ETI

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TOMORROW'S TECHNOLOGY TODAY

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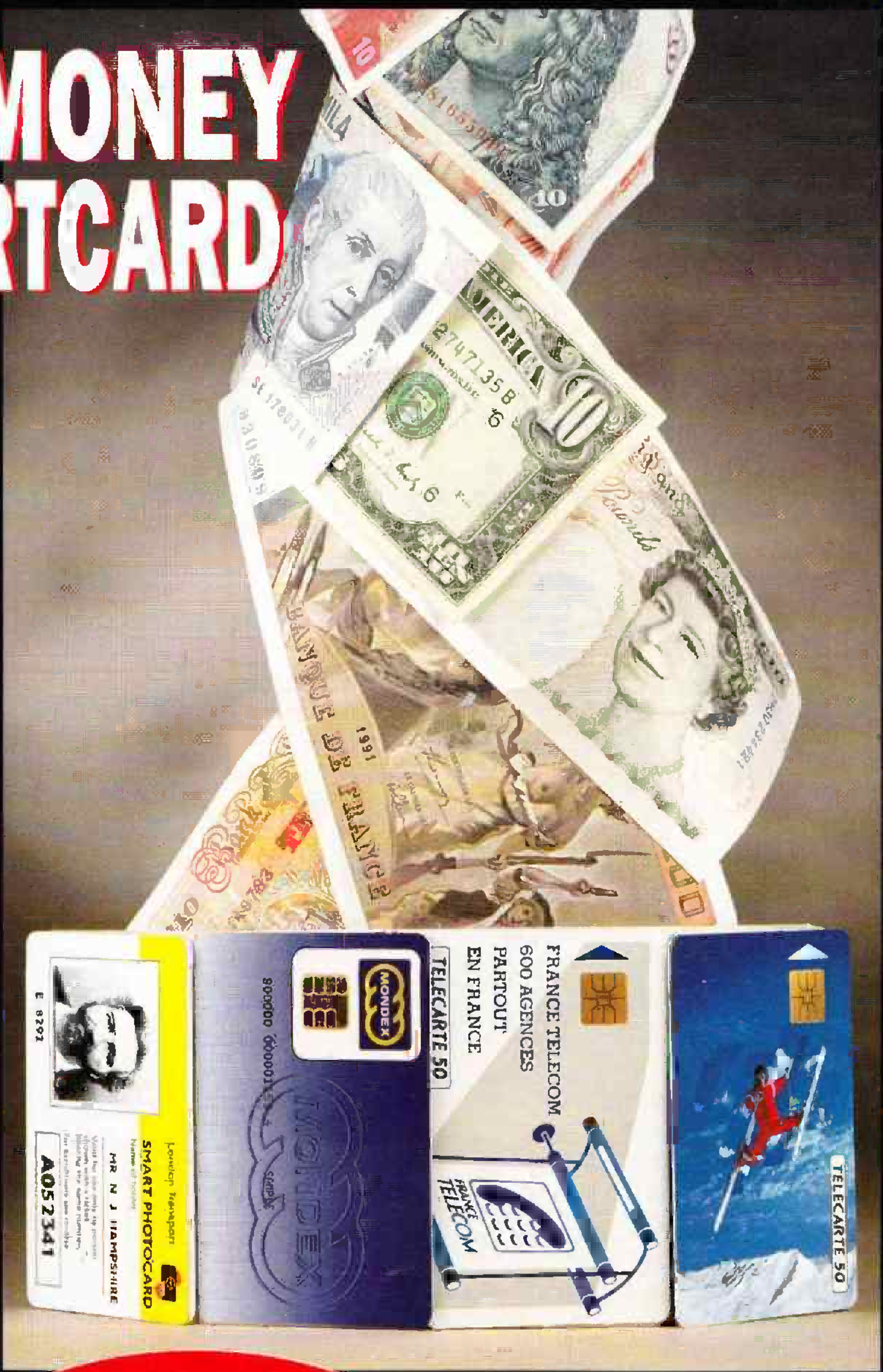

HOW ELECTRONICS WILL REPLACE THE CASH IN YOUR POCKET

KILLJOY
stop your kids playing endless computer games

HOW TO MAKE AN RS232 Breakout box

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Build a handy logic probe

BUILD A MIDI BASS PEDAL UNIT

Protect your valuables with a versatile loop alarm

P.C. CLINIC EXAMINES THE MOTHERBOARD

July 1994 £2.15

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ARGUS SPECIALIST asp PUBLICATIONS

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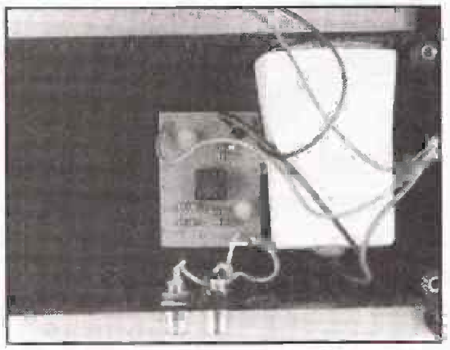
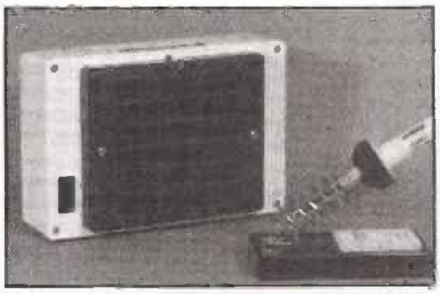
Volume 23 No.7

& Features Projects



Regulars



Competition 44

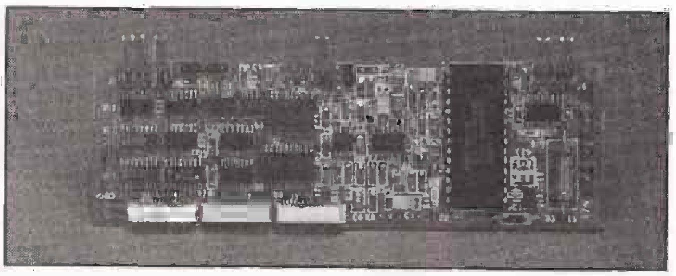
In this issue of ETI we have another great competition for readers to enter. Win a Fox alarm system to protect your home or business.

ETI News...

Save money with *ETI* and Number One Systems Price Breakers Card

On the front cover of this issue you should find a special discount card which can be used to obtain a 15% discount on Number One Systems' own range of popular, affordable and yet sophisticated computer aided electronic design and simulation software.
This card is valid only when purchasing full copies of Number One Systems OWN software products (for Educational Licences, the discount is valid for the first copy only - subsequent copies will be charged at Number One Systems standard Educational multi-user Licence rates).
This card has no cash value and cannot be used in conjunction with any other promotion.
To use the discount card, send it together with your order to Number One Systems before 15/7/94, the closing date for this offer.
For more details of the company's product range, see Number One Systems advert on page 5 of this issue, or contact Number One Systems on 0480 461778.

New voice recognition and synthesis module

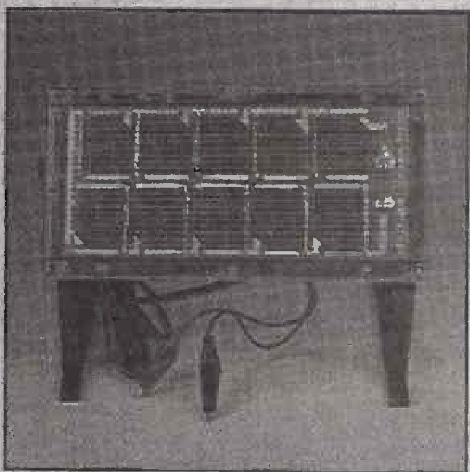


Colorado based Dovatron International has launched a miniature voice recognition and synthesis module which has been specifically designed for developers who require off the shelf PC compatible computing solutions in space and/or power constrained applications. Using the latest in surface mount technology and often populating both sides of the printed circuit board, Dovatron has miniaturised the products whilst retaining full PC functionality, particularly important if it is used with the miniature PC/AT products also produced by Dovatron.

The voice recognition and synthesis module was developed by Voice Connexion of Irvine CA and offers voice input and output by providing 500 word recognition per 64K of RAM, with better than 98% accuracy and unlimited text to speech synthesis. This system provides a natural means of operator/computer communications, reduces software training time by learning functions, not keystrokes. It also allows data entry on-site without keying in data and permits real time editing of entries. It provides an efficient hands free method of computer input and control.

For further information, contact Dovatron International of Longmont Colorado USA on 0101 303 772 5933.

Solar power in a rainy climate



A new range of waterproof and corrosion resistant solar panels for outdoor use has been launched by Maplin Electronics. The panels are weatherproof and resistant to wind, rain, humidity, snow, ice, sand, salt air and deterioration by ultra-violet light. As such they are ideal for use in a wide range of recreational activities, including boats, cars, tents and motor homes, and are capable of powering portable TVs, radios, tape players, etc.

The panels come in four sizes, ranging from a 3V 120mA panel at £9.95, to a 12V 120mA panel at £34.94. They are intended to be used as battery chargers and lead acid battery trickle chargers. A reverse blocking diode is built-in to prevent battery discharge and protect the panel cells. A tilt stand, made up from supplied parts, can be assembled and mounted on a vertical or horizontal surface, or be free standing, to catch the sun. Each panel is provided with red and black leads terminated in either insulated crocodile clips or car battery style clamps.

For further information contact Maplin Electronics of Rayleigh, Essex, on 0702 554161.

Remote data acquisition and control modules

IMS has announced a new range of intelligent sensor to computer interfaces, ideal for remote data acquisition and control. Supervised by a host computer over an RS232/485 network, the modules, with their own built in microprocessors, are able to monitor and control processes autonomously.

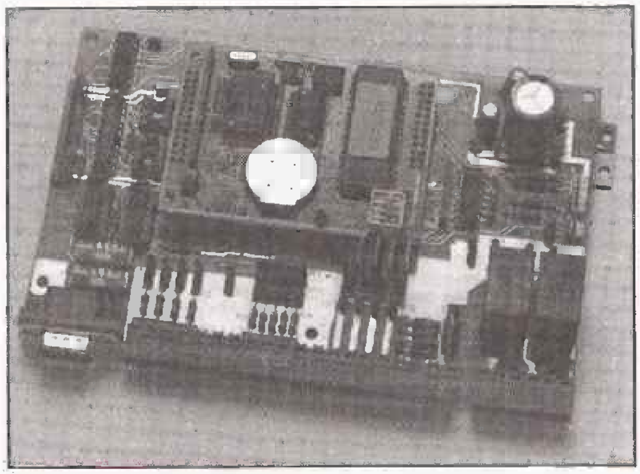
The ADAM range includes 14 analogue input types (including mV, mA, Volts, Thermocouple), analogue output, digital I/O, relay switching and RS-485 repeater, as well as an RS232/RS485 isolated converter module. These modules communicate with the host computer via a two wire RS485 multidrop network using an ASCII command/response protocol. Up to 256 modules may be networked together by using repeater modules, each supporting 16 modules up to 4,000ft apart.

All ADAM modules are fully configurable by software, are contained in hardened plastic shells and are easily assembled into systems. They are designed to accommodate unregulated power supplies of between +10 and +30V DC.

For further details contact Integrated Measurement Systems Ltd., on 0703 771143

Postcard sized low cost multi-tasking

The application potential of Cambridge based MicroRobotics' award winning multi-tasking embedded controller, the Scorpion K4, is widened considerably with the release of a new plug on I/O application module which provides a comprehensive range of analogue and digital I/O facilities, enough to provide a ready to use hardware environment for many typical machine control and automation projects. With the aid of the K4's built-in language, control systems can be developed quickly and easily.



The new I/O facilities on offer include two uncommitted relay outputs capable of switching 3A/240V, four digital 2A/240V outputs and four universal digital inputs. Analogue I/O comprises four 8-bit inputs and one 8-bit output with selectable voltage ranges. Also included are two channels of serial I/O, one of which can optionally be configured for RS485/422 levels, plus two general purpose expansion interfaces, a dedicated I2C serial port, and an 8 bit bus, suitable for LCD panel, keypad, etc.

This versatile controller board measures just 4.5 x 7in and is based on the Hitachi 63C03 processor, with on board EPROM holding the programming language. In one off quantity it costs £250. For further details contact MicroRobotics on 0223 323100.

76 piece tool set

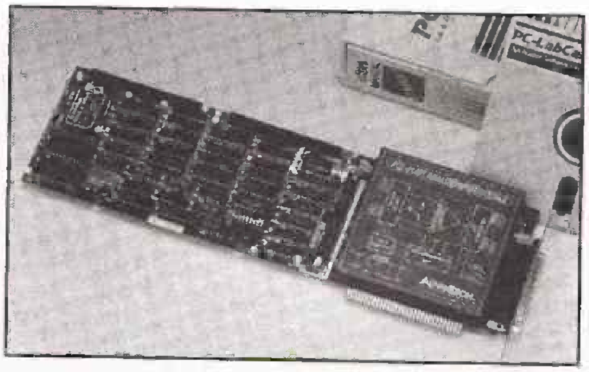
A new high quality 76 piece socket and wrench tool set is available from Maplin Electronics. It contains a comprehensive range of tools, making it ideal for the DIY motorist and for general maintenance and servicing of any mechanical equipment, whether in the field or in the workshop. This is the ideal kit for keeping in the car, since it is supplied in an extremely tough moulded plastic carrying case.

The tools are all manufactured in high quality chrome vanadium steel and bright chrome plating, the set contains eight combination spanners, five screwdrivers, one pair of universal pliers, one pair self-locking pliers, one crimping tool and a box of terminals, one hammer, six hexagonal keys in a holder, one thickness gauge, one low voltage tester and one battery terminal brush.

The set also includes a 1/2in. square drive socket set that contains 13 sockets, a ratchet handle, a sliding T-bar, two extension bars, a universal joint and a spark plug socket.

The complete kit in its case costs £38.95. For further information contact Maplin Electronics of Rayleigh Essex, on 0702 554161.

14 Bit modular data acquisition card



From Southampton based Integrated Measurement Systems Ltd. comes a new multi-function data acquisition card, the PCL814B. This card has been designed specifically for users who require a combination of high speed, high accuracy and high resolution in a PC environment.

The 814B's core high performance A/D module offers 16 channels of differential analogue signal measurement at 14-Bit resolution and 100kHz sampling rate. The card's specially designed analogue circuitry offers breakthrough noise rejection capabilities. Its modular design makes it easy to tailor to specific applications. In addition to its on-board 16 bit digital I/O, the card has two 64 pin piggy-back connectors which allow any combination of I/O modules to be added. These include a two channel 16 bit or 12 bit D/A module, a five channel 16 bit up/down counter timer module, or a 24 bit Intel 8255 digital I/O module.

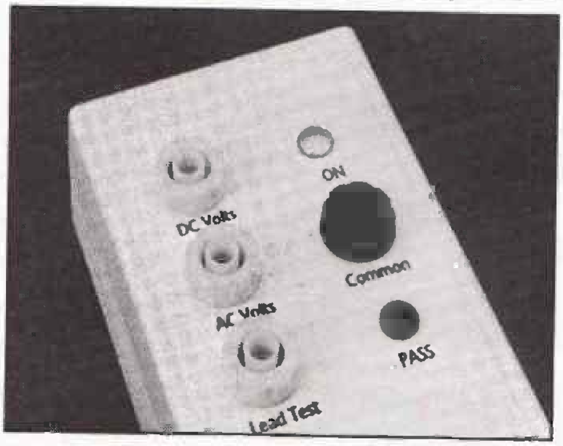
For further details, contact Integrated Measurement Systems Ltd on 0703 771143

Top range scope at an economy price

Maplin Electronics has just added a new 20MHz 2 channel Digital Storage Oscilloscope to its range of test equipment. This scope, the OS3020, is a dual trace unit with digital storage capability for 'freezing' and continuously displaying fast, complex or non repeatable frequencies. This is a useful function for digitising and observing high speed repetitive signals. In this method, one data item is sampled for every high speed sweep and the sampling point is shifted to the right with every sweep. Sampling is performed 1024 times, so that high frequencies can be digitised, even up to 20MHz.

The main features include a maximum two channel simultaneous sampling rate of 20ms/s, digitised 20MHz repetitive signal in equivalent modes, one-touch switching between real and storage modes, two save memories and pre-triggering, enabling observation of the waveform portions before the trigger point. There is direct copy of screen display using HPGL commands with RS232C interface, while roll mode provides continuous observation of slow waveforms. Averaging functions provide summation averaging of up to 256 times and the magnification function simplifies detailed waveform observation.

The OS3020 costs £749.95. For further information contact Maplin Electronics of Rayleigh, Essex, on 0702 554161.



Multimeter check

A new proving unit for checking the basic functions of both analogue and digital multimeters is now available from Manchester based Alpha Electronics. The battery powered hand held unit will verify the basic AC and DC voltage operation of any meter as well as providing a means of checking the continuity of test leads and integral fuses. The unit generates an output voltage of either 205 or 220V from both the AC and DC test sockets. The test voltage is indicated by an amber light while a green light shows the lead test to have been good or bad.

This useful low cost tool is priced at £49 and further details are available from Alpha Electronics Plc, on 0942 873434.

... ...*Event diary*... ... ...

6 June	D-Day Commemoration Display with working transmitters and receivers from the war. Wireless Museum, Puckpool Park, Seaview, near Ryde, Isle of Wight. Tel: 0983 567665.
7 June	Using Integrated Circuits. Sudbury and District Radio Amateurs. Tel: 0787 313212.
8 June	Junk Sale. Lincoln short Wave Radio Club, Lincoln. Tel: 0427 788356.
14-16 June	Multimedia 1994. Earls Court, London. Tel: 071 742 2828.
15 June	Walking Treasure Hunt. Lincoln Short Wave Radio Club, Lincoln. Tel: 0427 788356.
18 June	Electromagnetic Compatibility. Crystal Palace and District Radio Club, All Saints Parish Church Rooms, Beulah Hill. Tel: 081 699 5732.
19 June	Special Event Station at Great Cornard Middle School, Sudbury and District Radio Amateurs. Tel: 0787 313212.
27-29 June	5th Satellite Systems for Mobile Communications and Navigation Conference. IEEE London. Tel: 071 240 1871
20 June	Electrotech, NEC Birmingham. Tel: 0483 222888.
25 June	Special Event Station in Halstead, Sudbury and District Radio Amateurs. Tel: 0787 313212
13 Nov.	Midland Amateur Radio Society rally at Stockland Green Leisure Centre, Slade Road, Erdington, Birmingham. Doors open at 10am, admission £1. For further details ring 021 422 9787 or 021 443 1189 (evenings only).

Windows based real time data analysis

The new SciTech Hydra-Digis system is a Windows 3 based multi-processor, data acquisition and control system. It takes the user from graphical system description, through data capture, real time analysis and display to generating complete results documentation. Thus, the system could carry out a complex 1024 point FFT to floating point precision at a 5kHz real time rate (gap-free). This compares favourably with dedicated FFT analysers which typically provide a real time rate of only 2kHz.

The base hardware configuration consists of one Hydra PC card providing 16 analogue inputs, two analogue outputs, 16 digital inputs, 16 digital outputs, a trigger unit and a T805 25MHz Transputer. This configuration is controlled by Hydra-Digis software with post capture analysis and documentation by DIA-PC, the whole system running on a 486/ Pentium PC with Windows 3x.

The measurement and analysis process is designed graphically using a mouse to connect function blocks (icons), selected from a library. The library includes standard functions such as data capture, real time engineering unit conversions, PID control, time and frequency analysis functions, plus display options. Users can add their own functions written in C code.

The Hydra-Digis software generates the transputer object code automatically from the block diagram without compilation and downloads to the Hydra board, thereby freeing the PC for user interface functions. It is unnecessary for the user to write any code or have any knowledge of transputers.

For further information on this very sophisticated real time data acquisition and analysis, contact SciTech of Reading on 0734 758857.

Precision crimping tool

Crimping is a widely used method of connecting wires and cables to a whole range of different connectors, but the wide number of different types of crimp can cause a problem. To overcome this problem, Ideal Industries has introduced a new range of crimping tools.

The company has six ratchet crimp tools with a total of 45 interchangeable standard dies. The tools can be used with insulated terminal, non-insulated terminal, BNC/TNC coax, F-type connector and telephone plug applications. The tool's ratchet crimp action ensures a precise crimp time after time, to meet or exceed industry specifications. Interchangeable die sets are made from high grade carbon steel and have marked nests for easy and accurate selection. They can be changed quickly with any screwdriver

For further details contact Ideal Industries (UK) Ltd., of Warrington, on 0925 444446

Young Electronic Designer Awards 1994.

At the end of March, an award ceremony was held at the Science Museum in London to select from about fifty finalists three Young Electronic Designers of the Year, one from the under 15 age group, one from those between 15 and 17 and one from the group aged 18 to 25. Entrants for the award, which is sponsored by Texas Instruments and Mercury Communications, came from schools and colleges all over the country and the finalists had already gone through a rigorous selection process.

Entrants were judged on the quality and originality of a project submitted by them, and on how well it had been conceived and designed. Also under consideration was the research which had been conducted into the end user's requirements, the objects' ease of use. and the thought which had been given to manufacturing it easily and cheaply, as well as the flexibility of the design with respect to future enhancements.

The overall quality of the entries of all the finalists was outstanding (the editor of ETI would have given them all a prize). Over the next few months in ETI we will be introducing a few of the finalists, as well as the prize winners and describing their designs. We hope that this will encourage other young readers to follow their example and perhaps become a finalist or award winner in next year's Awards.

We will start by looking at a couple of the youngest entrants, Alys Paterson and Rebecca Salmen, from the King Edward VII School in Sheffield. In their own words, the following is a description of their project.

"We wanted a project that would be quite different to those which we had already done in our design technology lessons. We wanted to solve a real life need in a real life way and design something which would change the lives of those for whom we were designing, just like a professional designer. One of our ideas was to help other people less fortunate than ourselves and so we talked to parents and visited two schools for handicapped children in Sheffield.

Something which attracted our attention at Tapeton Mount School, Sheffield, was the way in which the children played board games, in particular snakes and ladders. As we watched the children play, the dice kept falling off the table and getting lost on the carpet. Obviously, this presented the handicapped children with a difficult problem and significantly interrupted their game!

On returning to school we brainstormed the problem and came up with many interesting ideas from which two solutions were adopted - a large illuminated dice and an illuminated spinning dice. We built a simple prototype of the spinning dice and returned to Tapton school many times over the following months to test and refine our design.

The design is quite simple, therefore robust and easy and cheap to make. It consists of reed switches mounted on a plastic platform and a rotating wooden arm that could easily be spun by a handicapped child, and which has a magnet attached to one end. As the arm is spun the magnet opens and closes the reed switches which in turn activates a display of high intensity LEDs. These LEDs were organised in six columns with between one and six LEDs in each column. When the arm comes to rest one of the six columns of LEDs remains lit and the number of LEDs corresponds to the number of dots on the dice.

We have built designed and manufactured both the electronics, the plastic case and the rotating arm. We are now further testing the design prior to supplying Tapton Mount school with their own number spinner."

Next month we will look at a physiotherapy aid designed and developed by 19 year old Samantha Haines, winner of the Mercury 'Planet' Award for the most socially or environmentally aware project.

POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

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ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

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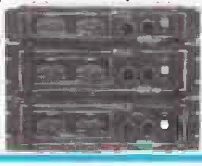
USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.



SIZES:- MXF200 W19"xH3½" (2U)xD11"
MXF400 W19"xH5¼" (3U)xD12"
MXF600 W19"xH5¼" (3U)xD13"
MXF900 W19"xH5¼" (3U)xD14¾"

PRICES:- MXF200 £175.00 MXF400 £233.85
MXF600 £329.00 MXF900 £449.15

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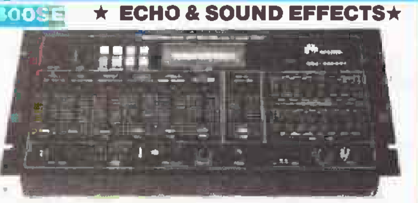
OMP XO3 STEREO 3-WAY ACTIVE CROSS-OVER

Advanced 3-Way Stereo Active Cross-Over, housed in a 19" x 1U case. Each channel has three level controls: bass, mid & top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 250/500/800Hz, Mid-Top 1.8/3/5KHz, all at 24dB per octave. Bass invert switches on each bass channel. Nominal 775mV input/output. Fully compatible with OMP rack amplifier and modules.

Price £117.44 + £5.00 P&P

STEREO DISCO MIXER SDJ3400SE ★ ECHO & SOUND EFFECTS★

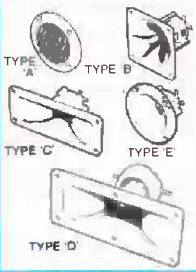
STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. **MANY OUTSTANDING FEATURES:- including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor. 8 Sound Effects. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.**



Price £144.99 + £5.00 P&P SIZE: 482 x 240 x 120mm

PIEZO ELECTRIC TWEETERS - MOTOROLA

Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved *transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required* these units can be added to existing speaker systems of up to 100 watts (more if two are put in series. **FREE EXPLANATORY LEAFLETS ARE SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN1036A) 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi speakers. **Price £4.90 + 50p P&P.**

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TYPE 'D' (KSN1025A) 2"x6" wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. **Price £9.99 + 50p P&P.**

TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. **Price £5.99 + 50p P&P.**

LEVEL CONTROL Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. **Price £4.10 + 50p P&P.**

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150 WATTS (75 + 75) Stereo, 150W Bridged Mono
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PRICES: 150W £49.99 250W £99.99
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These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

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OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P

OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P

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.
PRICE £81.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
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NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

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10" 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS97dB. PRICE £33.74 + £2.50 P&P
10" 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
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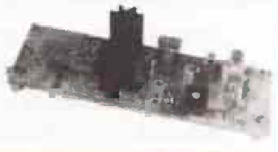

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TOMORROW'S TECHNOLOGY

Goodbye Money - *Hello Smartcard*

Developments in electronics look set to obsolesce the cash in your pocket and replace it with a microprocessor chip housed in a credit card sized piece of plastic. What we are witnessing is the beginning of the smartcard revolution.

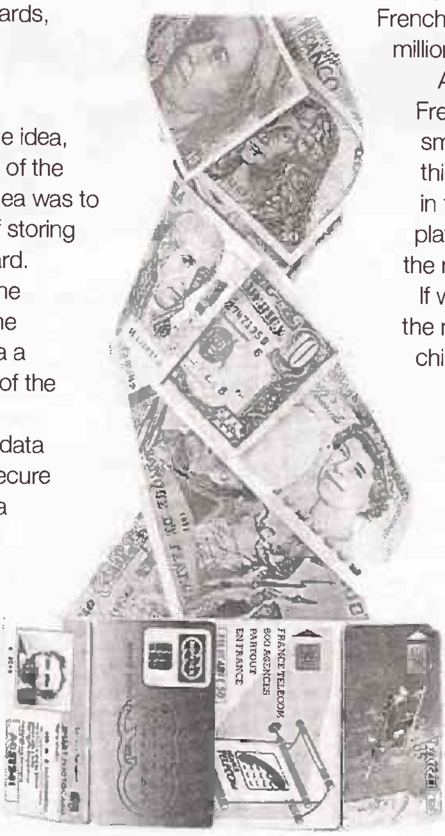
If you look up 'smartcard' in a dictionary, the odds are that, unless the dictionary is very recent and very comprehensive, you will not find it there, but by the end of this decade not only will everyone be talking about smartcards, everyone will be using them. So what is a smartcard?

The concept of the smartcard was first proposed in the mid 1970s. It was a simple idea, but one that was at that time a little ahead of the technology needed to implement it. The idea was to house a small integrated circuit capable of storing data inside a conventional plastic credit card. Data which would normally be stored on the magnetic stripe on the back of the card, the data on the smartcard being accessible via a number of electrical contacts on the back of the card.

The rationale behind this idea was that data stored in a memory chip would be more secure and less easily forged than that stored on a magnetic stripe, because the data could be encrypted in a way that would be extremely difficult for anyone to decode, and because the cards would require very high technology manufacturing equipment to produce.

The early manufacturers of smartcards saw them as being primarily used in applications such as access control and security. Rather limited and specialised applications. Theorists and commentators, on the other hand saw, them being potentially used as a sophisticated means of paying for goods and services, a view which was shared by some large companies around the world, in particular French Telecom. At that time, the late 1970s, they were looking for a technology to create the now ubiquitous phone card. A technology which would enable them to eliminate many of the problems associated with coin boxes, such as unreliability, the tendency to be vandalised and the need to be regularly emptied.

