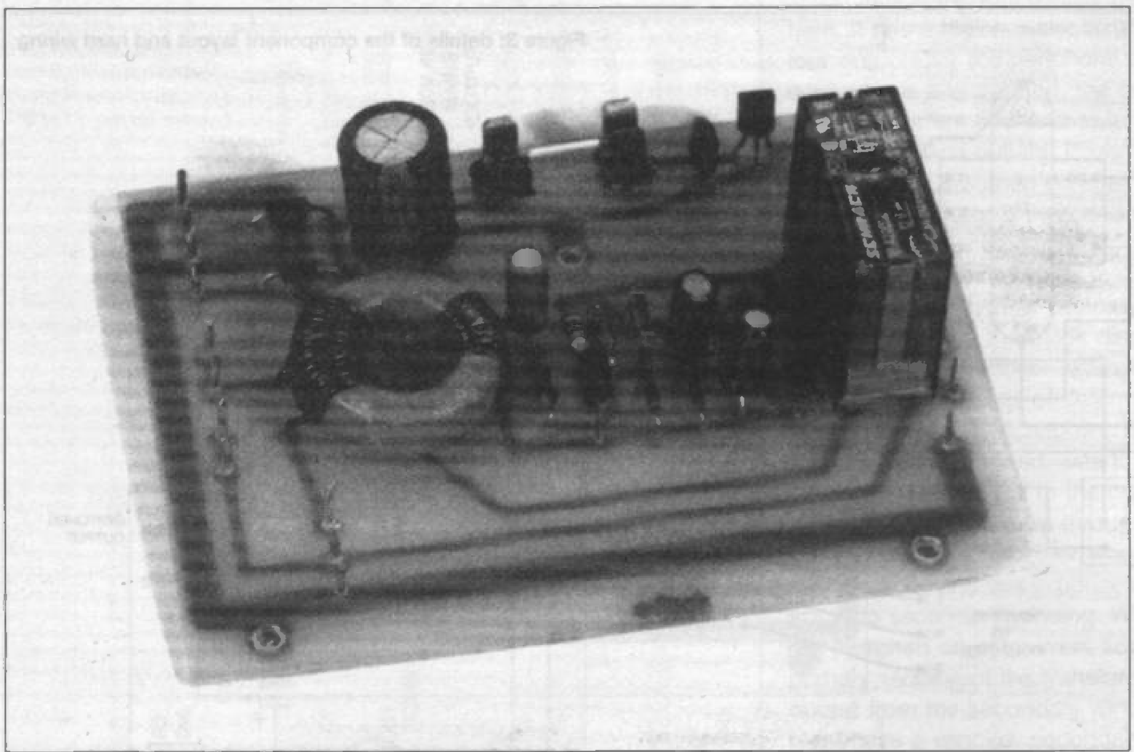


T2 is the current sensing transformer, and it is a simple home constructed component which is based on a ferrite toroid (ring). The 50Hz output signal from the secondary winding of T2 is coupled by C4 and protection resistor R1 to a simple common emitter amplifier based on TR1. The voltage gain of this stage is around 50dB, which is substantially more than adequate to ensure that the output signal at the collector of TR1 is severely clipped. There is a certain amount of stray pickup at the input of TR1 when the computer is switched off, and this could be sufficient to hold the unit in the "on" state. Fortunately, this stray pickup seems to be predominantly at high frequencies, and it is easily removed by some simple low-pass filtering. This filtering is provided by C5, which provides increased negative feedback and reduced gain at high frequencies.

C6 couples the output signal from TR1 to a conventional half-wave rectifier circuit (D1 - D2), and C7 smoothes the output from the rectifier to produce a positive dc signal of a few volts in amplitude. TR2 is a common emitter switch, and it is biased into conduction by the output signal from the smoothing circuit. It then activates the relay coil which acts as its collector load. D6 is the usual protection diode which suppresses the high voltage "spikes" that could otherwise be generated each time the relay switched off. RLA1 and RLA2 are the relay contacts which control the supply to the peripheral units. The attack time of the smoothing circuit is quite fast, and the peripherals are switched on almost at once when the computer is turned on. The decay time is relatively long at around two or three seconds, which ensures that any minor glitches on the mains supply do not result in power to the peripheral units being completely switched off for short periods.

Construction

Although this project is not highly complex, it is definitely not suitable for beginners. The printed circuit board carries the dangerous mains supply, as does much of the hard wiring. Construction of this project should only be undertaken by those with the necessary experience, or under the close supervision



mounted on the circuit board in very much the same way as the other components. It is clearly essential that the two windings are kept well separated, and it is a good idea to use some blobs of epoxy adhesive to ensure that both windings are firmly held in place on the toroid.

There are two basic options when deciding on the general form this project will take. Probably the neatest solution is to have the mains outlets for the peripheral devices mounted on the top of the case, together with a mains socket for the computer. One slight problem with this arrangement, especially if several switched mains outputs are required, is that it can be quite expensive. The cost of all the mains sockets would be quite high, and the price of a metal case large enough to accommodate them all could be very much higher. Also, making the panel cut-outs for several mains sockets would be a very difficult a time consuming job even if you have access to the right tools for the job. This approach is a good one if only one or possibly two switched outputs are required, but it is otherwise better to select the second option.

of suitably qualified persons. The case for this project must be of all-metal construction, and it must be reliably earthed to the mains earth lead. The case must also be a type which has a screw fixing lid, and not one which has some form of clip-on lid which would give easy access to the dangerous mains wiring.

The component layout for the printed circuit board is provided in figure.3, which also gives full details of the hard wiring. Construction of the printed circuit board is by no means difficult, but there are a few points that require some clarification. FS1 is mounted on the circuit board via a pair of 20mm fuse-clips, which must be the appropriate two-pin variety (Maplin type 1 or an exact equivalent).

From the electrical point of view, any relay is suitable provided it has a 12 volt coil with a resistance of 250 ohms or more, plus twin normally open or changeover contacts having suitable ratings. In practice it is difficult to use alternatives as they will not fit onto this printed circuit design. It is possible to mount the relay off the circuit board and hard wire it to the board, but as the relay is controlling the mains supply I would not consider this to be a particularly good or safe way of doing things. It is much better to use the specified relay, or an exact equivalent. Note that there are single pole relays which have the same pin configuration as the specified two pole type, but using one of these relays in this layout would result in the mains supply being short circuited.

As pointed out previously, T2 is home constructed. It is based on an FX4054 ferrite toroid, and the primary winding consists of ten turns of 20 swg or 0.9 millimetre diameter enamelled copper wire. The secondary is wound on the other side of the toroid, and it consists of 18 turns of 34 swg or 0.236 millimetre diameter enamelled copper wire. It is not essential to make the windings very neat, but the turns of wire should be tight kept as tight as possible. The windings should be left with short lead-out wires which should have the insulation scraped away using a small file or the blade of a penknife. The transformer can then be

This is to mount the mains socket for the computer on the top panel of the case, and the take the output of the unit to a trailing three or four way distribution board. These are often on offer in the local "Woolies" store at quite low prices. This enables a much smaller case to be used, and avoids much of the metal cutting that would otherwise be required. It is this second method that was adopted for the prototype.

Whichever method you select, it will be necessary to mount at least one mains socket on the top panel of the case. An ordinary wall mounting mains socket is suitable, but the fixing screws supplied are unlikely to be of much use for mounting the socket on a case. They must be replaced with two metric M3 screws about 12 to 25 millimetres long, plus two matching nuts. A large and irregular shaped cut-out is needed, and the exact shape seems to vary somewhat from one make of socket to another. Some measurements made on the socket itself should enable the top panel of the case to be marked with an appropriate shape for the cut-out. Fortunately, it is not necessary to make a highly neat and accurate cut-out, since the mains socket will totally cover the cut-out. This ensures a neat external appearance no matter how roughly the cut-out is made. However, make quite sure that the two parts of the panel that will take the two mounting screws are left intact.

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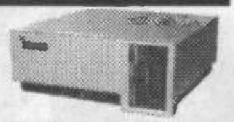

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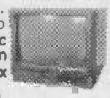

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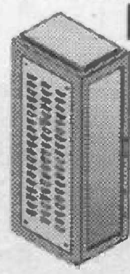

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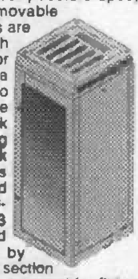

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The cut-out is easily made using a fretsaw or coping saw having a fine toothed blade. An "Abrafile" is also suitable, especially the type that is fitted in a coping saw style frame. Any miniature round file can be used, but many of these files cut quite slowly, and require a patient approach to things. In fact it is best to proceed slowly and carefully whatever type of tool you use. Rushing large and awkward cut-outs is usually a recipe for disaster. Of course, if several mains outputs are to be fitted on the case, you will have the pleasure of repeating this process for each of these sockets.

Mount the circuit board and mains transformer T1 on the base panel of the case. I would recommend using 6BA or metric M3 mounting screws for the circuit board rather than some form of plastic stand-off. As the board carries mains wiring it must be very securely fixed to the case, and screws are generally more reliable than stand-offs. Spacers about 10 to 12 millimetres long are used between the board and the case to ensure that the connections and copper tracks on the underside of the board are held well clear of the metal case. Soldertags fitted on T1's mounting bolts provide two chassis connection points.

S1 is mounted on the end panel of the case that is closest to T1. An entrance hole for the mains lead is also made in this panel, and (where appropriate) a hole for the output lead to the distribution board is made in the opposite end panel. Both of these holes must be fitted with grommets to protect the cables. Modern distribution boards are usually fitted with mains leads and moulded mains plugs. The mains plug must be cut off so that the lead can be wired to the switched output of the circuit board. The hard wiring is very straightforward, but as most of this wiring carries the mains supply it is essential to take great care over it, and to thoroughly check it all before connecting the finished unit to the mains supply. Check that the soldered joints are all reliable, and that all the interconnections are correct.

PARTS LIST for the Computer Auto Switcher

Resistors

(all 0.25 watt 5% carbon film)

R1	1k
R2	1M5
R3	5k6

Capacitors

C1	100u 25V radial elect
C2,3	100n ceramic
C4	1u 50V radial elect
C5	10n polyester, 7.5mm lead spacing
C6,7	47u 25V radial elect (2 off)

Semiconductors

IC1	uA78L12 12V 100mA positive voltage regulator
TR1,2	BC549
D1,2	1N4002
D3 to D6	1N4148

Miscellaneous

S1	Rotary mains switch
RLA1	12 volt 250R coil, DPDT 250V AC 6A contacts (Maplin FJ43W)
T1	Standard mains primary, 12 - 0 - 12 volt 100mA secondary
T2	see text
FS1	100mA 20mm quick-blow

Metal case about 152 x 114 x 76mm, printed circuit board, mains outlet, four-way distribution board with lead, control knob, materials for T2 (FX4054 ferrite toroid, 34 swg/0.236mm and 20 swg/0.9mm enamelled copper wire), 20mm fuse-clips (one pair), mains lead and plug fitted with 3A fuse, wire, solder, etc.

In Use

As an initial check of the unit, plug a table lamp into the mains outlet for the computer, and switch the lamp on and off a few times. When the lamp is switched on, the relay should be heard to "click" almost immediately as it also switches on. When the lamp is switched off there should be a delay of two seconds or so before the relay is heard to switch off. If the unit passes this simple test correctly, connect it to the computer equipment and test it in earnest. If there is any sign of a malfunction, disconnect the unit from the mains supply and recheck all the wiring. Note that this unit is not suitable for controlling high power loads. The relay has a current rating of 6 amps, which means that the total loading on the switched outputs must be no more than 1380 watts. Most computer peripherals consume under 100 watts, and in many cases consume no more than a few watts. Consequently, there should be no problems when the unit is used in its intended application, even if it controls three or four peripherals. It should work well in other applications provided only small/medium loads are controlled. ***The auto-switcher should not be used to control something like a high wattage electric fire.***

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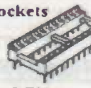
DIL Sockets



Stamped Pin
- 8 Pin DIL 0.3" £0.06
- 14 Pin DIL 0.3" £0.11
- 16 Pin DIL 0.3" £0.11
- 18 Pin DIL 0.3" £0.12
- 20 Pin DIL 0.3" £0.12
- 24 Pin DIL 0.6" £0.13
- 28 Pin DIL 0.6" £0.13
- 40 Pin DIL 0.6" £0.19

Turned Pin
- 8 Pin DIL 0.3" £0.11
- 14 Pin DIL 0.3" £0.20
- 16 Pin DIL 0.3" £0.23
- 18 Pin DIL 0.3" £0.29
- 20 Pin DIL 0.3" £0.29
- 24 Pin DIL 0.6" £0.35
- 28 Pin DIL 0.6" £0.41
- 40 Pin DIL 0.6" £0.64

SIL Header Strip
- 1 x 36 Way Straight £0.38
- 2 x 36 Way Straight £0.72
- 1 x 36 Way 90° £0.55
- 2 x 36 Way 90° £0.78
- 20 Way Socket Strip £0.54

Transistor Sockets
- T018-4 Base Socket £0.24
- T05 Base Socket £0.24

IDC Cable Sockets

- 10 Way Socket £0.23
- 14 Way Socket £0.34
- 16 Way Socket £0.31
- 20 Way Socket £0.26
- 26 Way Socket £0.30
- 34 Way Socket £0.42
- 40 Way Socket £0.66
- 50 Way Socket £0.75

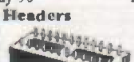
PCB Box Headers

- 10 Way Straight £0.27
- 14 Way Straight £0.36
- 16 Way Straight £0.36
- 20 Way Straight £0.41
- 26 Way Straight £0.49
- 34 Way Straight £0.52
- 40 Way Straight £0.63
- 50 Way Straight £0.96
- 10 Way 90° £0.36
- 16 Way 90° £0.47
- 20 Way 90° £0.53
- 26 Way 90° £0.58
- 34 Way 90° £0.72
- 40 Way 90° £0.83
- 50 Way 90° £0.99

PCB Latch Headers

- 10 Way Straight £0.50
- 16 Way Straight £0.70
- 20 Way Straight £0.78
- 26 Way Straight £1.00
- 34 Way Straight £0.86
- 40 Way Straight £1.56
- 50 Way Straight £1.29
- 10 Way 90° £0.58
- 16 Way 90° £0.78
- 20 Way 90° £0.82
- 26 Way 90° £1.06
- 34 Way 90° £1.14
- 40 Way 90° £1.26
- 50 Way 90° £1.74

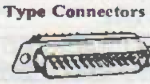
DIL Headers



- 14 Way DIL £0.54
- 16 Way DIL £0.59
- 24 Way DIL £0.90
- 40 Way DIL £1.02

Transistion Headers
- 10 Way Transistion £0.49
- 14 Way Transition £0.47
- 16 Way Transition £0.47
- 20 Way Transition £0.54
- 26 Way Transition £0.62
- 34 Way Transition £0.67
- 40 Way Transition £0.90
- 50 Way Transition £1.02

D Type Connectors



Solder Bucket
- 9 Way Male Plug £0.29
- 9 Way Female Socket £0.30
- 15 Way Male Plug £0.39
- 15 Way Female Socket £0.39
- 15 Way H.D. Plug £0.49
- 15 Way H.D. Socket £0.78
- 23 Way Male Plug £0.49
- 23 Way Female Socket £0.49
- 25 Way Male Plug £0.48
- 25 Way Female Plug £0.50

IDC Ribbon Mounting
- 9 Way Male Plug £1.08
- 9 Way Female Socket £1.08
- 25 Way Male Plug £1.26
- 25 Way Female Socket £1.26

Right Angled PCB

- 9 Way Male Plug £0.37
- 9 Way Female Socket £0.35
- 15 Way H.D. Socket £0.77
- 25 Way Male Plug £0.53
- 25 Way Female Socket £0.51

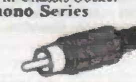
Plastic D Covers
- 9 Way Cover - Grey £0.30
- 9 Way Cover - Black £0.30
- 15 Way Cover - Grey £0.33
- 23 Way Cover - Grey £0.36
- 23 Way Cover - Black £0.36
- 25 Way Cover - Grey £0.36
- 25 Way D Cover - Black £0.36
- 9 to 9 Cover / Case £0.96
- 25 to 25 Cover / Case £0.86

Audio Connectors

- 2.5mm Jack Plug £0.21
- 2.5mm Line Socket £0.16
- 2.5mm Chassis Socket £0.09
- 3.5mm Mono Plug £0.24
- 3.5mm Mono Line Skt £0.30
- 3.5mm Mono Chassis Sk £0.14
- 3.5mm Stereo Plug £0.33
- 3.5mm Stereo Line Skt £0.37
- 3.5mm Stereo Chassis Sk £0.34
- ¼" Mono Plug £0.30
- ¼" Mono Line Socket £0.35
- ¼" Mono Chassis Socket £0.40
- ¼" Stereo Plug £0.40
- ¼" Stereo Line Socket £0.38
- ¼" Stereo Chassis Skt £0.44

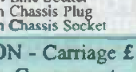
DIN Series
- 2 Pin Line Plug £0.21
- 2 Pin Chassis Socket £0.15
- 3 Pin Line Plug £0.27
- 3 Pin Chassis Socket £0.28
- 4 Pin Line Plug £0.24
- 4 Pin Chassis Socket £0.26
- 5 Pin Line Plug 180° £0.30
- 5 Pin Chassis Skt 180° £0.32
- 5 Pin Line Plug 240° £0.24
- 5 Pin Chassis Skt 240° £0.32
- 5 Pin Line Plug 360° £0.24
- 5 Pin Chassis Skt 360° £0.32
- 6 Pin Line Plug £0.27
- 6 Pin Chassis Socket £0.32
- 7 Pin Line Plug £0.34
- 7 Pin Chassis Socket £0.34
- 8 Pin Line Plug £0.45
- 8 Pin Chassis Socket £0.36

Phono Series



- Red Line Plug £0.20
- Black Line Plug £0.20
- Yellow Line Plug £0.20
- White Line Plug £0.20
- Red Line Socket £0.20
- Black Line Socket £0.20
- Yellow Line Socket £0.20
- White Line Socket £0.20
- Red Chassis Socket £0.20
- Black Chassis Socket £0.20
- Gold Plated Plug - Red £0.76
- Gold Plated Plug - Black £0.76

XLR Series - metal



- 3 Pin Line Plug £1.50
- 3 Pin Line Socket £1.82
- 3 Pin Chassis Plug £1.50
- 3 Pin Chassis Socket £1.70

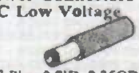
RF Connectors

- BNC Plug 50Ω Solder £0.93
- BNC Plug 50Ω Crimp £0.56
- BNC Plug 75Ω Solder £0.96
- BNC Plug 75Ω Crimp £0.70
- BNC Chassis Socket £0.80
- F Plug - Twist £0.27
- F Plug - Crimp £0.30
- TNC Plug Solder £1.20
- TNC Plug Crimp £0.78
- UHF Plug 5mm Cable £0.72
- UHF Plug 11mm Cable £0.66
- UHF Chassis Skt- Sqr £0.45
- UHF Chassis Skt- Rnd £0.58

Terminals

All Available in - Red, Black, Green, Blue, White or Yellow
- 2mm Solder Plugs £0.18
- 2mm Chassis Sockets £0.20
- 4mm Solder Plugs £0.30
- 4mm Stackable Plugs £0.40
- 4mm Chassis Sockets £0.23
- 4mm Binding Posts £0.54
- 33mm Crocodile Clips £0.13

Power Connectors DC Low Voltage

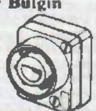


- DC Plug 0.7ID, 2.35OD £0.46
- DC Plug 1.3ID, 3.4OD £0.32
- DC Plug 1.7ID, 4.0OD £0.46
- DC Plug 1.7ID, 4.75OD £0.46
- DC Plug 2.1ID, 5.0OD £0.24
- DC Plug 2.5ID, 5.0OD £0.24
- DC Plug 3.1ID, 6.3OD £0.46
- DC Line Socket 2.1mm £0.56
- DC Line Socket 2.5mm £0.56
- DC Chassis Skt 2.1mm £0.46
- DC Chassis Skt 2.5mm £0.46

IEC Mains 6A 250Vac

- 3 Pin IEC Line Socket £1.14
- 3 Pin IEC Line Plug £1.83
- 3 Pin Chassis Socket £0.56
- 3 Pin Chassis Plug £0.72

8 Way Bulgin



- 8 Pin Line Plug P551 £3.93
- 8 Pin Chassis Skt P552 £1.25

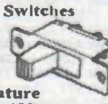
Toggle Switches

Sub-Miniature
3A 125V 1A 250V
5mm Ø Mounting Hole
- SPST 5 x 10mm £0.58
- SPDT 5 x 10mm £0.60
- SPDT C/Off 5 x 10mm £0.86
- DPDT 9.2 x 10mm £0.66

Miniature
6A 125V 3A 250V
6.2mm Ø Mounting Hole
- SPST 8 x 13mm £0.66
- SPDT 8 x 13mm £0.60
- SPDT C/Off 8 x 13mm £0.64
- SPDT C/O Biased 2 way £1.34
- SPDT C/O Biased 1 way £1.04
- DPDT 12 x 13mm £0.72
- DPDT C/Off 12 x 13mm £0.76
- DPDT C/O Biased 2 way £1.28
- DPDT C/O Biased 1 way £1.28

Standard
10A 250V Push on terminals
11mm Ø Mounting Hole
- SPST 18 x 30mm £1.14
- SPDT 18 x 30mm £1.28
- SPDT C/Off 18 x 30mm £1.52
- DPDT 21 x 30mm £1.78
- DPDT C/Off 21 x 30mm £1.78

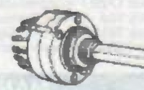
Slide Switches



Miniature
300mA 125V
7 x 15mm Mounting Hole
- DPDT 7 x 23mm £0.15

Standard
1A 125V
5.5 x 12mm Mounting Hole
- DPDT 12.5 x 35mm £0.24
- DPDT C/O 12.5 x 35mm £0.27

Rotary Switches



150mA 250V
Make before Break 22mm Ø
9.8mm Ø Mounting Hole
- 1 Pole 12 Way £0.84
- 2 Pole 6 Way £0.84
- 3 Pole 4 Way £0.84
- 4 Pole 3 Way £0.84

Push Switches

Miniature Round
250mA 125V 28 x 10mm
7mm Ø Mounting Hole
Non Latching Push to Make
- Black PTM £0.25
- Red PTM £0.25
- Yellow PTM £0.25
- Green PTM £0.25
- Blue PTM £0.25
- White PTM £0.25

Non Latching Push to Break
- Black PTB £0.25

Standard Square

1A 250V
39 x 15MM
12mm Ø Mounting Hole
Non Latching Push to Make
- Black PTM £0.60
- Red PTM £0.60
- Blue PTM £0.60
- White PTM £0.60

Latching
- Black £0.63
- Red £0.63
- Blue £0.63
- White £0.63

Rocker Switches

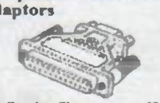
Miniature
6A 250V Solder Tags
- SPST 21 x 14 x 16mm £0.63
- DPDT 21 x 24 x 22mm £0.96

Standard
15A 250V Push on Tags
- SPST 30 x 11 x 22mm £0.62
- DPDT 30 x 25 x 22mm £1.12

Illuminated
15A 250V Push on Tags
- SPST 30x14mm Red £0.84
- DPDT 30x25mm Red £1.40
- DPDT 30x25mm Amber £1.40
- DPDT 30x25mm Green £1.40

Relays
PCB Mounting
- 1A 24Vdc DPDT 5V £1.44
- 1A 24Vdc DPDT 12V £1.44
- 3A 110V SPDT 6V £0.58
- 3A 110V SPDT 12V £0.58
- 5A 110V SPDT 6V £0.72
- 5A 110V SPDT 12V £0.72
- 5A 110V DPDT 6V £0.93
- 5A 110V DPDT 12V £0.93
- 5A 240V DPDT 6V £1.76
- 5A 240V DPDT 12V £1.76
- 10A 240V SPDT 6V £1.25
- 10A 240V SPDT 12V £1.44
- 10A 240V SPDT 24V £1.44