French Telecom was faced with two practical alternatives, the smartcard, or the much simpler holographic card that would later be adopted by British Telecom. The French took a bold forward looking move and decided to use the smartcard and the first real commercial application for smartcards was thus born.



The Decade of the Telephone Smartcard

Throughout the 1980s, the telephone smartcard was the main commercial use for the smartcard concept. All over France, telephone boxes were installed to take smartcards and today they comprise the majority of phone boxes. Similar developments have taken place in half a dozen other countries to which the French sold telecommunications equipment. Every year, millions of telephone smartcards are produced and sold.

As one would expect from a pioneering product, the French Telecom phone card is a very simple form of smartcard. To look at, it is the same size and thickness as an ordinary credit card, but on one side in the top left corner is a 1cm square patch of gold plated contacts, eight in all. These are used to connect the reader in the phone box to the chip on the card.

If we slice open one of these cards we will find that in the middle of the patch of contacts is a small silicon chip, about 1mm square. This chip is, in fact, just a very basic fuse link type read only memory. The reader will read the memory and determine how many charge units are left on the card and then blow a fuse link each time a charge unit is used.

To this extent the French card behaves, as far as the user is concerned, exactly like the holographic cards used by BT. However, the BT card can only be used as a phone card, but the France Telecom card can, by altering the electronics, be made to store a lot more information and be used for other applications.

Thus, when a BT card us used, it is simply thrown away (or one ends up with an annoying collection of cards with just one unit on them). The smart phone card, on the other hand, could be made rechargeable. Furthermore, by having a network of smartcard readers attached to the phone network, they were ready to take advantage of more sophisticated developments and applications for smartcards.

The Next Step

What the smartcard concept was waiting for was the development of low cost, very low power consumption, highly integrated silicon chips. With the availability of such chips it would be possible to store more than just simple data on the card, it would be possible to store intelligence. This meant placing a microprocessor chip on the actual card, a move that was essential if smartcards were to store more than a simple remaining charge value.

A microprocessor was needed to provide the security that was essential to protect any form of rechargeable card from fraudulent use. A simple electrically programmable and erasable memory on the chip would be far too easy for crooks to reprogram, and thereby

The London Transport Smartcard

In and around the London borough of Harrow, over 10,000 people are now carrying and using a bright yellow smartcard with a computer generated

image of themselves. They are all part of London Transport's first commercial trial of a smartcard ticketing system, so advanced that it is the first in the world and is attracting attention from transport system operators from as far away as Japan.

The Stored Value Ticketing project, or SVT, was born as the result of a feasibility study carried out in May 1992, which demonstrated that contactless smartcards could be used in all bus travel pass applications to give improved ticketing flexibility, better business information, faster boarding speeds and better revenue control. A later study carried out in conjunction with London Underground and British Rail has shown that the system can be extended to cover all forms of public transport.

The smartcard chosen by LT is manufactured by the British electronics and engineering giant GEC. It is a contactless card which incorporates a memory/processor chip and a loop aerial that is used to both collect power for use by the card and transfer data between the card and the card reader. The memory on the card includes an area which can be read or written to, allowing the validity of the pass to be quickly and accurately checked. The memory can also hold stored values to pay for journeys in the same way as a phone card.

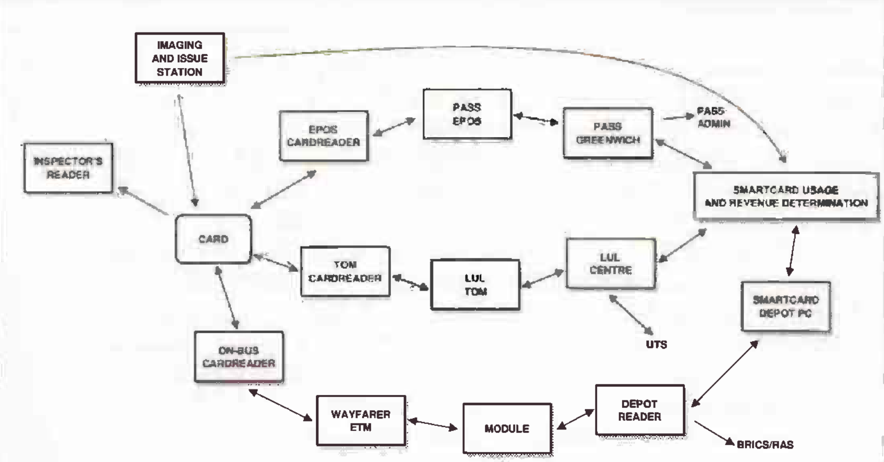
The passenger's card forms part of a complex network of computers and card terminals and this network is shown in Figure 1. In the trial system, which started on 3rd February 1994, over 200 buses on 19 different routes run by five different operators based at Harrow bus station, have been fitted with on-bus contactless smartcard readers. Local London Transport

PASS newsagents, and in the near future underground stations, have also been fitted with electronic point of sale, or EPOS, terminals which can be used to reencode smart travel cards, with the details of any new period, permit, or travel card (plus in a few months, the stored value Farecard). In addition, an office in Harrow bus station has been set up to issue new cards, each one bearing a computer generated portrait of the card holder.

On each bus, the smartcard reader will automatically detect whether a particular card is valid and give the appropriate audio and visual acknowledgement or warning. The reader is linked to the standard Wayfarer ETM (Electronic Ticketing Machine) which stores data from the card reader for later retrieval at the depot. This data is stored on a PC at the depot which is linked via a network to a main controlling system. The EPOS card readers in the PASS agents is also linked directly to the main controlling computer, as is the imaging and issue station terminal in Harrow bus station.

When the system is extended to London Underground, the card readers will be incorporated into the standard ticket barriers with direct linkage to London Underground's computer system.

As can be seen, all the systems are linked, in most cases directly via a network, to the central controlling computer. This will enable traffic usage and revenue generation to be very closely monitored. The result should be a more profitable system and a better service for the passenger.



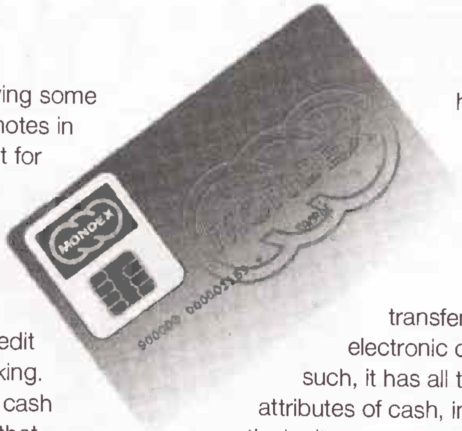
Flow diagram for London Transport Smartcard Ticket System

essentially 'print money'. It is necessary for the data to be stored in encrypted form, for access to be password protected and indeed for a host of special hardware and software security systems to be built into each card.

The Smartcard Today

The smartcards being developed today have in-built processors, memory and even ultra thin batteries. They no longer need to rely on direct contact with the reader as some now incorporate ultra-miniature radio receivers and transmitters which permit the cards to be used in close proximity to a reader but without actually touching it. Coupled with the availability of the electronics systems is the development of manufacturing techniques, such as surface mount devices, which make it possible to automatically construct

The National Westminster Mondex Cashcard



Most people, I suspect, like having some cash in their pocket and a few notes in their purse or wallet. You need it for all the little expenses in life, buying a newspaper or a bus ticket, paying the window cleaner, or a taxi driver, giving your children pocket money. All instances where a cheque or credit card is useless and cash is still king. However, much as we may find cash useful, it is probably true to say that most big businesses, including most banks, do not like cash. They do not like having to count notes and coins, they do not like the security problems associated with cash and nor do they like the fact that physical cash does not generate any interest (it is estimated to cost £2 billion in lost interest in the UK alone).

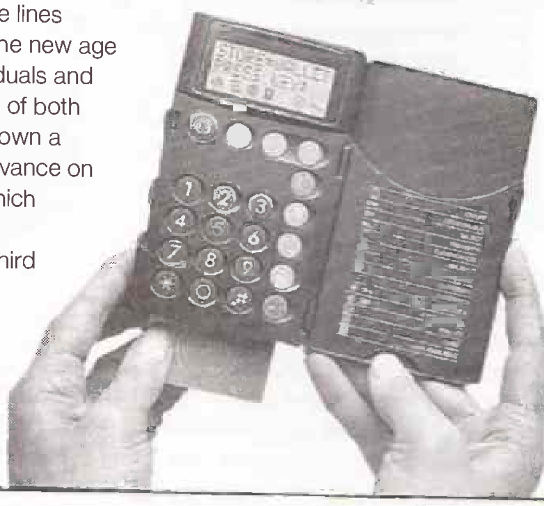
This dislike of cash has prompted banks and big businesses to look for ways to eliminate any need for it and in this quest they have turned to smartcard technology to create what they like to call the 'electronic purse'.

Although some trials of electronic purse systems have been held in Denmark and Portugal, the leading contender in the world today is a system called Mondex, that has been developed in the UK by a partnership of the National Westminster and Midland Banks. The system is said to be at least 18 months ahead of any other comparable project and goes on large scale commercial trials in the Swindon area early next year, with 1,000 retailers and over 40,000 users. So what exactly is the Mondex system?

Mondex uses an intelligent smartcard to provide a secure and simple way of holding and transferring electronic cash. As such, it has all the attributes of cash, in particular its anonymity and the ability for one individual to transfer money to another without having to go via a third party. But unlike physical money, it can be sent down a phone line and is virtually theft free, thereby making it easy for the individual to withdraw cash as it is needed and allowing shopkeepers to easily and safely bank their takings.

The fact that Mondex uses electronic cash rather than physical cash means that it is the ideal payment mechanism for the suppliers and consumers of the new electronic information and entertainment services being supplied directly into peoples homes, over the new optical fibre based phone lines network. This means that in the new age of the 'digital highway', individuals and businesses will have a means of both sending and receiving cash down a phone line, a considerable advance on the credit and charge card which can only transfer cash in one direction and then only via a third party.

The main difference between Mondex and other cards is the fact that it is unaccounted, in other words there is no need to link each transaction back to a specific bank account where checks are made to see if funds are available. Like physical cash, the money is either in the Mondex 'electronic purse' or it is not, therefore there is no need for the retailer to make authorisation checks or request signatures and thus no delay in receiving value. With Mondex, all that matters is that there is sufficient value stored in the card being presented to pay for the transaction, a factor which Mondex's designers have taken advantage of since this is a multicurrency system. It will be capable of handling over 100 different currencies, of which five can be held on the card at any one time. A degree of flexibility which has generated considerable interest in the EEC, in applications such as a payment device for Europe's motorway tolls (the French are already testing a contactless smartcard system attached to the vehicle for paying motorway tolls and in the UK a similar system is proposed for both motorway tolls and charging motorists to enter big cities such as London).



such cards in vast numbers and at very low cost.

In addition to the development of advanced cards, we have also seen the development of a wide range of smartcard readers. These range from remote wireless systems, to portable pocket sized terminals and terminals which can be built into any domestic phone.

The fact that the technology to create and manufacture sophisticated smartcards and reader systems has become available over the last couple of years has led to a renewed interest in smartcard technology and a new range of commercial applications. It is a resurgence which has seen British companies moving to the fore and taking a world leading position.

New applications include the world's first smartcard ticketing system launched by London Transport earlier this year and now undergoing a two year public trial in the North London area. The system has potentially enormous advantages for both the traveller and for London Transport. It will eventually enable the traveller to buy tickets in advance, at a discount rate, from any station or news agent (they are all equipped with special terminals to place the appropriate data on the customer's smartcard) and use them to travel on any transport system with discounted units in much the same way as a phone card.

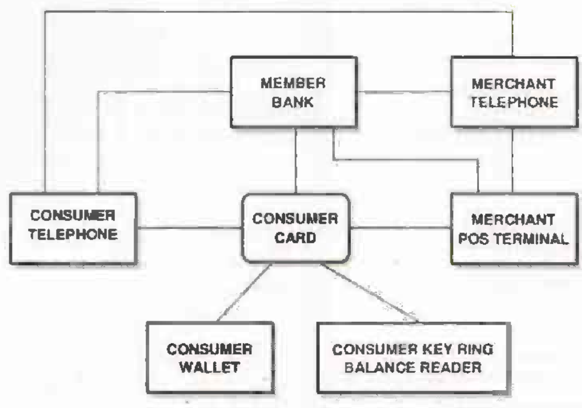
To get value into their cards a Mondex user will be able to charge up their cards using a range of different methods. They will be able to withdraw money from their bank accounts using special automated telling machines (ATMs) at their bank, or they can use a new generation of public phone which has been developed by British Telecom.

In the UK, this could increase the number of cash withdrawal points from the high street 15,000 ATMs to some 75,000 public phone boxes, plus semi-public phones in restaurants, bars, shops, etc. The fact that any ordinary phone, even a cell phone, will eventually be capable of being fitted with a Mondex reader that will turn it into an ATM, will eliminate all the security problems associated with handling large amounts of cash.

Another way for Mondex users to charge up their cards will be to transfer it from one individual to another. To do this a phone or an ATM is not needed, since the Mondex card comes with a special wallet into which their Mondex card fits. This wallet is more than just a holder for the card, it has a keypad and a display, looking a little like a pocket calculator. The display will show you how much money is in the card and will also give you full information about the last ten transactions for which the card was used.

To give money to another Mondex user, simply enter your four digit PIN number into the wallet keypad and use the appropriate keys to withdraw the required amount. This is held temporarily in the wallet processor's memory and can be transferred to another Mondex card simply by inserting that card into the wallet and performing a transfer. Besides being of use to the individual, the wallet offers what is in effect a basic terminal for small businesses and the self employed (I do have reservations about the time taken to transfer money using the wallet, if you buy a paper from a street corner news vendor, you simply give him the appropriate coins and take the paper, using a wallet will slow down the number of papers he can sell in a given time - Ed).

Thus the key elements in the Mondex system are the actual Mondex smartcard itself, the electronic wallet, the Mondex compatible phone and the Mondex compatible retailers till. All these components have now been developed and tested ready for next year's large scale launch in Swindon.



Data flow for Mondex Smart Cashcard

The actual Mondex cards are the same size and thickness as a conventional credit card, with a block of eight goldplated contacts in the upper left corner of the card. They decided on a card with contacts because it gives the user a better feel of control, in other words you have to have physical access to the card to do anything with it.

The cards and the wallets contain an 8 bit microprocessor chip and associated memory. Because the card will be used to hold and transfer cash, an enormous amount of work has gone into the card's security. The security system is in fact encoded into the chip on the card which means that the card can be used to transfer cash over standard unsecured networks, such as public phones and mobile phone networks.

The Mondex security system is extremely sophisticated and virtually impossible to crack. Every time a Mondex card is used, it generates a unique digital signature which can be recognised by other Mondex devices and it is this signature which ensures that the cards involved are genuine Mondex cards and that they are dealing with untampered Mondex signals.

The trick to the security programming used on the card is that whereas the 'key' to verifying the signature is open, the key to creating the signature remains secret and has been designed to be too complex for organised crime to crack on an economic basis. In addition the key will be frequently changed thus leaving fraudsters and hackers with a fast moving target that will make their work redundant, allowing Mondex to stay ahead of increasingly sophisticated criminals.

The cards are being made by Dai Nippon Printing Co. Ltd., and contain a chip manufactured by Hitachi, which is based upon its H8-310 microcontrollers. A similar chip is used in the wallet systems which are being manufactured by Panasonic and Texas Instruments. Special bank ATMs are being produced by AT&T Global Information Solutions and the phone terminals by BT, retailer terminals are coming from De La Rue Fortronic.

It will also enable the operator to be more flexible in his pricing structure, encouraging people to use buses and trains at the slackest time, or within more tightly specified areas. It will enable the operators to monitor with great precision the patterns of transport usage so that they can be more accurately tailored to users needs and to enhance the profitability of the operator. They will also allow different routes to be operated by different companies, with payment being electronically transferred from the main ticket vendor to the individual operators.

British companies are also leading the way in an even more important application for smartcard technology, one which prompted the main title of this article. This is the Mondex Global Electronic Cash project, which has been masterminded by the National Westminster and Midland Banks, together with a range of UK, Japanese and US electronics companies and British Telecom. It will be going into public service in the UK in 1995 and will be the world's first electronic cash payment that is intended to replace physical cash. The developers hope it will become a world standard.

Mondex is an extremely complex project and represents perhaps the ultimate in electronic financial systems. It will allow

continued on p55

Inside a Smartcard

Many smartcard manufacturers are naturally reluctant to give any real details about what is inside their cards and how they work. One company that will give information is Mitsubishi, with its contactless IC card.

The Mitsubishi smartcard is an advanced contactless card which can be read or written to from as far away as 80cm, thus being primarily intended for use in security, access control systems, cashless vending, product tagging in automated manufacturing and warehouse systems and in ticketing/toll systems. As can be seen from Figure 1, it is the same size as a conventional credit card and about twice as thick.

The smartcard electronics are sandwiched between two layers of plastic and a block diagram of these contents can be seen in

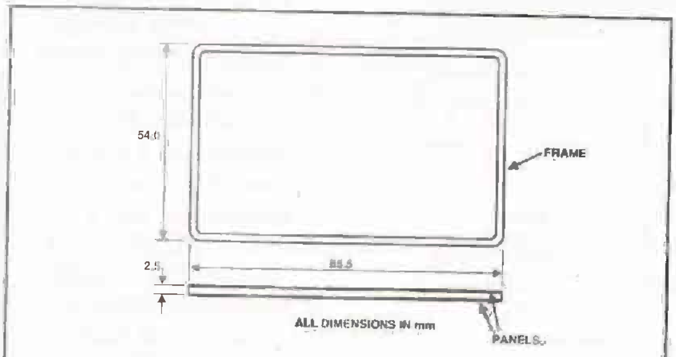


Figure 1: Mitsubishi smartboard dimensions

Figure 2. Note that the card electronics include an 8 bit microprocessor, RAM and ROM memory, a clock oscillator, I/O circuitry and a modulation/demodulation circuit with associated transmitter/receiver aerial, plus an ultra thin battery that will provide enough power for the card to be used more than 200,000 times. This is a very impressive amount of electronics packed into a very small area, most of it integrated onto a single chip which is mounted on an ultra thin circuit board with the aerial loop etched onto it.

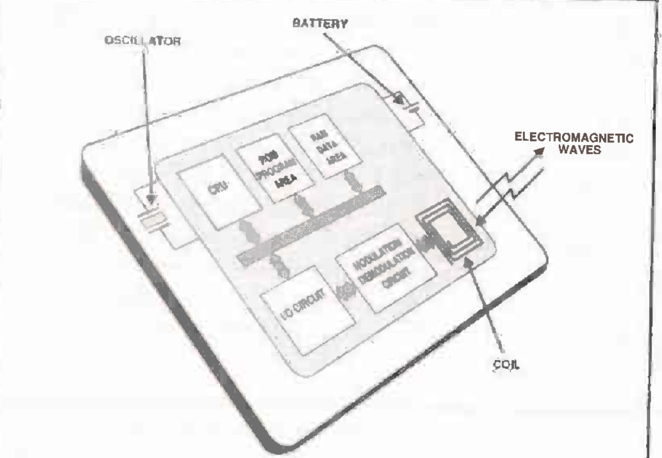


Figure 2: Inside the Mitsubishi smartcard

This card has been designed to operate as part of a system comprising a read/write device, attached to a computer network for data I/O read and write operations, as shown in Figure 3. In operation, the card is presented near to the reader/writer head, which automatically transmits data at up to 25.6Kbps, sufficient to allow a typical operation to take place in less than 0.2 seconds.

The data is transferred between the card and the terminal

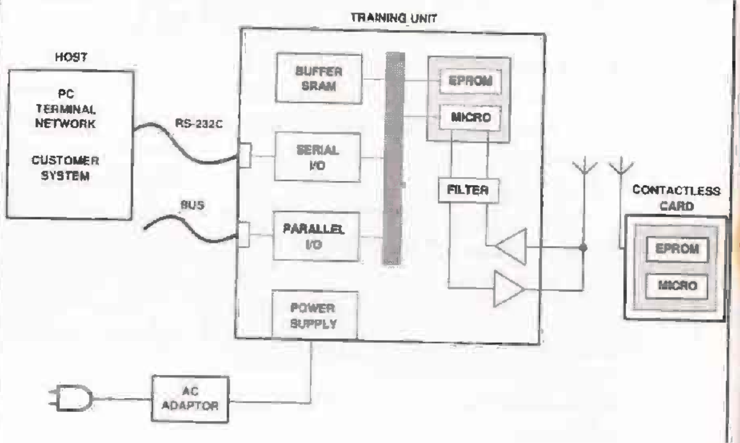


Figure 3: A contactless smartcard control system

using a strict communications protocol, which is shown in Figure 4. The data is transferred using a radion link that is based on

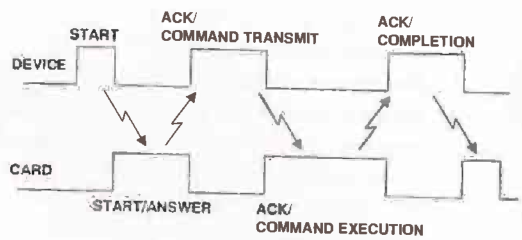


Figure 4: Contactless card communications protocol

Amplitude Shift Key, or ASK, modulation, as shown in Figure 5. The frequency can be customised for different applications and the actual data is transferred in packets, using the command and response format shown in Figure 6.

For readers who are interested in developing their own applications based upon smartcards, Mitsubishi can provide a contactless card development kit. This costs £799 and consists of three contactless cards, a card transceiver which can be connected directly to a PC and appropriate PC software and documentation. For more details contact Mitsubishi Electric UK Ltd., of Hatfield, on 0707 278652.

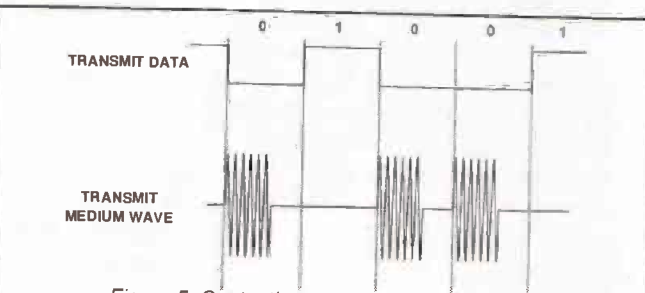


Figure 5: Contactless card signal modulation

DUMMY "00"	STC	NAD	LEN	COMMAND/RESPONSE	BCC
1	1	1	1	n	1

STC: START CODE
NAD: NODE ADDRESS
LEN: LENGTH OF COMMAND/RESPONSE
COMMAND/RESPONSE: BLOCK OF COMMAND/RESPONSE
BCC: BLOCK CHECK CODE

Figure 6: Contactless card command and response format

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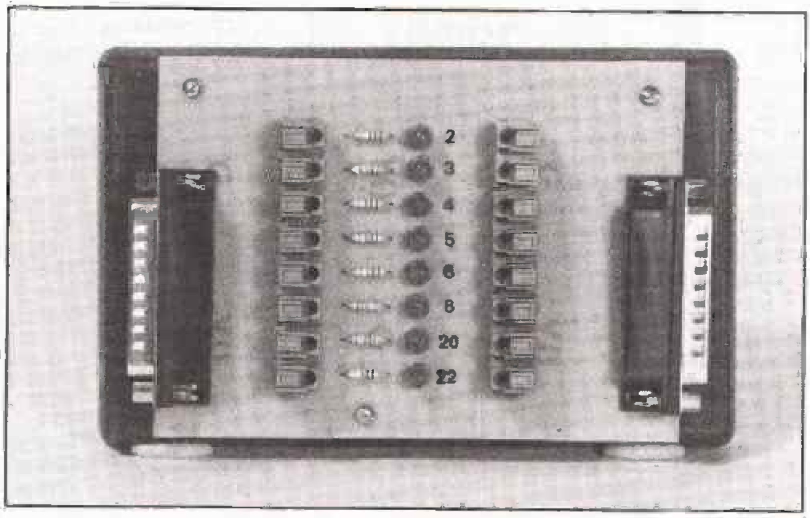
Breakout Box

PROJECT

Computer owners will find this design from Robert Penfold an indispensable tool when trying to solve those all too common compatibility problems associated with serial data communications



The world of computing is well known for its so-called standards that in reality are 'near misses'. Some computer ports conform properly to the electrical standards, but use some non-standard form of connector. Others use the right type of connector, but not necessarily with the right set of pin functions. Some do not seem to fully conform to any known standard, but are usable if you persist long enough with the interconnections, trying all the possible permutations!

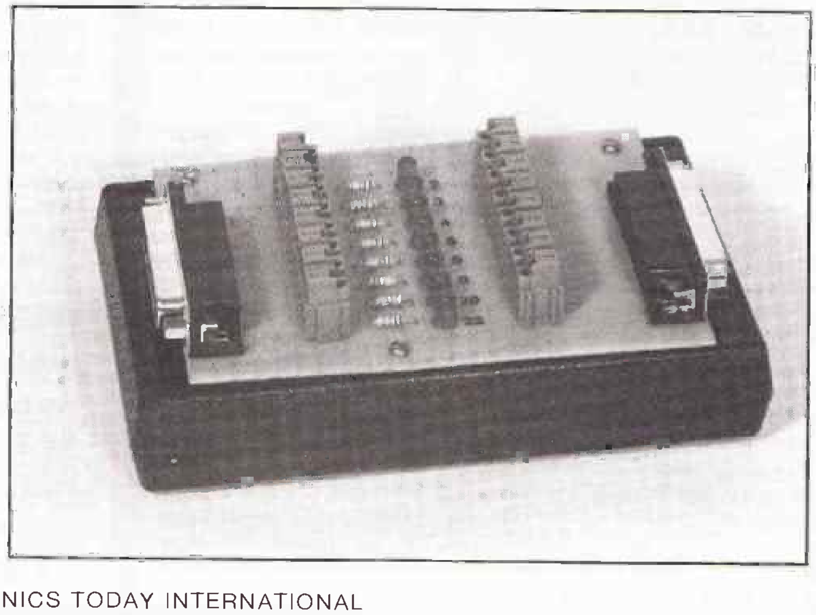
Parallel printer ports have not been without their idiosyncrasies over the years, but RS232C (V24) serial ports are probably the more contentious of these two popular forms of computer interface. In theory, it should be quite simple to interconnect two devices via an RS232C style serial interface, but 'real world' ports can be quite troublesome. Matters are complicated by the fact that this type of port exists in two different forms and variations in the handshake lines further confuse the situation.

An RS232C breakout box is a device which makes it relatively quick and easy to find the right set of interconnections. It consists basically of two connectors, one of which connects to the computer while the other is coupled to the peripheral device (printer, modem, etc.). The two connectors are wired together via switches which permit various connection methods to be used, or by way of jumper leads which permit practically any desired method of connection to be achieved. The unit featured here uses the jumper lead method and the use of spring-loaded terminal blocks enables it to be quickly and easily reconfigured. It incorporates a number of LED indicators which show the logic levels present on the main input/output lines. These are particularly useful when trying to establish which lines are inputs and which are outputs, as well as when trying to set up the correct handshaking protocol.

RS232C Basics

The standard connector for RS232C ports is the 25 way D type, but many serial computer ports use a different connector and a somewhat cut-down version of the RS232C interface. This is of largely academic importance, since the serial cables for these computers have a standard 25 way D connector at the end which connects to the peripheral. As we shall see, in a computing context the missing lines are of no importance. Figure 1 shows the connections for a standard 25 way serial port and for the typical cut-down computer version used on the IBM PC AT and compatibles.

Some of the pins on the standard 25 pin serial port are unused. Others are secondary lines which act as back-ups to the main lines, or have functions that are only appropriate to synchronous serial communications. In a computer context,



RS232C ports are only used for asynchronous communications where the data is transmitted at one of several standard baud rates. The synchronisation signals are sent on the same lines as the data, with no clock or other synchronisation signals being sent on separate lines. It is for this reason that cut down ports such as the PC AT type are perfectly acceptable. The missing sixteen pins serve no useful purpose in a computer interfacing context. In most cases some of the nine pins that are present are left unused.

For a basic two-way serial link, only three lines are required. One of these is simply the connection between the signal grounds of the two units, while the other two interconnections cross-couple the transmit and receive pins of the two units.