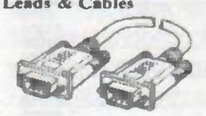
Computer Accessories Adaptors



- 9M Gender Changer £2.33
- 9F Gender Changer £2.33
- 25M Gender Changer £2.66
- 25F Gender Changer £2.80
- 9 Male - 25 Female £2.02
- 9 Female - 25 Male £2.09
- 9M - 6 Mini Din Male £2.55
- 9F - 6 Mini Din Female £2.54
- 5M Din - 6F Mini Din £3.02
- 5F Din - 6M Mini Din £2.28

Testers / Patch Boxes
- Mini Tester 7 LEDs £6.68
- Check Tester 18 LEDs £7.11
- Enhanced LED/Switches £15.25
- 25D Jumper Box M-F £2.90
- 25D Patch Box M-F £7.32
- Anti-Static Wrist Strap £5.30
- RS232 Surge Protector £5.43
- Mains Surge Protector £11.99

Leads & Cables



- 1.5m Printer Lead £3.40
- 5m Printer Lead £9.38
- 10m Printer Lead £12.38
- Serial Printer 25M-9F £4.20
- Serial Printer 25M-25F £4.45
- Null Modem 9F-9F £3.45
- Null Modem 25F-25F £4.63
- Null Modem 9&25-9&25 £5.54
- Modem Lead 25M-9F £4.08
- Modem Lead 25M-25F £4.75
- Interlink Lead 25F-9F £6.50
- Interlink Lead 25F-25F £6.50
- Interlink Lead 25M-25M £6.50
- Patch Lead 25M-25M £4.66
- Patch Lead 36M-36M £5.90
- Floppy Drive Cable A/B £4.50
- Hard Disk Cable 2xIDE £2.90
- Power Cable 3½-2 x 3½ £1.88
- Power Cable 5¼-2 x 5¼ £2.24
- Power Cable 5¼-2 x 3½ £2.24
- Power Cable 5¼-3½,5¼ £2.24

Networking
- BNC T Piece FMF £2.40
- BNC T Piece FFF £2.40
- BNC Coupler F £1.02
- BNC Coupler M £1.65
- BNC Ratchet Crimper £17.44
- RJ45 IDC Plug £0.39
- Thinnet Cable per m £0.48

Please Phone for items not Listed

Boxes & Cases
Many more sizes available

General Purpose Plastic
- 75 x 56 x 25mm £0.93
- 75 x 51 x 22mm £0.93
- 111 x 57 x 22mm £1.05
- 79 x 61 x 40mm £1.58
- 100 x 76 x 41mm £1.69
- 118 x 98 x 45mm £1.95
- 150 x 100 x 60mm £2.65
- 150 x 80 x 50mm £2.47

Diecast Aluminium
- 50 x 50 x 31mm £2.24
- 100 x 50 x 25mm £2.98
- 112 x 62 x 31mm £3.55
- 120 x 65 x 40mm £4.02
- 150 x 80 x 50mm £5.36
- 121 x 95 x 61mm £5.99

Two Piece Aluminium
- 133 x 70 x 37mm £2.08
- 102 x 102 x 37mm £1.94
- 102 x 70 x 37mm £1.76
- 133 x 102 x 37mm £2.19
- 102 x 63 x 50mm £1.86
- 76 x 51 x 25mm £1.34
- 152 x 102 x 50mm £2.90
- 178 x 127 x 63mm £3.62
- 203 x 152 x 76mm £4.68
- 102 x 102 x 63mm £2.15
- 133 x 102 x 63mm £2.57
- 152 x 102 x 76mm £3.23

Steel/Aluminium
Plastic coated steel top, Aluminium base
- 152 x 114 x 44mm £4.19
- 203 x 127 x 51mm £4.68
- 229 x 127 x 63mm £5.62
- 114 x 63 x 57mm £3.04

Wire & Cable

Ribbon Cable
Price per 300mm (1ft)
- 10 Way Grey Ribbon £0.11
- 16 Way Grey Ribbon £0.17
- 20 Way Grey Ribbon £0.22
- 26 Way Grey Ribbon £0.28
- 34 Way Grey Ribbon £0.36
- 40 Way Grey Ribbon £0.48
- 50 Way Grey Ribbon £0.53
- 64 Way Grey Ribbon £0.64

Enamelled Copper Wire
Per 50g (2oz) Reel
500g reels available
- 14 SWG Enamelled £0.68
- 16 SWG Enamelled £0.72
- 18 SWG Enamelled £0.78
- 20 SWG Enamelled £0.81
- 22 SWG Enamelled £0.83
- 24 SWG Enamelled £0.87
- 26 SWG Enamelled £0.97
- 28 SWG Enamelled £0.99
- 30 SWG Enamelled £1.02
- 32 SWG Enamelled £1.05
- 34 SWG Enamelled £1.10
- 36 SWG Enamelled £1.14
- 38 SWG Enamelled £1.20
- 40 SWG Enamelled £1.52

Tinned Copper Wire
Per 50g (2oz) Reel
500g reels available
- 16 SWG Tinned £0.72
- 18 SWG Tinned £0.78
- 20 SWG Tinned £0.81
- 22 SWG Tinned £0.83
- 24 SWG Tinned £0.87

Equipment Wire
Avaiable in Black, Brown, Red, Orange, Yellow, Green, Blue, Purple, Grey & White
Per 100m Reel
- Solid 1/0.6mm £2.33
- Stranded 7/0.2mm £2.14

Opto Electronics

LEDS
- 3mm Red Led £0.08
- 3mm Green Led £0.09
- 3mm Yelow Led £0.10
- 3mm Orange Led £0.10
- 5mm Red Led £0.08
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Fast Fivers

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

2 - Phoney intruder detector

Everyone, even the newest recruit into the ranks of the breaker-in, is familiar with the flashing red led that purports to indicate surveillance. In many instances it is just a flashing led, and that's all. This is much easier and cheaper to build than a than real passive infra-red detector or a real car security system, and possibly almost as effective. It plants doubt in the would-be criminal's mind and helps to induce them to try elsewhere.

This project represents the latest stage of thinking - the next step in bluffing. Instead of flashing the led regularly to suggest that there is a detector switched on, we flash it irregularly to pretend that the detector is actually detecting something - perhaps the person who is watching it! Detectors, especially PIR devices are extremely sensitive. They respond to minute changes in their environment and on a quiet day (or night) the changes are more-or-less random. The led flashes in a random way. It is only when the intruder gets nearer and a purposive non-random change is detected and the alarm is sounded. This circuit looks as if it is quite happy at the moment but could trigger the alarm if you come any closer.

Random numbers

The project is based on a random number generator (figure 1), the main part of which is a shift register. This consists of a set of registers, each of which holds a single binary digit, which can be 0 or 1. The registers are numbered from 1 upward. The shift register is driven by a clock, which produces a regular series of pulses. The contents of the registers (the data) are shifted every time a high clock pulse begins. Data in register n is transferred to register n+1. Register 1 receives data from the input. Data in the last register (register m) is lost.

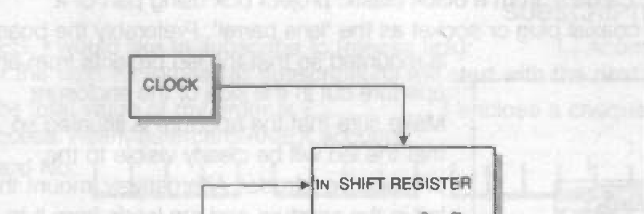

Figure 1: Pseudo-random number generator

If we take the data from register m and from one (n) or more of the other registers, send them to an exclusive-OR gate, and feed the output of the gate back to the input of the shift register, we find that the data in each register undergoes a series of changes which are predictable but which appear to be random. We say the changes are pseudo-random. To illustrate this idea, look at what happens in a 3-stage register, when the ex-ORed data from registers 2 (n) and 3 (m) is fed back to register 1. We begin with '1' in all registers:

Stage	Contents of registers			Ex-Or
	1	2	3	
		n	m	
1	1	1	1	0
2	0	1	1	0
3	0	0	1	1
4	1	0	0	0
5	0	1	0	1
6	1	0	1	1
7	1	1	0	1
8	1	1	1	and so on

At each stage, data in registers 1 and 2 is shifted to registers 2 and 3. The ex-OR operation gives a 1 if one or the other, but not both, of the inputs is 1. In the table, the ex-OR of registers n and m on one line is transferred to register 1 on the next line. Reading down the fourth column, the sequence of data in register m is 1, 1, 1, 0, 0, 1, 0, and then repeats. Watching an led flashing on for a 1 and off for a 0, we would soon notice the repetitions and realises that the led was not flashing randomly. But, with a longer shift register, the sequence may repeat only after several hundreds or thousands of stages. We could not recognise the repeats and so the led appears to be flashing randomly.

How it works

In figure 2, IC1 is the clock, operating at 1Hz. IC2 contains two 4-stage shift registers and we have joined these in series to give an 8-stage register. With an 8-stage register we need to feed back the data from three registers, numbers 4, 5, 6 and 8. The maths behind this is complicated, but the quadruple feedback is necessary to obtain a sequence of maximum length. In the table above, taking the register contents as 3-bit numbers (111, 011, 001 and so on), we see that the sequence contains all the seven numbers that are possible with three bits, except for 000. The all-zero number is not allowed because, if it occurs, the ex-OR is 0 and the system latches into an all-zero state. The same applies with the circuit In Figure 2. With 8 bits we can have 255 different numbers (again excluding all-zeroes 00000000). So this register goes through

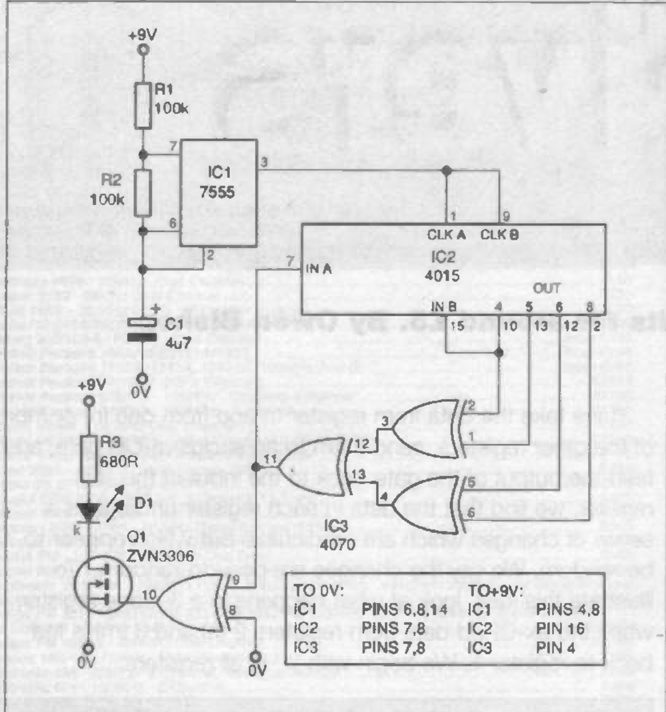

Figure 2: Pseudo-random led flasher

PARTS LIST

Resistors

(0.25W, 5% tolerance or better)

R1, R2	100k (2 off)
R3	680R

Capacitor

C1	4.7uF, electrolytic, axial leads

Semiconductors

IC1	7555 timer
IC2	4015 CMOS dual 4-bit shift register
IC3	4070 quad exclusive-OR gate
Q1	ZVN3306 n-channel enhancement mosfet

Miscellaneous

D1	Superbright led, red

Clip for PP3 battery; 0.1-in matrix stripboard 80mm x 25mm (10 strips x 31 holes); 0.1mm terminal pins (2 off); 8-pin dil socket, 14-pin dil socket, 16-pin dil socket; battery box for 4 x AA cells.

255 states and, clocking the register at 1Hz it takes over 4 minutes before the sequence repeats. It is almost impossible to distinguish between this repeating sequence and a non-repeating truly random one.

By definition, an ex-OR gate has only two inputs. With 4 outputs to feed back, we need three ex-OR gates. We ex-OR the outputs in two pairs to obtain two outputs. We use a third gate to ex-OR these to outputs to produce a single output for feedback. This is known as a parity tree, and is used when we want to compare two binary numbers to check that they are equal. The 4070 ic contains four ex-OR gates so we use the fourth gate simply as a buffer to switch on the mosfet, Q1, which turns the led on or off.

Construction

The stripboard layout is compact so that it can be fitted into a small case. First cut the strips where indicated, noting that there are NO cuts at C23, F23 and D27. When you have soldered in the ic sockets, do not insert the ics but make solder blobs between adjacent tracks, joining A8 to B8, A18 to B18, A29 to B29, and J15 to K15. Since this is mainly a logic circuit the bulk of construction consists of wire links. Check these point-to point connections very carefully. Check the board (use a magnifier) to make sure that tracks are properly cut where intended, and that there are no threads of solder bridging adjacent tracks. When you are ready for testing, insert IC1 in its socket and monitor the voltage at B15 and J18 to confirm that the clock is operating at about 1Hz. Insert IC2, apply +6V at pin 7 (use the socket for IC3 at pin 11), monitor the voltage at pin 2. After a few seconds it should change to +6V and stay at that level. Then apply 0V to pin 7; a few seconds later pin 2 should go to 0V. These tests generally indicate that IC2 is working properly, though there could be faults left undetected. Apply +6V to the socket of IC3 at pin 10 and the led should switch on. Finally insert IC3. The circuit is complete. When it is first switched on there may be a delay of several seconds before the led comes on. After that, it flashes on for apparently irregular periods with irregular gaps between.

With a superbright led the circuit takes 0.14mA when the led is off and 7.6mA when it is on. Since it is on for half the time, the average current consumption is 3.9mA. A battery of four type AA alkaline cells will last for about a month, operating day and night. If you have room, use a battery of D type cells. For compactness, the circuit will run on 9V, so use a PP3. But this will last only a few days.

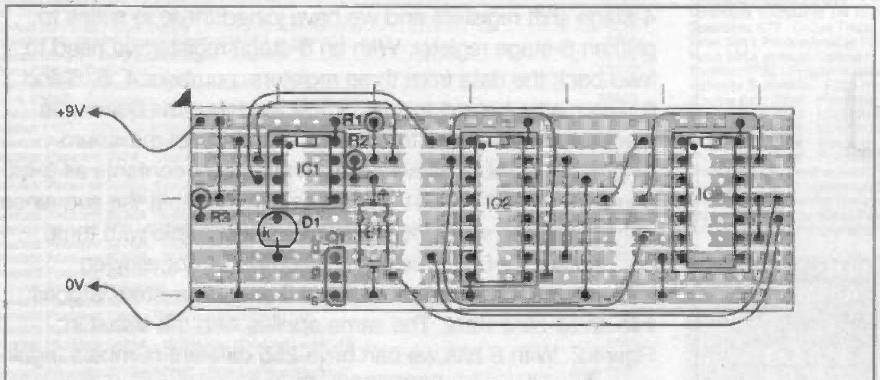

Figure 3: Layout of the Veroboard

Enclosure

An essential aspect of this project is to disguise it as the detector of some kind of security system. You may already have a sensor from an obsolete system which can be re-cycled into your new random 'system'. Or you can mock-up a 'camera' from a black plastic project box using part of a coaxial plug or socket as the 'lens barrel'. Preferably the board is mounted so that the led projects from an aperture cut in the side of the enclosure. Make sure that the aperture is situated so that the led will be clearly visible to the prospective intruder. Alternatively, mount the led in the aperture and run leads from it to terminal pins on the board, located at F5 and H5. Mount the 'sensor' where it (and the led) can be seen through a window. Just inside the fanlight over a front door is a good place in an older house.

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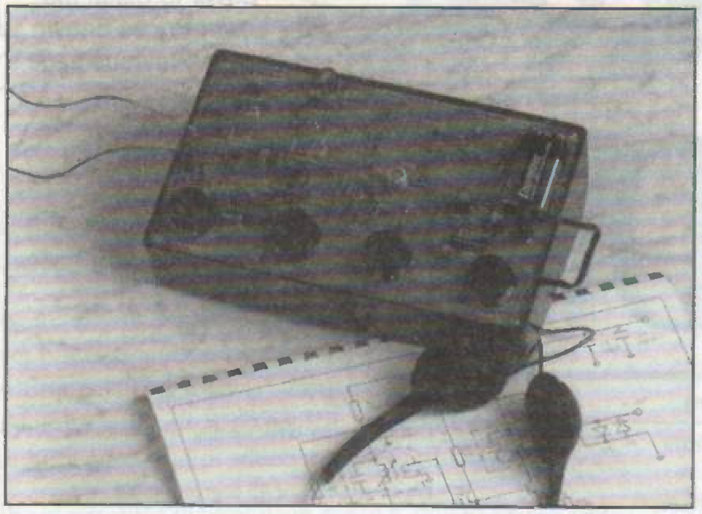

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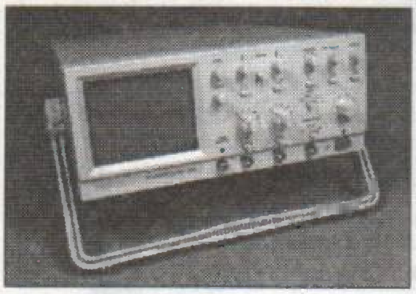

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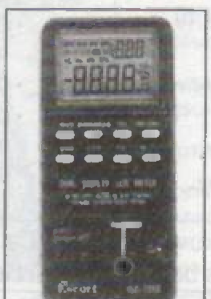

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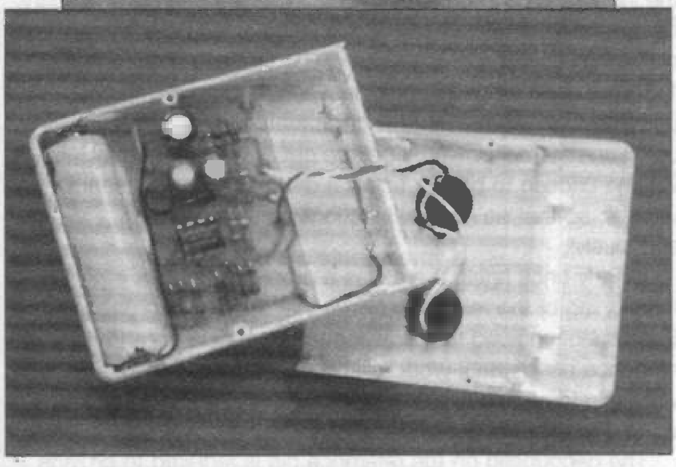
The Little Red Reading Light

This pocket light is small, weighs very little, and uses high-efficiency red leds to provide enough light to see by when you need to conserve battery power - and it has a time-out to make it last even longer. By Andrew Armstrong.

I have a friend who uses up torch batteries like Smarties. Each night she falls asleep reading a detective thriller - her favourite means of keeping off insomnia, believe it or not. At home all this means is that the electricity board gets a few more pence, but on holiday her usual source of sleep-inducing soporifica is to explore the tombs of long-dead Kings and Pharaohs, which means reading her mysteries by torchlight to allow other occupants of the tent/camel shed/tomb, etc., to get a quiet night's sleep.

Falling asleep in the middle of a paragraph, of course, means that the torch is left switched on and has generally used up a set of batteries by morning, so a two-week break in Egypt forces her to carry fourteen sets of batteries - no mean rarity in those far-off places, and no small weight either.

I looked at the possibility of a torch using solar-powered rechargeable batteries, but the amount of energy used by a torch in one night is enough to require substantial solar panels.



The interior of the Little Red Reading Light (with original switches fitted)

It would be easier, even if less environmentally sound, to keep using the disposable batteries. Another answer was needed, both to lighten the weight and to strike a blow for the preservation of the environment.

This is how I reasoned: solar powered would be ideal, but failing that something which uses less battery power would be a step in the right direction. Clearly the amount of light needed to read a book is less than that from a powerful torch used to find your way around, so some power can be saved by choosing an appropriate light output. However, what can be saved in this way is limited because it is still necessary to avoid tired eyes.

A more efficient means of converting electricity into light would be preferable, and several methods are more efficient then filament lamps. In fact, I can't think of a less efficient method in widespread use than a filament lamp.

Electroluminescent panels were first considered, in order to generate an even illumination to cover most of a page, but the power requirements were higher than I wanted, and the battery voltage needed to step up to the high voltage for the EL panel was also not preferred. Finally, protection for the user from the high voltage presented an assembly problem.

The remaining choice was between cold cathode tubes (of the type used to backlight liquid crystal displays) and LEDs, and for a while it was a close thing. LEDs scored with lower battery voltage and with their comparative robustness for travelling.

The most efficient LEDs are red. Could people read comfortably in red light? I tried it out myself, with a test setup using a set of LEDs with a series current limit resistor and a set of AA cells in series. I could read comfortably for as long as I tested it (half an hour) and other test subjects fared similarly, and then chose LEDs.

A case of two cells

My first idea was to use something simple - two cells in series to provide enough voltage to run a light emitting diode, and a series limiting resistor to set the current. Six LEDs in parallel gave enough light, and a pair of nickel cadmium cells in series ran them with only slightly declining brightness for over four hours. These cells could be recharged to a reasonable proportion by a solar cell of just barely acceptable size. There were several drawbacks, though only one of them was severe enough to make it worth complicating the simple idea.

The positive aspects were that the efficiency was good and that automatic low battery protection was included.

The two cells provided 2.4V, about 0.5V across the limiting resistor, with the rest doing useful work running the LEDs. If the light were left switched on, a degree of battery protection would be provided by the LEDs ceasing to draw current when the battery voltage fell to around 0.9V per cell. It has an elegant simplicity.

The downside with this simple system is that if the light is used as a reading light in the way envisaged, it is likely to be fully discharged each night, although a full recharge cannot be guaranteed during the day. The first attempt to solve this problem was to allow for the use of disposable cells in case the rechargeable ones were not fully charged at the end of the day. I had previously expected to use tagged nickel cadmium cells permanently connected to the circuit, but now a battery holder would be needed.

Unfortunately I could not find a suitable case with a battery holder for two AA cells. Available cases had holders for one PP3 battery, which holds about the same energy as two AA cells, but costs more. Use of a PP3 was possible with more LEDs in series, but recharging would be more of a problem. Also, the cost per unit of energy is greater with disposable PP3 batteries than with AA cells.

The few cases with a battery holder for two AA cells were much too large and clumsy for the purpose.

I then considered a timer built into the reading light so that it would not remain on all night. The most effective way to switch the unit would be to use a power mosfet, but that would need more than 2V4 to switch it fully on. In any case, some minimal amount of electronics would be needed for a timer, and few ics work on 2V4 (2V for end of charge). Perhaps the least bad way would be to use a voltage doubler chip if there was a suitable one in the ICL7660 family, and run the timer from over 4V, which would be easy.

The increase in complexity is significant for a modest improvement in functionality, so I sought another answer. The idea of using a separate pack of disposable batteries as a source of charging current did briefly cross my mind, but lack of elegance and efficiency ruled it out.

I chose the case I wanted to use - which is a small pager case with a holder for a single AA cell - and resolved to make a working light in that if at all possible. This would then be able to run from rechargeable batteries or disposable ones, and recharging could be carried out by a separate charger, solar powered or otherwise.

Step up

There was only one clear answer. A switched mode step up converter should be used to convert the 1V to 1V5 from a single cell to the approximately 3V9 to run a series/parallel set of six LEDs. Of the small converter chips stocked by Electromail, only one was ideal, so no difficult decisions were needed. The MAX757 will start from an input voltage of 0V9, and continue to run to a lower voltage. All other converters easily available from suppliers to the amateur need higher input voltages. This converter will run the LEDs at full brightness until the battery is down to 0V8 or less - the prototype showed no visible light reduction at 0V5. Little of the stored energy in an AA cell would be wasted by this.

The other main design requirement was that the maximum amount of energy should be transferred from AA cell to LEDs, with the minimum wasted in the circuit. It is no good to be able to run the battery down very flat if all the extra is used to warm the switching components. A final preference was to incorporate a timeout if it was practical.