These are pins 2 and 3 respectively. Of course, one of these cross-couplings is omitted if communications in only one direction is required. A serial link can therefore be as basic as a simple two-wire link, but in practice it is often necessary to implement something more than a simple two or three wire link. The main problem with a basic serial link of this type is that it does not permit hardware handshaking. In some cases the receiving device will be able to keep up with a steady flow of data, but many peripherals can not do so. For example, printers and plotters are relatively slow devices, which may not be able to cope with more than a few bytes per second. Handshaking enables the receiving device to control the flow of data so that it does not become overloaded.

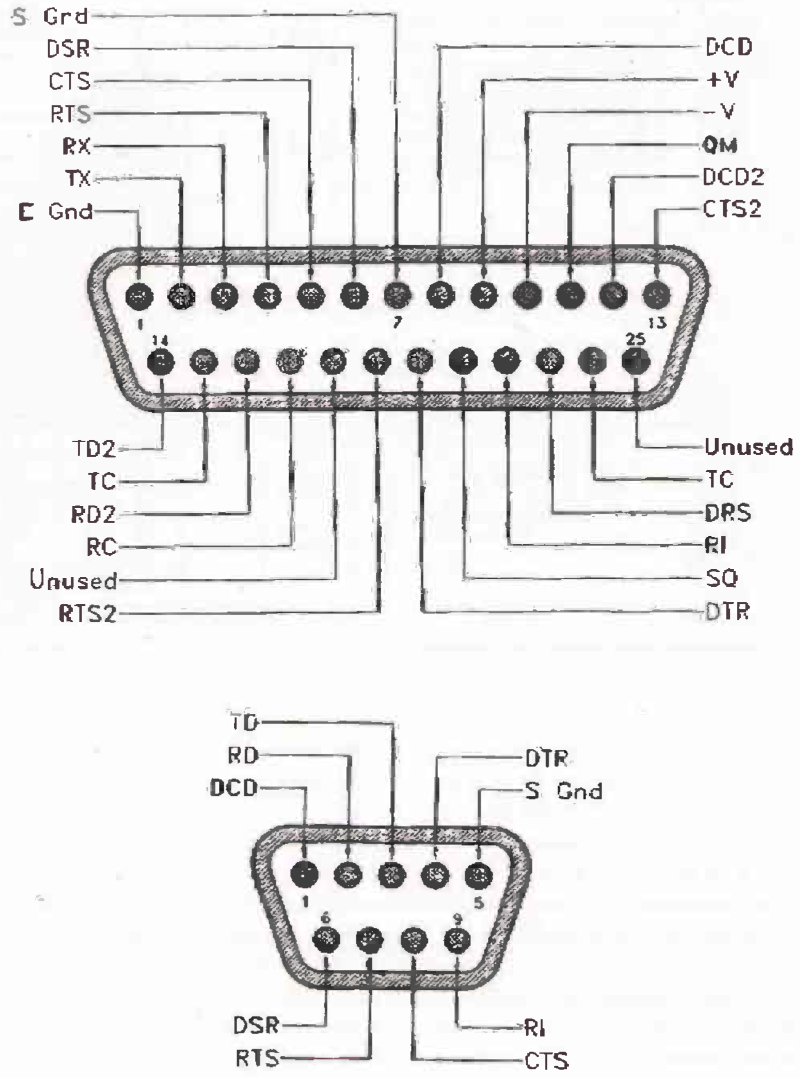


Fig 1. The standard RS232 port (above) and the PC AT version below

Handshaking can be achieved purely in software. The peripheral device sends a special code to the main unit to halt the flow of data, and another code to start the flow once again. These codes are sent down the same wires that are used to carry data and this is known as software handshaking, or 'XON - XOFF' handshaking.

Although described as software handshaking, there is actually a hardware element in this system as it requires three connecting wires, even if communication is only in one direction. This is a point which should be borne in mind when wiring up a system that uses XON - XOFF handshaking. Hardware handshaking requires an extra line to carry the on/off signal. For two way communications, two handshake lines are required, with separate lines being used to control the flow of data in each direction. Hardware handshaking works on the basis of the receiving device producing a positive voltage to permit the data to flow, or a negative voltage to halt it.

This method is clearly incompatible with software handshaking, so it is not acceptable to have one unit set for software handshaking and the other set to use the hardware variety. There are several handshake inputs and outputs on an RS232C serial port and it is largely this factor which complicates the interconnection of two serial ports. If there is such a thing as the standard method of RS232C handshaking, the way in which it is meant to function is far from clear.

The handshaking can be controlled by the RTS (request to send) and CTS (clear to send) lines. The RTS pin is an output on the receiving device and it is set high by the receiving device when it is ready to receive data. It is set low in order to halt the flow of data. RTS is coupled to the CTS input on the sending device, which should obviously send data only when CTS is taken high. In practice, CTS is simply set high all the time on many devices, particularly printers and in most cases it seems to be DSR (data set ready) and DTR (data terminal ready) that actually control the flow of data.

DTR is an output on receiving devices and it is set high when the device is ready to receive data. DTR is connected to DSR on the sending device and the latter will only send data when DSR is taken high. The RI (ring indicator) and DCD (data carrier detect) are used with modems. They respectively indicate that the modem has detected a ringing signal and that it has detected a carrier signal. They are not normally used in general serial interfacing, although DCD does sometimes seem to be used as a sort of off-line/on-line indicator.

Two Of A Kind

There are two basic categories of RS232C equipment. These are data terminal equipment (DTE) and data circuit-terminating

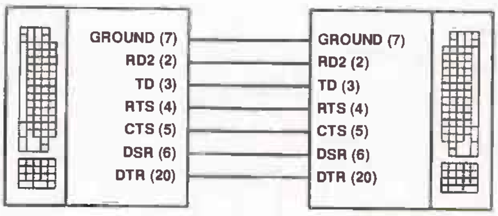


Figure 2: DCE and DTE devices are connected using a straight cable.

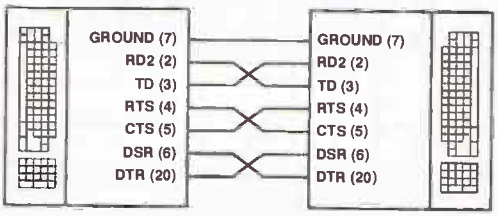


Figure 3: Most serial interfacing requires a null modem cable.

equipment (DCE). The latter is also known as data communications equipment. In general, DTE units are computers or some other major item of equipment at the heart of the system. DCE units are peripheral devices, such as printers, or plotters.

It is usually possible to tell which category a particular device falls into by looking at the 25 way D connector. If it is a plug, the unit is probably a DTE device - if it has a socket it is probably a DCE device. This is not a completely reliable method though, and many printers have a 25 way D socket but are actually examples DTE equipment. The difference between these two types of equipment is simply that DTE devices transmit data on pin 2 (TX), and receives it on pin 3 (RX). In other words, DTE equipment has a normal serial interface. DCE devices transmit data on pin 3 and receive it on pin 2. They have handshake lines which operate in the same topsy-turvy fashion, with inputs that are actually outputs, and vice-versa. The point of all this is that it enables a 'straight' lead to be used to connect a DTE unit to a DCE device. In other words, each pin on one connector is coupled to exactly the same pin on the other connector. Figure 2 shows this method of connection.

This is the method of connection normally used with modems, but this seems to be its only common computing application. Of course, this 'straight' method of connection is of no use when trying to interface one DTE unit to another. It would result in inputs being connected to inputs and outputs being coupled to outputs. RS232C outputs have current limiting, so this should not result in any damage to the equipment, but it will certainly not result in a data exchange either. When connecting one DTE unit to another DTE device (or when interfacing two DCE units) a so-called 'null-modem' cable is required. This has the data and handshake lines cross-coupled, as shown in Figure 3. It is a cable of this type that is normally required when connecting two computers together, or when connecting a computer to a printer or plotter.

The Circuit

The circuit diagram for the RS232C breakout box appears in Figure 4. SK1 and SK4 are the 25 way D connectors at the

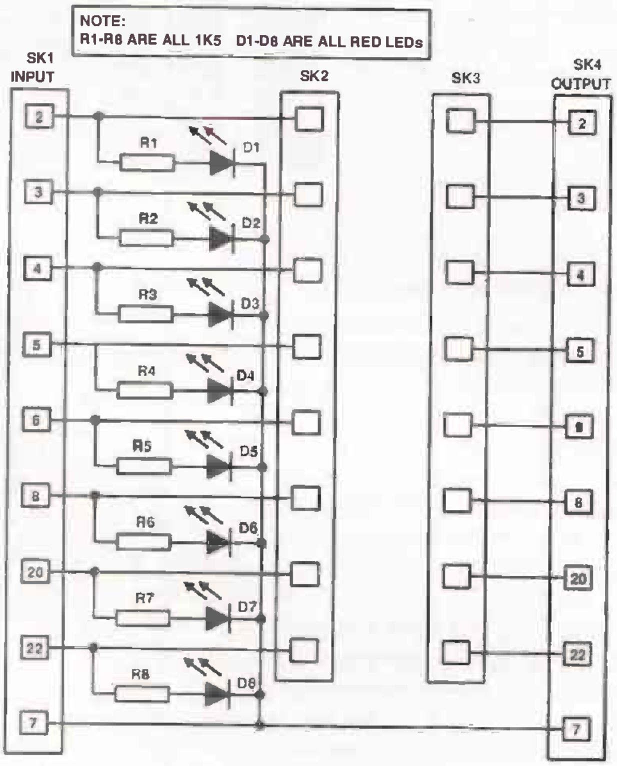


Figure 4: The RS232C breakout box circuit diagram.

notional input and output of the unit. In practice it is probably best to connect SK1 to the computer and SK4 to the peripheral device, but the unit can be used either way round. SK3 and SK4 are the spring-loaded terminal blocks rather than true sockets. These connect to the eight lines of the serial ports that are most likely to be implemented. The signal ground pins (the two pin 7s) are permanently wired together as these must always be interconnected, regardless of what other interconnections are used.

Eight LEDs on the input side of the unit indicate the state of each input/output line of SK1. Of course, once the interconnections are in place, these LEDs also indicate the states of the relevant pins of SK4. RS232C ports do not operate at normal 5V logic levels, but instead use voltages of approximately plus and minus 12V. The 1k5 current limiting resistors therefore set the LED current at about 6ma or so. This is high enough to give good LED brightness, but low enough to ensure that the LEDs do not excessively load the port outputs.

When connected with the polarity shown in Figure 4, a LED will switch on when the line driving it goes to +12V (the active state). When the line goes negative the LED will probably avalanche like a Zener diode, but the current limiting resistor will prevent it from being damaged. The resultant reverse current flow will not cause the LED to light up. If you would prefer the LEDs to switch on when the lines driving them are negative, simply connect them with the opposite polarity. Construction Units of this type can be hard wired, but construction is easier and more straightforward if the unit is based on a printed circuit board. Figure 5 shows the component overlay for this design. Note that SK1 and SK4 must be 25 way D plugs and not sockets. Sockets will fit onto the board properly, but the pin numbering for a socket is a 'mirror-image' of that for a plug. This would result in the terminal blocks to a large extent connecting to the wrong pins or the input and output connectors.

Two eight way terminal blocks are required. The correct spring-loaded terminal blocks are only sold as 2 way and 3 way blocks. The cheapest way to make up each eight way block is to use two 3 way blocks and one 2 way type, but four 2 way blocks will work just as well. The blocks interlock and it is easier if they are fitted together first, then fitted onto the board. The board does not provide a connection between pin 1 on SK1 and pin 1 on SK4 (the frame grounds or chassis connections). This connection can be hard wired if desired, but it is not really of any great consequence. It is probably not worthwhile fitting the unit into a case, but it is a good idea to mount it on a plastic box or a baseboard of some kind. Apart from giving a neater appearance, this will add strength to the unit and prevent the connections on the underside of the board from scratching practically any surface on which the unit is placed.

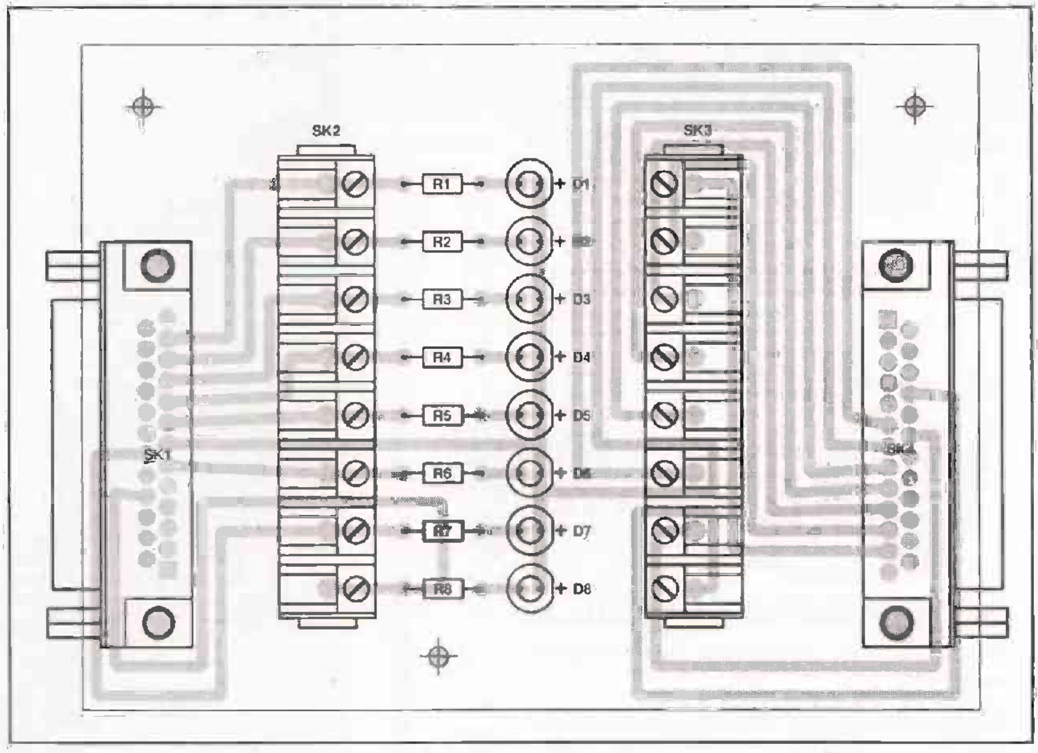


Figure 5: The component layout for the RS232C breakout box.

The terminals in the blocks and LEDs are arranged in the logical order. Working from top to bottom, they connect to pins 2, 3, 4, 5, 6, 8, 20, and 22. It is not essential to mark pin numbers onto the board, but mistakes are less likely to occur if the terminals and (or) LEDs are clearly labelled.

In Use

The best wire for making the connections between the terminal blocks is a fairly stout single core insulated type. If multi-strand wire is used, solder the ends of the leads so that the strands of wire are held together. The leads only need to be about 100 mm long and should have about 10mm of insulation removed from each end. Using the breakout box is likely to be easier if leads of several different colours are used. Different coloured leads should reduce the risk of wiring errors and make it easier to spot any that should occur.

It is quite easy to make the connections to the terminal blocks, but unless you have small fingers it will be easier to operate the spring-loaded levers using a small screwdriver. Make sure that the ends of the leads are fully pushed down into the holes in the blocks so that reliable connections are made. With the breakout box connected to the computer and the peripheral, it is quite likely that all the LEDs will remain switched off (i.e. all the outputs connecting to SK1 will be in an inactive state). It seems to be quite normal for serial ports to be totally inactive until some data is sent to them.

If the system is set to use software handshaking, it should only be necessary to get pins 2 and 3 coupled correctly. There may be some initial activity on some of the handshake lines, but the receiving device should simply ignore the handshake lines and respond to the XON and XOFF codes. In some cases, no handshaking will be used at all, but this is usually only possible when the software takes control of the computer's serial port. Software which provides high speed computer to computer links is often of this type. However, normal serial communications under the control of the operating system usually requires some form of handshaking, even if the peripheral device will never actually provide a hold-off. This can be problematic if the peripheral device does not provide handshake outputs.

A solution which is normally effective is to use the computer's own handshake outputs to switch on its handshake inputs. In other words, link pins 3 and 4, and pins 6 and 20 of SK1. When hardware handshaking is to be utilised, and the peripheral device does have handshake outputs, it is a matter of first trying the standard methods of interconnection that were discussed previously. If these do not work it is possible that one of the handshake lines on a peripheral device is not implemented, or is failing to go to the active state for some reason. In either case a lack of response from the appropriate LED should indicate that one of the handshake lines is not present and correct. Satisfactory operation is usually obtained if both pin 4 (RTS) and pin 20 (DTR) are driven from the single handshake output of the peripheral that is responding properly.

If you are unsure if a port is a DTE or a DCE type, couple it to SK1 using an ordinary null-modem cable. It is possible that none of the LEDs will switch on initially, but some should light up if data is sent to the port. If the LEDs for pins 5 and 6 switch on, the port is a DTE type. If the LEDs for pins 4 and (or) pin 20 switch on, the port is a DCE type.

PARTS LIST

R1 to R8 1k5	0.25 watt 5% carbon film (8 off)
	D1 to D8 5mm red LEDs (8 off)
SK1, SK4	25 way D plugs, right angle printed circuit mounting type (2 off)
SK3, SK4	Printed circuit mounting spring-loaded terminal blocks, 3 way (4 off) and 2 way (2 off)

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2N3820	£0.66
2N3904	£0.10
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2N4036	£0.31
2N5296	£0.57
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2N6107	£0.60
AC125	£0.30
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AC128	£0.28
AC187	£0.46
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AD149	£1.67
AD161	£0.92
AD162	£0.92
BC107	£0.14
BC107B	£0.15
BC108	£0.13
BC108A	£0.14
BC108C	£0.16
BC109	£0.17
BC109C	£0.17
BC114	£0.41
BC115	£0.41
BC116	£0.41
BC118	£0.41
BC132	£0.36
BC134	£0.36
BC135	£0.36
BC140	£0.25
BC141	£0.27
BC142	£0.31
BC143	£0.34
BC149	£0.21
BC154	£0.36
BC157	£0.12
BC159	£0.12
BC160	£0.28
BC170	£0.16
BC170B	£0.16
BC171	£0.11
BC171B	£0.16
BC172	£0.13
BC172B	£0.13
BC177	£0.18
BC178	£0.18
BC179	£0.17
BC182	£0.08
BC182L	£0.08
BC182LB	£0.08
BC183	£0.08
BC183L	£0.08
BC183LB	£0.08
BC184	£0.08
BC184L	£0.08
BC186	£0.33
BC204C	£0.72
BC206B	£0.72
BC207C	£0.72
BC208	£0.72
BC209A	£0.72
BC212	£0.08
BC212L	£0.08
BC212LB	£0.08
BC213	£0.08
BC213LC	£0.08
BC214	£0.08
BC214L	£0.08
BC237B	£0.09
BC238C	£0.09
BC239C	£0.10
BC251	£0.13
BC252	£0.13
BC261B	£0.24
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BC307	£0.10
BC308	£0.10
BC327	£0.10
BC328	£0.10
BC337	£0.10
BC338	£0.10
BC414C	£0.13
BC441	£0.40
BC461	£0.40
BC463	£0.29
BC478	£0.32
BC479	£0.32
BC490	£0.24
BC516	£0.22
BC517	£0.20
BC527	£0.20
BC528	£0.20
BC537	£0.20
BC546C	£0.08
BC547C	£0.09
BC548C	£0.08
BC549C	£0.10
BC550C	£0.10
BC556A	£0.08
BC557C	£0.08
BC558C	£0.08
BC559C	£0.08
BC560B	£0.09
BC637	£0.21
BC638	£0.21
BC639	£0.21
BC640	£0.21
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TIP137	£0.46
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4.7	–	–	£0.05	£0.08	–
10	£0.05	£0.05	£0.06	£0.08	£0.48
22	£0.05	£0.05	£0.09	–	–
47	£0.06	£0.06	£0.11	–	–
100	£0.06	£0.09	£0.11	–	–
220	£0.09	£0.12	£0.31	–	–
470	£0.15	£0.19	£0.57	–	–
1000	£0.22	£0.29	–	–	–
2200	£0.37	£0.57	–	–	–
4700	–	£1.11	–	–	–

ELECTROLYTIC AXIAL CAPACITORS

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1.0	–	–	£0.10	£0.10	£0.19
2.2	–	–	£0.10	£0.10	£0.22
4.7	–	£0.09	£0.10	£0.10	£0.34
10	–	£0.12	£0.12	£0.12	–
22	–	£0.09	£0.13	£0.17	–
47	£0.10	£0.11	£0.16	£0.20	–
100	£0.10	£0.13	£0.21	–	–
220	£0.13	£0.18	£0.42	–	–
470	£0.21	£0.24	£0.69	–	–
1000	£0.33	£0.40	£1.05	–	–
2200	£0.52	£0.64	–	–	–
4700	£0.90	–	–	–	–

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1N5400	£0.09
1N5401	£0.09
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1N5404	£0.11
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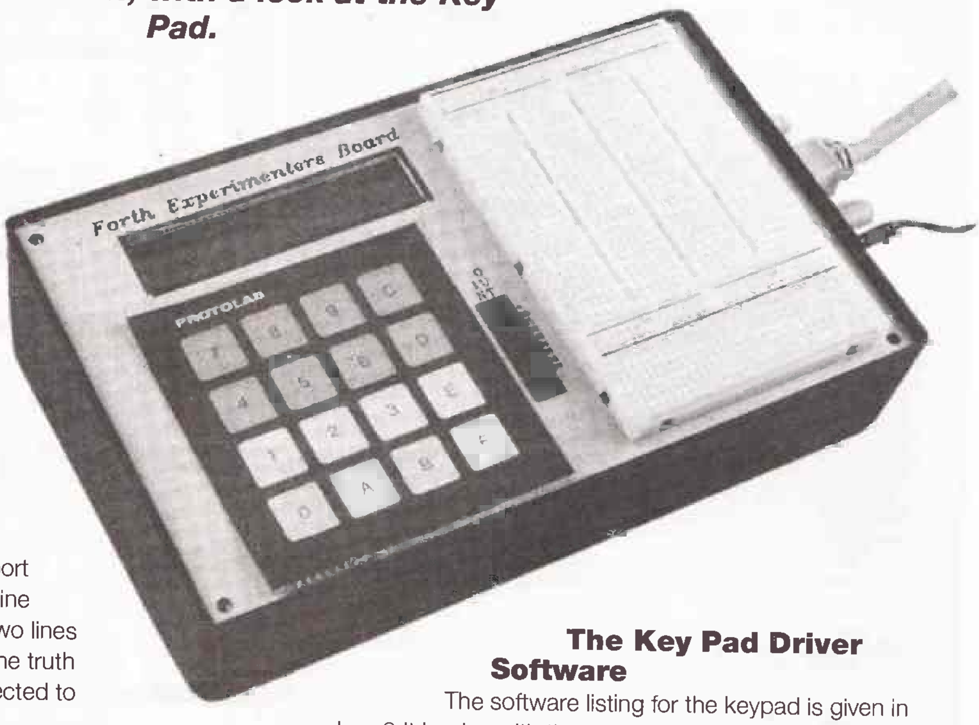
The *Experimenter's* Computer – Keypad and Display

This month we come to the final part of Jim Spence's project to build a versatile Experimenter's Computer programmable in FORTH, with a look at the Key Pad.



Last month we looked at the circuitry for the experimenter's computer keypad and display, plus the Forth routines needed to generate a display. We now turn our attention to the keypad.

If we look at the circuit in Figure 1 (repeated from last month) we can see that the remaining two output lines of port 0 are used to drive the two line to four line decoder. A binary combination of the two lines will bring pins 4 to 7 low, as shown in the truth table. The output lines of IC1 are connected to the rows of the keypad.

The keypad columns are connected to the lower nibble of input port 4 and are held high by four pull up resistors. Taking column 1 row 1 as an example, if no key is pressed then D3 will remain high. If the top left hand corner key is pressed, then D3 will only go low if the input to decoder IC is 11 (binary) because the top row is connected to pin 7 of IC1. In this way all 16 switches can be uniquely detected.

Truth table for IC1

Inputs			Outputs		
2	3	4	5	6	7
0	0	0	1	1	1
1	0	1	0	1	1
0	1	1	1	0	1
1	1	1	1	1	0

The Key Pad Driver Software

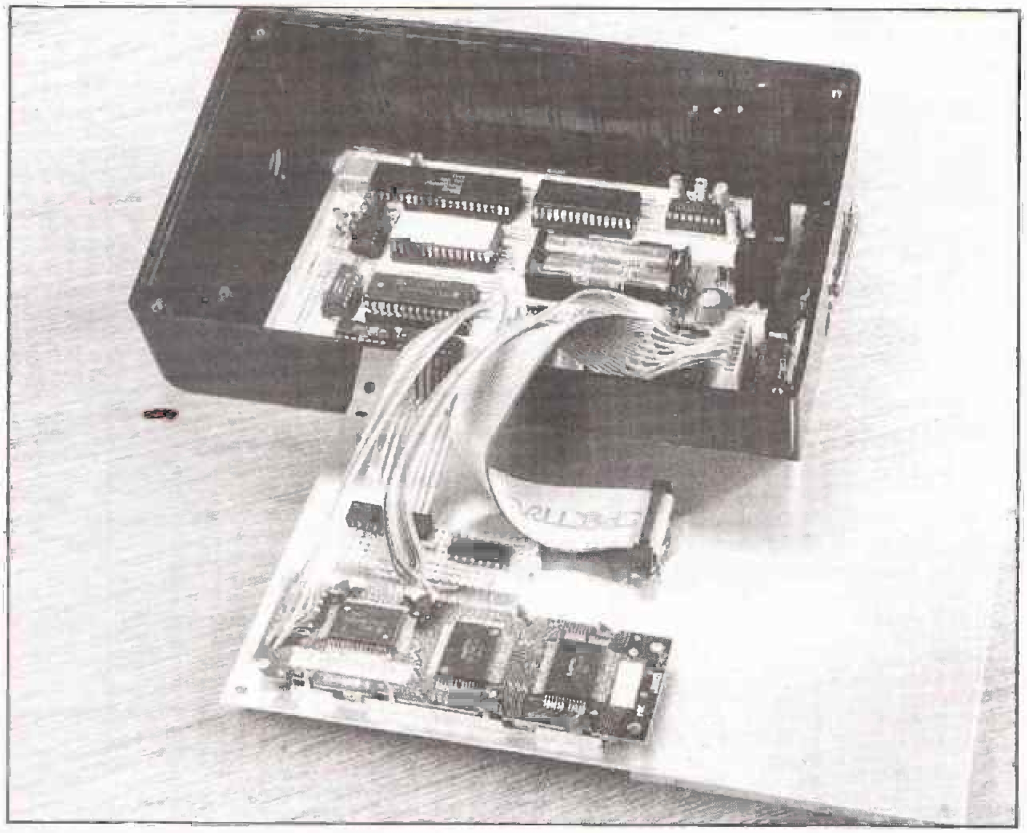
The software listing for the keypad is given in box 3 It begins with the word DIPP, which is the equivalent of DIP used in the display except that this time it outputs to bits D6 and D7, leaving bits D0 to D5 alone.

PAD@, pronounced pad fetch, leaves either a 0 on the stack if no key is pressed, else it leaves a number on the stack equivalent to the key pressed. However it will only return a key value from a valid or active row. In order to use this function properly, the row must first be set and this is the job of PAD-SCAN. Before leaving PAD@, it is worth noting the delay which has been introduced if a key is detected. All software routines which read switches directly should include a de-bounce. When you place your finger on the switch, it takes about 50ms for the switch to settle down. PAD@ re-reads the switch after this delay to make sure it is valid.

The (PAD?) pad query is the most basic useful keypad word. For simple applications no other words are needed. It will either return a 0 if no key is pressed or it will return a key code, more commonly known as a scan code, because the whole of the keypad has been scanned to see if a key was pressed.