The design shown here achieves all the objectives: it is small, neat, and light, it uses less battery power than an ordinary torch while giving a good light, it automatically switches off after about 40 minutes, and it is estimated to run for around five or six hours on a single alkaline AA cell, and one to and a half hours on a high capacity rechargeable. If use with rechargeable cells is intended as the normal mode, then it may be preferable to reduce the timeout by reducing the values of R7, R8, and R9.

How the circuit works

The heart of the circuit, shown in figure 1 is the MAX757 DC to DC converter ic. This contains all active components except for the diode. It is a self oscillating device, which switches at the rate needed to keep the output voltage at the correct level. Therefore the switching frequency depends on input voltage to output voltage ratio, power drain, and the value of the inductor.

As can be seen from an inspection of the internal circuitry, monostables set a minimum off time and a maximum on time, but apart from that the switching timing depends on external parameters. This is a pulse frequency modulation system with peak current limiting.

Because there is no oscillator, at high loads the inductor current self oscillates between the peak current limit and a lower value. At lower loads, the switching frequency self adjusts to keep the load voltage up to the required level.

The MAX757 also includes a low battery detector. If the voltage at LBI falls below the regulators internal reference voltage (1.25V) then the open drain output LBO sinks current to ground. Because the lowest battery voltage to be used in this project is below 1V25, the low battery detector is of no use for its intended purpose, but has been put into service as an on/off and timer control.

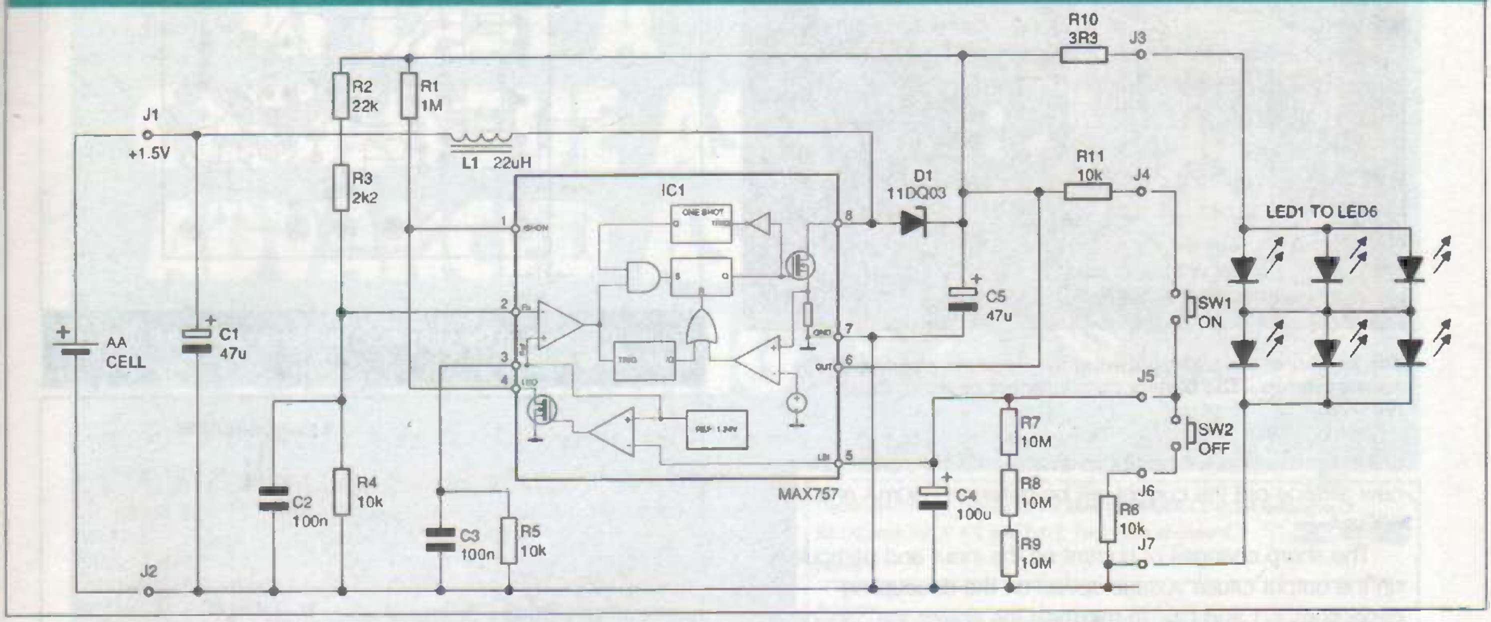
When the on switch, SW1, is pressed, C4 charges towards the input supply voltage via R11. When the voltage on C4 is close to the input voltage, the internal comparator switches and the SHDN# pin is pulled up to the output voltage. This allows the regulator to start switching and increase the output voltage to the level set by the feedback resistors. C4 then charges towards the output voltage while the switch is pressed.

If you look carefully at the low battery system, it is not clear why this should work. If a nickel cadmium cell is used as the power source, then the input voltage is below the specified reference voltage, and you might expect that the comparator would not switch over. It was found during development that the reference voltage does not reach the input voltage when the input is at 1V2, presumably because the reference circuitry cannot operate adequately at this voltage. Surprisingly, powering up was a problem only when a fresh alkaline cell at 1V5 was used. With this power supply voltage it was not possible to make the internal comparator switch, even by using an external power supply to charge C4 to 2V (test voltage chosen to be just under a diode drop below supply voltage, so that no internal junctions would switch on spuriously).

Clearly once again there was a problem with the functioning of the reference circuitry at such a low voltage. Experiment showed that drawing about 100uA from the reference pin made it work reliably, so R5 was added. The voltage reference pin is rated to source up to 250iA or to sink up to 25uA, so this is within its specification.

The decoupling on the reference pin is required to provide a clean reference to the internal circuitry.

Figure 1: the circuit diagram of the Little Red Reading Light



When the unit has been switched on, and the on switch is released, C4 will discharge via R7, R8, and R9 as well as via its own leakage current. The written specification for the electrolytic capacitor would suggest that its own leakage would exceed the discharge via the resistors, but in practice this is not so. The specified leakage, of 3uA, applies at the maximum temperature rating of the capacitor and at its maximum voltage, and would typically be less even under these conditions. Here the capacitor is used at below its rated voltage and at room temperature. The leakage will be much lower than the resistor current under these conditions.

The unit automatically switches off when the voltage on C4 falls below 1V25, which will take approximately one time constant ie R x C. R is 30 megohms, and C is 100 microfarads, so the theoretical timeout period is 50 minutes. In practice it will be slightly less due to capacitor leakage, which will be greater the first few times it is used. If a shorter timeout period is needed, lower value resistors can be used.

When the off switch is operated, C4 discharges much more rapidly and the regulator stops switching in under a second.

Boost converter

For those not completely familiar with the switched mode boost converter, it works as follows: The internal fet switches on conducting current via L1 to ground. The current in L1 rises approximately linearly until either the peak current limit is reached, or the maximum on time 1-shot switches. Then the fet is turned off and the current in L1 continues to flow via D1 into C5. Thus, while the fet is on, energy is stored in the magnetic field in L1, and then this energy is transferred to the output.

Because the voltage across the diode D1 could add up to a significant percentage reduction in efficiency, a Schottky diode is used. It is necessary to use a 1A diode to gain the maximum advantage because smaller diodes have too high a resistance. The average current is only 60mA, but the peak current is much higher, and the resistance of say a 200mA diode would add to the losses. On the other hand, a larger diode than 1A would cause extra losses due to the charging and discharging of its junction capacitance each cycle. The 1A diode is the best compromise between resistive losses and capacitive switching losses.

Figure 2 shows a trace of current and voltage waveforms. The current waveform is zeroed at the bottom of the screen, while the voltage waveform is zeroed at the graticule line corresponding to the bottom of the waveform. The converter is running in continuous mode, with current varying between 600mA and 700mA. This test is carried out with a 0R5 resistor in series with the inductor, and a nickel cadmium cell powering the unit.

Without the series resistor, the load current will be lower because the useful power delivered to the unit at a given current is reduced by the fact that the voltage on the input of the inductor is less. The current drawn from a nickel cadmium

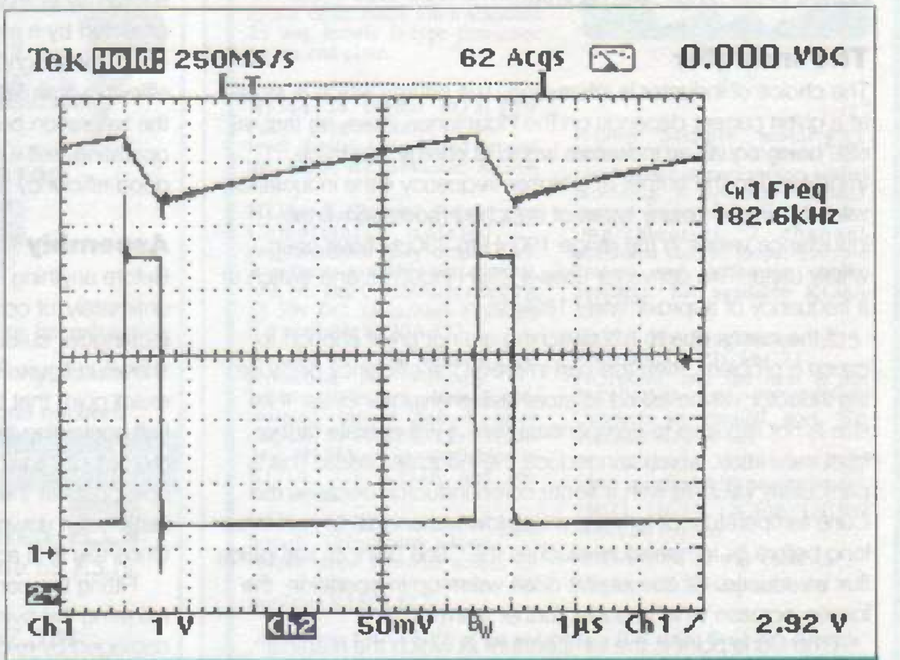
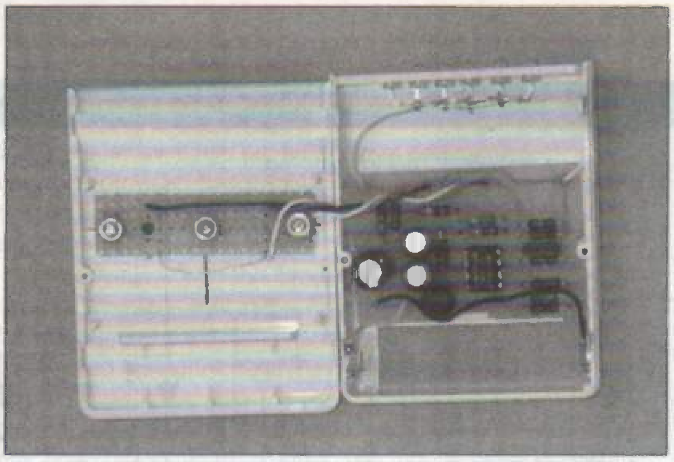


Figure 2: current and voltage waveforms



The interior of the Light, showing the Verostrip supporting the microswitches. (The battery compartment cover is shown removed).

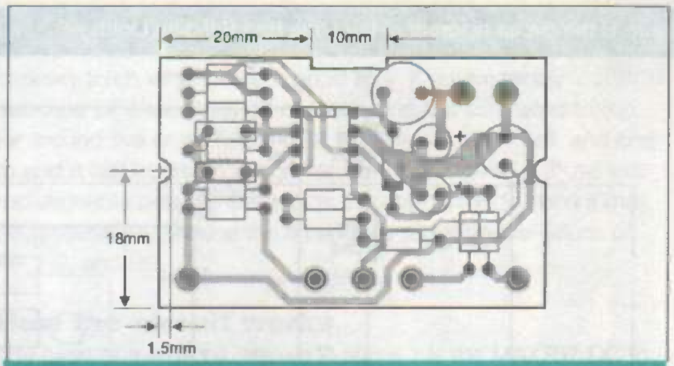


Figure 3: a guide to the cutouts to be filed in the pcb if using the case specified

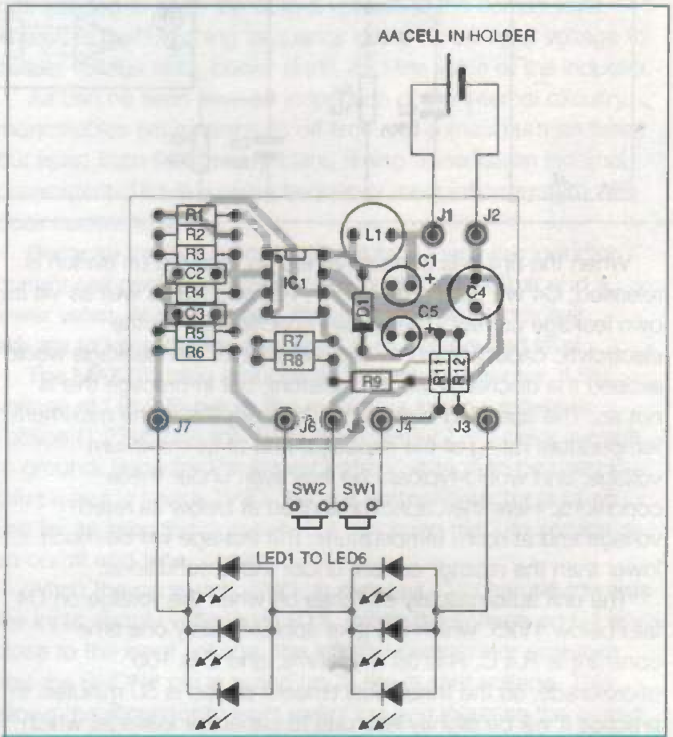


Figure 4: the component layout and offboard wiring

cell in normal use will be approximately 450mA, and from a new alkaline cell the current will be between 350mA and 400mA.

The sharp changes of current on the input and particularly on the output cause voltage spikes on the decoupling capacitors, C1 and C5. To minimise the spikes the capacitors used are specially low equivalent series resistance and series inductance. The Oscon capacitors specified for this project give a significantly better performance even than low esr electrolytics.

The output voltage is set by the choice of feedback resistors. The requirement is to feed a current of approximately 20mA through each LED, which means that a total of 60mA should flow. This corresponds with a voltage across R10 of just 198mV, so little power is wasted in this resistor.

The value chosen for R10 is as low as experiment showed could provide a reasonably predictable and constant current through the LEDs.

Because there is tolerance on the resistor values and the on-chip reference, an extra series resistor is included in the circuit. The typical required value for this should be 2.2k, but this can be changed it the LED current is wrong. If the current is too low, increase R3, and if the current is too high decrease R3. The current is best determined by measuring the voltage across R10. It should be between 170mV and 200mV for current in the range 52 to 60mA.

The inductor

The choice of inductor is interesting. The energy which is stored at a given current depends on the inductance value, so that, all else being equal, an indoctors worth of energy has to be transferred to the output at a higher frequency if the inductance value is lower. In many types of switched mode converter, inductance values in the range 100uH to 330uH have been wisely used. This converter uses a 22uH inductor, and switch at a frequency of approximately 180kHz.

If the losses due to the switching are not great enough to cause a problem, then this can improve the efficiency because the inductor will be asked to store less energy per cycle. If its size is not reduced to compensate then it will operate farther from saturation, which can reduce the inductor losses. This is particularly valuable with a ferrite cored inductor, because the Curie temperature of ferrite is much lower than that of iron, and long before its temperature reaches the Curie point its saturation flux is reduced. Of course, if it does warm up in operation, the losses increase which causes further warming.

(The Curie point is the temperature at which the material ceases to be magnetic. If an ordinary iron nail is heated sufficiently in a gas flame, it fairly suddenly ceases to be attracted by a magnet until it cools down a little.)

So, although ferrite cored inductors can be very efficient, the efficiency can fall dramatically if they are operated anywhere near the saturation point. In this circuit the very small inductor is operating well within its capabilities and contributes to the overall good efficiency and long battery life.

Assembly

Before anything else, if you are using the case specified (and untimately, of course, the choice is yours), the pcb needs a small rectangular cutout and two semicircular cutouts filed into it as shown in figure 3. File these a little at a time, checking for the exact point that the the pcb will fit neatly and firmlyl into the case half containing the battery holder. The friction from the endge of the cutouts against the battery compartment tab and the screw hole posts at the side will help to keep the pcb in place without fastening it down with adhesive pads (which is the alternative). Once this fit is achieved, the pcb can be assembled.

Fitting the components on the pcb is straightforward, following the overlay diagram, figure 4. The MAX757 can be damaged by excessive static electricity, so take suitable precautions, and do this part last.

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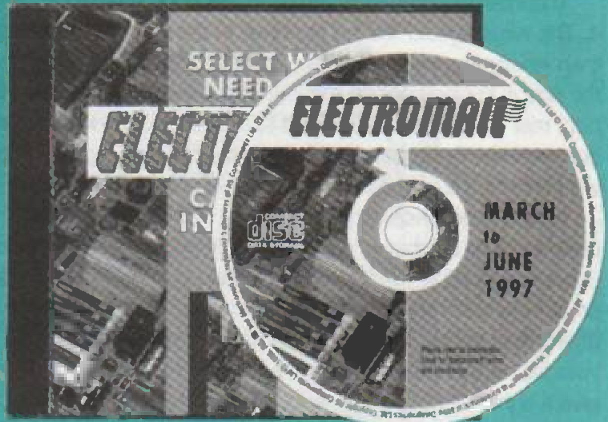

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The internal wiring is illustrated in the photograph and in figure 4. The wires should first be attached to the pcb, cut a little longer than strictly required so that they can be cut down to length when the pcb is in place. When the wires have all been soldered into the pcb, rest the board in place and trim, strip and solder the battery connections. Double check the polarity, because incorrect polarity will damage the circuit.

Now it is necessary to fit the LEDs. Drill the front panel of the case carefully as shown in figure 5. A good way to mark it out is to use a fine indelible marker on the inside face, and then to make small indentations with a centre punch or sharp point before attempting to drill. This should ensure that the drill does not wander, so that the holes are in a straight line. Use a 3mm drill to give a tight fit for the LEDs, and very lightly countersink both sides of the hole to remove any burr which may have been left behind.

Now check the LED polarity by using a battery or bench power supply and a limiting resistor. Even 1mA will give a visible glow, so a resistor chosen to pass only a few mA can be used to minimise the chance of damage. Then wire the LEDs together as shown in figure 6, so that the polarity of your set of LEDs will match that of the pcb to which it connects.

Fit the front panel and connect the LED wires from the pcb. Strip the switch wires and insert a battery. It is quite possible to insert the battery the wrong way round, so take care. Then check that shorting the centre wire to the one to the ON switch for about one second makes the LEDs illuminate. If they do not, measure the output voltage. If the voltage is around 3V8, then the pcb is working and the LED polarity is wrong. It should be possible to force all six leds out of their holes as a group and reinsert them the other way round, as a group, if this is done carefully, and if the hole spacing is accurate.

If the pcb is not working, check that C4 charges up to the input voltage level when the wires are shorted. If not, check that the correct wires are shorted, and check that the input voltage appears on R11.

If C5 charges to the input voltage and the pcb does not give a sufficient output voltage, check the values of the feedback resistors.

If it does not give an output voltage greater than the input voltage at all, then check whether the SHDN# pin is at ground or input voltage. If it is at ground, see if decreasing the value of R5 cures the problem. If it is at input voltage, check that the power and ground voltages are present on the correct pins of IC1.

This should debug any reasonably built unit.

Making the switch

Now remove the battery temporarily and fit and connect the switches.

You may have noticed that the switches in some of the prototype photos are different from the ones in the diagram: there is a story to this. The original switches (Schurter SPNO momentary, 125mA, 48VDC, Farnell order codes 150-242 through 150-251, depending on colour and bezel type, for those of you who habitually order enough components at a time to benefit from the Farnell catalogue) were ideal for the purpose, but prolonged search did not reveal any source that would supply them as one- (or even two-) off without a minimum order charge which would place them beyond a sensible budget for a one-off construction for a project of this size. After some hard searching to find another pair of switches that would lie low enough to the top of the case, have sufficient push resistance not to switch on accidentally if carried in a pocket or rucksack, and allow the time-out to work without any manual resetting, the switches chosen for the job

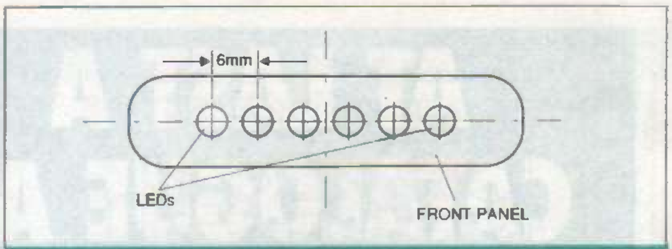


Figure 5: guide to drilling the LED holes - 3mm diameter - in the front panel

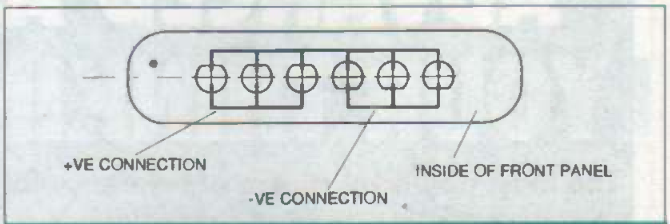


Figure 6: wiring up the LEDs

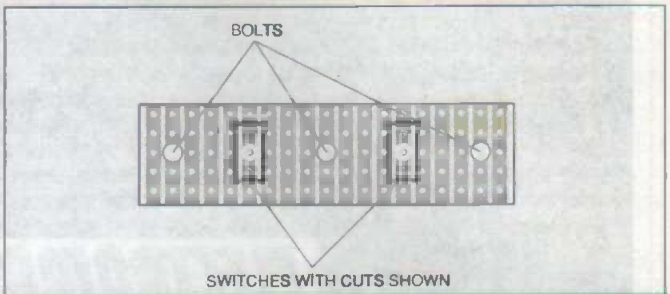


Figure 7: microswitch mounting on stripboard note the track cuts

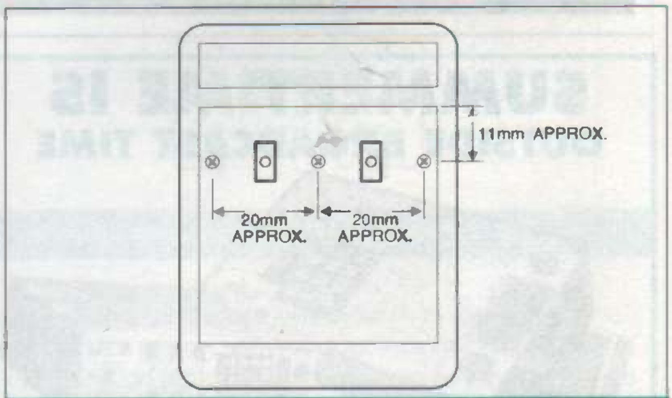


Figure 8: the top of the specified case, showing the position of the microswitches and 6mm bolts screws. See text. The Veroboard fitted inside the lid must clear the taller components on the PCB

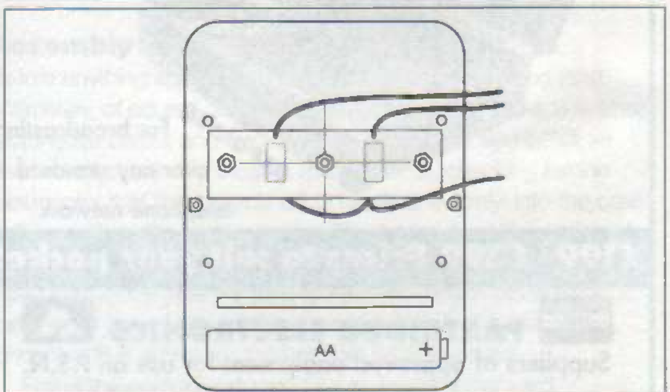


Figure 9: Inside of the the case lid, showing the approximate position of the Veroboard supporting the microswitches, the wiring to the switches, and the bolts securing the board to the case lid.

are tiny surface-mount ones, which are mounted on a piece of copper-faced stripboard inside the case lid.

Each switch is mounted along a track, on the track side. A cut must be made in the track around the switch area (between the surface mount pads and the switching mechanism) before the switch is soldered down, and the connecting wires soldered to the appropriate tracks on the stripboard to connect to the surface-mount pads (figure 7). The stripboard is held firmly to the top of the case by three bolts. These ensure that operating the switches does not flex the stripboard, and also help to prevent accidental operation of the switches by standing slightly proud of the case surface, fending off any contacting surface.

Of course, if your pockets are full of oddments with sharp corners, you may be beyond help - but you will be prepared, no doubt, for every eventuality!

The best procedure is to decide on the switch and bolt positions first. The positions chosen on the prototype are shown in figure 8. Then drill out the holes where the switch centres and the bolts are to go, just enough to poke a fine indelible marker through. Line up the stripboard on the inside of the panel, and mark through the relevant holes. Then carefully drill 3mm holes in the case where marked.

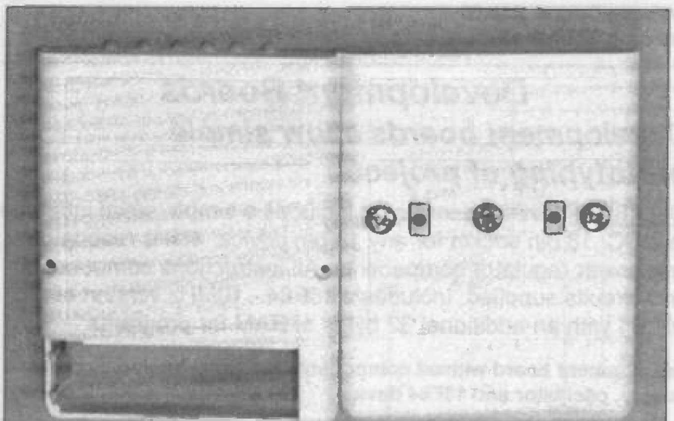
Next take a small square file and file out the switch holes so that the switches fit accurately. To check this, fit the switches to the stripboard and keep on checking the fit of the mounted switches against the filing as you go.

When it all fits, connect the wires to the switch tracks before mounting the stripboard (figure 9). Do not forget to join one end of the switches as the common terminal, connected to the middle pad on the edge of the pcb. Bolt the switch plate in place, and then test the unit.

Clip about 3mm off the end of the support pillars in the upper half of the case, and test it for fit. Trimmed like this, the pillars should hold the pcb in place with a small amount of clearance when they have been reduced to the required length. Figure 10 shows the pcb and wiring in place in the case.

Then put the case together, fit the screws, and admire your handiwork.

Given that several of the components are only available in packs rather than in single units, and that the cost per component is very economic if most of them are used, you could consider making a second light as a present. Because of the poor economics of manufacturing and distributing small quantities of printed circuits, it is probably cheapest to buy a second copy of the magazine to get an extra pcb! Then perhaps give your spare copy to a local library or school - minus its pcb of course.



The exterior of the case (bottom at left and top at right) showing the microswitches and the bolts supporting the Verostrip.

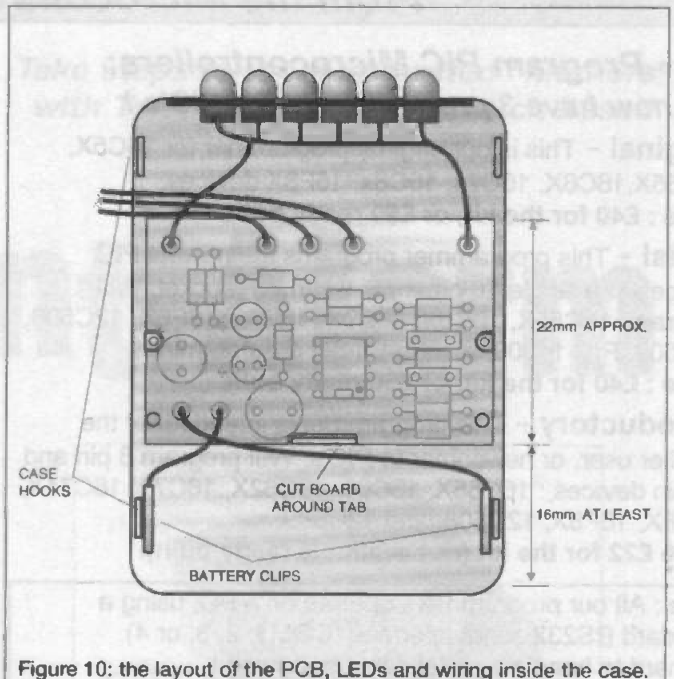


Figure 10: the layout of the PCB, LEDs and wiring inside the case. The battery clips have small loops to solder the wires to. The tab at the edge of the battery compartment separates the PCB from the compartment, and helps to retain it in place. See text.

PARTS LIST for the Little Red Reading Light

Resistors 5% 0.25W unless otherwise stated

R1	1M
R2	22k 1%
R3	2.2k
R4	10k 1%
R5, R6, R11	10k
R7, R8, R9	10M
R10	3R3

Capacitors

C1, C5	47uF 6.3V Low profile (Oscon Electromail part no 216) 2762 (sold in packets of 5)
C2, C3	100n polyester 0.2-in pitch
C4	100uF 16V miniature (eg Electromail 107-971)

Semiconductors

D1	11DQ03 1A Shottky diode
LED1 to LED6	Ultrabright low current LEDs (Electromail part no. 228-5023, sold in packets of 5)
IC1	MAX757 (Electromail, part no. 299-547)

Miscellaneous

L1	22uH 8RBS inductor
SW1, SW2	Surface mount microswitches

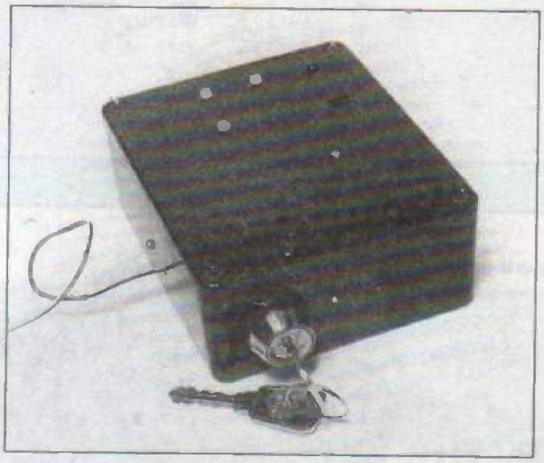
(Electromail 228-4569, sold in packs of 10)
Case: Electrospeed part no 65-22981K (without belt clip) or 65-22983B (with belt clip)
Small piece of Veroboard to mount microswitches; N3 6mm (or similar) bolts; wire.

Suppliers:
Electrospeed 01703 644555
Electromail 01536 204555

Caravan Movement Alarm

Take steps to avoid unwanted "hitchers" with Terry Balbirnie's tilt-switch based anti-theft circuit.

Left unprotected, caravans make rich pickings for bandits. All they need do is hitch them up to their own car and tow them away. A set of false number plates on the car to match those on the caravan will almost certainly prevent them from looking suspicious to the police. Once out of public view, the caravan may be stripped of valuable items such as televisions and CD players, and the vehicle itself can be sold for a high price after any identifying marks have been removed.



Good idea

It seems that some form of deterrent against theft is definitely required. Having a security device fitted may even be a condition of an insurance policy. With summer now imminent and the caravanning season drawing closer, this could be a good time to think about constructing an alarm. Even so, it must be remembered that no security system is totally foolproof - the determined professional thief will find ways of overcoming even the most sophisticated devices, and our best hope is to slow an intruder down long enough to deter and attract attention. This alarm is fairly basic and is designed to "sound the alarm" in the vicinity if the vehicle is moved while the alarm is switched on. Always make sure that your locks, wheel clamp and/or hitch locks are in good condition as well.

Although originally designed for caravans, this alarm would also be suitable for boat transporters, horse boxes, camping trailers and other towable vehicles. With small modifications, it may also be used for other purposes. It is unsuitable for use where natural movement exists, such as for a boat on water. The vehicle to which the alarm is to be fitted must be capable of being left stable and in a horizontal attitude.

Do not disturb

The Caravan Alarm triggers with movement that tilts slightly from the horizontal the case in which the circuit is housed. When correctly set, it should provide a warning long before the caravan has been hitched up to the tow car. Once operating, a "yelping" siren (the type associated with car alarms) will switch on for some preset time or until cancelled by a key-operated switch on the main unit.

If the cause of triggering is removed, the alarm will still continue to sound for its full term. If the caravan is left in a tilted position, the alarm will only sound once until the circuit has timed out - that is, it will not continue indefinitely and cause undue disturbance to the neighbours. However, when the cause is removed, the alarm will reset and be ready to operate again on further disturbance.

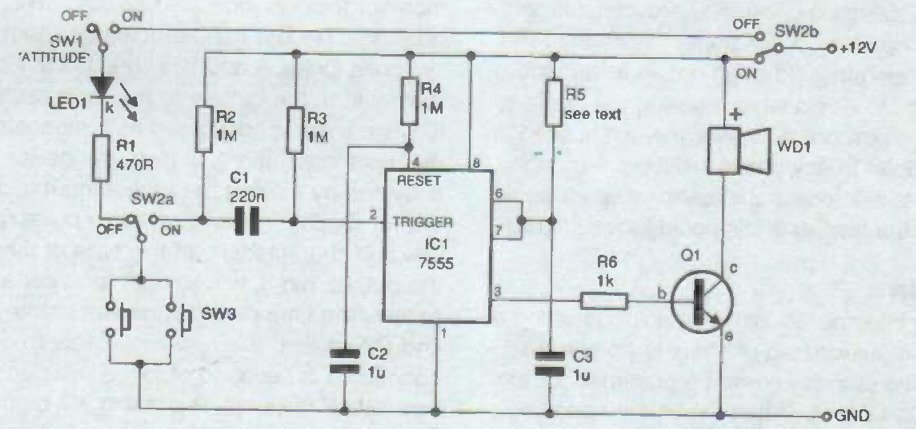


Figure 1: the circuit of the Caravan Movement Alarm

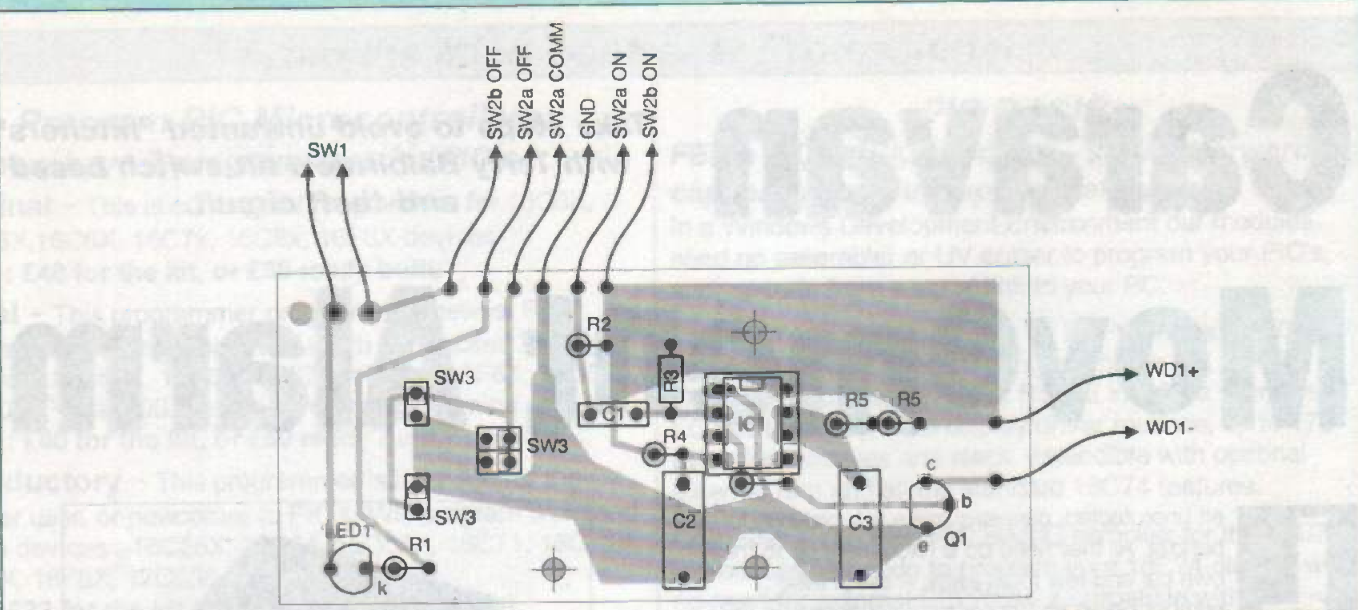
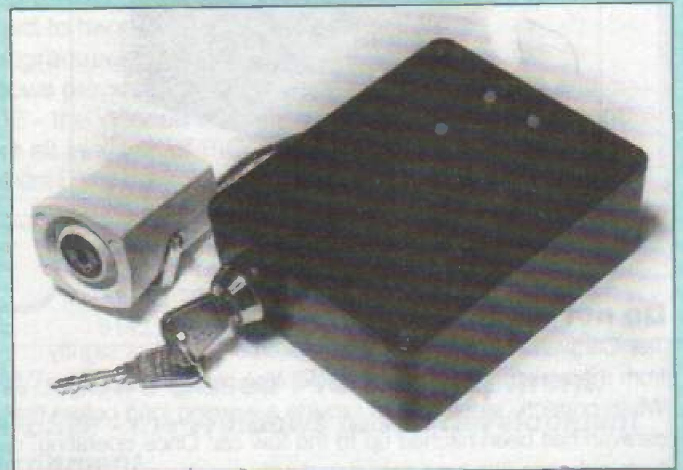


Figure 2: the component layout



The main unit has the key-operated on/off switch mounted on the side. There is also an "attitude" slide switch on top which works in conjunction with a red light-emitting diode.

The sounder will probably be placed underneath the caravan to provide maximum sound output. The main unit may be mounted inside the caravan or in some suitably protected place outside. Siting it inside has the advantage that the alarm is only accessible the door is opened, and this gives extra security. It will also remain clean and dry. The disadvantage is that a person getting in and out of the caravan to switch the alarm on or off may provide sufficient vibration to trigger it. However, if it is correctly adjusted this will not happen. It is desirable, although not essential, for the LED on the unit to be visible when levelling the outfit prior to switching the alarm on. Wherever the unit is sited, it must not be placed close to any gas installation. Although unlikely to happen, it is electrical equipment - a spark could be caused if there was a fault and this could ignite the gas.

No drain no gain

The main unit has an integral 12V battery pack consisting of eight AA cells. When it is switched off there is no current drain. While it is on, the standby current requirement of the prototype unit is around 85mA. When the unit is operating, the current will depend on the sounder used and may be anything up to about 300mA. A set of alkaline batteries may be expected to provide more than one year of service even if the alarm has sounded every now and again in the course of testing or attempted theft.

The circuit uses non-mercury tilt switches as position sensors and, as described, there are two of these mounted on the circuit panel along one axis. Their exact orientation is adjustable to provide the degree of sensitivity required. A caravan will be tilted along its long axis in the process of preparing it for towing. One switch will give a trigger pulse if the hitch is raised and the other will do similarly if it is lowered. Side-to-side motion, as might be caused by a strong wind, will have little effect if the switches have been correctly positioned along the axis and have not been set to be excessively sensitive. For certain alternative applications, where the item to be protected may be moved in various ways, there is provision for a further two tilt switches on the circuit panel. These would be connected in parallel with the first pair and at right angles to them.

It is not known how the switches would stand up to heavy vibration as would occur if the unit were left in the caravan as it moved along. No such problems have shown in the prototype unit but, up to the present time, the amount of use has been very light. To avoid possible trouble, it would be a good idea to remove the unit before travelling.

How it works

Figure 1 shows the complete circuit. Assume for the moment that key-operated switch, SW2, is in the ON position. This is a double-pole unit - that is, there are two switches (poles A and B) in one body. Pole B allows current to flow from the battery to the main section of the circuit. IC1 is a timer ic configured as a monostable. Assuming that the reset input, pin 4, is high, the device is capable of being activated by making the trigger input (pin 2) low for an instant. Such triggering on a low pulse rather than a high one is a characteristic of this type of device. Once triggered the output, pin 3, will go high for a certain time, then revert to low. The time period is dependent on the values of R5 and C3. In fact, this resistor is likely to consist of two units connected in series to obtain a sufficiently high value. With two 33MW resistors, the timing will be more than 1 minute. This may be increased or reduced, if necessary, by using a proportionally higher or lower value. In the prototype, a single 33MW unit was found to be adequate. When the output is high, base current flows to transistor Q1 via R6 and turns it on. Collector current then operates the audible warning device (solid-state siren) WD1.

Triggering is effected in the following way: switch SW2, pole A, connects one side of both tilt switches (labelled "SW3"), plus a further two if required, to the left-hand side of C1. The other contacts of the switches are connected to the ground (0V) rail. Assume the tilt switches are off for the moment. R3 maintains IC1 trigger input high and this prevents false operation. Additionally, IC1 reset Input (pin 4) is kept high through R4, so enabling the device.

Timing cycle

If the contacts of one of the tilt switches "make" momentarily, C1 transfers a low pulse to IC1 pin 2. The monostable then begins a timing cycle and WD1 will sound in the manner already described. If the switch contacts remain closed, there will no further effect because C1 will only allow a single brief pulse to flow.

Suppose now that switch SW2 is off. Pole B disconnects the battery from the main circuit. However, it now provides a feed to LED1 via "attitude" switch, SW1, providing this is on. Additionally, SW2 pole A connects the tilt switches to the lower end of the LED via current-limiting R1. Thus, if the contacts of one of these switches close, the LED will operate. This will be used to check that the tilt switches are off - that is, that the caravan is level - before arming the alarm. Note that switching the attitude switch on while the key switch is also on will have no effect. In fact, a potential thief attempting to disarm the alarm by doing this is likely to cause enough vibration to trigger it.

The purpose of C2 is to hold IC1 reset input low for an instant on switching on. This prevents self-triggering which might occur otherwise. This works because C2 must charge through R4 sufficiently for pin 4 to become high before IC1 is capable of triggering. With the values stated, this will take about one second.

Construction

Construction of the Caravan Alarm is based on a single-sided pcb, and the component overlay is shown in figure 2. Begin by drilling the three mounting holes. Solder the ic socket and attitude switch, SW1, in position. Follow with all resistors and capacitors. Note that with R5, one or two resistors will be used to obtain the value required. It would be a good idea to solder short wire stalks to the four "R5" pads. These will allow a single resistor of low value (and therefore giving a short timing) to be connected for testing purposes. It will then be replaced with the correct resistor or resistors when testing is complete. It is suggested that a 10MW resistor is used to begin with, providing a timing of about 10 seconds. This should be soldered between the outermost pair of stalks. Note the specified type of component used for C2 and C3. These should not exceed 10 mm in height, as taller components could make if difficult to operate the attitude switch when the circuit panel is in position on the lid of the box. Solder the transistor in place the right way round, using minimum heat. The small tag on the body is closest to the emitter (e). Add the LED in the right polarity (the shorter lead denotes the cathode end and is labelled "k" in figures 1 and 2). The top of this component should stand approximately 12mm above the circuit panel

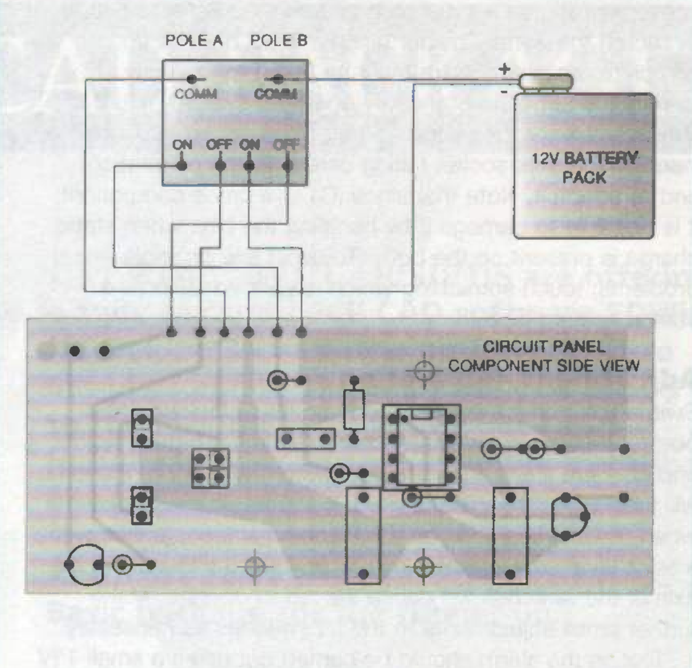


Figure 3: wiring up the parts

Using fine-nose pliers, grip the tilt switch end wires about 2mm from the body and bend them through right angles. If only two switches are being used, they should be soldered to the pads nearer to C1 (note all these switch positions are labelled "SW3" in figure 2). They should not be mounted flat on the circuit panel but should stand about 2mm above it to allow for adjustment to the orientation relative to the circuit panel. Bend the wires so that the plain end of each switch stands slightly lower than the end with the connecting wires. This provides the sensitivity adjustment and can only be carried out accurately after a period of testing. If the circuit panel is tilted slightly one way then the other, the switches will be heard to operate in turn. There should be a small angle through which neither switch is on.

Tag connections

Solder the negative (black) wire of the PP3-type battery snap to the "gnd" pad on the pcb. Solder 10cm pieces of stranded connecting wire to the pads labelled "SW2B off", "SW2A off" "SW2A comm", "SW2A on" and "SW2B on" (the letters "A" and "B" refer to the corresponding poles of SW2). It would be a good idea to use pieces of "rainbow" ribbon cable here to avoid confusion with the switch connections to be made later. Solder similar pieces of wire to the pads labelled "WD1+" and "WD1-".

Check how the internal components will be mounted in the enclosure. The battery pack is mounted on the base and the circuit panel is attached to the lid. Remember that the pcb must be horizontal in service. Mark the positions of the mounting holes and those for the led and attitude switch on the lid. Drill these holes and mount the pcb temporarily using nylon nuts and bolts. Use 10mm high plastic stand-off insulators on the bolt shanks. The led should then protrude a little through its hole and the tang of the attitude switch be just above the face of the box. It should be possible to operate it without difficulty. Attach the two-section piece of screw terminal block in a free place and connect the sounder wires leading from the pcb to this. If the alarm is to be removed frequently, it may be more convenient to use a small plug and socket. Refer to figure 3, secure the battery holder using a small bracket and complete the wiring. Care must be taken to correctly identify the contacts of the key-operated switch - figure 3 shows those for the specified unit. Remove the pcb again, insert IC1 into its socket taking care over the orientation, and re-attach it. Note that since IC1 is a cmos component, it is possible to damage it by handling the pins when static charge is present on the body. To avoid any possible problems, touch something which is earthed such as a central heating pipe.

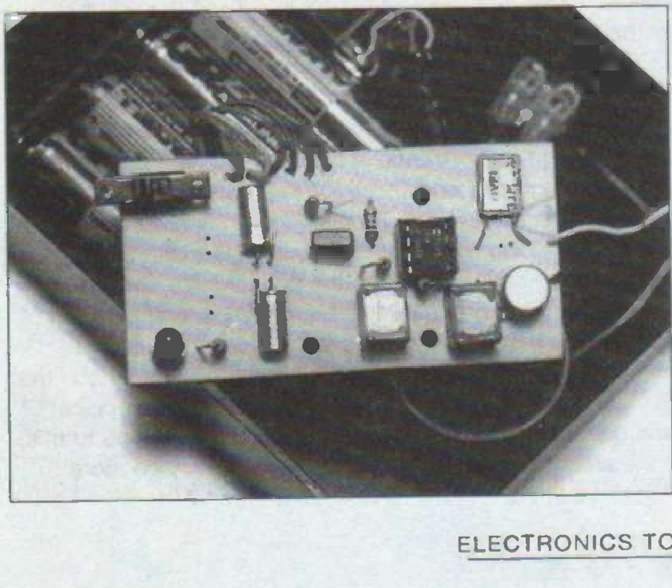
Adjustment and testing

Switch SW2 off if it is not already so (anti-clockwise key position). Insert eight alkaline AA cells in the battery holder and connect it up. If the attitude switch SW1 is on, the led will flash when the case is tilted. It should be found that when the unit is placed on a horizontal surface, (check with a spirit level), the led remains off. Any slight tilting along the axis of the switches will cause the led to operate. Make further small adjustments to the tilt switches as necessary.