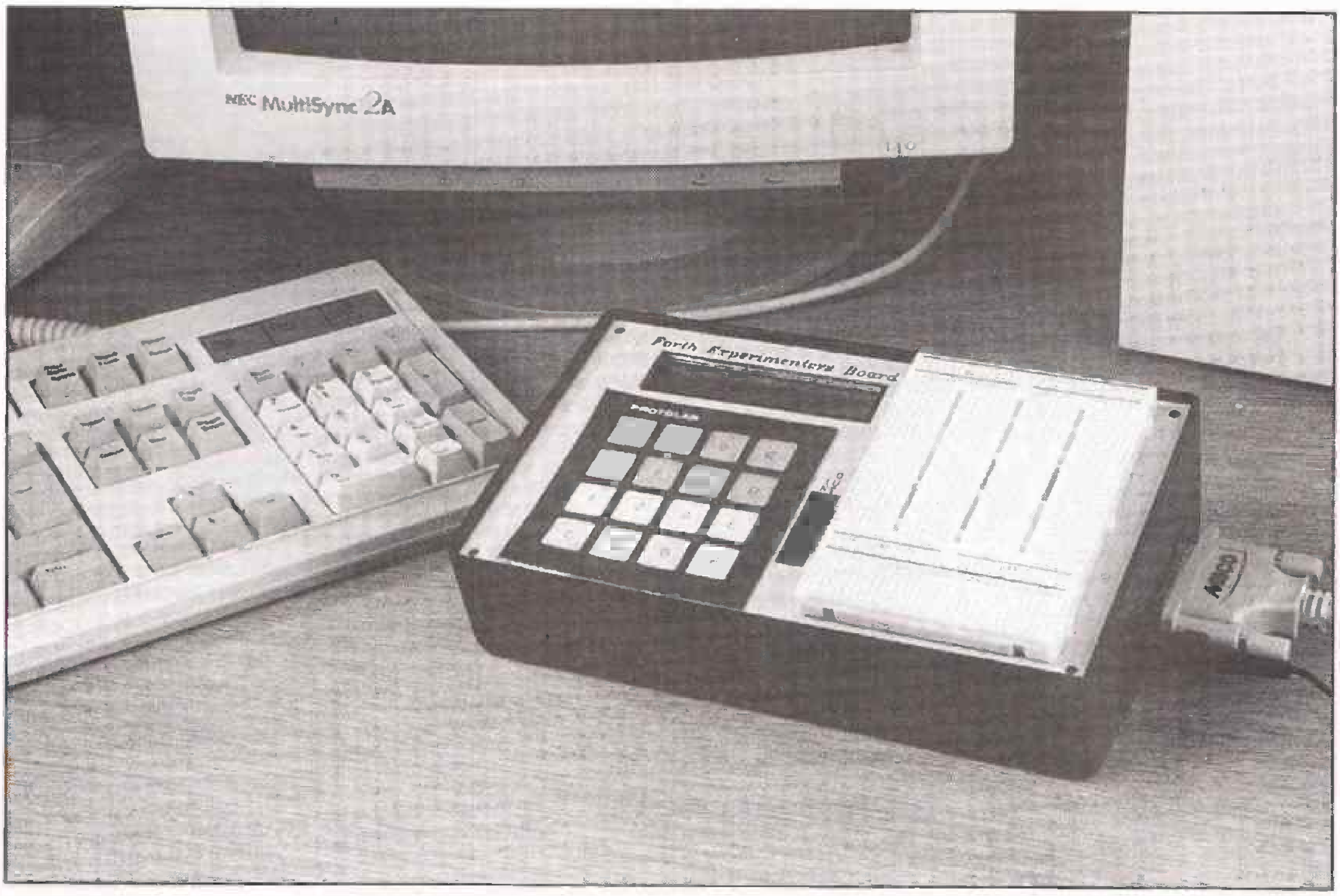
PAD-LOOKUP translates the key scan codes into more meaningful numbers and the technique for doing this is worth explaining.

A table is created called PAD-TABLE. The word CREATE expects some text to follow it, in this case PAD-TABLE and this is now a new FORTH word. After this, bytes are compiled into the table using the word C, (pronounced see tick). When the word, PAD-TABLE, is later executed, the address of the table is left on the stack. The word PAD-LOOKUP uses this address to look along the table for the key scan code. When found, it returns with the offset in bytes along the table. So, for example, if the scan code 4D was given to PAD-LOOKUP, it will return 3 (4 bytes along including 0) which is much easier to remember than 4D. In the code given. the table has been arranged in a more or less standard calculator layout with 0 being the bottom left. Telephone users may feel free to alter this to the other way round.



The 'High' level words are KPAD and KPAD?. The former waits for a keypress and the latter doesn't. KPAD? is useful for aborting continuous loops.

The following code is the FORTH routine necessary to implement the Keypad on the Experimenter's Computer.



```
@L:\ Key pad driver
hex

\ Sends byte b to port specified by dport but only to
\ bits 6 & 7, leaves 0 to 5 alone
: dipp           ( b -- ) \ Display+pad o/p port
        c0 and           \ mask bits 0 - 5
        pvalue c@\ get copy of actual port contents
        3f and           \ mask bits 0 - 5
        or               \ combine
        dup
        dport p!         \ o/p to port
        pvalue c!\ store in variable
        ;

\ Primary read of key pad port, simply fetches data byte b
: (pad@) ( -- b )
        4 p@             \ get port contents
        0f and           \ mask other bits
        ;

\ Returns a value, b if there is a key pressed on the keypad
\ at the scan position otherwise it returns zero
: pad@   ( -- b )
        (pad@)           \ read keypad
        0f =             \ 0f returned when nothing pressed
        if
                0        \ leave 0
        else
                32 0 do del1 loop \ 50ms debounce delay
                (pad@)           \ get key value
                dup      \ check once more for valid
keypress
                0f =
                If
                drop 0           \ drop other f and leave 0
                endif            \ else leave key value
        endif
        ;

\ Scans the keypad at ROW and returns VALUE. A zero value
\ indicates that no key is pressed on that row
: pad-scan       ( row -- value )
        dipp                     \ set row
        pad@                     \ get value
        ;


\ Scans the keypad and returns a value. If a key is pressed
\ the value is the scan code for that key. Returns 0 if no key
pressed
: (pad?) ( -- value )
        0                \ assume no key pressed < X see
below >
        f0 0             \ scan rows from 0 to c0
        do
                i        \ put index on stack
                pad-scan \ scan at bottom row
                ?dup     \ duplicate return value if not 0
                if
        i or     \ get index and combine it with ret value
        swap drop \ drop starting value < X >
                leave    \ leave loop
                endif
                40       \ increment i (index value) by 40
        +loop            \ gives i of 0 40 80 and c0
        ;

\ This look up table converts the scan codes to key numbers
create pad-table
        07 c, 47 c, 4b c, 4d c, 87 c, 8b c, 8d c,
        c7 c, cb c, cd c, 0b c, 0d c, ce c, 8e c,
        4e c, 0e c,

\ Given a key SCAN-CODE it will look up the pad-table and
\ return a number corresponding to that position in the table
\ If no scan code can be found it returns the SCAN-CODE
: pad-lookup      ( scan-code -- key-number )
        10 0     \ search table 16 bytes long
        do
        dup      \ value we are searching for
                pad-table i +            \ offset into
table
                    c@                   \ get value
                    =                    \ see if same as value
                    if
                    drop                 \ duplicated value
                    i                    \ leave index
                    leave                \ the loop
                    endif
            loop
            ;

\ Test to see if any key pressed, returns the scan code b if
\ a key is pressed else it returns 0
: kpad?  ( -- b )
         (pad?)             \ get keypad data
         ;

\ Waits here until a key is pressed and returns the key
number
: kpad           ( -- key-number )
         begin
         (pad?)             \ wait until key press
         ?dup               \ duplicate if > 0
         until
         pad-lookup         \ look up translated value
         ;


\ ---------- Test Keypad and Display Together ----------
variable kk1
variable kk2

decimal
\ Dokey1 & 2 update the variable kk1 and kk2 respectively,
each time
\ they are called the variable is either incremented or
decremented
\ depending on the flag. -1 or true vale increments
: dokey1          ( flag -- )
         if
         kk1 @ 1 + dup kk1 !
         else
         kk1 @ -1 + dup kk1 !
         endif
         line1
         14 gxy di.
         ;

   : dokey2       ( flag -- )
         if
         kk2 @ 1 + dup kk2 !
         else
         kk2 @ -1 + dup kk2 !
         endif
         line2
         14 gxy di.
         ;

\ Test displays two variable to the display which can be
either incremented or
\ decremented by pressing the appropriate keys. This would
be useful for making
\ a pulser with adjustable mark space ratio.
: test
init                         \ initialise display
d" Key1 value ="             \ print to display
line2                        \ set display to line 2
   d" Key2 value ="          \ print to display
   begin                     \ start continuous loop
         kpad?               \ see if any key pressed
         if                  \ yes
                   kpad      \ get value of key
                   case      \ process key
                             1 of 0 dokey1 endof
                             2 of 0 dokey2 endof
                             4 of 1 dokey1 endof
                             5 of 1 dokey2 endof
         1                   ine2 d" ABORTED " abort
                   endcase
         endif
   again
   ;
```

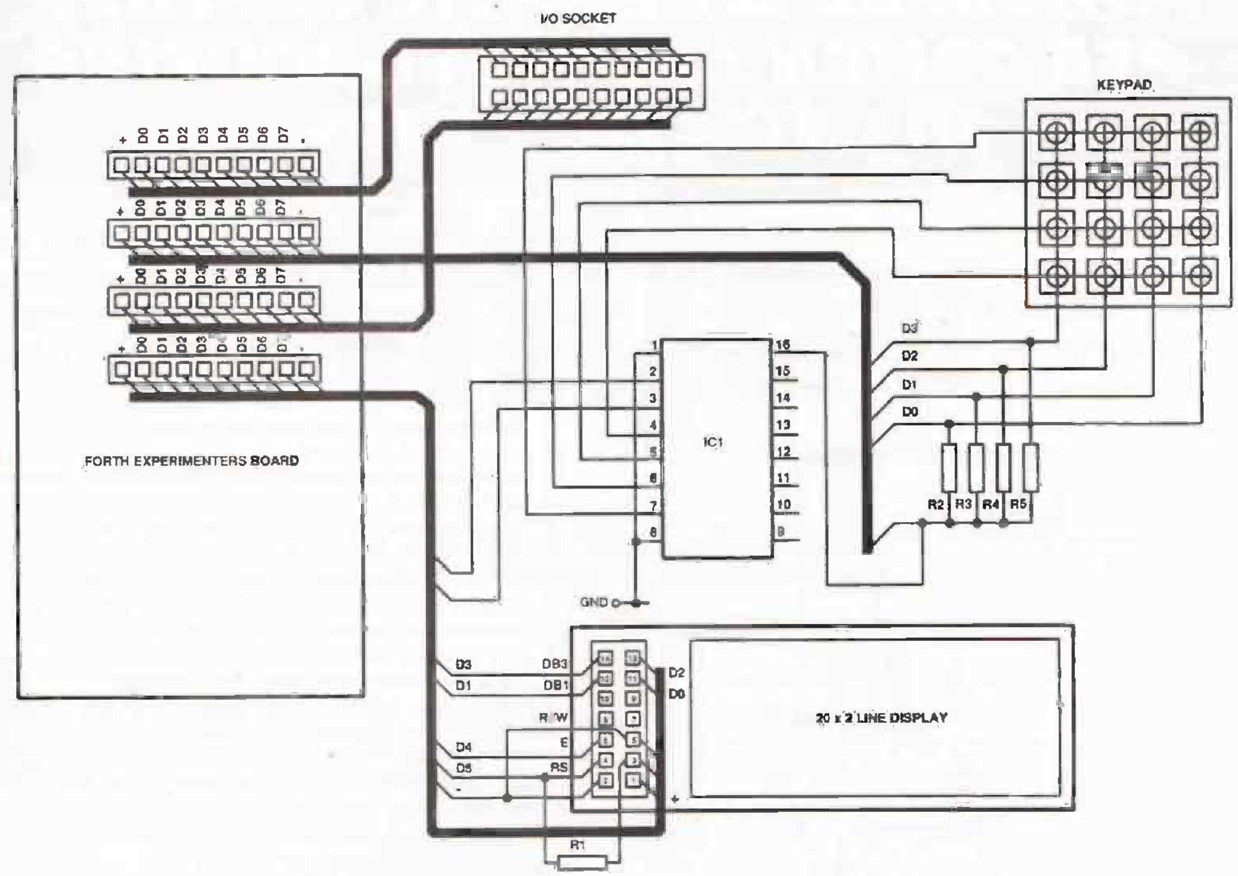
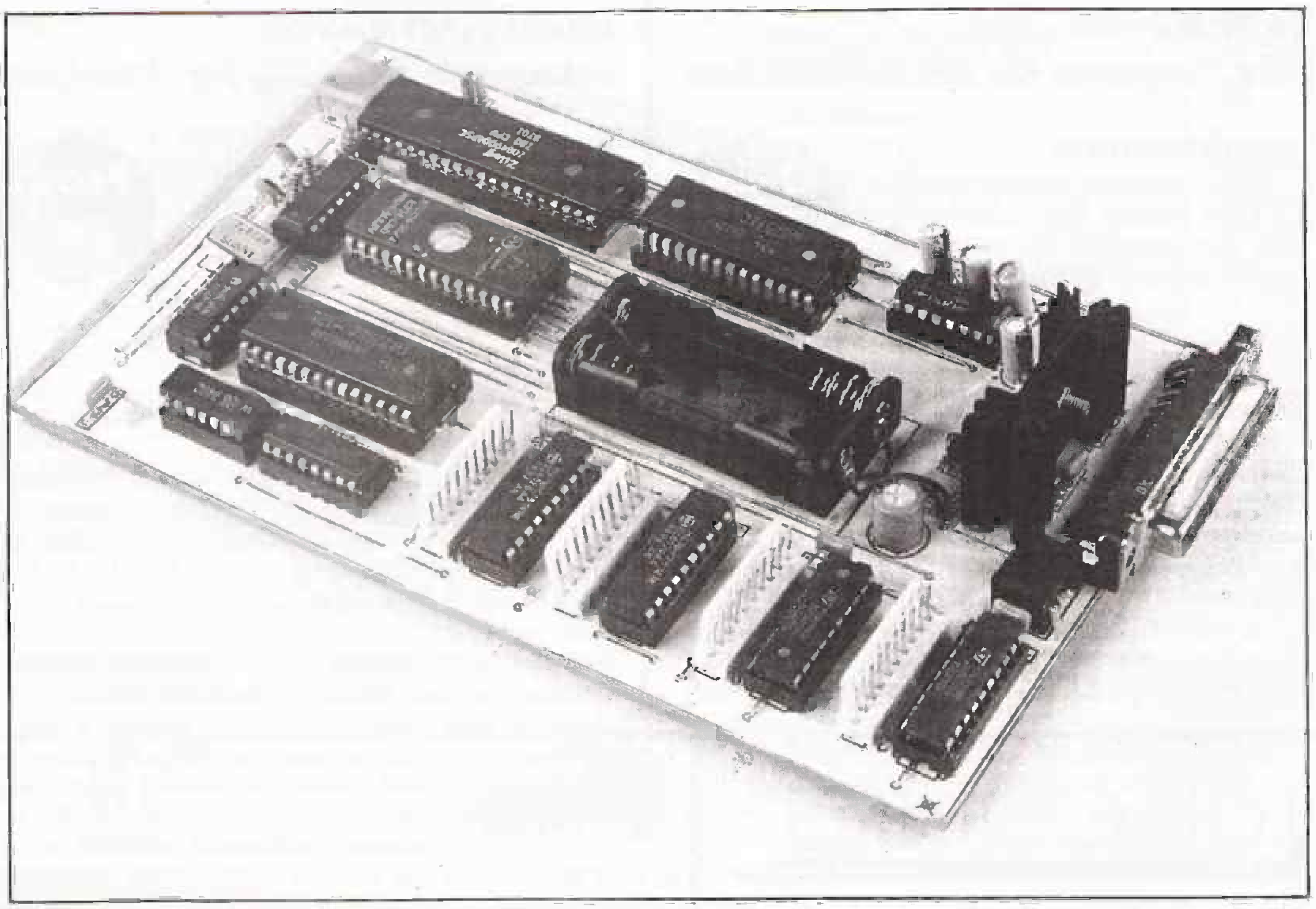
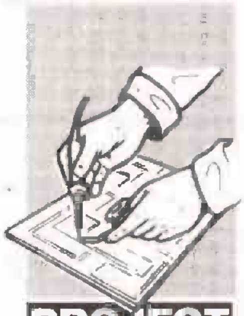


Figure 2 Display and keypad circuit diagram





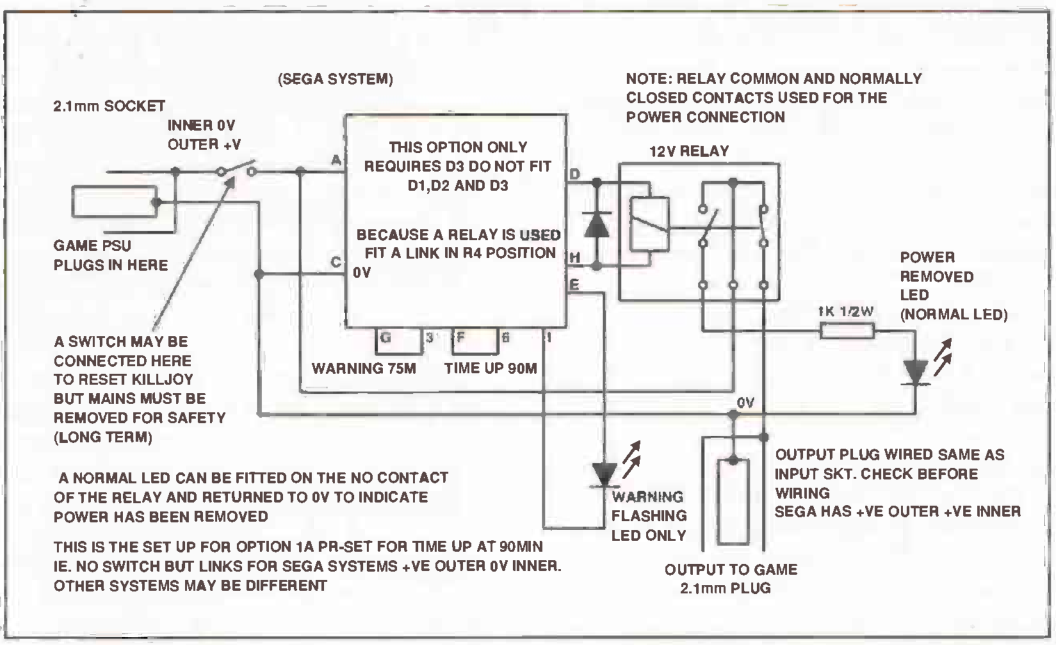
PROJECT

Killjoy

Bob Noyes made himself seriously unpopular with his two sons with this computer game limiter project.

A great debate has been going on in medical circles and in the media recently as to the possible risk of computer games, notably Sega and Nintendo. It has been suggested that they can cause some people to have epileptic fits. At the time of writing this project, no concrete proof has been produced to support these concerns but the general consensus seems to be that shorter rather than protracted periods of time in front of computer games may alleviate the risks.

This is fine in theory but how do you prise children, mesmerised by Sonic the Hedgehog or Mario the Plumber, away from the TV set? "Just one more minute, Dad, this is the farthest I've ever got on this game before and if I turn it off I'll have to start all over again" - or words to that effect. Imminent starvation, when the rumbling of stomachs can be heard above the noise of the games, seems to be the only thing that gets bums off chairs and away from the TV screen.

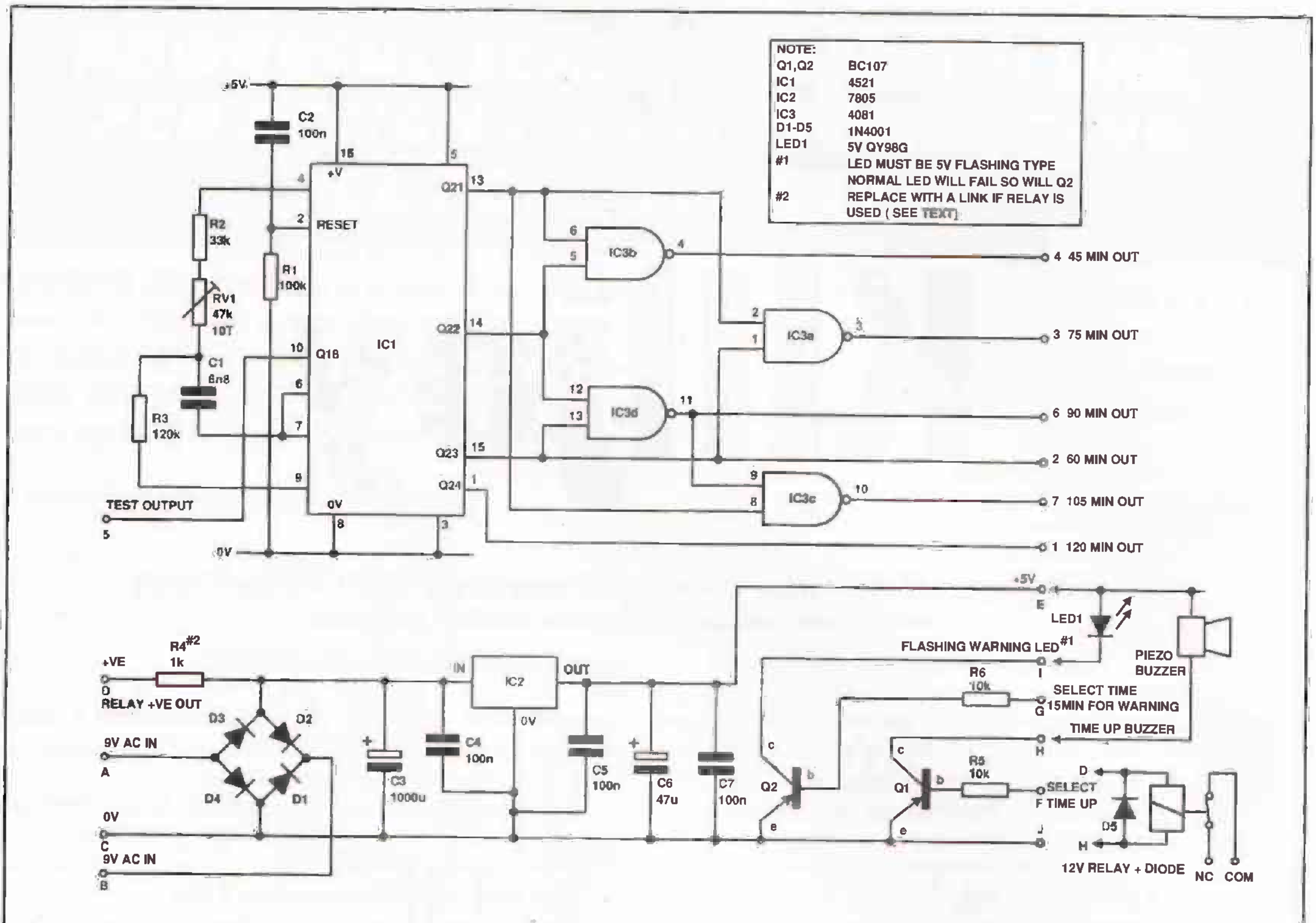


Having two boys, each with a computer system in their room, it's hard to keep track of which one is on and for how long. The lads are aware of the possible health risk, but because they've suffered no ill effects so far they give the matter little or no thought and play on the games, regardless of the time. A device was needed to remind them how long they had been at their games, say an hour, and if they didn't respond then it could be used to either shut down the computer or sound a buzzer or siren to indicate 'Time Gentlemen Please'.

The advantage of Killjoy over an ordinary timer is that it gives 15 minutes visual warning before switching off the game or sounding the siren - essential, as strategies in the game may change when the player/s know time is tight.

Like most switches or systems, Killjoy can be got around, but most children (or adults) who are worried about continuous sessions on computer games are quite happy to have an 'enforced' break. Because no time limits have been forthcoming from the Department of Health, I have chosen three - 1, 1.5 and 2 hours, each limit having a flashing light which comes on 15 minutes before the time limit is up. If at any stage someone in authority gets off the fence and specifies a maximum time limit outside of the three I've set, simply adjusting the oscillator frequency can easily double or half these time frames (see setting up details).

When designing long period timers, one chip - ZN1034E - always comes to mind. Although a useful chip that can be made to time from seconds to days, it only provides one output. Killjoy requires an output to give a warning 15 minutes before power is removed, so another chip is needed.



Killjoy master circuit.

After consulting data sheets, I found it - the 4521, normally associated with crystal oscillators and long division chains resulting in a time base for very accurate equipment such as clocks or frequency meters. As well as supporting a crystal oscillator, it can be made to oscillate using only C and R components. This means that much slower frequencies can be used, well outside the standard crystal ranges. Although not quite as accurate as a crystal, in this application ultra exact timing is not required, so the use of capacitor/resistor timing presents no problem.

The heart of the circuit is a 4521 CMOS oscillator and divider chain, giving Q18 to Q24 outputs or, putting it another way, it will divide by two, 18 to 24 times, giving an output for each one. Lower order divisions are not brought out in order to keep the pin out down to 16 pins.

The oscillator built around the 4521 has been arranged in such a fashion that the Q24 output will remain low for 2 hours after switch on, and then go high. It follows that if Q24 takes 120 minutes to go high, Q23 will take 60 minutes, Q22 30 minutes, Q21 15 minutes and so on. Using simple AND gates, the following times can be achieved: Q22 AND Q21 = 45 minutes, Q21 AND Q23 = 75 minutes, Q22 AND Q23 = 90 minutes, ninety minutes output from previous gate AND Q21 = 105 minutes. These combined with Q23 - 60 minutes, Q24 - 120 minutes, give all the required outputs for 1, 1.5, 2 hours as well as a 15 minute warning for each of these, 45, 75 and 105 minutes. These are taken to a switch, a 2 pole 3-way, in such a way that the switch is the selected switch off time or time up. The switch sections are wired as shown on the diagram.

The poles of switches A and B are taken to two transistors via resistors - these transistors provide the two outputs. The warning output is an active low and goes to the -ve side of a flashing LED (this attracts more attention than a normal LED), the +ve of which goes to a +5V and is wired off the board on the front panel, so as to be seen clearly when playing the game. The time up output, also an active low, can either be taken to a relay to switch the power 'mains' or low voltage to the offending computer game. Alternatively, it can be connected to a piezo siren/buzzer, loud enough to draw attention to the time up, but not so sneaky as to remove the power on the final few seconds at a crucial level of Sonic 2 or such like.

The power supply for the CMOS ICs has been set at 5V (although these will work anywhere within the CMOS range 3-18V). This will enable the power to be drawn from the DC output of the mains power supply for the game, normally around 10V DC. As this circuit draws next to no current, there is no problem taking power from the games supply. Alternatively, a small 6Va (or larger) transformer, either 4.5V - 0 - 4.5V or 9V - 0 - 9V, can be used. If the former is used, all 4 diodes D1-D4 are required. If the latter is used, then D1 and D4 should be omitted (refer to the diagram for exact wiring).

The 7805 regulator has a small heat sink, which is merely a precaution as the CMOS ICs draw next to no current and the flashing LED only a few milliamps. Because of the low power consumption, technically the 78L05 (rated 100Ma) could be used, but the cost saving is so small that the larger 7805 (rated 1A) has been chosen.