Testing the alarm should be carried out using a small 12V bulb (say 2.2W rating) in a suitable lampholder instead of the sounder. It will be necessary to drill a hole for the wires to pass through to the terminal block. Choose a suitable place for the unit and decide how it is to be secured. A good method would be to use keyhole slots in the back which will engage tightly with screws in the floor of a cupboard. Some users check that the caravan is horizontal with a spirit level before leaving it. In this case, there will be no need to site the unit so that the led can be seen. It will simply be checked to ensure that it is off before switching the alarm on.

Fit the lid of the box and level the caravan. Check that the led is off. Turn the key-operated switch clockwise. Any disturbance will now cause the lamp to light for 10 seconds approximately. The tilt switches should not be adjusted to be too sensitive, or triggering will take place with random movement, gusts of wind, etc., but set just sufficiently sensitive for the purpose. In the prototype, operating the key switch did not cause sufficient vibration to trigger the alarm. However, it will do this if performed clumsily.

It is suggested that R5 be left with the reduced value for a few days while the system is put on trial under real conditions. If there is any tendency towards false triggering, at least the alarm will not sound for very long. When the tilt switches have been finally adjusted, they could be locked in position using a little quick-setting epoxy resin adhesive.



Choice of sounder

The audible warning device should be of the car alarm type. It must combine a high sound output with a low current requirement (up to 300mA). Decide on a suitable position for it. This will probably be underneath the caravan. A piece of twin wire may be passed though a small hole in the floor and the box to the terminal block. Choose a fairly inaccessible place for the sounder to make it difficult for a thief to crawl underneath the caravan and cut the wires. Take care to observe the polarity or it will not work.

After the period of trial, R5 should be replaced by resistors of the correct value. It is suggested that the timing should be set for no longer than 2 minutes (corresponding to about 100MW or, say, two 47MW units connected in series). In the prototype unit, a single 33MW resistor was used and this provides a timing of about 35 seconds. Note that the maximum time an alarm may sound might be subject to local regulations.

Final point

If the caravan is not level and the alarm is switched off, or when the unit is removed, remember to switch off the attitude switch. If this is not done, the led will drain the batteries.

PARTS LIST for the Caravan Alarm

Resistors

R1	470R
R2, R3, R4	1M
R5	See text. Also additional 1M resistor for testing.
R6	1k

Capacitors

C1	220n metallised polyester with 5mm pin spacing
C2, C3	1m polyester layer 10mm pin spacing - see text.

Semiconductors

IC1	7555
Q1	BFY51
LED1	5mm red LED

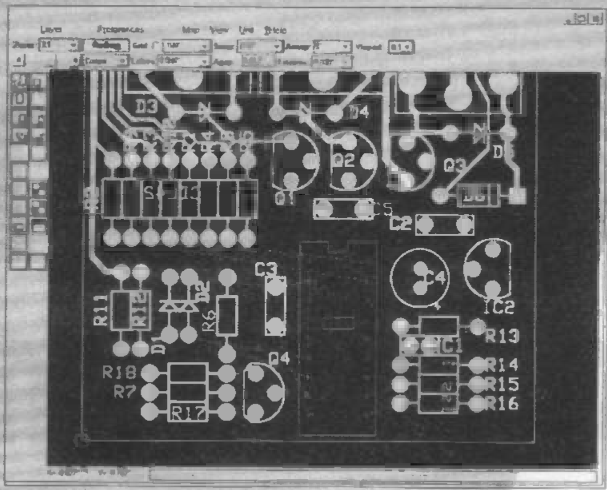
Miscellaneous

SW1	Non-mercury tilt-switches 2 (or possibly 4 required) - see text.
SW2	DPDT key-operated switch
SW3	Sub miniature SPDT slide switch.
WD1	Piezo sounder - see text
TB1	2A screw terminal block - 2 sections required, or small plug and socket - see text.

Printed circuit board. 8 AA size alkaline cells and holder. PP3-type battery connector. 8-pin dil socket; plastic box for project.

All components are available from Maplin. The resistors used for R5 may be "high voltage" resistors and the order code for 33M is "V33M". The sounder may be order code JK42V or JK43W (which is louder). The key-operated switch was order code FH40T.

WIN A PCB CAD PACKAGE



ETI and Swift Designs are offering a fully-featured PCB CAD software EDWin NC Deluxe 3 - with the options EDSpice Simulation and Thermal Analysis added - to the lucky winner whose skill and judgement can answer 3 simple questions about EDWin NC.

And!! We have a copy of the EDWin NC Basic package for the runner-up.

The first entry out of the hat with the three correct answers will win a copy of EDWin NC Deluxe 3, along with Thermal Analysis and EDSpice Simulation. The second correct entry will win our runner-up prize of EDWin NC Basic.

EDWin NC is an established professional PCB Computer Aided Design package, now made available at a non-commercial-licence price to home users, students, teachers, etc. Capable of Schematic capture, PCB layout and Mixed Mode Simulation, EDWin has dozens of features, as well as additional options such as EDSpice simulation and Thermal Analysis.

Two Prizes!

Here is an opportunity to switch to engineering-orientated Computer Aided Design at an affordable price. Or WIN a fully-featured version free!

EDWin NC runs under Windows 3.X, Windows 95 or Windows NT, a 386 or larger CPU, 8MB of RAM and a CD-ROM drive.

***Look at the two-page advertisement introducing EDWin NC that appears elsewhere in this ETI and then answer the questions - it's as simple as that.**

***Reminder!* EDWin agents Swift Designs Ltd. are offering ETI readers a 10% discount on selected EDWin products - refer to this Competition Page or to our review of EDWin NC last month.**

Answer these three questions on the coupon provided:

1. ***What types of analysis does the mix-mode simulator support?***

2. ***What is the largest number of layers that EDWin can ROUTE on?***

3. ***How many systems must schools and colleges order to get the price benefits of non-commercial EDWin?***

WIN EDWIN NC Deluxe 3

Send your completed coupon to: EDWIN COMPETITION, ETI, Nexus House, Boundary Way, Hemel Hempstead, Herts HP2 7ST.

Entries must arrive by 14th May 1997.

My answers to the three questions are:

1. ....

....

2. ....

....

3. ....

....

Name ....

Address ....

....

....

Please send your entry on this coupon or a photocopy of it.

Competition rules: entries must arrive at Nexus House on or before 14th May 1997. Winners will be notified by post following the judging. The judges' decision is final and no communication will be entered into concerning the results. Employees of Nexus Special Interest Ltd. and Swift Design Ltd., associated companies and family members are not eligible to enter. Multiple entries will not be accepted.

REV

Press-n-Peel have produced a PCB transfer film that cuts out the exposure stage of PCB-making to give good results with home equipment. The makers also supply PCB etching kits.

PRESS-N-P

Short-run PCB-ma

Making prototype and one-off pcbs always poses a challenge. To have a pcb made up by a pcb supplier is usually prohibitively expensive for single boards or short runs but, in my experience, amateur transferring and etching has many pitfalls.

The normal problem I have experienced is that the ultraviolet-exposed etch resist is frequently not sufficiently tough, and allows hairline breaks in the track. So it was with interest that I opened the pack to do a "live" test of the new Press-n-Peel system to make myself a first prototype board for this month's ETI cover project.

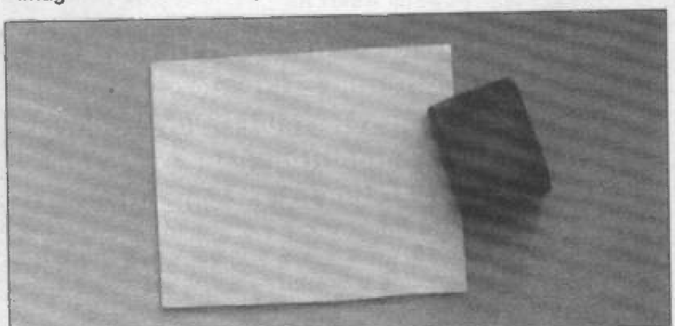
The Press-n-Peel kit includes the proprietary transfer film which gives the kit its name, etching trays, a tub of etchant, protective gloves and glasses, a permanent marker for touching-up, and a plastic bottle of Press-n-Peel resist stripper, with tough tissues for applying it. Sheets of glass fibre laminate were also provided. The items you have to bring to the process of pcb production are a component-side PCB foil (from whatever source), a laser (or other suitable) printer or a photocopier, and mechanical tools such as a drill and hacksaw.

The first step to making a pcb using the Press-n-Peel system is to print the pcb track layout on to the special transfer film. Either a laser printer or a photocopier is suitable for this, but it must be a clear, single-sized, component-side plot (that is, as if looking through the board from the component side), because that will be your master that will be transferred (giving a reversed image to form the track layout) for the etching.

I opted to use my printer. I found that the only way to get the film to run through the printer without being tempted to jam (the film is a little thicker than ordinary paper, and ought to run through a printer without difficulty - but some printers, as users know only too well, have ideas of their own) was to fix it carefully to a sheet of A4 paper using Pritt Stick (making sure, of course, that the adhesive did not ooze from between the sheets and get into the printer with drastic results). This led me to the discovery that by using this approach it was possible to use only half a sheet of Press-n-Peel film at a time - a useful way to make very small pcbs without wasting too much film. I would however not recommend this approach to

The P-n-P Stripper, marker and ferric chloride etchant. Press-n-Peel now supply colourless sodium persulphate/sodium bisulphate etchant.

Protective gloves and glasses - and a pair of successfully-transferred films - the blue film becomes transparent as the image transfers correctly.



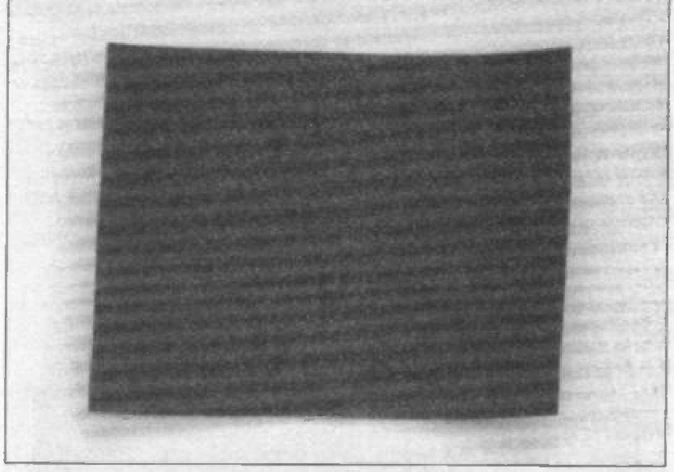
Cleaning the copper board with a mildly abrasive pad (not supplied). Wire wool can also be used.

IEW

EEL

king kit...

anyone who is not absolutely sure of their printer's ability to tolerate it - getting expensive printers repaired is an expensive pursuit it itself.



A pair of PCB images, printed wrong-reading (component view) by laser printer onto the emulsion (matt) side of the transfer film. These images come from a CAD program.

Mirror image

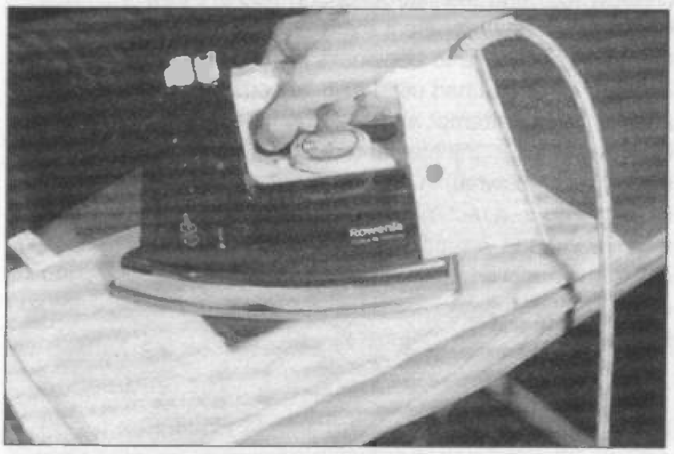
After printing the track pattern in mirror image (viewed from the Component side) on to the dull side of the film, the procedure is to cut and clean a piece of pcb, following instructions, and then use a domestic iron to transfer the image directly to the pcb. My first attempt, setting the knob on the iron to what I thought was the recommended ironing temperature, caused the film to buckle and start to melt. I then tried again using a slightly lower temperature, with much better results.

The first test pcb on which the printing came out clearly was etched in the standard ferric chloride provided with the first evaluation kit (since that time an improved etchant has also been added to the kit). I started with a fairly weak solution, and added ferric chloride crystals until etching proceeded at a reasonable rate. Using warmed water to mix the solution, in about 40 minutes a clear set of tracks was etched on to the pcb. Even the text of the project name was clear, and there were no hairline breaks or fuzz around the edges of the tracks at all. The only thing which did not come out perfectly was the holes in the middle of the pads, so helpful to guide the hand operated drill.

In the event this did not cause much problem, because the drill did not wander very much in practice, and the pcb was drilled and assembled, and worked with no need to scrape off stray bits of copper or link broken tracks, which problems have often formed such a significant part of home-etched pcb production.

The improved etchant, to be supplied in all kits instead of ferric chloride, is sodium persulphate/sodium bisulphate. Ferric chloride is generally corrosive and stains anything it contacts, while the new etchant, although of course still a corrosive to be handled with respect, is clear and does not stain.

A layout for a future project was duly arranged and printed out, to try the new etch solution. I took the precaution I duplicated the layout several times using the block copy



Ironing on the image - take care to keep the film from moving; after a few moments it will develop some adhesion. Do not press too hard. A linen teatowel is being used here to give some extra thermal insulation to help the board heat evenly.

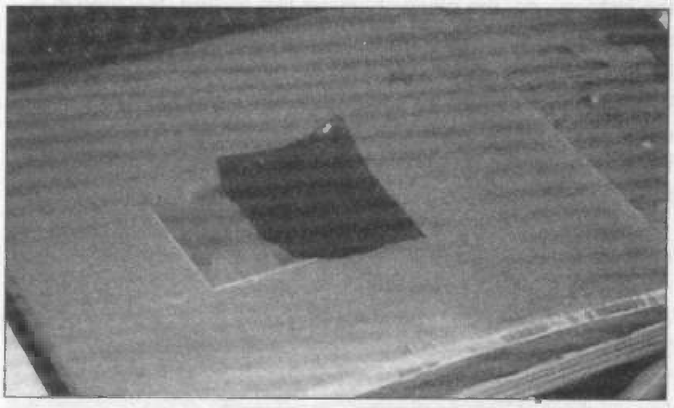
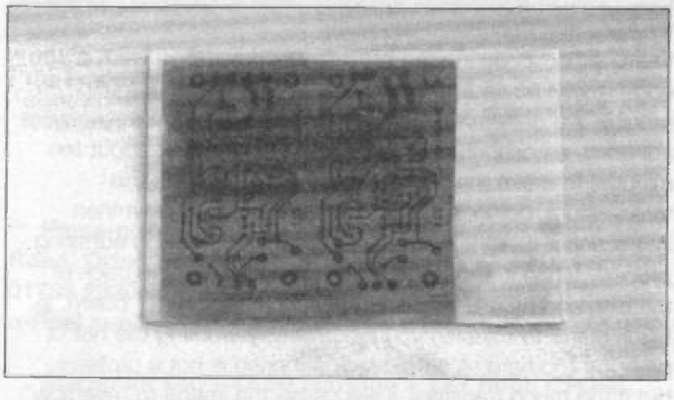


Image transferring to the copper plate - the image shows black through the film backing. The unadhered edges tend to curl up when heated, but the ironed-on area should lie flat.



A pair of pcb images successfully transferred to the copper board - the correctly transferred images are blue in colour.

command on my CAD package, so that if I happened to make a mistake on the first attempt, I would be able to try again without having to repeat the printing process. I drew in corner-markers near the corners of the pcb using a thin track, then copied the block including the corner markers as many times as would fit comfortably on an A4 sheet. I then processed the multiple blocks so that the CAD program thought that they were all one pcb (including, of course, all the corner-makers) and prepared to print all as one sheet. This process or something similar will be available on at least some CAD packages.

Having printed out my multiple pcbs onto one sheet of Press-n-Peel film, I proceeded to the transferring stage, and delegated my assistant to try the transferring process, carefully following the instructions. It was at this point that it began to become apparent that that my previous good result had been partly due to beginner's luck (and native intuition, of course), and that I had used all the "beginners luck" up. My assistant's first attempt at transferring the image resulted first in a reluctance to transfer, and then (when the iron was turned up somewhat) in a badly spread image, with the "E" of ETI reduced to a rectangular block with rounded corners. I thought that the iron might be running too hot, but a phone call to the suppliers elicited the information that probably too much enthusiasm and too much pressure had been used, so I tried again.

Temperature

In order to aim for a scientific result, I decided to use a soldering thermostat to set the ideal temperature on the iron (which, like most domestic irons, has no absolute scale of temperature).

At 200 degrees, the minimum temperature suggested in the instructions, the plastic backing film melted, resulting in a spoiled transfer and plastic film adhering to the underside of the iron. Delegating my assistant to an iron-cleaning session with Panda Stick and wire wool, I made another enquiry and established that the specified temperature was in degrees Fahrenheit - the cost of assuming that "degrees" normally means Centigrade these days.

For the next attempt I set the iron to 95 degrees centigrade. After considerable careful heating, after which I could see the printed layout faintly through the back of the film as should be the case, I peeled off the backing to reveal a pcb heavily discoloured due to the heat except in the areas where the tracks should have adhered, in which areas the pcb was a beautiful clean copper colour.

On the fourth attempt, with the iron set to 140 degrees centigrade (238 Fahrenheit), almost all the pattern stuck to the pcb. Parts of a couple of the edge pads were missing, and trying further heat at this point did not succeed in sticking them, although during the process gentle peeling back of the edge to check, and reheating, certainly did enable me to monitor the pattern's progress and make sure the edges were adhering, as described in the instructions. It took about ten minutes to make the pattern stick to the board at this temperature, going, admittedly, cautiously, heating it then inspecting it then heating some more. The image is adhering properly when it appears as a black pattern on the back of the film, and as a clean blue pattern on the copper board. If black starts to transfer, you are probably working too hot or pressing too hard. A bit of black adhering is not a problem, but if too much transfers, it will cause the image to "overflow" and spread.

Component side or track side?

The traditional approach to a PCB "foil" or "mask" is to print or tape the layout from the track or copper side (sometimes called "right-reading", because any legend or title on the board will "read right" on that side) onto a transparent or translucent base, and then tape this pattern directly, still right-reading, to etch-coated copper board for exposure to UV light. The taped side will be away from the board, with the result that a small amount of light from the exposure will leak under the tracks and degrade the image slightly - but if the film base is thin, the leakage is usually too small to affect any but thin tracks.

The exposed board will then be left with a pattern of tracks in the etch-resist, which must be etched away to form the final pattern of copper tracks.

If the foil is produced by a laser-print or similar method straight from a computer (or printed on by certain industrial processes), the pattern can be printed on in mirror-image, allowing the mask to be turned over, contacting the dark image directly to the copper board and preventing any light leakage under the film during exposure This allows a finer resolution and more densely-packed boards to be produced.

Only recently has laser-printing come within reach of the home constructor, but with the advent of affordable CAD, more home and educational constructors are using computer-originated pcb masks.

A problem then arises for those who publish pcb patterns for public consumption - some users will be copying the foils by hand, some perhaps by photocopying onto transparent or translucent film (which is easy to do but can be difficult to achieve good results with, because the resulting image is sometimes not dark enough to allow a good contrast for exposure), and some by scanning into a CAD program with a hand-held or other type of scanner. But to get good results on exposure, a wrong-reading image on the down-side of the transparency is ideal.

When using a transfer system like Press-n-Peel, the exposure process is by-passed by transferring direct to bare copper - but to do this, a wrong-reading original is needed to obtain a wrong-reading transfer - which is turned over to produce a right-reading image on the bare copper board.

In the event, all the tracks and pads transferred well, including the 6-thou tracks I had used as corner markers. Normally I would use large pads for a single-sided board such as this, but I have used fine-line pads and drilled them, and they still give a satisfactory result.

An indelible marker pen is provided in the kit in order to touch up any missing segments, and I used this to good effect with the incomplete pads, which were the only flaw in the transfer apart from the rather resistant drill holes.

Some of the holes in the pads came out, some didn't. My consultant at the supplier said that he used the tip of a scalpel or a paint brush to dislodge any flakes of resist which remained in the holes. He assured me that they were not stuck, and would easily brush off. In the event it took a hard scrub with a toothbrush (and toothpaste, which is mildly abrasive) to remove most but not all of the resist covering the centre holes.

The multiple copy printing was paying dividends. While the test board was etching, I made one more attempt to perfect the process. With the iron set so that its thermostat cycled it between 145 and 155 centigrade, and paying special attention to heating the edges, I obtained an almost perfect print in 10 minutes. There was one break in one track, but as I was printing two copies of a small pcb there will be one perfect copy etched. Oddly enough, the centre holes mostly came out cleanly as they were supposed to, this time.

It appears that the Press and Peel pcb kit works very well in laminating machines, because the heat is applied evenly and from both sides. It is harder to apply even heat with a domestic iron, and in any case it is only applied from one side, so that it takes time for the pcb to heat up sufficiently. Clearly the pcb must rest on something with good thermal insulation, such as a tea towel on top of the ironing board. However, as I had found with my first attempts, if you hit the right combination of heat and patience, you can produce a good result quickly. The Press-n-Peel does not (unlike some types of transfer) respond well simply to increases of heat and pressure, but needs a little time for the transfer to take place evenly. Once this is done, it produces a good result.

The instructions give little guidance about the exact technique required to make this system work when applied with a domestic iron, but as we have seen, good results are possible, particularly once the heat setting and time needed for a particular iron have been established by practice. The first few attempts should be treated as learning rather than expecting to make a good pcb first time. Of course, if you print several copies on the same sheet, you can clean a failed attempt off the copper board and try again, so you should get a good pcb from your first sheet if several copies will fit on it.

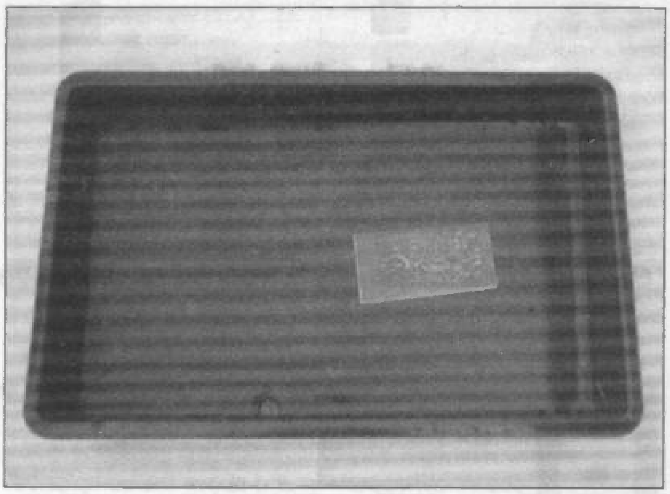
The etched pcbs turned out well, with a couple of the centre holes having etched properly even though there had appeared to be a layer of resist over them. The final test sample transferred at 150 centigrade has only a couple of centre-holes missing, and did not need to be scrubbed with toothpaste to remove the others.

Using the specified concentration of etchant, the etching again took 40 minutes. This would probably have been quicker using a heated etcher such as the ETI Shake & Etch, because the etching slowed down as the solution cooled from the initial recommended 50 centigrade.

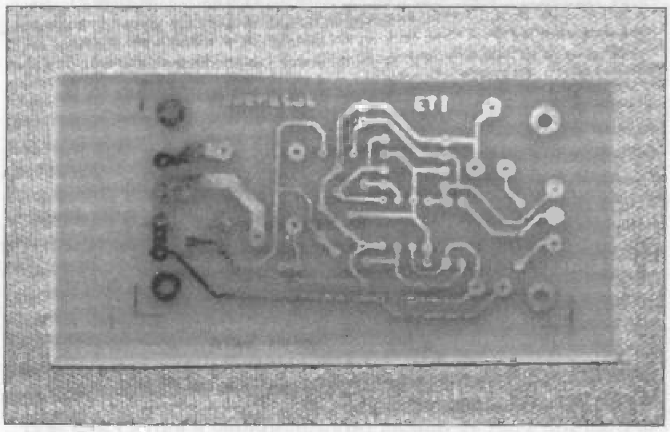
Despite the teething troubles, the results from this have been considerably better than from many other attempts at home etching. From my point of view, the system is good enough to use to prototype my projects on single sided pcbs. The kit is good, but the instructions could do with a bit of tweaking to cover the differing "lab" circumstances used by home constructors.

We are told that the system works particularly well on an office- laminator. Press-n-Peel can also supply laminators, for people and organisations whose budget stretches well beyond a flat-iron, which may well be of interest to schools and workshops throughputting a considerable number of boards.

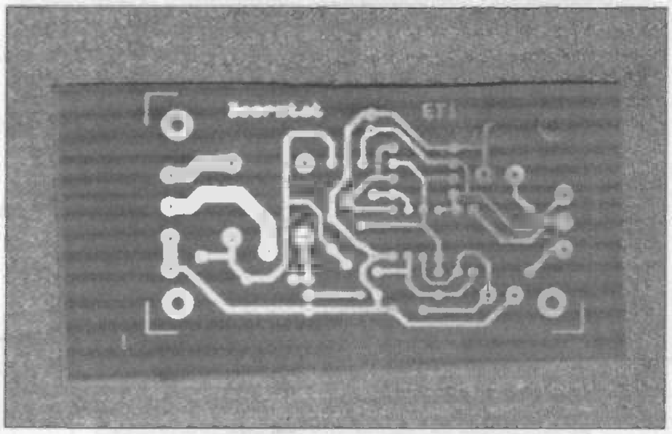
For two-hobby families, Press-n-Peel system can also be used for transferring decorative laminates onto copper surfaces.



A single board in the P-n-P etching tray.



The board after emerging from the etching tray. The resist may appear partly blue and partly grey at this stage, but both will clean off with the stripper provided.



The board etched and cleaned and ready to drill. It may not be quite as "sharp" as an industrially-produced board, but the results are good nevertheless - and much cheaper.

Press-n-Peel Etching Supplies Service, 18 Stapledon Road, Orton Southgate, Peterborough PE2 6TD. Tel 01733 233043 Fax 01733 231096. Maplin is also a Press-n-Peel supplier.

Starter kit £40 + £6.50 carriage + VAT (total £54.64). Enquire to Press-n-Peel for full supplies price list. Replacement items are available separately

Spiced Circuits

Circuit simulation with software, by Owen Bishop. This month, part 2 - AC analysis.

Before we take up this month's topic, let us look at the problems set last month.

The best way to investigate compliance is to see what happens in and above the compliance range. Plot the voltage at the collector, base and emitter of Q1 (nodes 2,3 and 4) as the load is swept from 50W to 250W. Plot the load current on the same graph. To set this up, click Time => Probe nodes and select 2, 3, and 4 as the first three output nodes with node 0 as the reference.

For the fourth plot select 'i' but, as currents are in tens of milliamps, we will not see the shape of the current plot unless we plot it on a larger vertical scale. Enter 100 in the 'x' box of plot 4. In the netlist, for Rload, enter 'vs=50 vf=250'. Next Analyse => Tolerances and temp, and select the function Value Sweep, and Linear mode. Make N = 51 to obtain smooth curves. Analyse => Quiescent Sweep gives figure 1, which we have labelled for clarity.

Current is constant up to about N=30, which we showed last month represents a load of 110W. As load increases in the range 50W to 110W, with constant current, the voltage across the load increases proportionately (Ohm's Law) and the collector voltage falls linearly. Eventually it is only a little higher than the emitter voltage; the transistor is saturated. Above 110W, the collector voltage continues to fall, but not so steeply and, with decreasing load current, there is decreasing current through R2, and decreasing voltage across it. In the constant current region, the base voltage is held at 3.9V by the zener.

There is also a more-or-less fixed base-emitter voltage drop. To measure this, place the cross-hairs on the emitter voltage curve. Press and hold the mouse button to zero the value in the status line. Still holding the button, move the cross-hairs up to the base voltage curve. Release the button and read v = 764.1m, the base-emitter voltage drop, in millivolts. The plot also shows that when load resistance is near the top of its

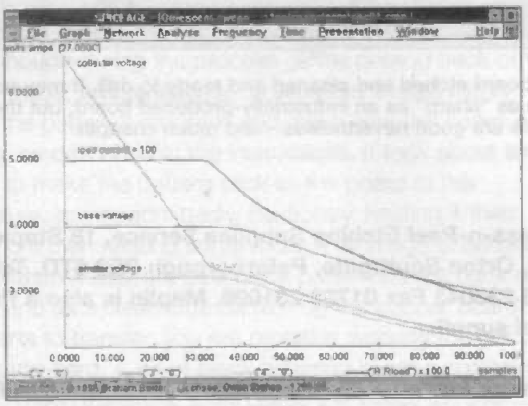


Figure 1: quiescent sweep output for last month's Problem

compliance range, the base voltage exceeds the collector voltage by as much as 600mV. The base-collector junction is then *forward* biased, but by not quite enough to begin conduction. Results similar to these are obtainable with a breadboarded circuit.

Calculate R

In the second project we calculate a suitable value for R2 to give 10mA through the load. The equation gives R2 = 450W. Key this into the netlist and alter the zener value to 5.1V. Set the sweep values for Rload to "vs=50 vf=500". Increase the scale of the current plot to x500. The resultant plot has the same features as figure 1, but shows that the constant current is only 9.8mA. The equation for calculating R2 is only approximate, because the base-emitter voltage is actually greater than 0.6V. So try reducing R2; after a few trials we settle on a value of 442W.

A quiescent sweep shows the current falling off at about sample 90. To find the point more exactly, click Graph => Zoom x 4. We can scroll to any part of the enlarged graph, using the scroll bars. A 2 percent fall-off of current is 9.8mA and, using the cross-hairs, we find this happens at sample 90 exactly. With a resistance range of 50W to 500W, or 450W, this is equivalent to 50 + 90 x 450/100 = 455W. At the other extreme, the current is constant at 10mA even when Rload is less than 1W, so we rate the 2 percent compliance as 0W up to 455W.

Frequency effects

Last month we introduced DC analysis, the first of the three main types of analysis available in SPICE. Now we look at the second type, AC analysis.

When asked to perform AC analysis, SPICE first performs a DC analysis to obtain the quiescent voltages and currents of the circuit. It replaces non-sinusoidal voltage and current sources with their internal resistances. Then it applies a small sinusoidal signal to the circuit from any sine-wave sources present in it, and measures the amplitude of voltage and current signals at all nodes. Note that, although the netlist may specify amplitude and frequency for sine-wave sources, these are ignored at this stage. The amplitude is set to be so small that it does not disturb quiescent values and the frequency is swept over a preset range.

To see what all this means, consider the simplest possible frequency-dependent circuit, a capacitor/resistor high-pass filter (figure 2). This month we have produced the schematic by using *SpiceAge's* sister program, Geseca. Component values were calculated from the equation f = 1/2pRC, and give a cut-off frequency of approximately 1kHz. Using the Inspector, we have named the nodes *input, output and gnd,* instead of numbering them, to indicate their purpose in the filter.

Clicking on the SpiceAge button causes the netlist to be generated (figure 3). Select the frequency range for the analysis by clicking on Frequency => Frequency range. Set Start frequency to 100, set Stop frequency to 10k, ignore Spot frequency, set Frequency steps to 100 and deselect the ticked options by clicking on them. Analyses => Frequency response produces figure 4.

You can see how the output amplitude (scaled to the actual amplitude of the source) increases with frequency, reaching 1V at about 700Hz. At 1kHz it is approximately 0.7V; according to theory we expect, 0.7071V (that is, the square root of 2/2), the voltage at which the power is half of the maximum.

Because we are often dealing with wide frequency ranges and big changes in amplitude, it is more common to plot this graph on logarithmic scales. This is done by returning to the Frequency range panel and clicking the Log freq and dB scale options. For further information we also click Phase.

The analysis is in figure 5, and is known as a Bode plot. We have set the cross-wires on the amplitude curve at the cut-off frequency, 1kHz. As expected, the amplitude is -3dB on the decibel scale, the half-power point. The phase plot shows that, the output signal leads the input signal by 45 degrees at 1kHz.

Wide-band amplifier

A common base amplifier (figure 6) is useful for high frequencies because it avoids the Miller effect. The resistor values were calculated assuming a 1mA collector current. First a quick DC quiescent analysis shows collector current to be 0.973mA. Quiescent (no signal) output is 3.09, nicely halfway between the supply lines for minimum distortion. To check the frequency response, click Frequency => Frequency range and make Start freq = 30Hz and Stop freq = 1MHz. Select Log freq and dB plot. The consequent Bode plot (figure 7) shows roll-off at low and high frequencies. Taking the -3dB point as the limit to a satisfactory response, the response range is 363Hz to 145.8kHz, so this hardly qualifies as a wide-band amplifier. What can we do about it?

The input and output capacitors (C1 and C2) act as high-pass filters; altering these could improve the low-frequency response. Sweep them from, say, 1nF to 1000uF to see how this affects the Bode plot. In the netlist, for C1 add 'vs=1n vf=1000u'. Click Frequency => Frequency range and set Start to 30Hz and Stop to 1MHz; select log frequency and dB plot. Under Analyse => Tolerances and temp, select the function Value sweep, and under mode select Logarithmic and N=8. This gives eight frequencies a decade apart: 1nF, 10nF up to 100uF, 1000uF. We are not interested in responses much less than -3dB so to display just the upper region of the graph go to Presentation => Graph scaling and there select Hold under dB Min, and enter -4.

Values lower than -4dB will not be plotted and the graph will be scaled accordingly. The plots (figure 8) with labelling added it identify them show that varying C1 has little effect on high-frequency response, but that increasing it to 100µF will bring 30Hz into the -3dB range. Alter the netlist to change C1 to 100uF.

A similar investigation, sweeping C2, gives 8 coincident curves. In other words, the value of C2 makes no difference. But this is because there is no load attached to it. Adding R5 between node 4 and node 0, with a value of 10kW and re-testing produces a family of curves similar to figure 8, but 30Hz is within the -3dB range with R2 = 10uF, so there is no need to alter it.

Now to turn our attention to high-frequency response. Part of the trouble may be that the high-frequency signal is being lost to ground by way of the base of Q1. Stabilising the base voltage by

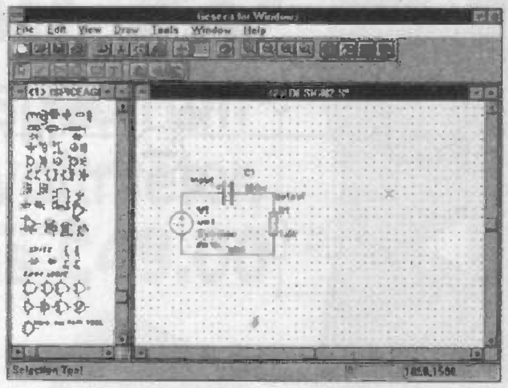


Figure 2: a high-pass filter schematic shown on Geseca

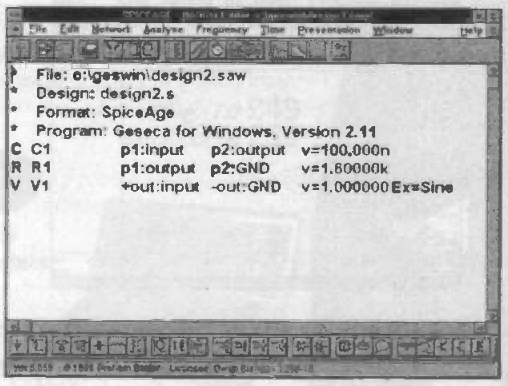


Figure 3: the netlist generated for the circuit by SpiceAge

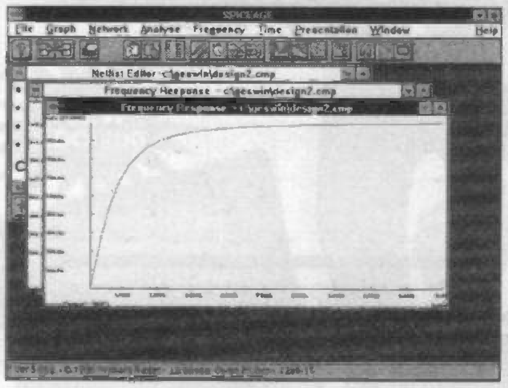


Figure 4: the frequency response analysis

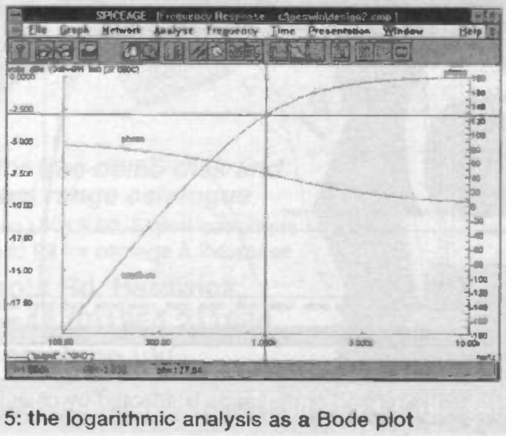


Figure 5: the logarithmic analysis as a Bode plot

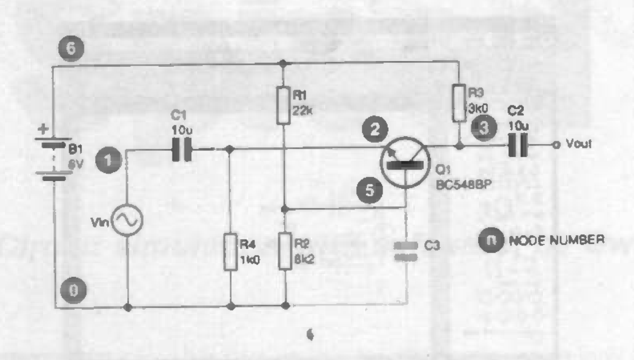


Figure 6: a common-base amplifier

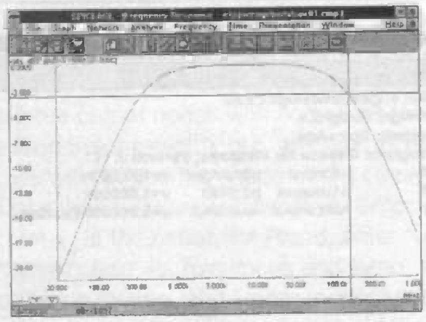


Figure 7: the Bode plot of frequency response for the circuit in figure 6.

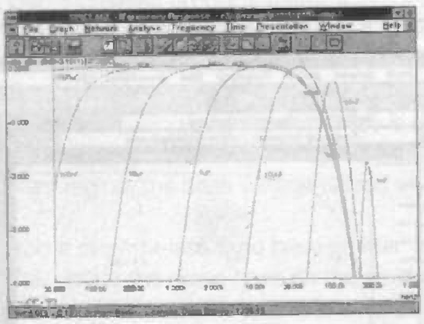


Figure 8: a series of plots show that changing C1 affects frequency response very little

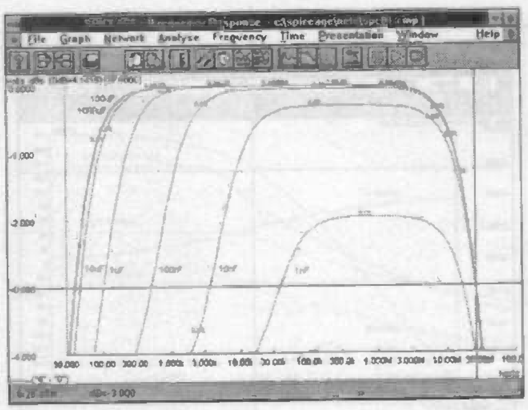


Figure 9: the lower end of the range is affected by changing C3, affecting the choice of C1

a capacitor (C3) connected from node 5 to node 0 should reduce this. Add C3 to the netlist with the same sweep range as before. The result of the sweep shows that a capacitor of any value above 1uF increases the upper frequency to such a high value that we have had to extend the frequency range to plot it, at 26MHz. In figure 9, the lower end of the range is a little affected by adding C3, so we need to increase C1 by a small amount.

This is now a really wide-band amplifier. Is there more we can do? Another possibility is to use a transistor intended for radio frequencies. Here we reap the benefit of using a simulator, as we do not need a vast stock of component types. Our simulator library includes the popular 2N2222A, often listed as an RF transistor, so enter this instead of the BC548BP. This produces the upper -3dB frequency at 13.14MHz, so presumably we already have a transistor suitable for RF in the BC548. Substituting the ZTX325, however, gives a massive increase in range, to 53.37MHz, and the BFQ31 (a surface mount device) increases it further to 60MHz. We leave the amplifier at this point, but will return to it again another month to look at distortion and other characteristics.

On the breadboard

To test these circuits on a breadboard requires a signal generator and an oscilloscope. This illustrates another of the conveniences of using a simulator. If you have these items, follow the development of the circuits with breadboarded versions. Feed the test circuit with a sine wave, amplitude 0.1V, of varying frequency, and measure the amplitude of the output, using the oscilloscope. If *am* is the maximum amplitude (obtained with intermediate frequencies) and *af* is the amplitude obtained at a given frequency, the decibel rating *n*, of *af* relative to *am* at that frequency is defined as:

$$n = 20 \times \log10(af/am)$$

Taking measurements at different frequencies over as wide a range as your equipment will allow, produces plots similar to those given above.

The project

Investigate, either with a simulator or on a breadboard, the frequency-dependent behaviour of the circuit of figure 10. In *SpiceAge*, the netlist line for the op amp is:

```
> Opamp  TL081C:lib   +v:5   -v:6   +in:0   -in:3   out:4
```

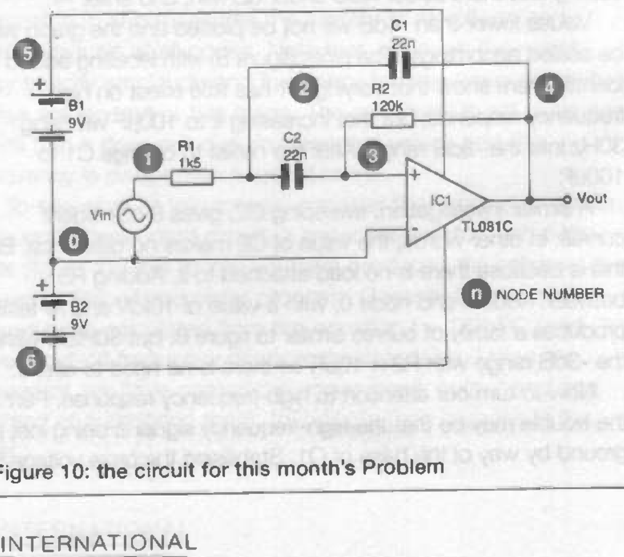


Figure 10: the circuit for this month's Problem

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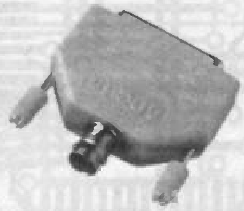

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ETI Shake'n'Etch ...update

A new temperature control circuit for February's PCB bath project.

By Bob Noyes.

Owing to the sudden demise of the LM 3911, the following circuit has been designed as a plug-in replacement to the Shake'n'Etch (ETI February 1997) Temperature Control Board; some wiring changes are required.

The replacement sensor is the LM 335, a three-pin transistor lookalike; only two of the pins are used in this circuit, as the adjust or calibrate lead is not required. This may be snipped off to remove it completely.

I have called the replacement for the LM 3911 the "Phantom Board", and constructed it on Veroboard for speed. The basic principle is very simple, with the supply originally going to the LM 3911 now being taken to the power input on the phantom pin A. Instead of the LM 3911 regulating at 6.8 volts, I have regulated at 5 volts via ZD1, to give around 5 milliamps of useful current. The LM 335 is powered via R3, and acts as a temperature controlled Zener. It's output voltage has been designed to give an output directly proportional to the temperature in degrees Kelvin, so that at 0 degrees Celsius the output is 2.73 volts (0 degrees Kelvin = minus 273 degrees Celsius) and rises 10 millivolts for every 1 degree C increase. This means that if a voltmeter is wired across it when in operation, the readout will be the temperature in degrees Kelvin.

In this case, the circuit is required to work in the range of 40 degrees C to 70 degrees C, so the expected output is 2.73 + (40 x 10 millivolts) to 2.73 + (70 x 10 millivolts) or 3.13V to 3.43V. A potential divider consisting of R1, VR1 and R2 is used to provide this voltage range on the wiper of the pot.

The output from the pot is connected to the input of a comparator or op amp with an extremely high gain. When the temperature is below that required or set on the pot the output of the comparator will be low, holding off TR1, but when the temperature rises above that set, the output of IC1 goes high, turning on TR1, which shuts down the heaters on the temperature control PCB (as did the LM 3911).

Because of the rise or fall in temperature is very slow, the output of IC1 could change slowly, causing the triac on the temperature control board to chatter and possibly overheat. To overcome this, a small amount of hysteresis has been introduced via R5 and R6, which prevents any slow output changes.