Options

As already mentioned there are several Killjoy options

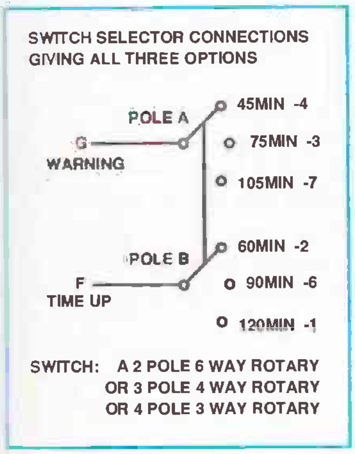
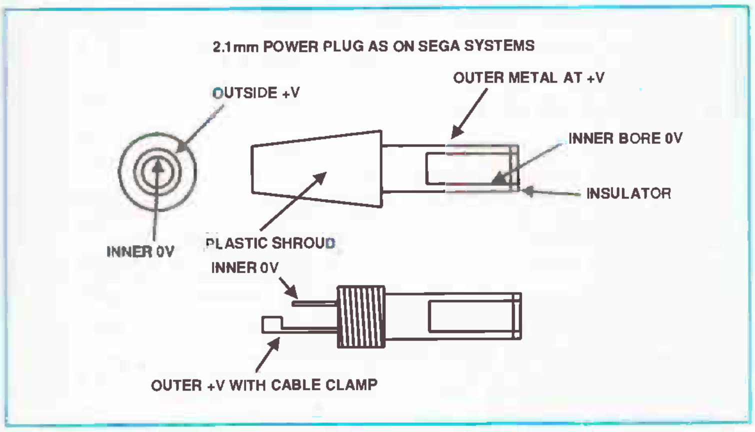
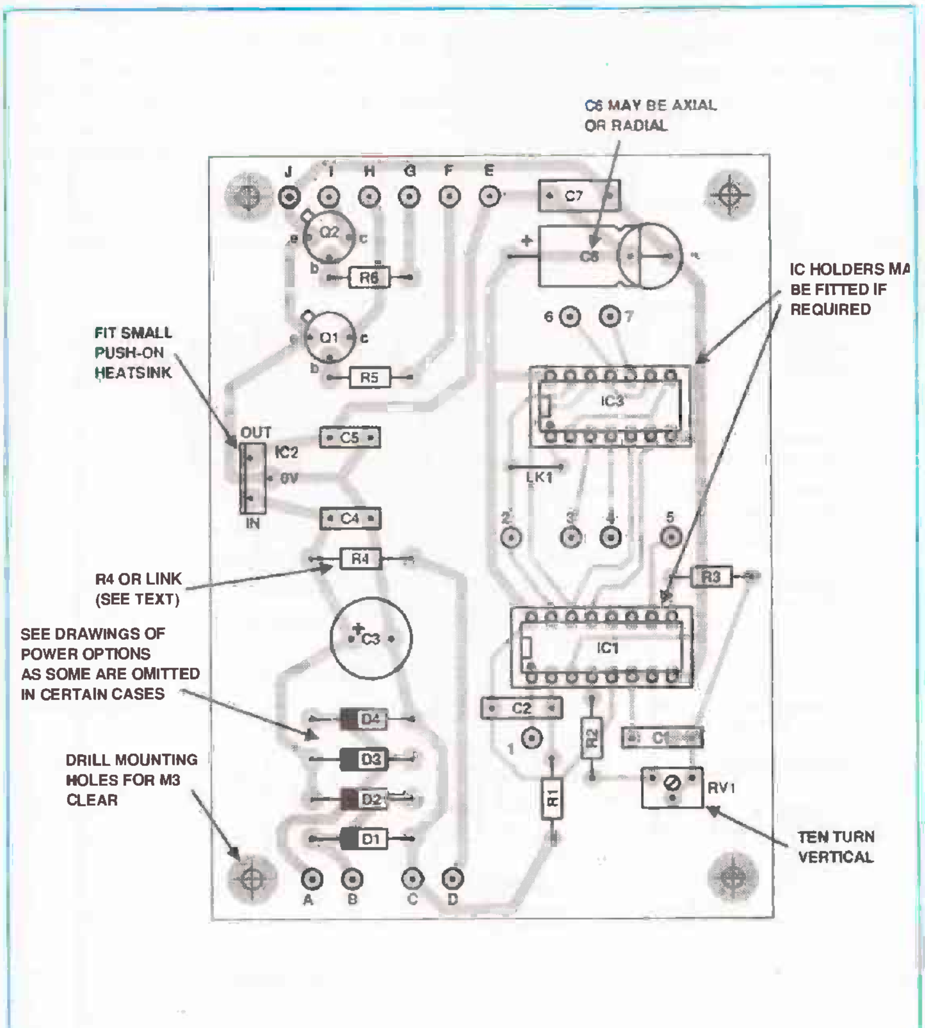


TABLE OF LINKS IF SWITCH NOT FITTED

	1 HOUR	1.5 HOUR	2 HOUR
WARNING G	45M 4	75M 3	105M 7
WARNING F	60M 2	90M 6	120M 1

EG. FOR 1 HOUR
LINK G TO 4 45MIN THEN WARNING
LINK F TO 2 60MIN TIME UP





Component overlay for Killjoy PCB.

Option 1a

The time up switches the supply to the game, either mains or the DC supply via a relay. When a relay is used, fit link in place of R4.

Option 1b

The time up can be connected to a piezo buzzer/siren to indicate time up. This allows a crafty extra couple of lives to a player if a game is going well, bearing in mind no specific times have been suggested.

Option 2a

The power supply can be taken from the power pack that's supplied with the game. Care must be taken to connect the supply the correct way round - measure first with a meter.

Option 2b

A transformer can be used, either 4.5V-0-4.5V or 9V-0-9V.

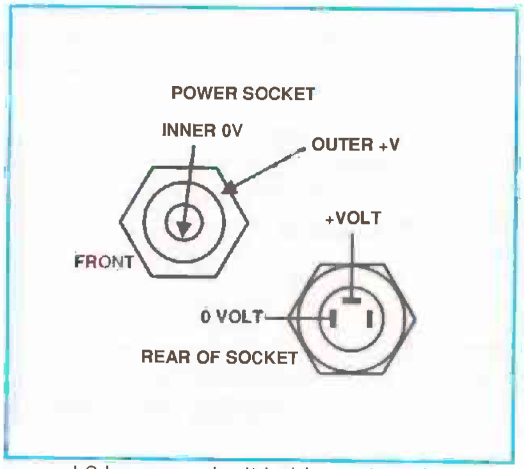
The same PCB is used for all options, although the diodes D1-D4 are used in different combinations (refer to the diagrams).

Setting Up

The 4521 division chain is the heart of the system. The output Q24 is required to remain low for 120 minutes (to provide the 2 hour output), pin 1 of the PCB. This is only half the time when considering the frequency at Q24. The frequency is the low plus the high time, therefore Q24 has a repetition rate of 4 hours. When this is divided back to the basic time/frequency it comes out to 0.0008583 seconds or 1165.09Hz. R1, R3, RV1 and C1 are chosen to provide this frequency, ideally with the setting of RV1 in the middle allowing adjustment in either direction for adjustment to 1165.09Hz. Here, the 10-turn preset comes into its own.

If a frequency meter is available, set a frequency of 1165.09Hz at pin 4 by adjusting RV1. For those without a meter, the Q18 has been brought out to pin 5 of the PCB as a monitor pin only - it is not used in the time functions. This can be monitored using a volt meter in respect to 0V, to give a high out 5V after 112.5 seconds or 1 minute 52.5 seconds after switch on.

To set up without a frequency meter, switch power on and set a volt meter on pin 5 of the PCB, at a range to monitor 5V. This pin should go high after 1 minute 52.5 seconds. Adjust the RV into roughly the middle position. Short pin 2 to pin 16 of the IC using a small length of wire. This resets the counter chain and stops the oscillator. Release this short and note the time as accurately as possible. The time taken for pin 5 of the PCB, Q18 to go high should be noted and RV1 adjusted to make it go high after 1 minute 52.5 seconds. This should be done as accurately as possible, because any error in the procedure will result in an even larger error in the high time outputs, i.e. Q24 will have an error 64 times greater than that of Q18. Once Q18 has gone high, the preset should be adjusted to correct any error. This can only be done by trial and error. When adjusted, pin 2 of the IC should be shorted to +5V pin 16 of the IC to reset the counter chain, the procedure being repeated until pin 5 of the PCB goes high 1 minute 52.5 seconds after switch on, or the short on pin 2 of the IC to +5V removed. In practice this takes



several attempts, but you get there in the end.

Once the setting is right, pin 2 of 4521 should be shorted to +5V and this time Q24 monitored. This will take around 2 hours so don't hold your breath. RV1 can be given a final little tweak (if required) to set it to go high after exactly 2 hours. You can get an indication at 1 hour by monitoring pin 2 of the PCB - if more or less than a few seconds out, RV1 should be adjusted and the procedure cancelled at this stage and started again, i.e. shorting pin 2 of the IC to +5V. Any error at one hour, Q23, will be doubled at 2 hours, Q24.

The time selector switch can be mounted on the front of the box or the time can be selected and mounted inside the box to prevent longer times being selected. Alternatively, the switch can be removed and a time chosen and wired directly. The mains or power is turned on causing the switch on capacitor C2 and R1 to instantly provide a switch on positive reset pulse to the 4521, making the counter start from zero. After being divided the correct number of times, the selected output switches the warning LED on. This flashes for 15 minutes before the final time is up and this can be used to either remove power or activate a piezo siren to indicate that time's up.

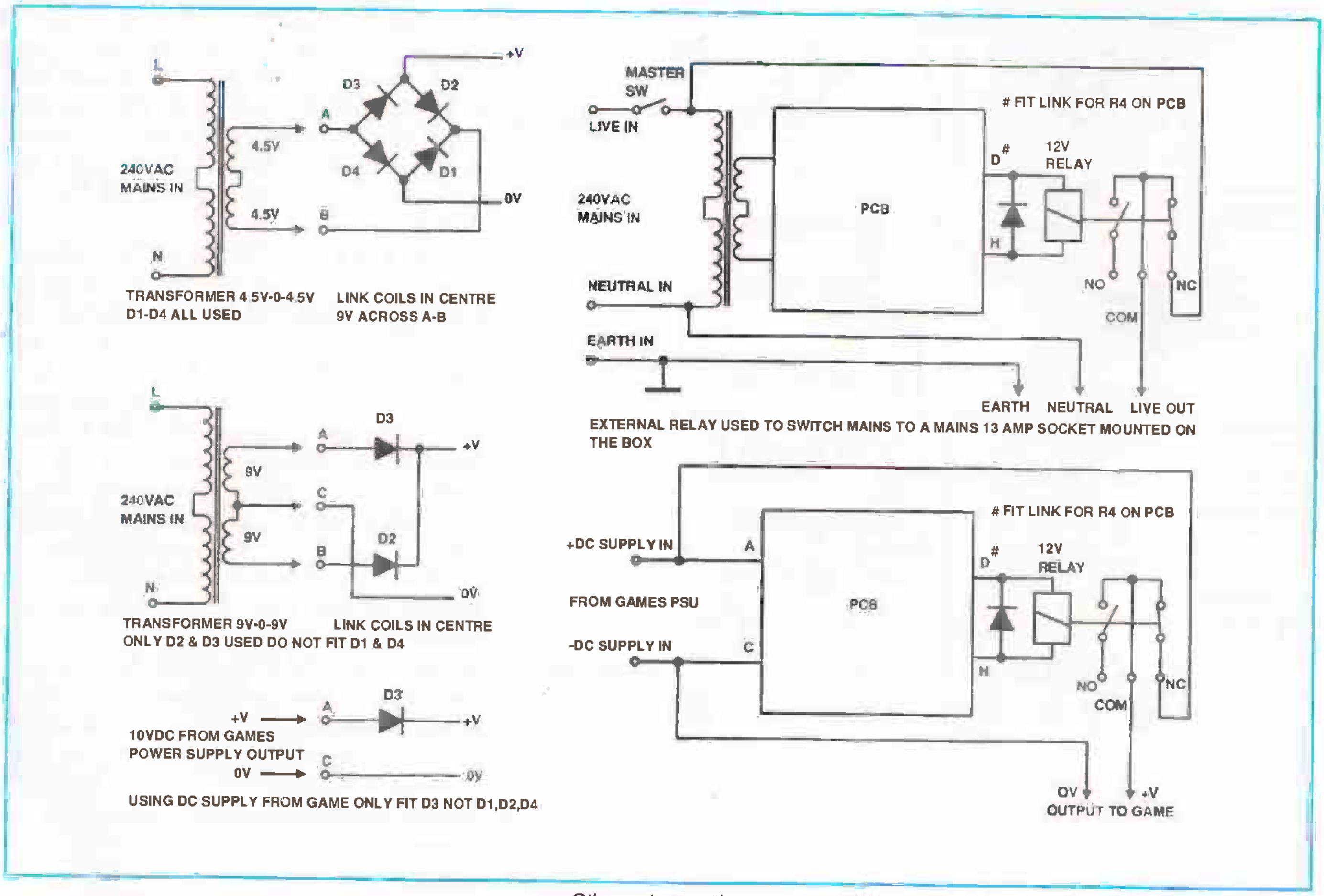
If at some stage the Department of Health specifies a maximum recommended time for playing computer games outside of the three I've selected, the oscillator - set to run here at 1165.09Kz - can be speeded up to reduce the time intervals, or slowed down to increase them. This will also increase or decrease the 15 minute warning time, but the circuit will still function in the same manner. Should specified times be much shorter or longer such that there is not enough adjustment on RV1, then C1 can be changed. Reducing the value of C1 to 5.6nf would increase the speed of the oscillator and hence reduce the time intervals, whereas increasing C1 to 8.2nf would reduce the speed of the oscillator and increase them.

Boxing and Construction

Firstly, the options required should be sorted out, i.e. is Killjoy going to be powered by its own mains supply (Option 2b) or be powered by the game's supply (Option 2a - easier and safer if you are not too sure).

Secondly, is Killjoy going to cut the supply to the game (Option 1a) or sound a siren/buzzer (Option 1b).

If Option 2b is chosen, then a slightly larger box should be used and the transformer, PCB and possibly the relay all mounted on a metal plate which should be earthed for safety. The box recommended is Vero Part No. 202-21039N, known at Maplin as LQ 09K, 180 x 120 x 90mm. This gives enough room for all the wiring. Because mains is involved, every wire should be checked and double checked before power is applied. If you are in any doubt at all, ask someone more competent to do it for you. If the mains plug supply is brought in from the games' own (altogether a safer option for newcomers to electronics), then a smaller box can be used such as an ABS M1005, known at Maplin as LH 63T, 161 x



Other set-up options.

96 x 61/39mm. Here, a 2.1mm power socket is mounted on the plastic box, this is important as the mounting of the socket is normally at +ve 10V (see diagram). If Killjoy is going to switch the power DC to the game, great care should be taken that the output plug is wired in the same fashion as the plug already fitted on the power supply. I have installed Killjoy on a Sega Megadrive and Sega Master System, both of which had the outside of the power plug at +ve and the inside core 0V, as per diagram. Other systems must be tested and wired accordingly.

As previously mentioned, the time selector switch can be brought to the front panel, where the time selection can take place or can be hard wired, i.e. links put in for one time option as per time listing. If a piezo siren/buzzer is used, holes must be drilled in the box to let the sound out, several small holes rather than one large one being necessary to eliminate the risk of fingers getting into the circuitry.

No particular layout is required, but if mains is involved, connections should be sleeved and great care taken that nothing can short and touch. All metal work should be earthed. On the mains version shown, the mains 13A socket is mounted in a white mains box on top of the control box to ensure that the mounting bolts to the socket are securely fitted. If a hole is cut in the top of the control box and the socket mounted directly, great care must be taken to ensure that the mounting bolts are securely fitted.

The mounting of the flashing warning LED should be such that it shows up clearly, i.e. mounting it in a black LED clip for a good contrast. The lettering on the front panels was done with rub down print that you can get at WH Smith or any good stationers.

If a relay is not fitted and Killjoy is going to sound a piezo siren/buzzer at time up, a power-in LED can be fitted using R4 1Kn 1/2W as the +ve supply output pin (D) of the PCB and the -ve of the LED taken to 0V.

If a relay is fitted, the R4 becomes a link and output pin (D) of the PCB goes to the relay and the +ve of a diode fitted across the relay coil.

In all options, the PCB is mounted on 4 bolts with spaces between the PCB and the base. The bolts used are countersunk so as not to protrude under the box. Rubber feet, either stick on or screw in types, can be used. If they are screw in, care should be taken that the screws don't touch any of the wiring or other parts mounted in the box.

The principle of operation is that, after power has been given to the PCB, the oscillator starts and the counter is zero'd by the switch on reset. The 4521 starts to count. If a relay is used, the normally closed contact and the 'common' connections provide power to the game. Once the selected time period is up the relay is activated, which means that the normally closed contact supplying the game with power is no longer connected to the common, thus power is removed from the game.

Killjoy has switched the game off on the mains option (2b). When the television is turned off, the switch on Killjoy should be turned off as well. This removes the mains supply from it so that when Killjoy is switched on again, some time later, the switch on reset will activate and the time period will start from scratch.

In option 2a, although the action of the PCB is exactly the same and power is removed from the game, the DC supply should be switched off at the mains just as you would do if Killjoy wasn't there. This is basic safety practice.

I didn't expect to be the most popular Dad in the world when I installed Killjoy in my sons' computers and I'm not - my nice guy ratings are zero minus, but at least I feel I have some peace of mind in that I've done something positive to alleviate a possible health risk.

PARTS LIST

RESISTORS (1/4W Carbon Film)

R1	100K
R2	33K
R3	120kn
R4	1Kn 1/2W for LED or link if relay used
R5	10K
R6	10K

CAPACITORS

C1	6.8nf Disc 25V
C2	0.1µf Disc 25V
C3	1000µf 25V Radial
C4	0.1µf Disc 25V
C5	0.1µf
C6	47µf 10V Radial/Axial

TRANSISTORS

Q1	BC 107
Q2	BC 107

ICs

IC1	4521
IC2	7805
IC3	4081

DIODES

D1	IN 4001 *
D2	IN 4001 *
D3	IN 4001
D4	IN 4001 *
D5	IN 4001 *

* fit depending upon option required.
(See drawings).

RV 47Kn 10-turn vertical

MISCELLANEOUS

Not all these parts are required (see options).
Maplin part numbers given.
5V flashing LED, QY 986G.
PCB
Box for mains unit, LQ 09K
Box for non mains unit, LH 63T
Power plug for Sega 2.1mm, HH 61R
Power socket for Sega 2.1mm, JK 09K
Transformer (if own supply used), 9V type, WB 11M
Mains switch (if own supply used), FH 30H
12V relay suitable for mains or DC
Supply switching, JM 18U
Suitable siren, FK 84F
Nuts and bolts, M3, to suit options
Switch, 2 pole 6 way, FF74R (break before make)
Knob to suit switch

PC Clinic

Nick Hampshire continues his series on maintaining, repairing, and upgrading PCs with a look at two vital components of any PC - the motherboard and the power supply.

Take the case off your PC and look inside. The first thing you will notice is an assortment of application boards, the power supply, the disk drives and an odd assortment of cables and wires. Then, as you look a bit closer, you will see at the back or bottom, of the case in the shadow, a large printed circuit board. A board which probably contains two or three very large rectangular integrated circuits, the sockets into which the applications boards plug and banks of memory chips.

This is what is popularly referred to as the motherboard, or more correctly the main system board. It contains all the main circuitry for the computer, the processor and associated control circuitry, system memory, cache memory, the BIOS EPROM chip, CMOS memory with its back-up battery, keyboard and serial I/O, plus all the clock, interrupt, and DMA circuitry.

The motherboard also contains the main expansion buses, ISA, EISA, VESA, etc., which allow the basic system board circuitry to be expanded by using plug in adapter boards. Typically, these would include the disk drive controller board, a display adapter board, an I/O board and perhaps a sound generation board (we examined these expansion buses in last month's issue of ETI, and will be looking at adapter cards in depth in two months time).

However, the motherboard does not need any of these adapter boards to work, it is after all a self contained and fully functional computer system, complete with memory, I/O, and some very low level software on the BIOS EPROM. Of course, without a video display board you will have to rely on a printer, or terminal, connected to the motherboard serial I/O port in order to generate any from of output, the keyboard can be used as a source of input. Input and output will be very limited since without disk drives the system will be unable to load DOS, relying instead on the very low level BIOS functions.

The independent nature of the main system board means that the power supply and the motherboard form the two most fundamental components in any personal computer. If the system is faulty then these two components should be the first to be checked out thoroughly.

We can check the motherboard for a range of faults by using a set of special routines built into the BIOS software. These routines are known as the Power On Self Test or POST code system and they generate a comprehensive set of diagnostic messages which can be displayed with the aid of a special adapter board. Repairing or replacing a motherboard is a lot cheaper than repairing or replacing an entire system.

Indeed, replacing the motherboard in a system is an excellent way to upgrade a system at minimum cost. If we change the motherboard and its in-built processor and control electronics, we can easily change, say an 8MHz 286 system into a 33MHz 486. We can keep the same case, same power supply, same adapter cards, perhaps even the same memory chips, the same disk drives, display and keyboard. In other words, by simply replacing the motherboard and processor it is possible to convert an old system into an infinitely more powerful new system, for just a couple of hundred pounds.

This will not be necessary on newer 486 based systems, since they have been designed to be more easily upgradable and it should be possible to upgrade merely by replacing the CPU chip with a faster or more powerful version. Thus, if you have a 486SX running at 25MHz and want to upgrade it to a full DX system, complete with maths co-processor, then one simply replaces the 486SX with a 487SX. Similarly, if you have a 486DX system running at 33MHz and want one running at 66MHz, then all one has to do is change the processor chip, no need to change the motherboard (we will be looking at upgrading CPUs and the use of over drive chips next month).

This month we will, therefore, be looking at all the various constituent components of a typical motherboard, the different types of motherboard and how to choose and install the appropriate one for you. We will also see how to track down and cure motherboard faults, plus the power supply and the various cables which link them and the keyboard, display LEDs, switches and so forth.

Bus Types

A computer bus can be defined as the collection of data, address, and control lines which link the processor to memory and I/O circuitry. The use of a standard bus which can be accessed through one or more extension sockets allows one to add additional memory or I/O to a system, by means of plug in adapter cards.

There are currently five different bus types used on PC motherboards and these are as follows:

ISA (Industry Standard Architecture) - This is the most widely used PC bus and is found on all PC ATs, XTs and 100% compatible systems (with the exception of most portables). Because so many systems support the ISA bus there are a very large number of available commercial adapter boards. The only limitation with the ISA bus is that it has a fairly slow 16 bit data bus which can prove restricting in fast I/O applications.

EISA (Extended Industry Standard Architecture) - This is a much faster 32 bit version of the ISA bus. Unfortunately, although technically superior to the ISA bus, it has not been a commercial success and there are relatively few EISA adapter cards available.

MCA (Micro Channel Architecture) - This is a proprietary IBM bus which was developed for their PS/2 systems in response to the need for an improvement on the original ISA bus. As such, it is a competitor for the EISA bus, but like that bus it has not been a great commercial success and there are relatively few adapter cards available.

VESA Local Bus - Another approach to speeding up the ISA bus has been to develop an interconnection, or local bus, which allows some circuitry on the adapter board to communicate directly with the CPU, rather than via the ISA bus. This local bus is primarily used for memory to memory data transfers and has thus allowed the creation of high speed video and disk adapters which are significantly faster than their ISA equivalents. The VESA local bus has been a commercial success and most 486 motherboards now have one or two VESA bus slots.

PCI Local Bus - This is a new bus standard which maintains compatibility with the ISA bus, but offers the enormously enhanced performance benefit of a 64 bit local bus. This is a very new development and we have yet to find out whether it is a commercial success but it is, however, very well suited to the Pentium and will in the long run probably prove to be the natural bus for such systems.

If you want a good versatile bus system for your motherboard which will allow connection of a wide rage of adapter cards as well as being able to take advantage of future developments, then an ISA bus system with VESA local bus is probably the best option.

Full technical specifications for the ISA and EISA bus, including pin specifications and bus timings, were included in part 1 of PC Clinic, published in the June 94 issue of ETI. We will be looking at the local bus in depth in three months time.

Choosing a New Motherboard

It may sound obvious, but the first question one should ask when deciding which motherboard to buy, whether as a replacement for one that has failed or as an upgrade for one that is obsolescent, is which processor do I want and what processor speed do I need?

Most of us will have a natural tendency to go for the fastest and best that we can afford, but before doing so it is a good idea to sit down and carefully analyse what the system will be used for, how much money is available and whether you will want to further upgrade the system at a later date. After all, if the system is only being used for simple applications such as word-processing, then there is little need for a high powered system, but high power will be needed if applications involve CAD, multimedia, etc. These are all the sort of basic questions anyone buying a PC should ask themselves.

If you do not require lots of processing power, then a cheap 386 motherboard will be adequate. If you require lots of power then a 486DX running at 66MHz is the best option. This can be upgraded to a Pentium at a later date, if required. At the time of writing, a Pentium motherboard is probably not an economic option.

Having decided whether you want to use a 386 or 486 based motherboard, the next decision is what type of processor - a SX, a DX or a DX2. With the 386 family, the SX version has a 32 bit internal bus but only a 16 bit external bus, whereas the DX version has both a 32 bit internal and external bus. The result is that the DX version is considerably faster at the same clock speed. On the other hand SX chips have lower peripheral overheads and motherboards based on such chips are thus about £70 cheaper than their DX counterparts.

In the 486 family of processor chips, the difference between the SX and DX version depends not on the bus width, both use a 32 bit internal and external data bus, but rather on the presence or absence of a maths coprocessor on the chip. With 386 systems, a separate maths coprocessor will be needed in order to perform computationally intensive programming such as running a CAD program like AutoCAD. On the 486DX the maths coprocessor is actually built onto the main processor chip, but the SX does not have the coprocessor and therefore, although faster than a 386 system, is less suitable for applications like CAD.

If you want to add a maths coprocessor to a 486SX system, then depending on the motherboard design, this can be done by replacing the 486SX with a 487SX or inserting a 487SX into the spare socket provided for the purpose.

The next consideration when selecting a motherboard is processor speed, a critical choice since speed equates with

Installing a motherboard

Installing a new motherboard, or replacing an existing one, is quite easy. Indeed, by going through the following steps installation can be done in little more than thirty minutes:

- Before doing anything, it is important that you have a large clear space on which to work, a newspaper covered dining room or kitchen table is ideal. Also, because the motherboard and associated CPU and memory chips are expensive and easily damaged by static electricity, it is a good idea to discharge your static (see box on this page) before touching any of the electronic components.
- Having discharged your static, open the static proof bag in which the motherboard is shipped. Try to handle the board by touching just the edges and do not touch any bare connections on the back of the board or any of the chips. Then place the board on a good flat surface, ideally covered with an anti-static mat, component side upwards.
- At this stage, the board should be checked for shipping damage.
- Get out the documentation that comes with the board and read it carefully, preferably two or three times!
- If the motherboard has cache memory, it should be checked to ensure that the cache is the right size and speed. If it is not, then you may have to remove the existing cache memory chips and replace them with the correct ones. The documentation which comes with the motherboard should tell you which chips to use.
- The next stage is to install the RAM on the motherboard. Today, RAM usually comes in the form of SIMMs, but on older boards the memory chips were either socket mounted or soldered in. If necessary you may need to set some DIP switches or

processing power. The standard CPU speeds available today are 25MHz, 33MHz, 50MHz and 66MHz. The rated speed of a motherboard is set by the clock circuitry and is often defined by a wire link or a special plug in clock generator. With a 486 system, it is possible to double the processor speed by using a clock doubler, or DX2, processor chip. Thus, with a 486DX2 processor a 33MHz 486DX can be made to run at 66MHz. The most powerful system one can buy without buying a Pentium motherboard is one based upon a 486DX2.

Processing power is also affected by memory access times, the use of slow memory will entail the use of wait states and thus a reduction in the number of instructions which can be processed per second. This means that the motherboard will have to be fitted with memory of sufficient speed to keep wait states to a minimum. The use of a block of between 64K and 256K of very fast memory, what is usually referred to as a secondary cache, will further speed up memory access and thus overall processing speed. If processing power is important, then fast secondary cache memory is essential (we will be looking at cache memory and different processor designs next month in ETI).

Besides having fast memory, the motherboard should also be capable of allowing memory expansion so that you will be able to add as much memory as necessary throughout the proposed life of the system. Most motherboards will support between 16MB and 64MB of RAM on the motherboard in SIMM sockets.

If you are upgrading or replacing a motherboard then it is also very important to ensure that the board is of the correct size to fit the case. Today, the majority of commercial motherboards conform to what is known as the mini-AT size form factor and measure 13.25 x 8.75in. This size motherboard will fit into most cases. However, some older systems used a standard XT sized board which measured 12 x 8.5in and some more compact systems were designed with a 2/3AT board, which measures just 8.5 x 9in. Note that Amstrad 1512/1640 systems used a totally non-standard board with built in video, serial and parallel I/O ports, such machines are best left alone since there is little to be gained in trying to upgrade them.

When upgrading a system with these smaller motherboard sizes it may prove necessary to buy a new, larger size case that will take one of the standard sized motherboards, which will cost about £75. When buying a new motherboard you should also check that the mounting holes are all in the correct place, however, these are fairly standard.

Repair or replace?

When faced with a faulty motherboard, the big question is whether to try and repair the fault or simply replace the motherboard with a new one. Of course, this decision depends upon the nature of the fault and the way in which the motherboard is constructed. A simple fault such as a defective capacitor, or a dud IC can usually be corrected, once located, by carefully unsoldering and replacing the component. However, motherboards are increasingly being constructed using very high levels of integration, multilayer printed circuit boards and surface mount devices, which can make it very hard to successfully repair a board without access to a surface mount workstation.

The result is that the modern generation of motherboard has largely been designed as a disposable commodity. Indeed, if one looks at the actual price of motherboards compared with the price of a processor chip on its own, then one realises how little they actually cost. For example, a 25MHz 486SX motherboard costs about £180 and the processor chip by itself about £140. This means that if you are going to upgrade a system, it is almost as cheap to replace the entire motherboard as it is to change the processor chip.