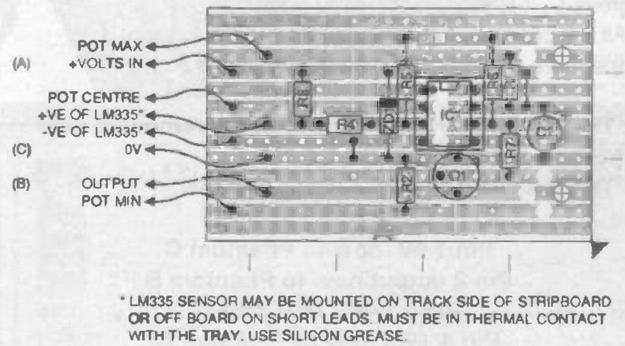

Figure 2: the Phantom Board. Note the 11 track cuts, including the one under R4

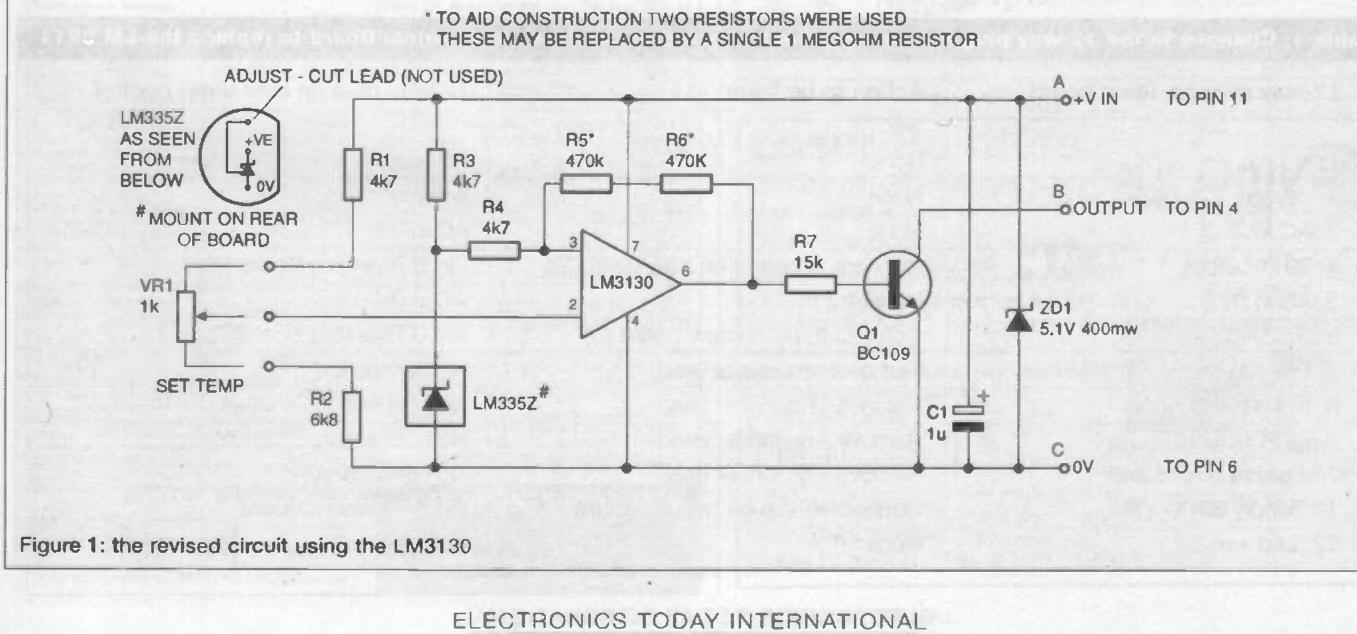

Figure 1: the revised circuit using the LM3130

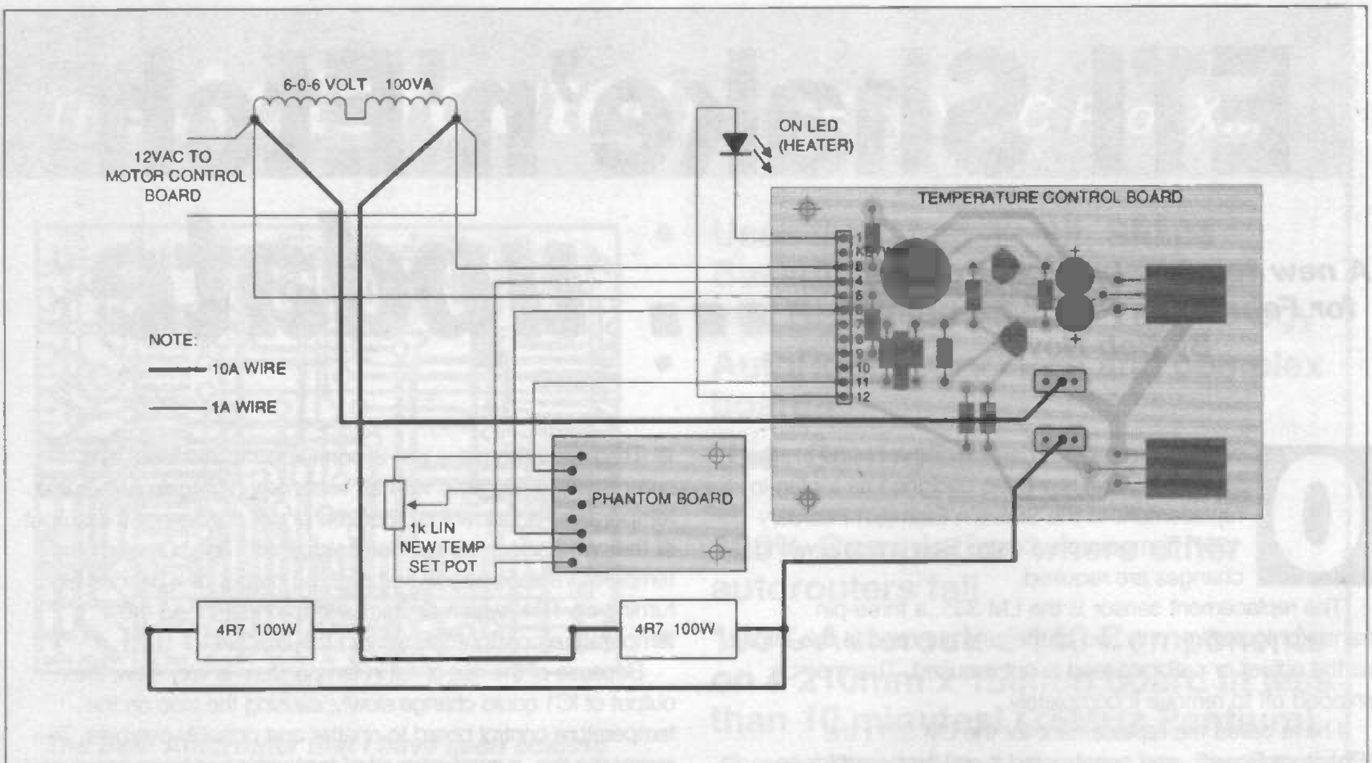

Figure 3: the new connections to the temperature control board

Although this does add a slight error, albeit only 1 or 2 degrees C, it is still a worthwhile addition.

All the changes to the connector on the original temperature control board are shown, namely:

1. The old temperature control pot is removed; note 5 kohms, not 1 kohm.
2. The following LM 3911 wires are now:

Pin 1 0V now to Phantom C
Pin 2 output now to Phantom B
Pin 3 WIRE NOT USED
Pin 4 +Vin now to Phantom A

We apologise for any inconvenience that has arisen from the non-availability of the LM 3911. This was freely available when the project was written, but in the meantime has ceased production after a long and honourable career, with no direct equivalent on the market - which may explain why stocks have run out so quickly.

Less popular chips now considered old-fashioned by industry usually take some time to go 'out of stock' when production ceases, while a more modern equivalent is introduced.

PARTS LIST

Resistors

R1,R3,R4	4k7
R2	6k8
R5,R6	470k
R7	15k

Others

C1	10uF
IC1	LM3130E
ZD1	5.1V 400mW
Q1	BC109
Sensor	LM 335

Table 1: Changes to the 12-way plug on the temp control board to connect the Phantom Board to replace the LM 3911

12-way plug on Temp board	Action to be taken	12-way plug on new temp control
1 led -ve	None	led -ve
2 keyway	None	keyway
3 AC in	None	AC in
4 3911 output	Connect to output on new board (B)	Pin B Phantom Board
5 AC in 0V	None	AC in 0V
6 0V 3911	Connect to 0V on new board (C)	Pin C Phantom Board
7 Pot +ve end	Remove - no longer used	No connection
8 Pot wiper	Remove - no longer used	No connection
9 3911 adjust	Remove - no longer used	No connection
10 Pot -ve end	Remove - no longer used	No connection
11 Supply 3911	Connect to +ve on new board (A)	Pin A Phantom Board
12 Led +ve	None	led +ve

Experimenting with video

PART 5

A video test pattern generator and modulator

Develop and set up your video equipment with this video test signal generator

by Robin Abbott

In the last part of our series on experimenting with video we shall look at another piece of test equipment, a video test pattern generator, which includes a modulator for viewing the test patterns, or a composite video signal on a normal TV receiver.

When creating circuits to modify a video signal, it is useful to be able to generate a test signal without having to use a TV tuner or a video camera. A video test generator guarantees a repeatable signal which can be set to the best characteristic for the system being developed. The pattern generator described in this article is also suitable for setting up television receivers, as it provides lines and bars that can be used to check alignment of horizontal and vertical circuits.

Once a system is set up using a pattern generator, it should be tested with an off-air composite video source, as only this can reveal dynamic effects. For example, the prototype of the sync separator in the first part of this series suffered from false vertical synchronisation (causing the screen to flicker) when the input signal changed rapidly from bright to dark pictures. Oddly, this only seemed to happen during advertisements or Top of the Pops!

Description

This circuit is intended to be as simple as possible, and therefore does not include a colour capability. A colour generator would be considerably more complex, and beyond the scope of this series. The generator will produce the following pattern types:

- A black field (blank raster)
- Horizontal lines
- Cross hatch lines
- A matrix of dots
- Vertical lines
- A horizontal gray scale
- A white field

The blank raster generates an empty synchronisation pattern which is particularly useful for developing sync separator circuits. The generator operates with 625 line signals as shown, but is easily modified for a 525-line standard as shown in the circuit description.

The circuit includes a power regulator and an optional video/audio modulator. The modulator allows composite

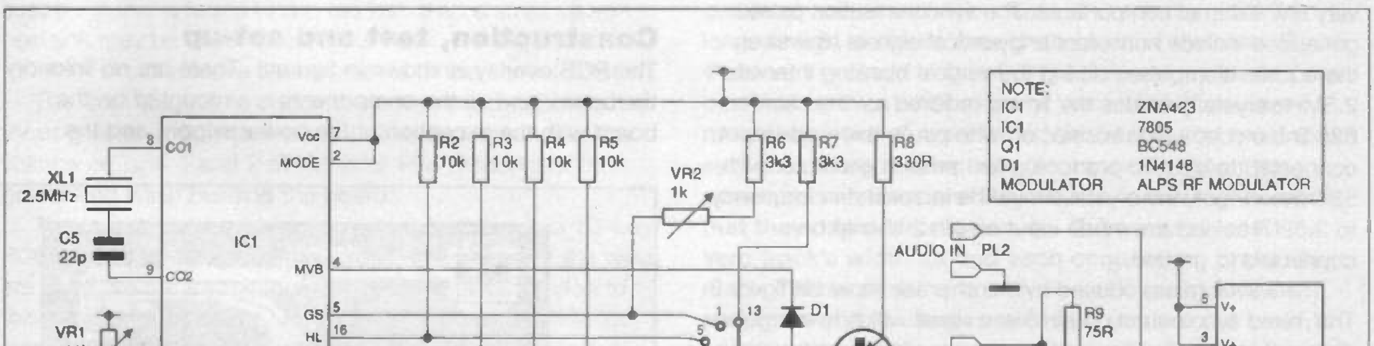

Figure 1: the circuit of the video test pattern generator

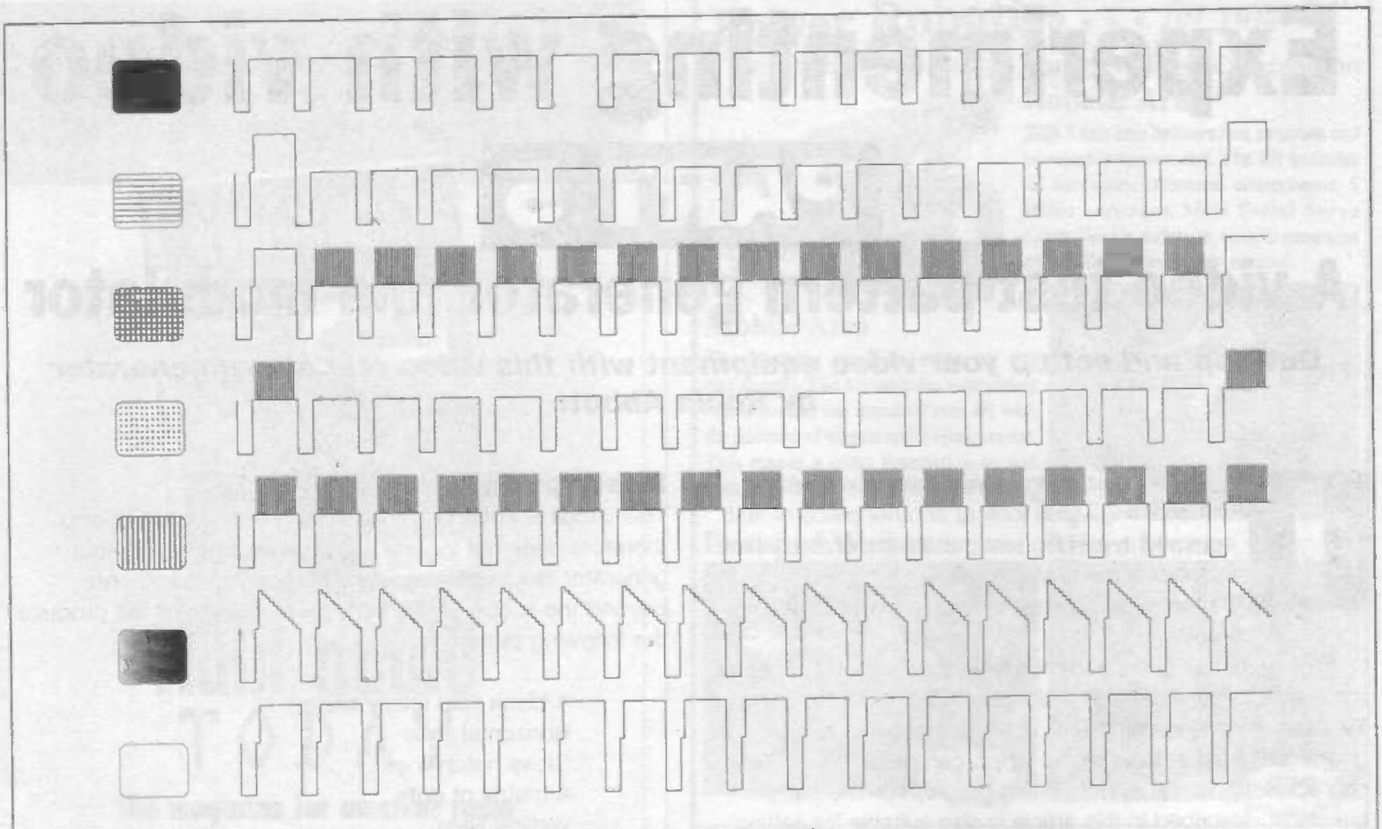

Figure 2: waveform generated by IC1, shown during the main raster. Not to scale

video, and line level audio signals to be injected externally, or the modulator can be switched to use the internal test pattern generator.

Circuit description

Figure 1 shows the circuit diagram of the pattern generator. The circuit makes use of GEC-Plessey Semiconductors ZNA423. This ic makes available all the signals required to generate the described test patterns on a single chip with very few external components. The synchronisation pulses generated include horizontal and vertical signals as well as the equalisation pulses during the vertical blanking interval. A 2.5MHz crystal provides the timing required for the chip for 625 line mode, which is selected with pin 2, the mode input, connected to Vcc. To produce a test pattern generator with 525-line output, the crystal should be increased in frequency to 2.52MHz, and the mode input on pin 2 should be connected to ground.

The waveforms produced by the chip are shown in figure 2. The mixed sync output on pin 3 is a signal which is low-going during sync pulses. This output is open collector, and could be used with a pull-up to Vcc for a general purpose sync signal capable of driving digital logic. The video blanking output is used to switch off the video test signal outputs during raster video blanking (during horizontal and vertical synchronisation pulses). This output (mixed video blanking) is on pin 4 of IC1.

Q1, R8, VR3, and VR4 are used to mix the test pattern signal outputs with the mixed sync output and the video blanking output. This circuit is slightly more complex than required for a simple mix of the digital signals produced by the chip; this is due to the DC offsets produced by the grey scale and white field outputs. Q1 operates as an emitter follower to signals produced by the chip, the signals are open collector, and can therefore be overridden by the MVB output through D1.

The blank field is generated by connecting the base of Q1 to ground, simply producing the sync output. The other patterns are generated by producing digital logic signals at the correct points in the line as shown in figure 2.

The modulator is a standard device intended for use in video recorders; it has a video and audio input, and an antenna input and output. An output on a phono socket is provided for the video's internal circuitry, which is not used in this application.

Construction, test and set-up

The PCB overlay is shown in figure 3. There are no links on the board, and all the components are mounted on the board with the exception of the power supply, and the

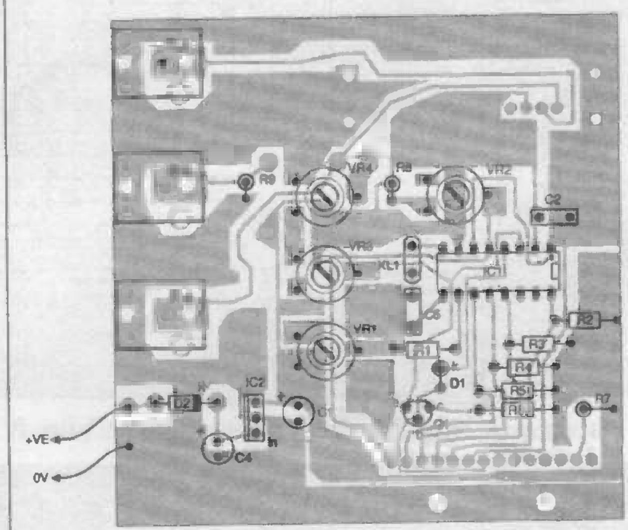

Figure 3: the component layout

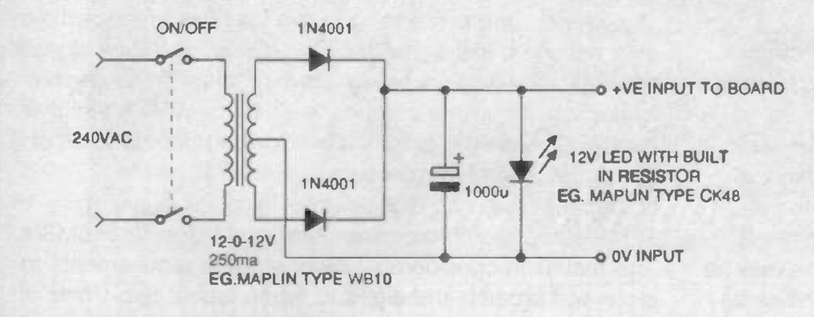

Figure 4: the circuit diagram of the power supply

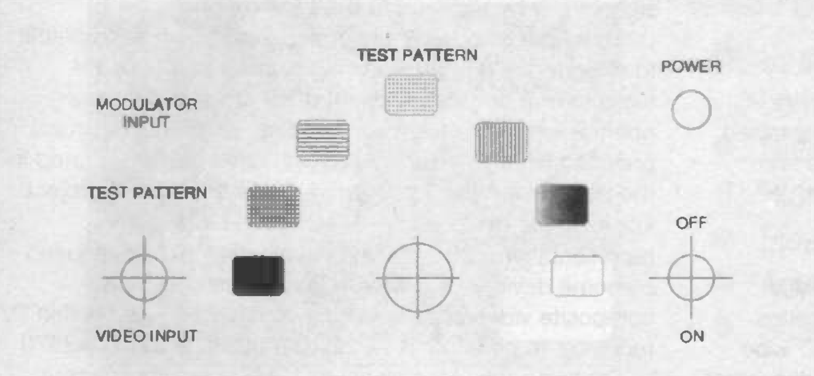

Figure 5: a layout for the front panel

switch used to select between the external video input and the internal test pattern. IC1 should be socketed.

Insert all the horizontally mounted components first, starting with the resistors and the ic socket, followed by the larger components. The vertically mounted components and the capacitor are mounted next, followed by all the other components, but do not yet insert IC1, the selector switches, or the modulator. The voltage regulator IC2 may require a heatsink, but this depends on the external voltage supply - if this is found to run too hot, then a small clip-on heatsink may be used. Check your work, looking particularly for short circuits. Move all the presets to the central position.

The next stage is to check the power supply. Connect a 9V or greater supply to the input pins, and check that the voltage on pins 1 and 2 of IC1 is at +5v. Disconnect the power and finish building the board.

The switch used to select the video patterns is a 12-way PCB-mounting design. In this circuit, only seven of the ways are used, so the switch must be set to limit its rotation to this number of positions. To do this, turn the switch to its maximum anti-clockwise position. Unscrew the fixing nut completely, and pull out the small circular washer with a tab. Insert the tab in the position marked with the number 8, and then screw up the fixing nut to secure it. Check that the switch now only allows rotation to seven different positions. The switch is mounted by its leads, and is mechanically secured by two fixing screws through the PCB. When the test pattern generator is mounted in a case, the switch is operated from the front panel, whereas the PCB is attached to the rear panel, so it is not wise to cut the spindle until the PCB is fitted to the case.

Finally, the modulator may be inserted into the board if it is to be used. It is supported by the mounting tabs on the case and should be eased gently into the PCB. Solder in the modulator and selector switches, insert IC1 (pin 1 is towards the edge of the board), and connect power to the board once more.

The best method for checking the board is to use the RF output from the modulator. However if this has not been fitted, the composite video output may be used, connected either directly to a TV, or via a video recorder with a composite video input. Using the modulator, move the test switch to the upper position, and connect the output of the modulator to a TV receiver. The output of the modulator is on the upper RF connector. Tune the TV receiver to around channel 36 to view two vertical bars on the TV. Move the test switch to the lower position.

Move the pattern selection switch to cross-hatch pattern and connect the two Vero pins for the modulator input switch which are close together by the modulator. This will connect the output of the test pattern generator to the modulator. A cross hatch pattern should appear on the screen, however, it may be rolling or even invisible at this stage. Adjust VR3 and VR4 (move VR4 first) until a stable picture is obtained. Change VR1 to adjust the vertical line width to match the horizontal line width. Move the pattern selection switch to the grey scale position and adjust VR2 to obtain the best grey scale (this may require interaction with readjustment of VR3 and VR4). Check all positions of the pattern selection switch to ensure that all available patterns are correctly displayed.

Finally connect a composite video signal, and audio signal to the input connectors, connect the modulator input veropin to the video input veropin, and check that the signal is displayed (and heard) correctly on the TV.

The PCB may now be mounted into a case. The shape of the PCB forces the PCB to be mounted in the back left corner of a small aluminium case, the spindle of SW1 is long enough to mount through the front of the case. Figure 4 shows the circuit diagram of the power supply, which can be made up on a small piece of Veroboard. **If you are mounting a transformer onto Veroboard, you must make sure that there is adequate clearance between the power connections and any object, including the case, that they might short or arc to. Cut away at least one Vero track's width around each connection, preferably more. This is a mains board, so seek assistance of someone with mains experience if you are not used to constructing mains devices.** The rear and side of the case should be drilled to allow access to the phono sockets and RF connector. In the prototype holes were drilled which were slightly larger than the sockets to allow connector insulation on leads to be pushed through the case. The case should be earthed, and caution must be taken with the layout of the mains input circuitry to avoid the possibility of short circuits. Use a strain relief grommet, and connect the input cable to the transformer by using screw block connectors mounted with M3 nuts and bolts to the base of the case. The input to the power supply is switched, and the front panel should contain the pattern selector switch, the modulator input switch and the power supply switch.

Figure 5 shows the overlay for the front panel of the case.

In use

To keep the cost and size of the unit down to a reasonable level, the composite video output of the unit has not been buffered. In practice, this proved not be a bar to the use of the unit with a 75-ohm terminated input, although the video level had to be adjusted. If a buffered output is required, a circuit similar to that shown on the input circuit of the sync separator from part 1 of this series may be used.

The modulator includes an antenna input, and this may be used in addition to the test pattern output to route off-air as well as test signals into a TV receiver. The antenna input is mixed with video signals fed into the modulator. Please note that the antenna input signal will not be routed to the output unless power is supplied to the modulator.

Obtaining components

The only obscure components in this design are the ALPS modulator, and the ZNA423. The ZNA423 may be obtained from Maplin or from Farnell. The ALPS modulator is from Maplin.

Further Experimenting with Video

In this series we have looked at the format of the video signal, and developed projects to derive synchronisation signals from a composite signal, to switch, fade and wipe video signals, and to select individual lines in the video raster. It is of interest to look at the implementation of some other video projects which make use of the composite video signal.

Working with digitised video signals

Most of the handling of video in commercial and more complex projects is carried out in the digital domain. Most of these projects still employ analogue techniques to demodulate the RF signal and to derive the composite video signal. Only then is the video signal digitised and further processed.

Fast (flash) A to D converters are widely available. For example, the CA3306 is a 6-bit converter. A typical application, demonstrating how straightforward the device is to use, is shown in figure 6. This particular device has a maximum sampling rate of 15MS/s (megasamples per second). This type of A to D converter operates by using an array of comparators connected to a voltage divider ladder made from resistors. It is particularly simple, but expensive because a 6-bit converter requires 64 comparators. This device may be used with a clock, which sampling theory states should be at double the maximum frequency of any component of the incoming video signal. The device can be connected in a pair to make a 7-bit device by combining the internal resistor ladders. It is also possible to combine two A to D converters, each of which is operating at a specific clock rate to make a single A to D converter operating at double the clock rate, by making each converter operate on the opposite phase of the clock.