The high price of the processor chip with respect to the motherboard means that if one has a defective board, it is well worth checking to see if the processor is still OK. If it is, then a bare CPU board without CPU can be acquired and the CPU chip and any transportable RAM and cache memory chips transferred from the old defective board to the new one. If you are upgrading a system, then it may also be possible to transfer some chips from the old board to the new, thereby saving money.

When upgrading a motherboard, there are a few procedures which should always be followed:

- First make a note of all the CMOS set-up settings on the old board, in particular those relating to the hard drive.
- Switch off the power, unplug and open the case.
- Make sure you have discharged the static from yourself, then disconnect and remove all the adapter cards.
- Identify and label all the cables which run from the mother board to the front panel and power supply before unplugging them.
- Finally, unscrew the motherboard and save the screws and any nylon or brass spacers attached to the back of it. Put the old motherboard, minus any recycled components, into the static free bag which contained the new motherboard.

jumpers in order to tell the system how much memory is installed (we will be looking at memory in depth in a couple of months time).

- Your motherboard may have a jumper which determines whether the system uses a colour or monochrome video adapter - if it exists this should be set according to the documentation.
- If the motherboard has a 386, you may want to add a coprocessor, this should be added at this stage and the appropriate jumpers set.
- Next, depending on the system's case design, you may need to attach, with the supplied screws, a number of small brass or nylon spacers to the board. These slot into the chassis and keep it rigid, thus preventing damage when plugging in a new adapter card, or changing the processor chip. The position of the spacers should be shown in the documentation, otherwise compare the board to the case and select the correct holes. Always bear in mind that by bending a printed circuit board, you can easily crack the tracks and cause failure.
- The motherboard can now be positioned in the case with the bus slots towards the back. Position the spacer supports correctly, line up the mounting holes with the threaded studs in the chassis and then fix the motherboard in place, using the screws and washers provided with the chassis. Do not force anything to fit and do not overtighten screws - you might need to undo them later.
- With the motherboard installed, the power connectors can be attached (make sure that the PC is NOT connected to the mains before you do this, otherwise you could damage the system or yourself).
- Next, all the front panel connectors should be attached (a box showing cables and connectors is shown on pages 40 and 41).
- Connect the backup battery to the battery connector on the motherboard, making sure that the +ve terminal of the battery is connected to the +ve terminal lead on the board.
- Finally, double check everything before adding the video and disk controller adapter boards, reassemble the system and switch on. The system should power up, but will not boot directly into DOS since you will first of all have to set the system CMOS configuration (more about how to do this next month).

The Motherboard

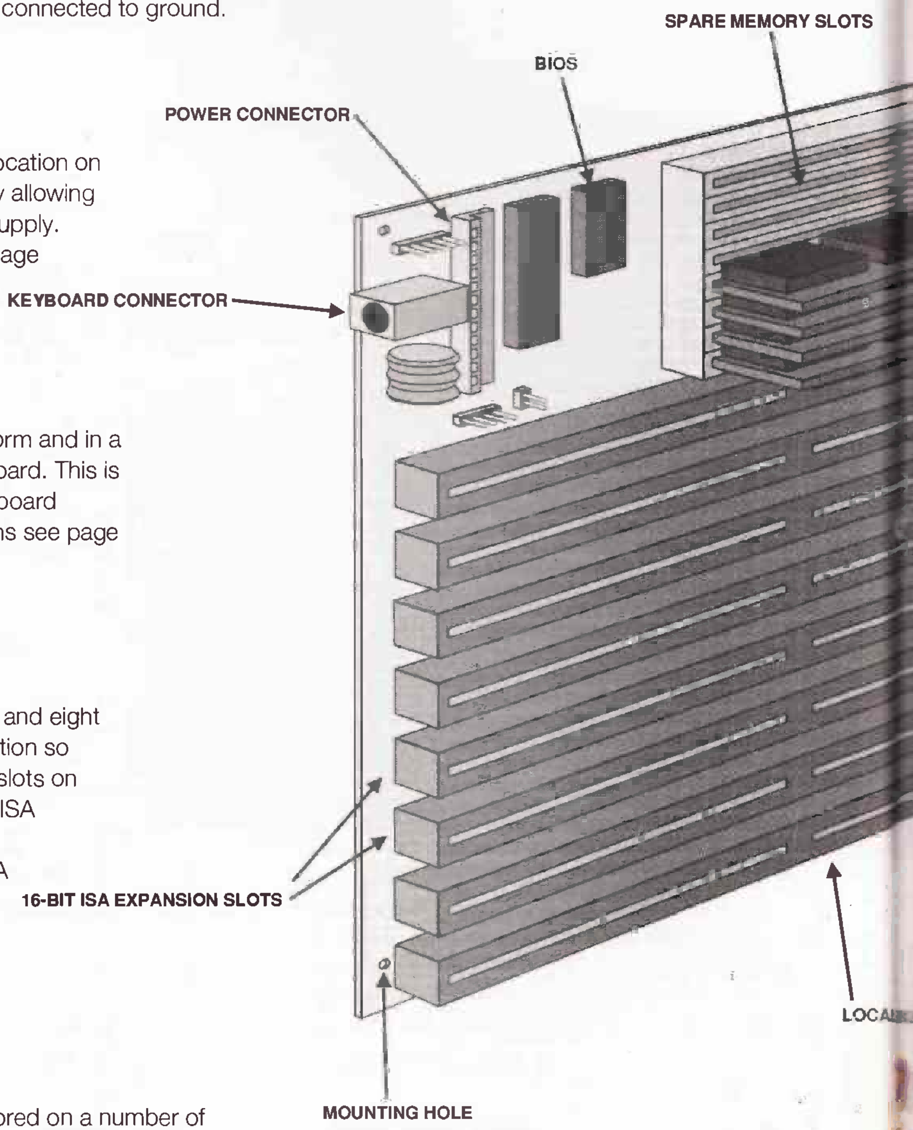
In this centre spread diagram, the motherboard is a standard VESA Local Bus 486DX2, with ISA expansion slots, cache memory, and space for up to 32MB of main system RAM. Different boards will have components in slightly different locations, but they should be easily identifiable from this diagram

BIOS chip

The BIOS chip is just a standard EPROM memory chip, on which is stored all the fundamental low level programs which make the system work as a whole - the routines which scan the keyboard, output a character to the display, etc. The BIOS chip also contains the Power Up Self Test, or POST, diagnostic routines (more about them on page 42). It should be noted that there are several different types of BIOS chip in use, which have been developed by different manufacturers but are all more or less equivalent to each other.

Power LED and keylock connector

As its name implies, the power LED is used to indicate that the processor is switched on. On many systems the keylock, which can be used to prevent the keyboard being used, is on the same connector. The keyboard is inhibited when the keyboard inhibit line is connected to ground.



PSU connectors

The two power supply connectors are in a standard location on all motherboards and have a standard format, thereby allowing all motherboards to be connected to any PC power supply. The power supply connector pin outs are shown on page 41.

Keyboard connector

The keyboard connector on all PCs is of a standard form and in a standard location at the right hand rear edge of the board. This is so that all motherboards will fit into all cases. The keyboard connector is a standard 5 pin DIN - for the connections see page 40.

Expansion slots

A typical motherboard will probably have between six and eight bus expansion slots. These are put in a standard location so that all motherboards will fit all cases. The expansion slots on the average motherboard will all be capable of taking ISA standard bus adapter cards, with probably six 16 bit slots and two 8 bit slots. If the board supports a VESA local bus, then two of the 16 bit slots will also have VESA bus sockets (for full specifications of the ISA bus, see June ETI pages 40-42)

RAM

Since this is a 486 board, the main system RAM is stored on a number of 1Mb or 4MB SIMMs. By using the 4MB SIMMs, this board will take up to 32MB of RAM in eight SIMM sockets.

CMOS chip and battery

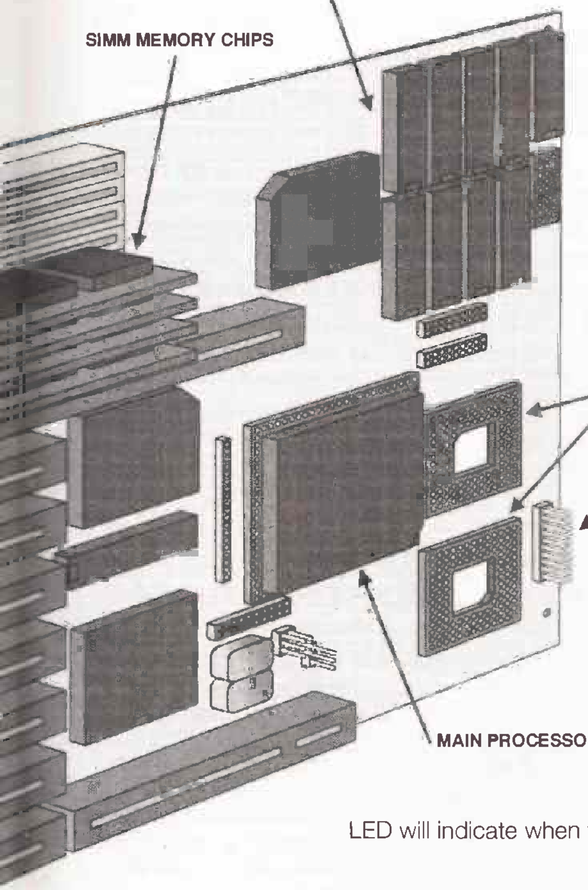
The CMOS chip is a small memory chip which is used to store the system set-up information required by BIOS when initialising the system during power up or reset, as well as information on current time and date. The data stored in this memory chip is retained, even though the system is switched off, thanks to a small battery, sometimes actually soldered to the motherboard. This battery will need replacing occasionally.

Cache memory

In order to overcome speed bottlenecks caused by memory being slower than processor access time, some high power systems have a special block of between 32 and 256K of very high speed RAM called cache memory (see ETI next month for a more detailed look at cache).

Overdrive socket

The 486 family and their motherboards are designed to be upgradable by simply changing processor chip. To allow for this, boards have an Overdrive upgrade socket. This socket can be either a separate socket, into which the upgrade processor can be plugged, or the existing processor can be mounted in a zero insertion force (ZIF) socket, so that it can be easily removed and replaced with the upgrade processor. A ZIF socket is identifiable by the small lever at the side of it. If there is an additional socket, then it is worth checking whether it is for an Overdrive chip or a Weitek coprocessor. If it is for an Overdrive, then the socket will have 169 pins and if for a Weitek, just 142 pins.



Reset switch

This push-button switch provides the system with a hardware reset function. Pushing this switch connects the two lines and causes the system to revert to a start up condition.

Speaker

All PCs are equipped with a simple speaker, usually a small Piezo electric type sounder. Output to this speaker is derived from a single output line and consists of a square wave of variable frequency. This means that the speaker is capable of outputting sounds of variable frequency but not of generating sounds of sufficient quality to produce good speech or music (both speech and music can be generated, but have a very course grating sound). To generate good quality sound output, an analogue waveform must be generated using a special adapter card, such as the popular SoundBlaster.

Turbo switch and LED

The turbo switch allows the user to change the processor speed. Connecting the two turbo switch wires together will cause the PC to run at a slow speed. The LED will indicate when the processor is running at high speed.

Clock circuitry

The system clock provides a regular synchronising signal for the entire system. It is derived from a crystal oscillator of a frequency which depends on the processor being used. The clock frequency is divided down to provide the processor clock, clocks for synchronous keyboard scanning and communications. The system's real time clock is derived from another clock source.

Processor

Since this board is for a 486DX2 you will find it as a large rectangular 105 pin chip with probably a large finned metal heat sink mounted on top. Older, lower power, processors may not have the heat sink (for a detailed look at processor chips see next month's ETI)

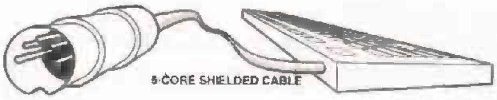
Serial port

On some, but not all, motherboards there is a built in serial RS232 communications port - COM1. It is usually located at the rear of the board and is connected to a proper 25 pin D type connector with a short length of ribbon cable.

Standard connections

The motherboard is connected to the power supply and front panel by a number of fairly standard connectors and cables. Although these standards are not universally adhered to, most manufacturers do use the same wire colours and of course all use the same cable connectors and the same connector configuration, in order to allow different motherboards to be used. You should find that your system has all of the following connectors:

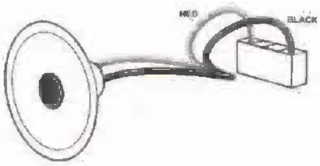
Keyboard connector



The keyboard connector socket is actually soldered onto the motherboard in a standard position at the rear of the motherboard. This is so that the connector on any motherboard will always match up to the appropriate hole in any case. The connector is a 5 pin DIN with 45 degree angle between pins, and the pin designations are as follows:

pin 1 keyboard clock pin 2 keyboard data
pin 3 N/C pin 4 ground pin 5 +5V

The above pin configuration is for a standard AT keyboard, in other words all modern PC keyboards. The keyboards for XTs are different.

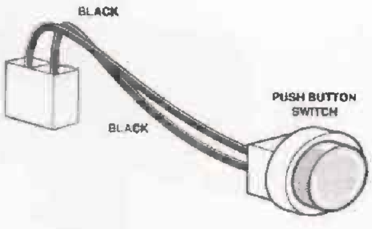


Speaker.

This is a 4 way socket with two wires connecting it to the speaker, the pin designations are as follows:

pin 1 data pin 2 N/C
pin 3 N/C pin 4 +5V This socket can be connected either way round.

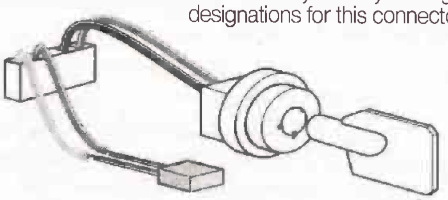
Hardware reset



Momentarily connecting these two lines together with the push button switch will initiate a hardware reset. This socket can be connected either way round.

Power LED and Keylock

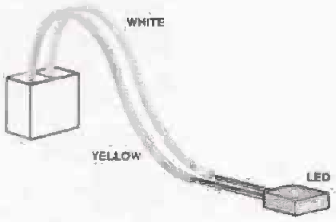
This five pin connector performs two functions, it indicates whether power is applied to the system and it also allows the user to disable the system by locking out the keyboard using a keyswitch. The pin designations for this connector are as follows:



pin 1 +ve power to LED pin 2 N/C or polarising key
pin 3 ground pin 4 keyboard inhibit
pin 5 ground

It is important that this connector is inserted the right way round.

Turbo LED



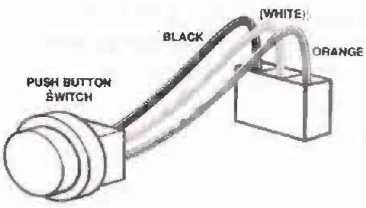
This LED indicates the speed of the motherboard, high or low. It uses a two pin connector and the pin designations are as follows:

pin 1 LED anode (+ve) pin 2 LED cathode (-ve)

It is important that this connector is the right way round. Note that on some larger cases the single LED is replaced with an LED display of the speed in numbers rather than a simple on/off indicator.

Turbo switch

The turbo switch connector is one of the least standard connectors. On some systems it uses two wires which, when connected together, will cause the system to run at slow speed. On other systems three wires are used, connecting lines 1 and 2 will make it run at one speed and lines 2 and 3 at the other speed. The three wire connector is the less common of the two forms, but with either sort, it does not matter which way round the connector is inserted.



External CMOS backup battery

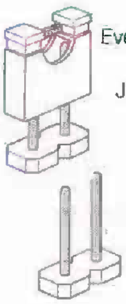
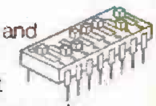
Some systems use an external battery to supplement the power of the on-board NiCad battery, which is used to retain the system set-up data and real time clock stored in the CMOS memory chip. It is usually a four pin connector and pin designations are as follows:

pin 1 +3.6 or 6V pin 2 N/C or polarising key
pin 3 ground pin 4 ground

It is of course very important that the battery is connected the right way round, usually the +ve connection has a red wire and the ground connections black wires. If you are in any doubt, it is better to leave the external battery unconnected, the system will still work with the on-board NiCad battery, so long as it is not left unused for long periods. It should also be noted that some systems use a 3.6V external battery whilst others use a 6V battery.

Some systems may have additional displays, for example a four digit status display, but since these are non standard they have not been included in the above list. In fact you may be unable to use them if you change motherboard. Unless otherwise specified all connectors are 0.1in PCB connectors with the socket on the end of the cable. When removing, always make sure that they are reinserted the right way round, not all of them use a polarising pin and incorrect reconnection can in some cases cause damage. N/C indicates that there is no connection to that pin

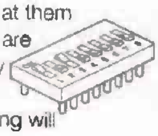
Jumpers and DIP switches

Every motherboard will need to be configured in some way or another and this usually done by carefully following the manual and setting the various jumpers and/or DIP switches so that the system has the desired configuration.

Jumpers are simply very small plugs which are used to short together two pins. The jumper is open when the plug is absent and closed when it is present. Fitting jumpers can be very fiddly, they are very small and often arranged in banks which can make setting them even harder. A small pair of tweezers is the best way of removing or inserting jumper plugs.

DIP switches are easier to set, they are in fact small banks of switches, usually eight in a bank. If you look carefully at them you will see that the individual switches are numbered and that one side is marked on and the other side off. There are two types of DIP switch, one has small rocker switches and the other has slide switches. Both types are best set by pushing the appropriate switch to the desired on or off setting using a small screwdriver.



Always carefully double check settings, they are all very small and it is all too easy to make a mistake. Errors in setting will probably not cause any damage but they will stop the system from working properly.

The power connectors

:Power is delivered to the motherboard from the PSU via two 0.2in 6 pin connectors. The pin configuration and usual wire colours are as follows:

pin 1	power good signal	orange
pin 2	+5V	red
pin 3	+12V	yellow
pin 4	-12V	blue
pin 5	ground	black
pin 6	ground	black
pin 7	ground	black
pin 8	ground	black
pin 9	-5V	white
pin 10 +5V		red
pin 11 +5V		red
pin 12 +5V		red

The PSU

The power supply in a PC consists of a sealed unit which encloses a switched mode power supply capable of converting an AC mains input to a low voltage DC output. In standard systems, the CPU and main processor circuitry all need a 5V DC power supply to operate (with the exception of low power SL based systems where the CPU operates at 3.3V). In addition a 12V DC power supply is needed for motors in disk drives, etc.

The power supply in a modern 486 based system should be rated at about 200W, sufficient to power the system and any additional memory, adapter cards, disk drives, etc. The rating of a power supply is usually displayed on a label attached to the top of the PSU and with a 200W PSU the current available at each voltage is as follows:

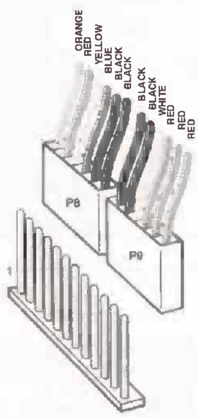
+5V	20A
-5V	0.5A
+12V	8A
-12V	0.5A

It can be seen from this table that on a 200W PSU there is in fact only 100W of available power at +5V. With a lot of adapter cards installed, in particular modems and network cards which draw a lot of power, this may prove insufficient and give rise to intermittent faults. If this is the case, you may need to install a larger PSU.

Intermittent faults can also arise from an improperly grounded power supply producing a high level of bus noise. A good power supply will have a ground wire which is attached to the chassis. If one does not exist, it is a good idea to add one - simply solder a length of 20 gauge wire to the input ground wire going into the power supply and attach the wire to the chassis

PSU faults

As I have already stated, the power supply on a PC is a sealed unit and thus should not be considered an item which can be easily repaired. They are relatively cheap and it is better to replace a faulty power supply than run the risk of damaging the rest of the system. Replacing the PSU is a very simple operation and just involves undoing the connectors, removing a few fastening screws, sliding out the old unit and then inserting the new one (when working with the power supply, always make sure it is unplugged from the mains before doing anything).



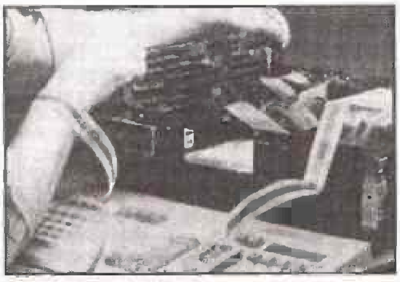
The most common reason for a power supply to fail is that there has been a high voltage surge or spike on the line (these can totally destroy the PSU and may even destroy the whole system). We can define a spike as an over voltage of less than one millisecond and a surge as one lasting between several milliseconds and several seconds. The reverse situation is a short period of under voltage, a so called brown out, which is by and large not damaging to the system, but could cause it to reset with consequent loss of data.

There are two main causes of spikes and surges. One is as the result of fluctuations in the power supply, caused primarily by a large appliance on the same circuit cutting off and on. The other common cause is lightning strikes near to the PC or the power lines. If you think that there is a danger of spikes or surges, for example the PC is being used in a factory full of heavy electrical machinery, then a wise precaution is to invest in a surge protector inserted in the mains power supply to the PC, although even this may not protect you from the type of spike encountered in a lightning strike (it is said that putting a knot in the power cord will absorb the surge from a lightening strike and burn out the lead rather than the power supply, although, I have never had reason to test this idea out!). Conversely, if brown outs and power failures are a problem, then an uninterruptable power supply is a good investment.

It is always a good idea to check the mains power supply before attaching a PC, since if it has been wired incorrectly it could not only damage the PC but render the system dangerous to the user. It is also a good idea to ensure that your PC is the only device on a circuit and it should never share a circuit with devices with large electric motors (e.g. washing machines), photocopiers, or resistive heating devices, all of which can cause spikes and surges. It is also a good idea to make sure that your PC and its peripherals all share the same ground. This can be done by plugging them into the same outlet via a distribution block.

Lastly, keep your power supply clean. It generates a lot of heat and if cooling is prevented by insufficient airflow across it, the power supply can easily overheat and fail. The fan and air vent holes should be cleaned regularly, using a soft brush and/or a can of air duster. You will be surprised how much dust a PC can accumulate in a relatively short time.

Anti-Static Precautions



We all tend to build up a small static charge in our bodies as a result of moving around, the friction of clothes, etc. Normally, such charges are small and quickly dissipated. However, the widespread use of synthetic fibres in clothing, carpets, and furnishing fabrics, plus the use of synthetic rubber soled shoes, means that there are fewer chances for the static charge to dissipate. Consequently the human body, acting as a large capacitor, can store quite a considerable charge.

Static electricity is an ever present hazard when handling electronic components, because the very high voltages present in the body of the handler, if discharged, can easily destroy sensitive integrated circuits.

The best way to eliminate this problem is to discharge the static from your body prior to handling any sensitive circuitry. This can be done by simply touching something conductive which is attached to earth, for example a mains water pipe, a metal central heating radiator, or electrical earth on the mains system.

The trouble is that it is not always convenient to have to keep touching an earthed metal object in order to discharge your static electricity. A better way is to use an anti-static wrist strap, which is a simple conductive band held onto the wrist by a Velcro fastener. The conductive strip is attached to a cable via a 1Mohm resistor for safety and the other end of the cable is attached via an insulated alligator clip to electrical earth. This simple little wrist strap will drain away all damaging static charge, however, be careful to remove the strap before working with live voltages.

Anti-static wrist straps are available from Maplin Electronics and cost £6.95 each.

Testing and Troubleshooting a Motherboard

If you are faced with a non-functioning motherboard, all is not necessarily lost. There can be a number of causes which if rectified will restore the board to full operation.

- The first step in testing and troubleshooting any electronic device is to thoroughly check the power supply. To do this, you will need a good multimeter set to measure DC at the next range above 12V. Then, using the power connector diagram on page 41 as a guide, check the voltages on the following pairs of connectors

Minimum voltage	Maximum voltage	Black -ve meter probe	Red +ve meter probe
+4.8	+5.2	P8 pin 5	P9 pin 4
+4.5	+5.4	P9 pin 3	P8 pin 6
+11.5	+12.6	P9 pin 1	P8 pin 3
+10.8	+12.9	P8 pin 4	P9 pin 2

Failure can also be caused by AC ripple getting through the power supply. This is a common source of intermittent failure, but we can test for this problem with a multimeter by setting it to read AC voltages in the range just above 12V and then checking the motherboard power connectors with power applied, thus:

Black probe	Red probe	Voltage
P8 pin 5	P9 pin 4	less than 0.25V
P9 pin 3	P8 pin 6	less than 0.25V
P9 pin 1	P8 pin 3	less than 0.6V
P8 pin 4	P9 pin 2	less than 0.6V

If all the measured voltages fall within the ranges in the above two tables, then the board power supply is OK. If not; then disconnect the power supply from the motherboard and recheck the voltages in order to isolate whether the fault lies in the PSU or on the motherboard.

- Next, unplug the system from the mains and check all the motherboard connectors and socket mounted ICs, to ensure that they are plugged in correctly.
- Look for any foreign object such as a screw, small piece of wire or solder which may have accidentally dropped onto the board.
- Check that all the system board switch and jumper settings are correct.
- Check for signs of overheating (a brown scorched board).
- Check for broken tracks and poorly soldered joints.
- Then, remove all adapter cards and unplug the power connectors. Now set the multimeter to measure resistance and measure the resistance between the various pins on the motherboard power connectors in accordance with the following table:

Black -ve meter probe	Red +ve meter probe	Resistance
5	3	17ohms
6	4	17ohms
7	9	17ohms
8	10	0.8ohms
8	11	0.8ohms
8	12	0.8ohms

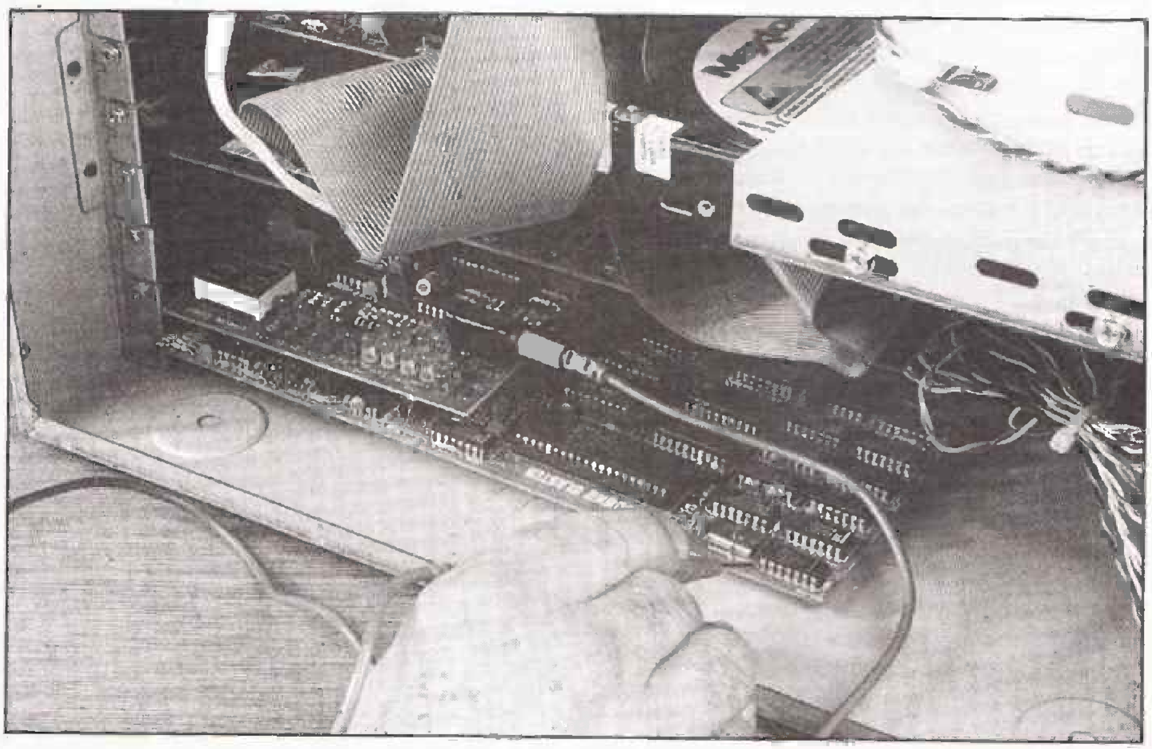
Improper resistance reading may indicate that the motherboard is defective, most likely a single defective component.

Unfortunately tracking down a fault on the motherboard can be very difficult without a little help.

Complete board failure is relatively rare and will only happen when the power supply is at fault or the CPU chip fail. In most situations the board will still work after a fashion and in such cases we can use the processor and the BIOS self test procedures to help us locate faults on the motherboard. To do this we need a special plug-in adapter board called a POST card, a typical example of which is POST Probe by Micro 2000.

With a POST tester, it is possible to track down most faults with a PC, including a large number of motherboard faults and it is an essential tool for anyone seriously involved in repairing and maintaining PCs. The Micro 2000 POST Probe card and its associated diagnostic software allows one to track down faults at all levels of functionality, even faults on boards unable to produce POST codes.

For more details on the POST Probe card contact Micro 2000 in Letchworth, on 0462 483483.



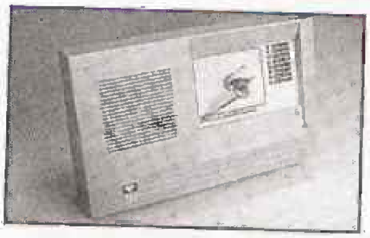
Using a POST probe cord.

Next Month...

We shall be looking at processors, co-processors, overdrive chips, cache memory and high speed bus systems.

ELECTRONICS TODAY INTERNATIONAL

Competition



WIN A SUPER SOPHISTICATED *'FOX' WIRELESS ALARM SYSTEM* FROM MAPLIN ELECTRONICS

The Fox alarm system is an advanced way of protecting a home or business from intruders which does not require the installation of yards of ugly wiring around the building. There is no wiring, because the intrusion detectors and the control panel all communicate using small radio transmitters. This means that the system is very easy to install requiring just simple DIY skills.

This sophisticated alarm system can easily be moved or expanded and there is a wide range of additional sensors and accessories which can be added. Furthermore, because there are no wires, it is not so easy for a knowledgeable intruder to detect and disable.

The system has been ergonomically designed and is very easy to use - just one button controls arming, disarming and panic functions. The control panel is compact and attractively designed and included with the basic system is the wireless control panel, a wireless PIR intruder detector, a wireless contact transmitter for use on doors and windows and a two button key-fob transmitter for remote operation (note that the Fox alarm fob will also operate the Maplin Vixen car alarm). Highlight features include:

● 4 detection zones, part of full arming capability ● Remote control panic alarm ● Easy to install, simple instructions ● No unsightly wiring between detectors ● Fully DTI approved transmitters ● Full remote control operation via key-fob transmitter, up to four transmitters can be used ● Built-in 120dB siren ● Fully expandable system ● Automatic battery back-up during mains failure and low battery warning ● Intrusion history display shows when alarm was triggered.

The complete basic system costs £99.99 and can be won by one lucky *ETI* reader. That reader could be you!

To enter this competition all you need to do is find all the hidden words in the following puzzle. To make it easier we will give you one clue - *all the hidden words come from the text on this page.*

Send your list of the words you have found, written on a postcard or the back of an envelope, to:

ETI, FOX Competition, Argus House, Boundary Way, Hemel Hempstead, Herts., HP2 7ST.

All entries must be received before July 30th when a draw will be made from all correct entries to decide the winner.

Rules The competition is open to all UK residents other than employees or their families of ASP and Maplin. The prizes are as stated and there is no cash alternative. The editor's decision is final and no correspondence can be entered into.

T	H	M	G	V	D	Y	S	K	Y	R	V	M	I	O
Q	X	E	N	R	O	T	C	E	T	E	D	D	I	L
I	M	K	K	F	E	Y	H	A	E	T	K	G	W	J
I	B	K	T	I	W	D	S	L	C	T	W	T	E	V
O	L	J	W	Y	W	L	U	A	N	I	T	V	I	B
E	T	N	J	N	L	Y	Y	R	E	M	N	X	N	M
F	H	L	N	S	N	U	V	M	T	S	E	R	P	Q
H	V	G	O	R	V	E	O	K	O	N	R	W	T	S
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D	S	Q	O	Y	T	R	K	H	D	R	S	V	M	I
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B	U	B	F	O	C	M	O	L	O	K	O	J	O	V
V	G	D	O	O	H	E	E	C	G	T	O	C	D	S
F	E	I	B	L	X	S	W	W	A	H	V	E	Y	I
M	F	X	P	N	S	B	D	R	X	R	U	X	L	O

Loop Alarm

Keep thieves at bay - build Terry Balbirnie's link alarm

This type of loop alarm may already be familiar to readers because it is often to be seen in camera shops and stores selling audio equipment. It works by passing a continuous link wire through the handles of any items that need to be protected. The ends of the wire are then plugged into the unit. If the loop is broken, either by cutting the wire or unplugging it, the alarm sounds. It is thus impossible for a potential thief to remove an item without setting it off. Replacing the plug, or re-connecting the wire does not silence the alarm - re-setting can only be achieved by using a key-operated switch.

This alarm will be of particular interest to shop owners and market traders since it provides good protection against theft, yet allows people to handle the goods freely. It will also be useful to anyone who needs to protect their valuable Hi-Fi and video equipment, cameras, etc. With a little ingenuity, most items can be accommodated. Another use for the device is to provide a warning when drawers, doors, cupboards, windows, etc. are opened. For this type of purpose thin, breakable wire could be used. The link wire itself may be of any reasonable length so the alarm can be used to protect equipment over a very wide area.

The alarm is housed in a plastic box with integral battery pack and sounder. The key-operated arm/disarm switch is mounted on top and there are two phono sockets on the back, to which the ends of the wire loop are connected. The sounder used in the prototype has the familiar 'yelping' tone associated with alarms and the one specified is very loud, while having a reasonably low current requirement. Readers are advised not to use small, cheap buzzers which will not be loud enough for the purpose.

While armed, the circuit requires less than 15mA and the 12V battery pack may be expected to provide a life in excess of 1 year. While sounding, the current rises to 150mA but this will only happen occasionally and for short periods of time. It should therefore have little effect on battery life.

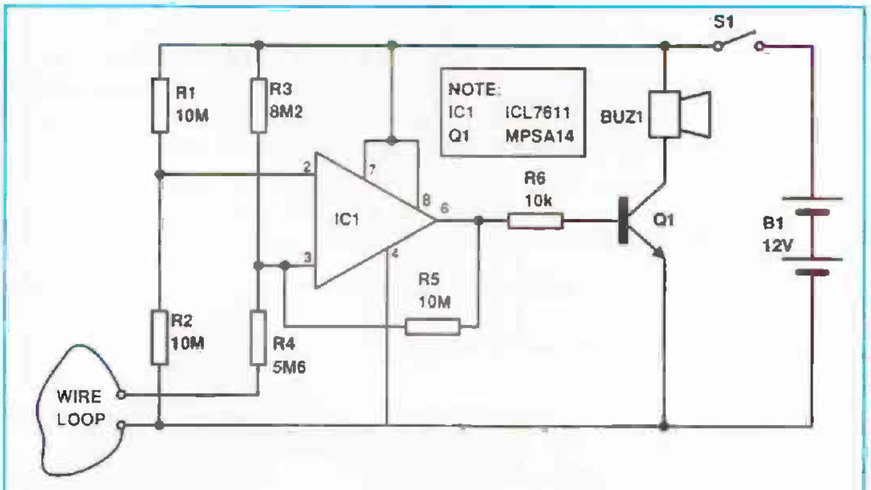


Figure 1: Loop alarm circuit diagram

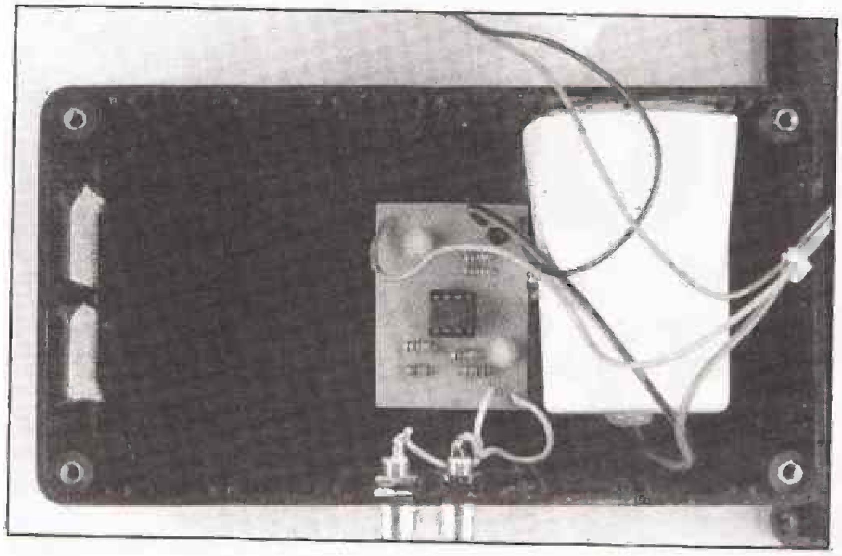
Circuit description

The circuit for the loop alarm is shown in Figure 1. The main component is IC1, a micropower CMOS op-amp which is used here as a voltage comparator. This particular device has been chosen because of its exceptionally small current requirement, which is essential for a long battery life.

Resistors R1 and R2, form a potential divider connected across the nominal 12V supply. Since the arms have equal values, this applies a steady voltage equal to one-half of this value (nominally 6V) to the op-amp inverting input, pin 2. With the loop connected, resistors R3 and R4 provide a further potential divider which (ignoring the effect of R5 for the moment) applies a voltage of 5V approximately to the non-inverting input, pin 3. Thus, the voltage applied to the inverting input is higher than that at the non-inverting one. Under these conditions, the op-amp is off with the output, pin 6, low. There will therefore be no effect on transistor Q1 and the rest of the circuit.

When the loop is broken, R4 is disconnected and R3 makes pin 3 high (+12V). The input conditions are now reversed with the non-inverting input being at a higher voltage than the inverting one. The op-amp therefore switches on with the output high. Current enters the base of Darlington transistor Q1 via current-limiting resistor R6, so turning it on. This operates the sounder, BUZ1, in the collector circuit.

In fact, the operating conditions are more complicated than



described above, due to the effect of resistor R5. This applies some positive feedback from the output to the non-inverting input. Taking this into account and with the loop intact, the voltage at pin 3 will be 3.6V approximately when the circuit is switched on. Being less than 6V, the output will be off. When the loop is broken, the voltage will rise to 6.6V, so triggering the alarm. With the output on, the non-inverting input voltage will immediately rise to 12V and maintain the on state. If the loop is re-made, the voltage will fall but only to 6.6V, so the alarm will remain triggered. Cancelling operation is effected by first re-connecting the loop, if this has not already been done. Key-operated switch S1 is then switched off to break the supply then on again. With the output low, the voltage at pin 3 will be 3.6V and the alarm will revert to standby mode.

Note that as the battery voltage falls with age, the input conditions remain the same. This is because the voltages at IC1 inverting and non-inverting inputs are derived from potential dividers connected across a common supply. They will therefore fall together and the operating point will be the same. Eventually the batteries will need to be replaced, simply because they will fail to operate the sounder loudly enough.

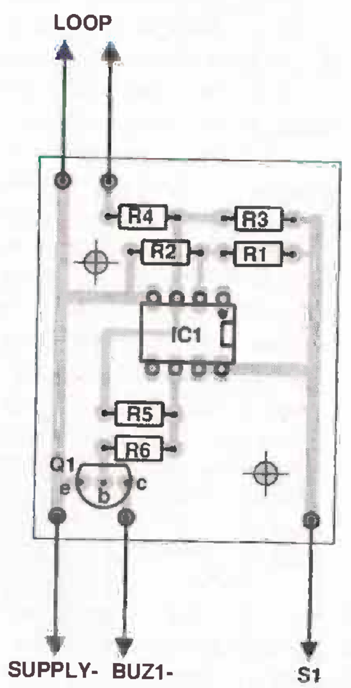


Figure 2: Loop alarm component overlay

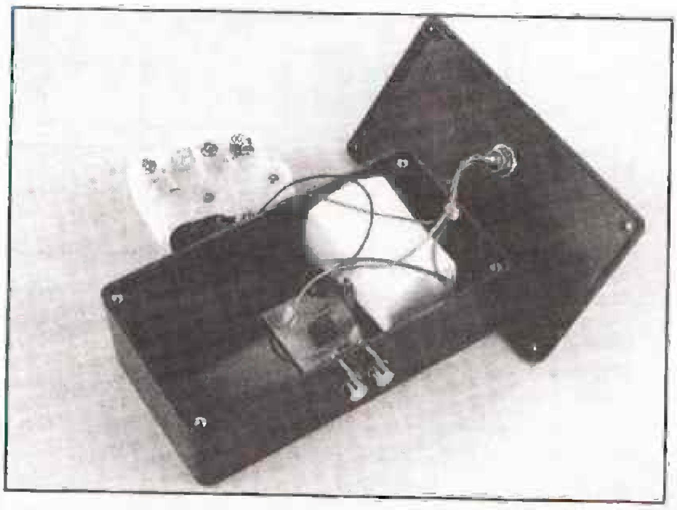
Construction

Construction of the loop alarm uses the single-sided PCB layout shown in Figure 2. Begin by drilling the two mounting holes in the positions indicated, then solder the IC socket into position. Follow with the resistors and transistor. Do not insert IC1 into its socket yet. Solder pieces of light-duty stranded connecting wire to the three pads marked loop and S1. If the battery holder has a PP3 type snap connector, solder the negative wire of this to the pad marked supply -. if it is of the type having solder tags, use a piece of wire instead.

Drill the hole in the lid of the case for the key switch. Drill holes for BUZ1 mounting bracket and one 35mm in diameter for the sound to pass through. Make holes in the back panel for the phono sockets and two in the base to correspond with those in the circuit panel. Solder the negative sounder wire to the pad marked BUZ- and mount the remaining components. Insert IC1 without touching the pins. Alternatively, touch something that is earthed before handling it. This is because IC1 is a CMOS device and could, in theory at least, be damaged by static charge which might exist on the body. When attaching the circuit panel, place some plastic washers on the bolt shanks to keep the soldered connections clear of the base of the box. Complete construction by wiring up the positive battery pack connection, the switch, positive sounder wire and the phono sockets as shown in Figure 3. The battery pack could be secured using Velcro pads or a block of foam plastic. Attach self-adhesive plastic feet to the base of the box if necessary.

Testing

Testing the loop alarm is simply a matter of checking for correct operation. It may be helpful to cover the sounder hole with cardboard during testing because it is very loud. Make a wire loop using a piece of wire with a phono plug soldered to each end. Note that only the centre (pin) connections are used. Plug the link wire into the sockets, insert eight alkaline AA size cells in the battery holder and switch on. The alarm should remain silent. Remove one of the plugs and the alarm should sound, continuing to do so even when it is replaced. Cancel operation by switching off, then on again. If the circuit works



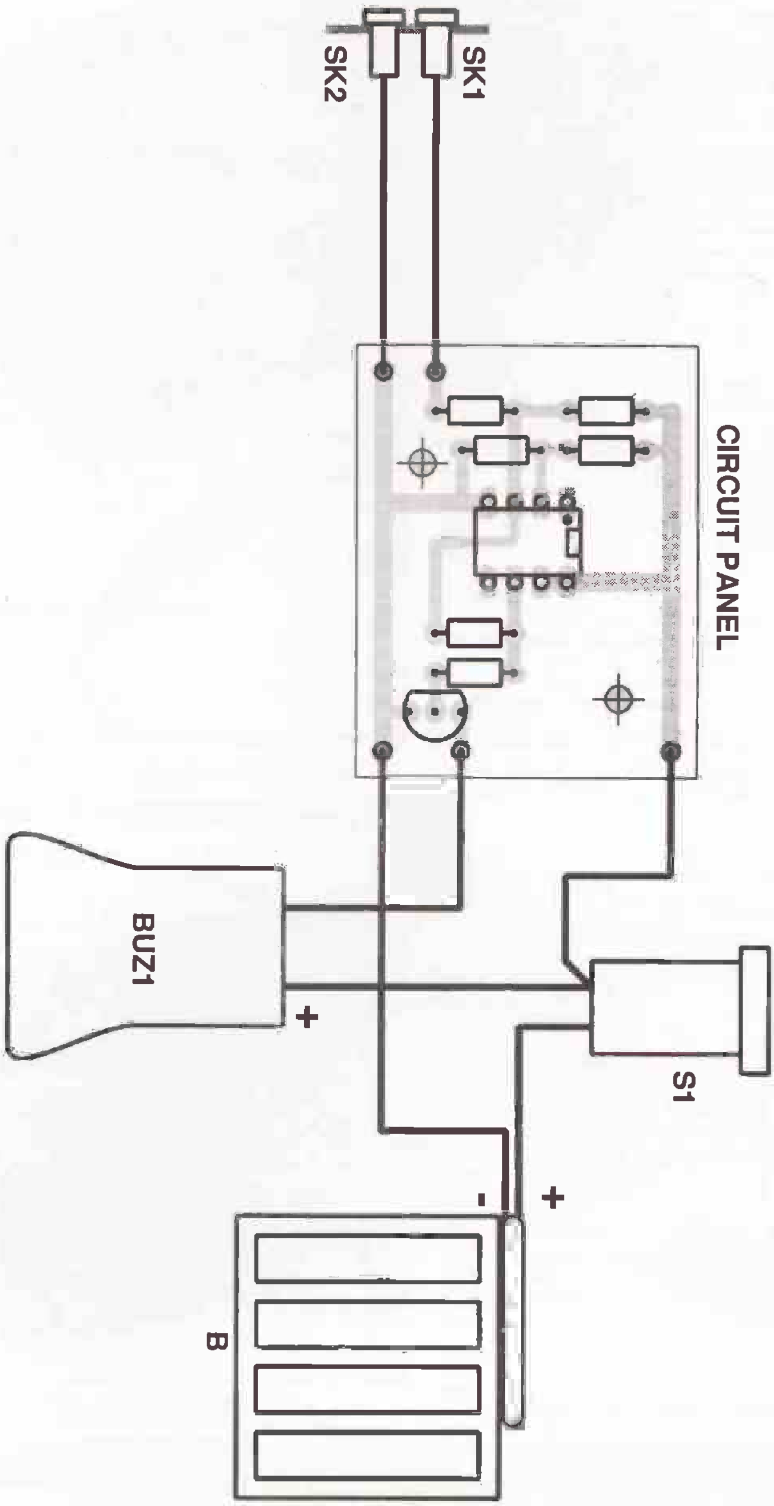


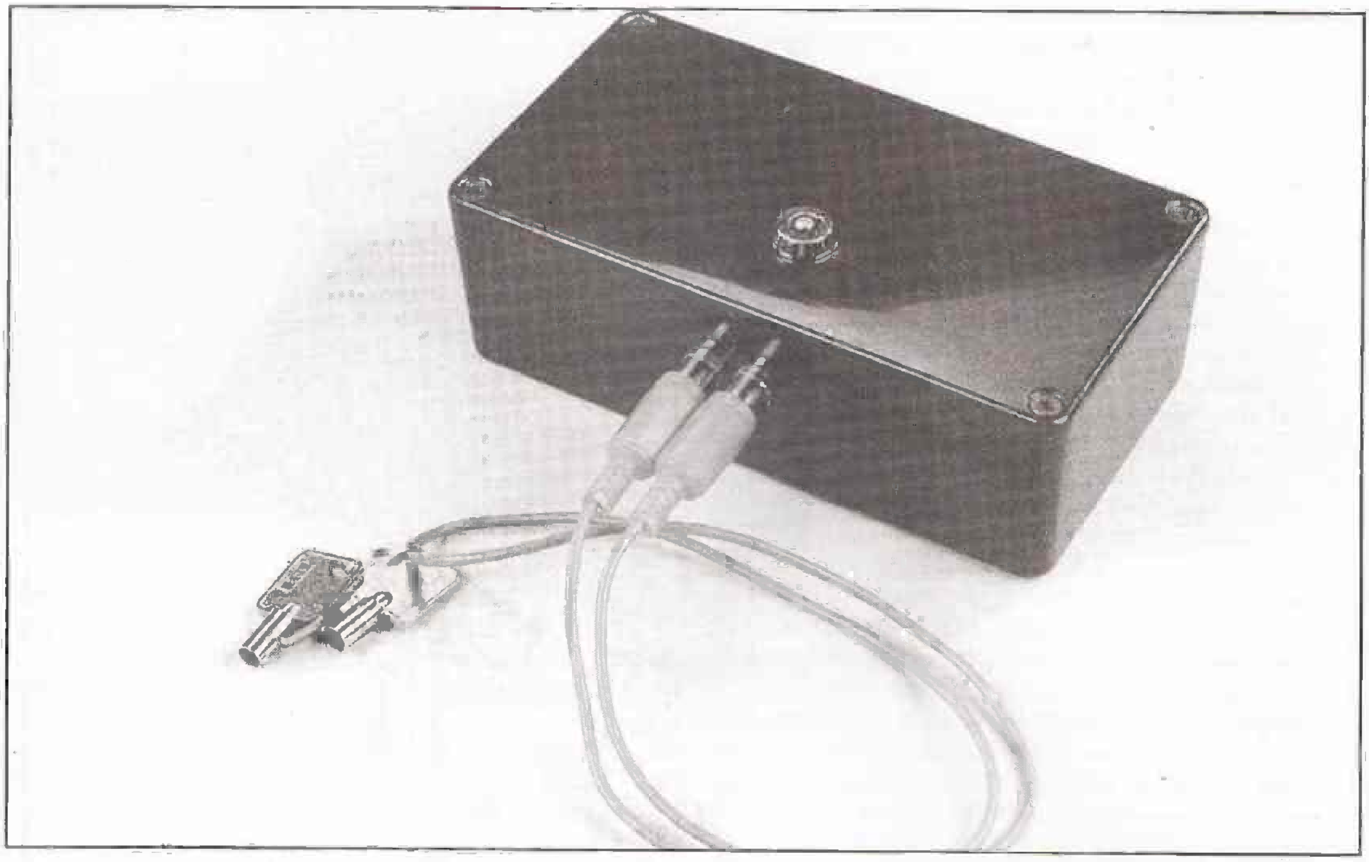
Figure 3: Loop alarm wiring configuration

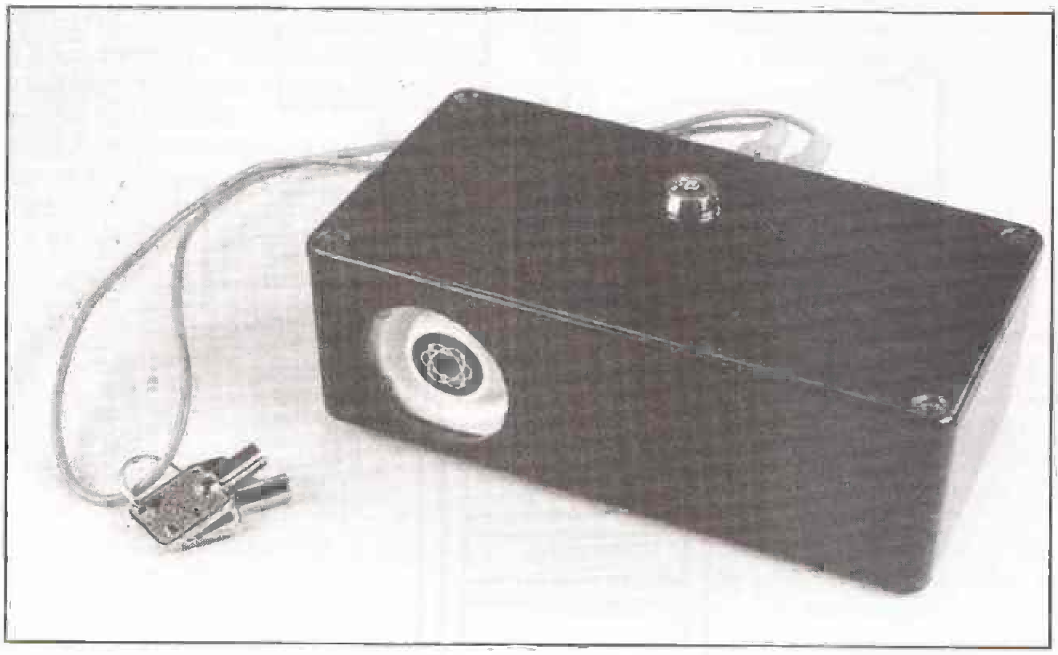
correctly, it can be put into permanent service. It may be useful to make up several loops of different lengths to suit the application. Note that for best reliability, wire sold as 'extra flexible' should be used. Do not use single-core wire as this will break in service and trigger the alarm. S1 may be used to switch the unit off if it is not to be used for a long time. It will also be used when items need to be added or removed from the system.

The alarm should be checked every few weeks to ensure that the batteries will operate the sounder effectively. It is recommended that the batteries are replaced at least every year and more frequently if the unit has been called upon to sound often.

BUYLINES

Most of the components for the loop alarm are freely available. The ICL7611 op-amp is not stocked by all suppliers but may be obtained from Electromail, Cricklewood Electronics and Greenweld. The sounder was obtained from Maplin (order code JK42V). Extra-flexible wire can also be obtained from Maplin.





PARTS LIST

RESISTORS

R1,2,5	10M
R3	8M2
R4	5M6
R6	10k

All resistors should be of the metal film 1% type.

SEMICONDUCTORS

IC1	ICL7611
TR1	MPSA14

MISCELLANEOUS

S1	SPST Key-operated switch
BUZ1	Micro siren. 12V 150mA operation. Output 110dB at 1m.
PL1,2	Phono plugs
SK1,2	Chassis phono sockets.

PCB materials. 8-pin dil IC socket. Plastic case size 150 x 80 x 50 mm external. Battery holder for 8 AA cells and alkaline cells to fit. PP3-type snap connector for battery holder (if needed). Extra-flexible wire for loop as required.

PROJECT

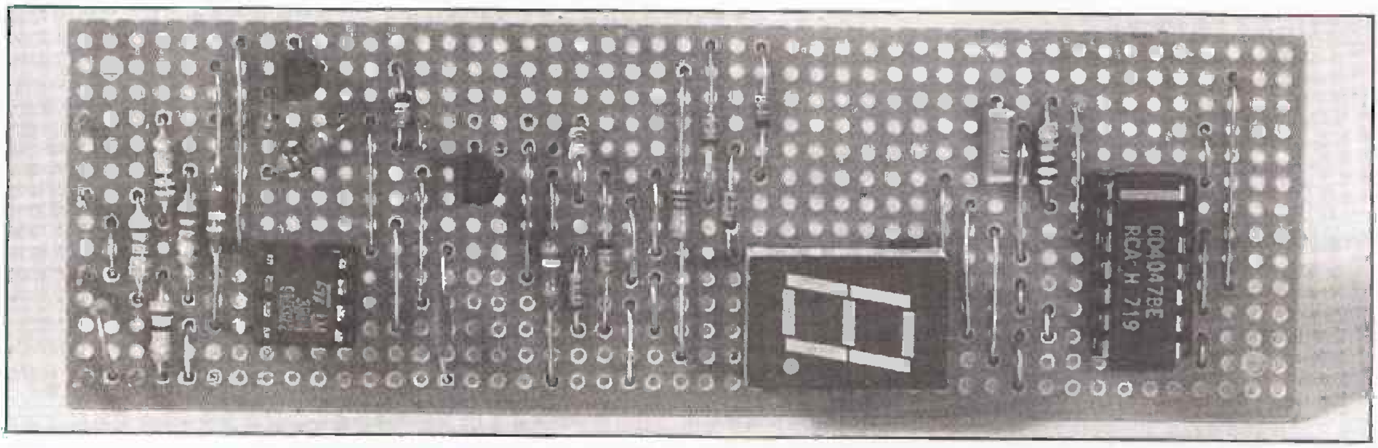
BASIC CIRCUITS

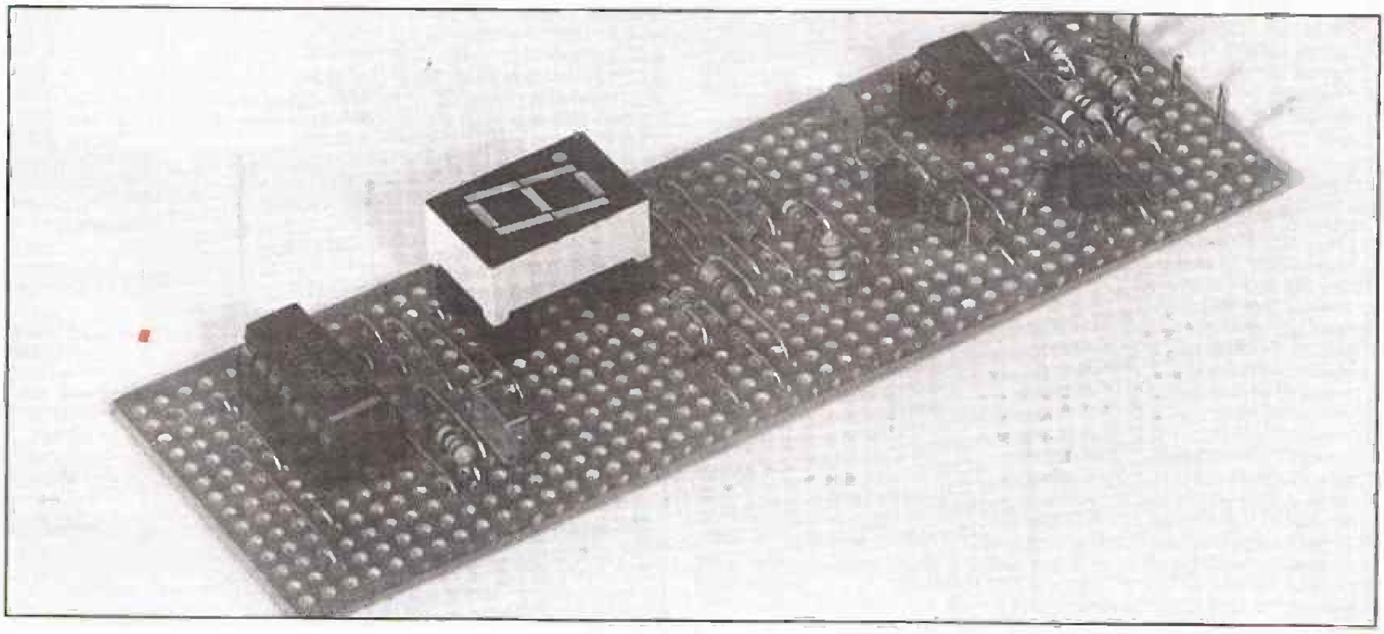
Logic Probe

In the first of a new series of low cost circuits which can be built by anyone in a couple of hours, using just a soldering iron and a few basic tools, Robert Penfold describes how to make a versatile logic probe

It is the generally accepted wisdom that a multi-range test meter ('multimeter') is the essential first piece of test gear. However, for someone who is primarily involved in digital electronics some form of simple logic tester could reasonably be deemed just as important as a multimeter. In fact, it could be judged more important, as it is likely to provide more useful information than the voltage ranges, etc., of a test meter. The most common form of basic logic tester is a logic probe and the one featured here is CMOS compatible, but will also work quite well with circuits based on TTL devices, or devices which operate at standard TTL levels.