In practice the colour signal is decoded into the luminance and colour difference signals - Y,U and V. The Y signal represents the brightness of the incoming signal, and is effectively the black and white signal. The U and V signals are colour difference signals which represent the Green signal with the Red signal subtracted, and the Blue signal with the Red signal subtracted. By combining these appropriately with the luminance signals (which is effectively Red + Green + Blue), the final Red, Green and Blue signals may be derived. The Y,U and V signals may then be digitised.

Digitising and processing in this way has an advantage over decoding the signal into Red, Green and Blue signals and then digitising these signals separately, because the luminance signal in a composite video signal has a higher bandwidth than the chrominance (colour) components of the signal. Therefore by decoding into Y,U and V components we can digitise the luminance signal at 12MS/s and the chrominance signals (U, and V) at 6MS/s. This results in considerably lower storage requirements to store and process the digitised frame (about two-thirds of the requirement for 12MS/s sampling on Red, Green, and Blue channels). In addition, the luminance signal may be digitised with 7-bit resolution, while the chrominance signals can be digitised at 6-bit resolution.

There are a wide variety of integrated devices available to decode the composite video signal into Y,U and V signals. Unfortunately most of them are designed to operate within the television receiver, and require signals provided within the receiver, which must be regenerated if the devices are to be reused in a different type of project. For example the "sandcastle" pulse (an internal representation of the synchronisation signals), is required by some devices. A device which can decode the composite video signal, and which is widely used within TV receivers to generate a sandcastle pulse, is the TDA2579

Digitising the video signal at 12MS/s results in about 640 samples per line (we do not bother to digitise the synchronisation signals during the horizontal blanking period). If we digitise a total of 575 lines (again we do not bother to digitise the signal during the vertical blanking period), then the requirement for storage of a single frame from a TV picture is 368k samples for a black and white picture, or 736k samples for the colour picture encoded

PARTS LIST for the Video Test Signal Generator

Resistors

R1-R5	10k (1%)
R6, R7	3k3 (1%)
R8	330R (1%)
R9	75R (1%)
VR1	100k preset
VR2-4	1k preset

Capacitors

C1,4	10uF 16V
C2	100n
C3	Not fitted
C5	22pF ceramic

Semiconductors

D1	1N4148
Q1	BC548
IC1	ZNA423
IC2	7805

Miscellaneous

XL1	2.50MHz crystal
PL2-4	Board mounted phono socket (Maplin type HF99)
Modulator	ALPS RF modulator (Maplin type WC20)
SW1	12 way PCB mount switch (Maplin type FT56)
SW2	SPDT switch
Veropins	5 off (for PL1 and SW2)

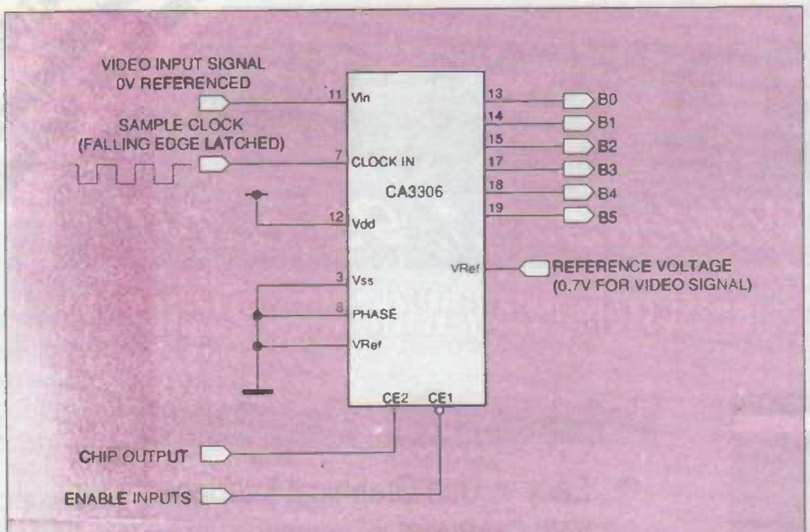

Figure 6: digitising video signals with the CA3306

using the Y,U and V signals. In most implementations each sample is stored in a single byte. The complete frame may now be processed as required. To reduce the memory requirement then only the first field of the frame may be digitised and stored, during the second frame, the first frame can be repeated, this results in a loss of resolution, but makes processing easier.

Fairly complex digital logic is usually required by systems which operate on digitised signals. The derived synchronisation signals must be used to synchronise internal clocks for the A to D converters to sample the incoming signal. A typical system would have two banks of RAM. Each digitised signal is written to each bank of RAM in turn, while the bank of RAM not currently being written to will be read by other logic which is clocking out the signal to further processing.

Mixing signals

Those readers who are interested in video cameras may be aware of digital video mixers that are capable of mixing two signals from different sources, which are not synchronised. These systems operate by digitising one of the input signals - the slave signal. The other signal is used as a reference, and the output of the mixer is generated by using the synchronisation from this master input. The slave signal is digitised and stored in RAM as described above. This RAM is read, and the output is then converted back to analogue form and mixed with the master input. However the RAM is read at a different position from where it is being written (the line number and position across the line are derived from the current line being transmitted in the master signal) and therefore the two pictures may be locked together.

This type of mixer tends to be very expensive (around £600), but offers the capability for locking independent signals, performing a perfect freeze frame, and for chroma keying. Chroma keying is the technique widely used by broadcasters to place one scene in front of another - for example, weather forecasters delivering a forecast in front of a computer-generated weather map. Whenever a particular colour is encountered in the master signal, the slave signal is shown. This switching is usually performed in the digital domain, and normally a small range of shades and brightnesses are allowed to ensure that an exact colour match is not essential.

Genlocks

Genlocks are used to lock a computer video output signal with a composite Video signal from a video camera or other source, and then superimpose the computer graphics on top of the video signal for captioning purposes. The computer which has been most popular for this purpose for the amateur market over the last few years has been the Commodore Amiga. This is because it allows the internal video circuitry to use externally derived synchronisation signals. Graphics may then be superimposed simply by switching to the computer output when it exceeds a certain level, so that black parts of the computer screen allow the video signal to show through, while brighter parts obscure the signal, or can be mixed with it to create a transparent graphic effect. Unfortunately, the Amiga is not now widely available.

The PC has had a number of Genlock solutions made available for it. However, most of these have been fairly difficult to use as they have employed the feature connector of the PC's video card, which has apparently not been implemented identically by all manufacturers, and this type of Genlock has been proved unreliable on some PCs. An alternative solution which is much easier to use is the type of Genlock which takes the video output of the computer, digitises it, retimes it, and then superimposes it on the video signal as shown above. An example of this is the Vine Micros Multigen. This type of genlock can be used with any computer that provides an interface to a standard VGA or SVGA monitor.

100Hz digital televisions

A relatively recent development in the television receiver market has been 100Hz scanning rates. This type of TV digitises the input signal at 50Hz and then scans the screen at double the rate. This results in an extremely smooth and flicker free picture. Some 100Hz televisions also attempt to improve the picture quality by scanning two 50Hz pictures and interpolating them.

Picture in Picture (PIP)

Picture in picture processing allows a TV to display a smaller picture showing an alternative channel, or video input, within a full screen picture from a main channel. The uses of this may seem somewhat limited, but the feature is becoming available on an ever wider range of receivers. This type of display is also produced digitally. An example chip set intended to produce this type of display is the SDA9187 and SDA9188 from Siemens. These chips are designed to operate within a TV receiver and require support from typical TV circuitry such as the derivation of the sandcastle pulse.

The main input signal is not used by chip set except to derive the synchronisation and timing information for the output signal which includes the PIP. The secondary signal is digitised in the Y,U,V domain as shown above, the digitisation in this case is limited to a much smaller number of samples per line to reduce the memory requirement considerably, as the secondary signal is only displayed in a small sub picture. Once digitised the sub-picture is displayed by switching from the main picture to the sub-picture at the appropriate point in the main signal.

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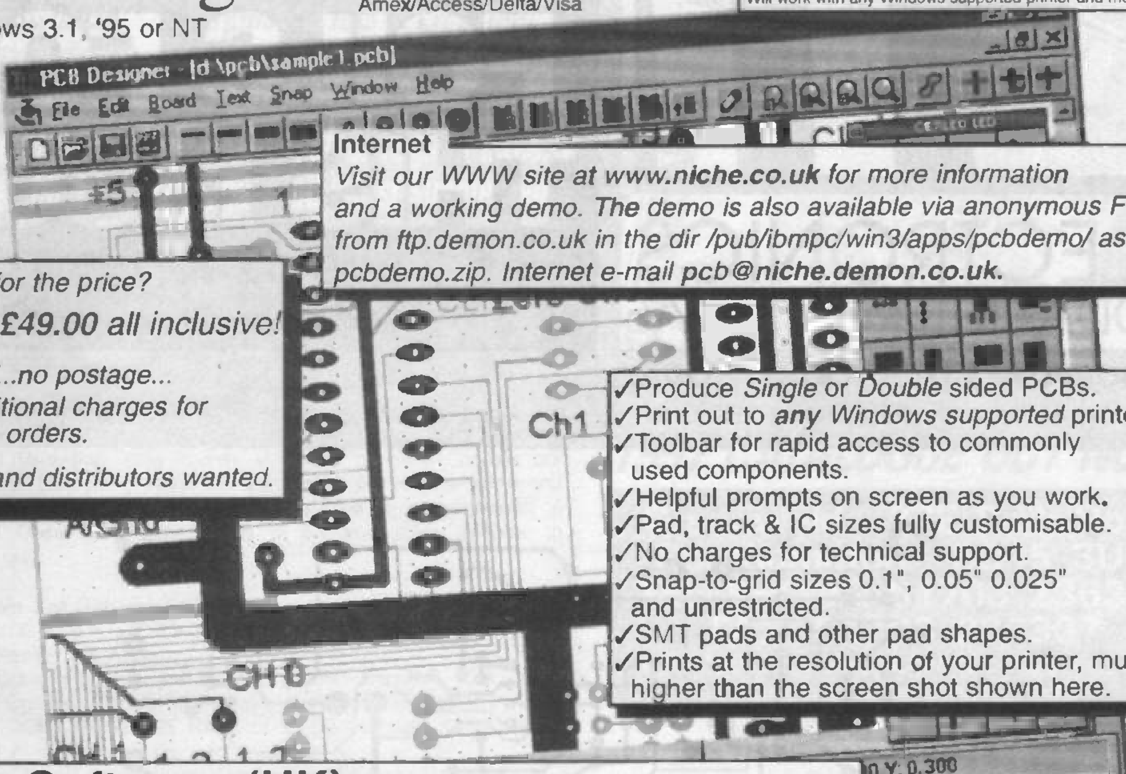

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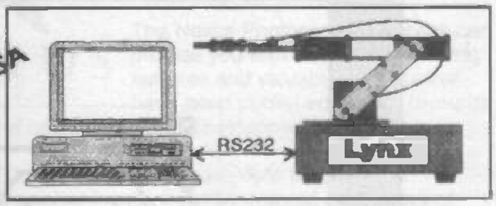

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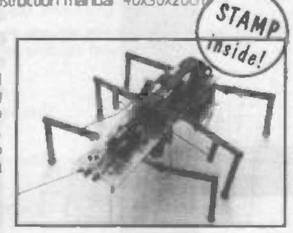

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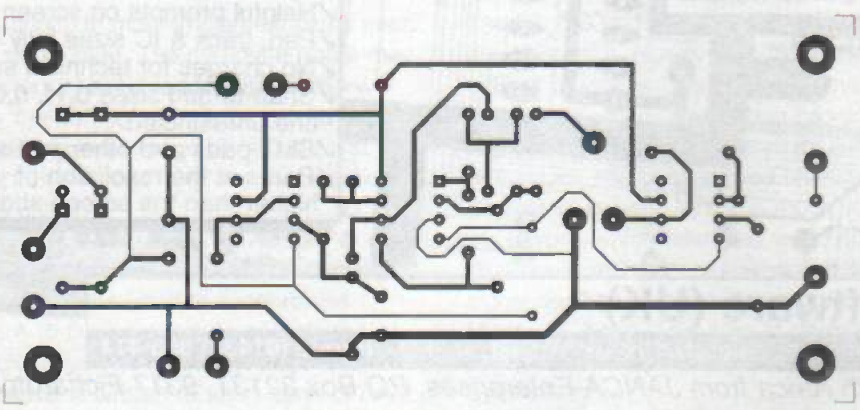

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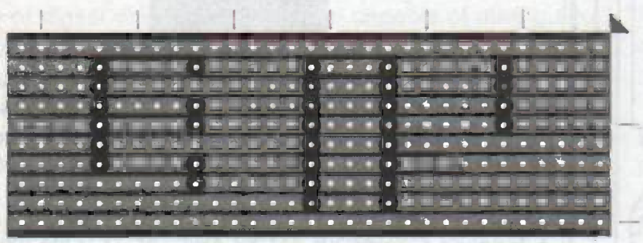

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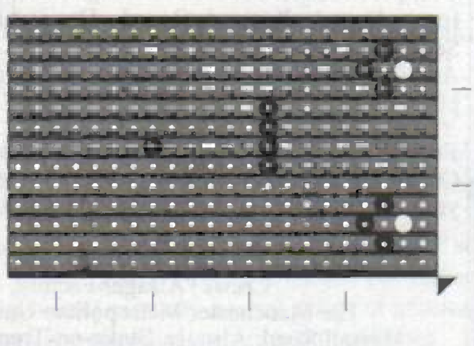

SHAKE AND ETCH UPDATE

CARAVAN MOVEMENT ALARM

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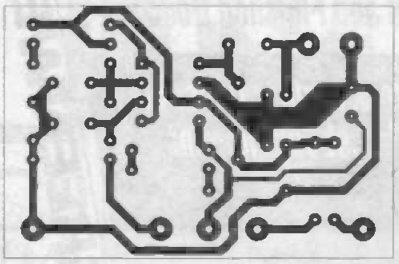

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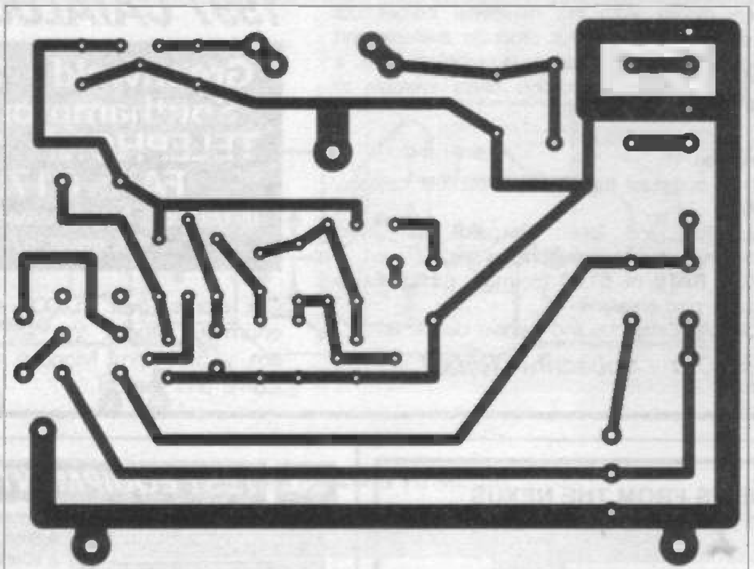

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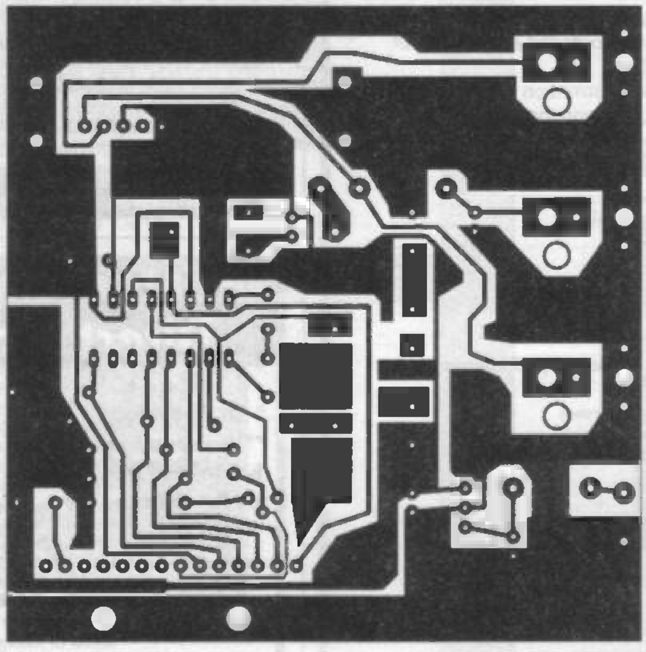

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Practically Speaking

BY TERRY BALBIRNIE

Over the last few months of Practically Speaking we have been looking at various aspects of connecting wire. We shall now finish this topic by examining the way wires should be joined together. We shall also look at how they should be secured under terminals.

Almost all failures of amateur circuits are due to simple things. This may be nothing more than the joint between a pair of wires breaking. Sometimes a joint partially fails so that the wires make intermittent contact. This can result in the circuit failing to work unless it is moved or shaken first. Sometimes the joint exhibits a high resistance whose value varies with vibration or temperature. This can result in a range of curious symptoms such as the circuit failing to work when it has been switched on for some time (and warms up).

Dirty joint

Joints in wires should be avoided wherever possible. When they are unavoidable, they should be made strong enough for the purpose and have as low a resistance as possible. When making a joint, make sure the wires are clean to begin with. If necessary, gently scrape off any oxidised material with a blunt blade. This is especially important where single-core wire is involved. A sharp knife tends to form a nick in the surface. This weakens the material and the wire is likely to fracture at that point sooner or later.

Do not solder wires together without making some type of mechanical connection first, such as twisting them together. This will make the joint stronger and will also reduce its resistance. The top wire in the illustration is an example of a very poor joint. Here, the two wires have not even been placed in contact before soldering. The solder bridges the gap between them and provides what little mechanical strength there is. This type of joint is not only weak but will have a relatively high resistance.

Twist and shout

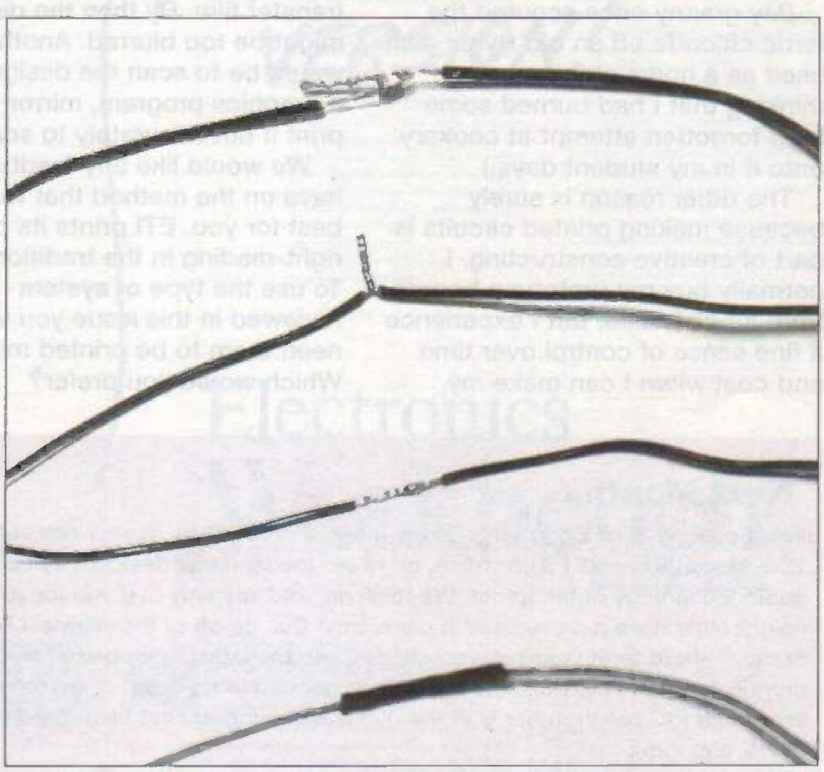
Amateurs often twist wires together as shown in the second example. This method is not very tidy and makes the joint difficult to insulate. A better method is to twist the wires together horizontally as shown in third example. Where stranded wires are involved, a better joint may be made by interweaving the strands of each before twisting and soldering. This provides a very neat and strong joint.

A good joint will be little thicker than one of the original wires with the insulation on. A piece of sleeving of the correct diameter may then be slid tightly over the joint to insulate it. The use of sleeving requires a little forethought - it needs to be slid on to one of the wires before the joint is made. Sleeving may be bought, or a little stripped-off insulation from some thicker connecting wire may be used. Often a better alternative is to use heat shrinkable sleeving. When this is heated to about 120 degrees C, it reduces its diameter by up to 50%. This will grip the joint firmly and it will not slide out of position (see the bottom wire in the illustration).

Heat shrinkable sleeving is available in a variety of diameters. To use it, choose a size a little wider than the wire and slide it over the joint. Heat it evenly - a hair dryer used close to the work will probably be sufficient for the purpose. Alternatively, a hot air blower of the type used for stripping paint will do. It is also possible to stroke it using the hot side of the soldering iron (not the bit) to achieve the same effect. Take care not to overheat it, though.

Getting clamped

When wire is to be clamped under a terminal, a neat open loop should be made in it. The wire should be passed round the terminal in such a way that tightening the screw tends to close the loop. If it is wound the other way, the loop will tend to open and the wire will be forced out. This may only happen some time later. The wire should not be twisted into a closed loop since pressure from the head of the terminal can fracture the wire at the overlapped section.



Around the Corner

In this month's ETI we review a new system for making pcbs (printed circuit boards) on a small scale. "Small scale" may mean a single project board, a couple of prototype boards - or short runs of twos and threes or fives if you are a teacher, lecturer or professional designer.

In each case, the cost of buying boards from a pcb manufacturer - which might be very good value in the hundreds - is often prohibitive. PCB makers use photoplots and numerically controlled drilling machines, which produce an extremely high quality result, and are labour saving in large volume production, but which cost disproportionate amounts of time and money for one-offs.

This is probably the main reason why electronics constructors continue to make their own pcbs at home, despite the inconveniences - UV light boxes, tapes and dots, transparent film, baths of caustic etchant, often with a tendency to stain anything it comes into contact with.

(My granny once scoured the ferric chloride off an old Pyrex dish used as a home etching bath, thinking that I had burned some long-forgotten attempt at cookery onto it in my student days.)

The other reason is surely because making printed circuits is part of creative constructing. I normally buy my prototype boards from a pcb maker, but I experience a fine sense of control over time and cost when I can make my own. It does not compete with fully industrial quality - no automatic hot-air levelling, or any of that - but I can see how it is coming out, and I know (well, usually I know) exactly when I am going to get it. And I am not paying set-up charges that can be up to £100 for a small run.

(Set-up charges vary, but manufacturers who will do a single small foil, delivered to them as a Gerber file, for less than £30 set-up charge, plus the cost of the board and delivery, are rare indeed.)

So any process that makes home pcbs easier is welcome.

To pcb designs from ETI with a UV exposed pcb, you could photocopy the design from the page on to a transparent sheet, and use the sheet as the mask. To use it with the transfer system reviewed in this issue, you would need to mirror the design first.

One way to do this is to photocopy it onto a transparent sheet, then to photocopy the transparent sheet (looking through from the other side) onto the transfer film. By then the design might be too blurred. Another way would be to scan the design in to a graphics program, mirror it, and print it out accurately to scale.

We would like any feedback you have on the method that works best for you. ETI prints its pcb foils right-reading in the traditional way. To use the type of system reviewed in this issue you would need them to be printed mirrored. Which would you prefer?

Next Month...

Volume 26 no. 6 of Electronics Today International will be in your newsagent on 23rd May 1997 ... NXT's ultra-thin, coneless loudspeaker design may be the audio technology of the future. We think so, and say why ... If you (or your neighbours) have a problem with car alarms that go off at the slightest breeze, or can't afford to fit your beloved chariot with the latest immobiliser, try a cryptic car-alarm look-alike to encourage bandits to move on ... we have an advanced PIC programmer is in the pipeline ... another Fast Fiver ... all the news, and more ...

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Nexus House, Boundary Way,
Hemel Hempstead HP2 7ST
Telephone (01442) 66551
Fax (01442) 66998