B:The logic state at the test point is indicated via a seven segment LED display. If the test point is at logic 0 (low) a '0' is displayed - if it is at logic 1 (high) a '1' is displayed. If the input is





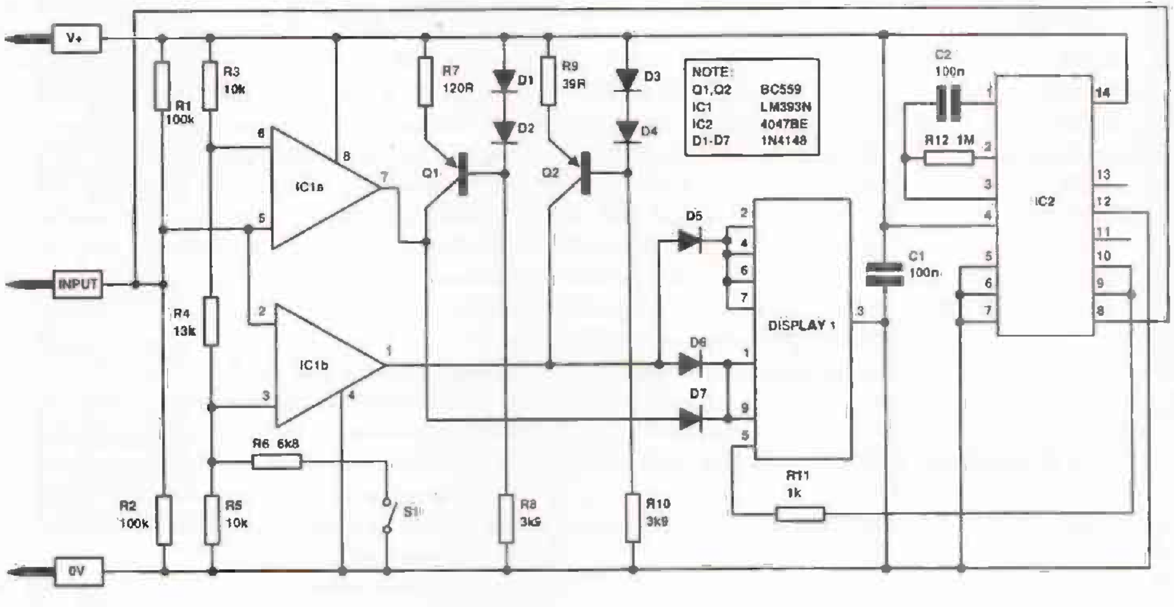


Figure 2: The logic probe circuit diagram.

taken to an invalid voltage between the maximum low and minimum high levels, the display goes completely blank. If the test point is pulsing at a low frequency, the displayed number will be seen to change in sympathy with the input logic level.

At input frequencies of more than about 25Hz, the switching of the display will be too fast for the human eye to perceive it properly. A figure '0' will appear to be displayed continuously. The two left hand segments will be brighter than the other four if the input signal is at logic 1 for a greater percentage of the time than it is at logic 0. Apart from this, the main display will not give a clue that the test point is pulsing. To avoid confusing results, a pulse detector circuit flashes the decimal point when a pulsing input signal is present.

Construction

To make the construction of this project as easy and simple as possible, it is built on a piece of standard Veroboard. Details of the component panel are provided in Figure 3 (component side) and Figure 4 (copper side). This layout is based on a 0.1in pitch stripboard panel measuring 47 holes by 14 copper strips.

The first stage in construction is to cut the board to size and then cut the appropriate tracks. After cutting the board to size, drill the two mounting holes and make the breaks in the copper strips. These breaks can be made using the special cutter, or a hand held twist drill bit of about 5mm in diameter will do the job quite well.

Fitting the components is mainly straightforward, but the board is quite crowded in places. This makes it essential to use modern miniature components. C2 should be a printed circuit mounting type having 7.5mm (0.3in) lead spacing. Be careful not to omit any of the link-wires, which can be made from about 22 s.w.g. tinned copper wire, or the trimmings from resistor leadout wires.

The integrated circuit, IC2, is a CMOS device and it therefore requires the standard anti-static handling precautions. It does not have full internal protection circuitry, making it more important than usual to take these precautions. This essentially means earthing yourself before handling this component in order to discharge any static electricity you may have picked up from wearing clothes made from synthetic fibres, walking across a carpet, etc. One can effectively earth oneself by touching any bare metal object which is 'connected' to the earth, such as a metal water pipe. It will then take some time for your body to re-acquire a static charge.

As a further precaution against damage, from either static electricity or overheating, the ICs should be fitted in a holder rather than being soldered directly to the circuit board. The ICs can then be inserted when the rest of the assembly is completed. When inserting the chips into their sockets, take great care not to bend any of the pins so that they fold under the IC, and also make sure that they are inserted the correct way round. The little notch in one end of the IC indicates the location of pin 1.

The display must be a common cathode type, not a common anode display. It must also be a 0.5 or 0.6in type, having the standard ten pin base and pin-out arrangement if it is to fit into this component layout properly. Ideally, it should be fitted into a holder, but a suitable ten pin holder will probably prove to be unobtainable. 'Soldercon' pins can be used to make up a suitable holder, or a standard 14 pin type can be carefully cut to produce two 5 pin s.i.l. holders which will take the display.

The probe draws its supply current from the circuit under test via a couple of leads, which are terminated in crocodile clips. It is advisable to use red and black crocodile clips and (or) leads to show the polarity of the supply leads, red on the +ve lead and black on the -ve lead. Getting the supply polarity wrong could easily result in one of the integrated circuits being damaged.

Units of this type are normally built as probe devices, but it is not

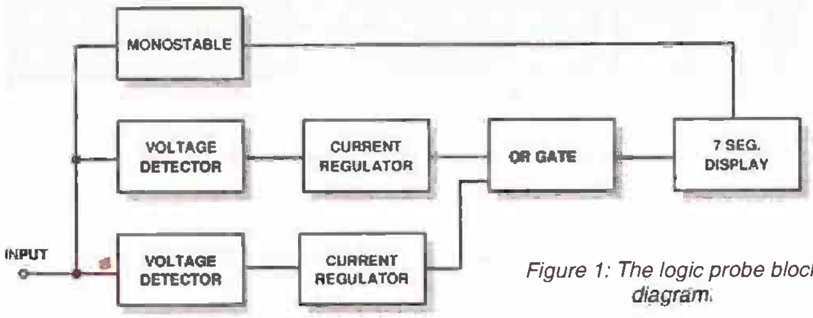


Figure 1: The logic probe block diagram.

PARTS LIST

RESISTORS (All 0.25 watt 5% carbon film)

R1, R2	100k
R3, R5	10k
R4	13k
R6	6k8
R7	120R
R8,	R10 3k9
R9	39R
R11	1k
R12	1M

CAPACITORS

C1	100n ceramic
C2	100n polyester (7.5mm lead spacing)

SEMICONDUCTORS

IC1	LM393M
IC2	4047BE
TR1	BC549
TR2	BC549

D1 to D7 1N4148 (7 off)

DISPLAY

1 0.5 or 0.6in common cathode LED display

MISCELLANEOUS

S1 is a s.p.s.t. miniature toggle switch. Probe type case (carefully check inside dimensions to ensure board will fit before buying), available from suppliers such as Maplin. 1 piece of 0.1in pitch stripboard, having 47 holes by 14 copper strips. 1 off 8 pin d.i.l. IC holder. 1 off 14 pin d.i.l. IC holder. 1 off display holder (see text). Test leads made from 50cm of red multicore wire and 50 cm of black multicore wire with the appropriate red or black crocodile clip attached to one end of each wire. Tinned 22 s.w.g. single core copper wire for making wire links. Solder pins, etc.

Overall component cost is approximately £10

essential to build the unit in this form. However, the board has been made fairly long and thin so that it can be fitted into a probe type case of adequate dimensions. The input of the circuit must connect to the metal tip of the probe assembly. A probe tip can be improvised from a long 6BA or metric M3 bolt. This can be left in its raw form, or filed into the usual needle-like shape. The connection to the bolt can be made via a soldertag. Of course, a display 'window' must be cut at the appropriate place in the case and ideally, though not completely necessary, this would be fitted with a small piece of red display filter material.

Testing the circuit

The first stage after constructing the probe is to check that the unit actually works. Before applying power, first thoroughly recheck that you have the right components in the right places, that the tracks are cut in the right places and that the ICs are inserted the right way round. Also carefully check that no small pieces of solder are accidentally bridging two or more tracks, if such a solder bridge is found, remove it carefully with the soldering iron and a piece of solder wick. Do not rush this stage, faults picked up here can save you damaging the circuit. Having visually checked that the circuit is basically sound, it should be connected to a supply voltage in the range 3 to 15V (in the absence of a bench power supply, a standard 4.5V bell battery with screw terminals is a good power source for testing this type of circuit). Make sure that the polarity is correct with the red clip attached to the +ve and the black clip to the -ve power supply terminal. When power is connected, none of the display segments should be switched on at this stage. If one or more segments is lit up then something is wrong with the circuit, disconnect power immediately and recheck the circuit for faults in construction We can now test whether the probe actually works. If the probe tip is connected to the positive supply, in other words the +ve or red power supply terminal, a '1' should be displayed and if connected to the 0 volt supply, the -ve or black terminal, then a '0' will be displayed. If these displays are generated, then the circuit works and you can finish the task of putting it in its case.

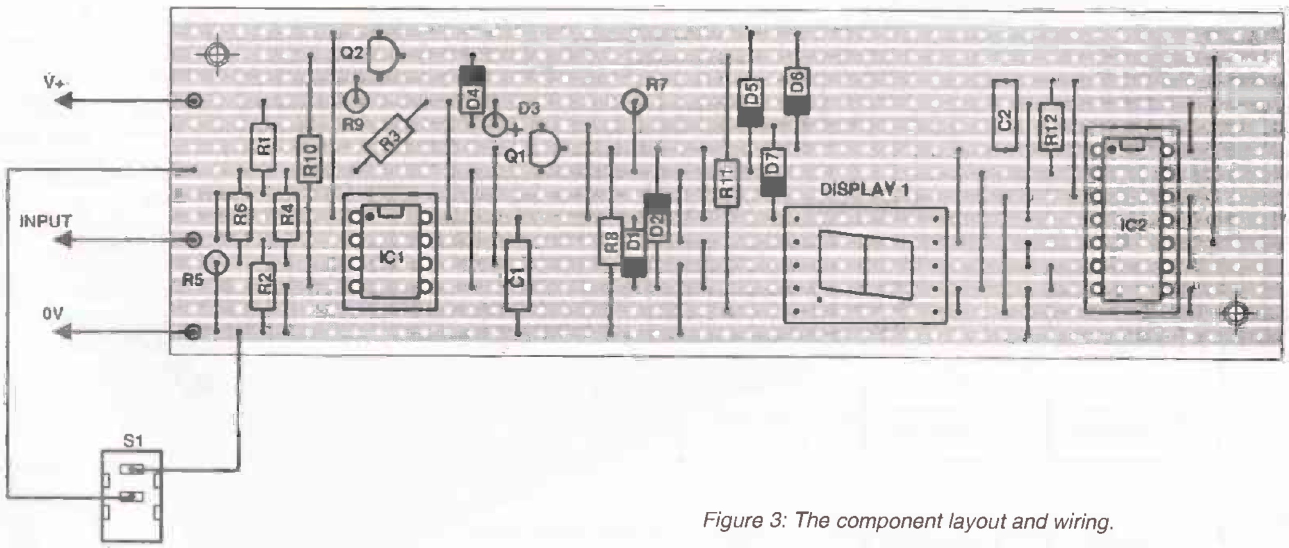


Figure 3: The component layout and wiring.

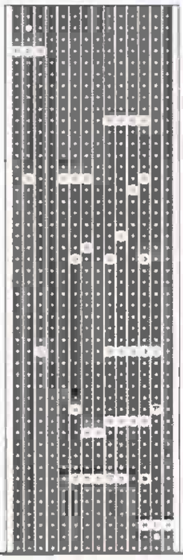


Figure 4: The underside of the component panel.

In Use

The completed device is very simple to use. Just connect the two probe power supply leads to the correct polarity power supply lines on the device under test and then use the probe to check the logic state of any track or component on the circuit under test. Obviously you will need to know what logic levels to expect in various parts of the test circuit, in order to perform any worthwhile troubleshooting and you may also need to have some means of injecting pulses into the test circuit. Even if you do not go this, far a logic probe is an excellent way of checking the power supply in a circuit and the state of any output lines. Note that there should be a flash from the decimal point when connecting the probe tip to one of the supplies and when disconnecting it. This is because you effectively generate input pulses when connecting the probe tip to some test points. These trigger the monostable and produce a brief flash from the decimal point segment of the display. Therefore, in normal use you must ignore any pulse indications from the display when initially connecting the unit to a test point.

How It Works

A static logic output is either at logic 0 or logic 1. These are respectively represented by a potential of between about 0 and 30% of the supply voltage and a potential of between about 70 and 100% of the supply voltage. The main function of the unit is to check the input voltage and indicate whether it is at logic 0, logic 1, or an invalid intermediate voltage. As can be seen from the block diagram of Figure 1, there are two voltage detectors at the input of the unit. One of these detects whether or not the input is within the valid logic 0 voltage range and drives the appropriate segments of the display if it is. The other voltage detector provides the same basic function, but it checks for a valid logic 1 voltage and drives the appropriate two segments of the display. If the input voltage is between the two valid logic levels, neither detector will be activated and none of the LED segments will be switched on.

@B:The display is driven via a simple OR gate which prevents the output of one voltage detector interfering with the output of the other. Current regulators are also included at the outputs of voltage detectors. CMOS integrated circuits will operate over a supply range of 3 to 15V. Using resistors to set a reasonable display current with a 3V supply results in a rather high current drain when using a 15V supply. The current regulators prevent the display from being driven with an excessive current when the probe is used with supplies of about 10 to 15V.

A monostable is also driven by the input signal and this will be repeatedly triggered if the input is pulsing. This stage drives the decimal point segment of the display and the decimal point will therefore flash when a pulsing input signal is present. In fact, the decimal point will appear to light up continuously if the input frequency is fairly high. The output pulse from the monostable is quite long at around 250 milliseconds, so even very brief and intermittent pulse signals will produce a clear indication from the display.

The full circuit diagram for the logic probe is shown in Figure 2. The voltage detectors are based on the two voltage comparators in IC1. R4 and R5 provide reference voltages which are approximately equal to 30% and 70% of the supply potential. R1 and R2 bias the input to about half the supply voltage under quiescent conditions, which takes both outputs of IC1 low. If the input is taken above 70% of the supply potential, the voltage at the non-inverting input of IC1a is taken higher than the voltage at the inverting input, resulting in the output of IC1a going high. Segments E and F of the display are then driven with a current of a few milliamps via gate diode D7. This results in a '1' being displayed.

If the input voltage is taken below 30% of the supply potential, the inverting input of IC1b is taken lower than the reference voltage at the non-inverting input. This sends the output of IC1b high and drives a current through all but the G segment of the display. D5 and D6 act as the gating diodes when this happens and a '0' is displayed. The output stages of IC1 are open collector transistors and in this circuit their collector loads are constant current generators. These are conventional current regulators based on TR1 and TR2. The currents are set by R7 and R9. Two segments are switched on when a '1' is displayed, but six segments are turned on when a '0' is displayed. R9 has a lower value than R7, giving a higher drive current when a '0' is displayed, but approximately the same current per display segment.

IC2 is a CMOS 4047BE astable/monostable, which is used here in the positive edge triggered monostable mode. It is therefore triggered by low-to-high transitions at the input. C2 and R12 are the timing components and the output pulse duration is about 2.48 C2 R12 seconds. The Q output of IC2 drives the decimal point of the display via current limiting resistor R11. A constant current generator could be used to control the drive current, but as only one small segment is being driven in this case, a simple resistor gives acceptable results.

Although mainly intended for use with CMOS circuits, this probe will work quite well with TTL types. TTL and CMOS devices are largely incompatible for a number of reasons. The most important reason in this case is that they have different logic voltages. TTL circuits always operate from a 5V supply and they do not have the symmetry of CMOS devices. The valid logic 0 voltage range is 0 to 0.8V. Logic 1 outputs must be in the range 2.4 to 5V. Closing S1 gives improved compatibility with TTL switching levels by pulling both reference voltages much lower.

Although the monostable circuit is not properly TTL compatible, in practice it will usually trigger reliably from pulses at TTL levels. However, it must be borne in mind that the CMOS integrated circuits are quite slow by TTL standards. It will trigger reliably from a squarewave input at frequencies of up to a few megahertz, but do not expect it to detect narrow pulses at 20MHz or more.

ETI Talkback

ELECTRONICS TODAY INTERNATIONAL

Dear ETI

It is well known that free phase organs, in which each note has its own generator so that relative phases of the signals can drift like organ pipes, give a more natural pipe sound than modern organs, in which all the notes are phase locked. Hitherto, free phase organs have used inductors which make them big, heavy, expensive and difficult to build - reasons why they have unfortunately lost much of their former popularity.

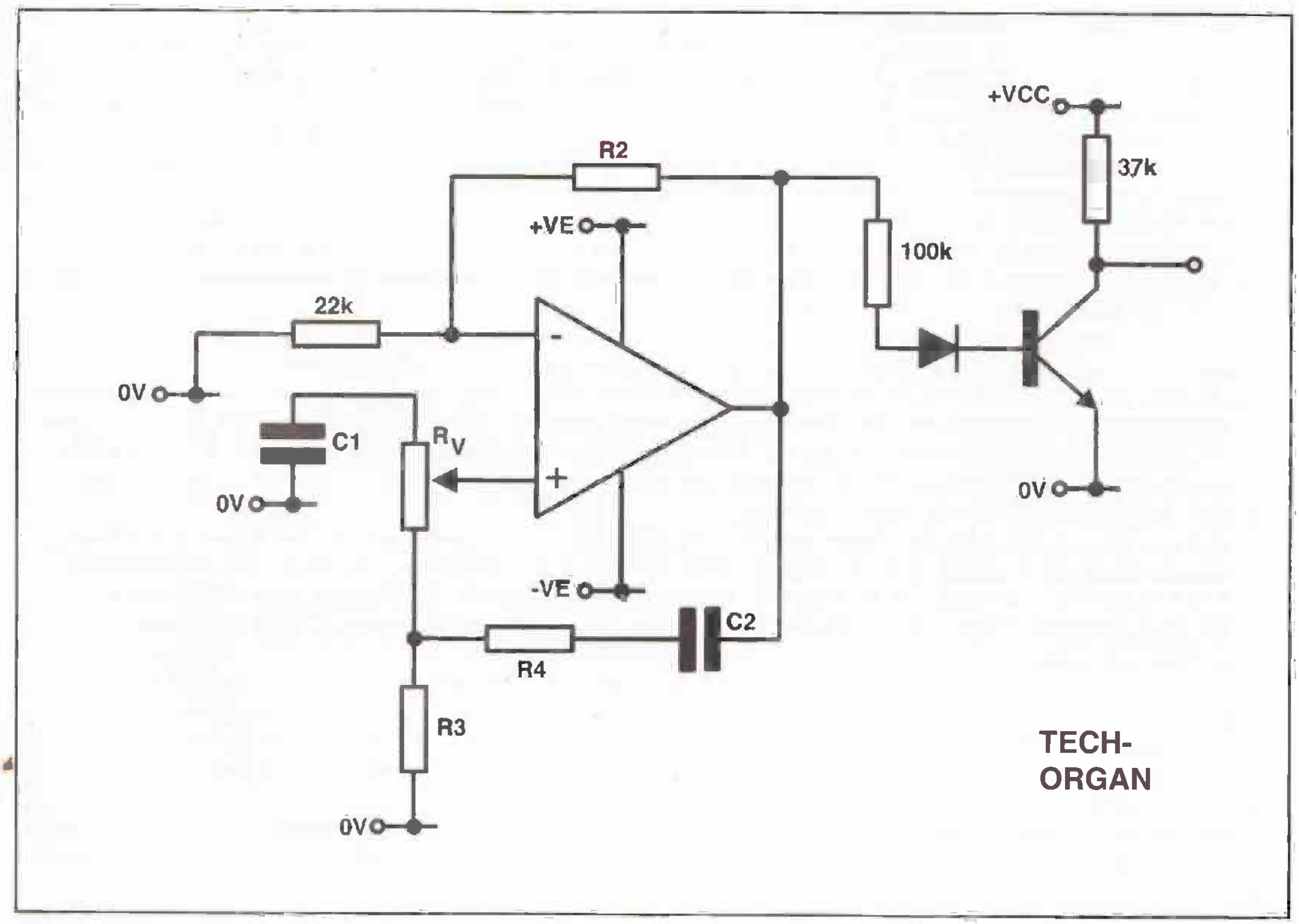
The advent of stable, inexpensive, metal film resistors make possible the use of RC oscillators which are light, small, inexpensive and do not take long to build.

The simple sine to square converter (transistor, diode and resistor only), make possible the use of well established square wave gates and tone forming circuits, as shown in the accompanying circuit diagram.

The component schedule for this free phase electronic organ is as follows:

L: R1 22k
R2 47k (R4 = R3)
51K (R4 ≠. R3
(R4+R3)xC1 = 1/∏ F
F = frequency of note.
R4 = R3 or next E24 step up.
R1 through R4 should be 1% or 2% metal film
C1, C2 Both the same value,
value determined in above formulae.
capacitors should be Mica, styrene, carbonate or ester.
R5 100k
R6 33k
Rv 10% of R3 rounded up to next obtainable value.

I can supply values, answers to questions and low cost components for this project.



Club News

We would like to bring readers' attention to the forthcoming Sussex Amateur Radio and Computer Fair, which is being held on Sunday 10th July between 10.30am and 4pm on Brighton Race Course. This is the thirteenth year that the event has been held and last year it was attended by over 2000 people. There will be trade stands, bring and buy stalls, refreshments and a free shuttle to Brighton sea front. It should be a great day out and for more details, contact the organisers on 0273 501100.

ETI has a large overseas readership, (we are a truly international magazine!) and we have had a recent request for help from the Amateur Electronics Club of Sierra Leone. They would like help in obtaining information on electronics magazines, books, data, etc. Any readers who would like to help should get in touch with the Club's President, Gabril S Dabo, at the Dept. of Electrical Engineering, Fourah Bay College, University of Sierra Leone, Mount Aureole, Freetown.

We have also had a letter from a Mr Wilkes of High Wycombe, who is looking for an electronics enthusiast club in his area. If anyone can help, please send details in to the editor and we will pass them on to Mr Wilkes.

Club contacts

British Amateur Electronics Club. Contact the club secretary Mr J.F.Davies on 0606 883742

Crystal Palace and District Radio Club, Tel: 081 699 5732.

Lincoln short Wave Radio Club, Lincoln, Tel: 0427 788356.

London Live DIY Hi-Fi Circle. Contact Launcelot Dow, 7 Pymmes Gardens South, Lower Edmonton, London N9 9NT.

Midland Amateur Radio Society, Tel: 021 422 9787 or 021 443 1189 (evenings only).

Sudbury and District Radio Amateurs. Tel: 0787 313212.

Thanet Electronics Club. A youth group for school age people in East Kent. Contact the club secretary Roy Ashley on 0304 812723.

If you run a club that is concerned with some aspects of electronics and computing we would like to hear from you.

If you have any problems, suggestions, or ideas which you would like to see printed in the pages of *ETI* then why not send them, we would love to hear from you.

Feedback

Here at the editorial offices of ETI we want to provide you, our readers, with the sort of magazine that you want to read. We can of course guess what you would like to see in each issue of ETI. but a far better way is to rely upon feedback from readers.

To help us in this process we are instituting a new concept, the 'Feedback Box'. We are asking readers to take a few minutes and write down on the back of a postcard the ratings which they would award to each article in this issue.

Ratings should vary between 1 and 10, with 1 being poor and 10 being brilliant.

A – Goodbye Money Hello Smartcard
B – Sending Your Data By Laser Beam
C – PC Clinic
D – The Experimenter's Computer
E – An Introduction to MIDI
F – An RS232 Break Out Box
G – Basic Circuits – Logic Probe
H – Loop Alarm
I – Killjoy

Just write the article letter followed by your score for that article and send to
Feedback Box,
July 94, *ETI*,
Argus House,
Boundary Way,
Hemel Hempstead, Herts. HP2 7ST.

To add an extra incentive, all replies received before July 30th 1994 will go into a draw and the winner will receive a couple of the latest electronics books published by Bernard Babani.

continued from p15

users to transfer cash, with a highly sophisticated electronic security against fraud, without having to go via the bank. Using special pocket terminals supplied with the card it will be possible for one user to easily transfer cash to another user, automatically reducing the amount of cash on his card by the specified amount and increasing it on the other person's card by the same amount. Retailers will have similar terminals linked to their tills.

The cash stored on a card, which can be in sterling or up to five different foreign currencies, can be increased or reduced by withdrawing or depositing in a bank account. This can be done through any phone fitted with a Mondex card reader, thereby potentially turning any phone into a low cost automatic telling machine. This is a major step towards the all electronic bank and away from a cash based economy.

Into The Future With Smartcards

With the production of intelligent smartcards, the technology can truly be said to have come of age. By putting more memory and more intelligence on a card, a great many more applications are opened up and existing ones can be made much more sophisticated. At the moment, most intelligent smartcards use very simple processor chips, by and large details are not released, but it is probably fare to say that most are derived from one or other of the widely used families of eight bit micro-controller chips. Simple processors, operating at very low speed and with very small data and program storage areas.

Already designers are looking at systems which have more powerful processors and a lot more memory. Here once again, the UK is leading the field with the development of a smartcard that contains a very powerful 32 bit RISC processor and which runs state of the art neural network software, to create the 'thinking' smartcard.

The processor used in this smartcard is the Acorn ARM processor, the same processor which is at the heart of the British company's Archimedes range of computer workstations. The neural network software has come from Southampton based Neural Computer Sciences and the whole project, known as CASCADE, has been funded by the EEC (for once spending money on something worthwhile!).

The rationale behind the CASCADE project is the development of smartcards which can process biometric information, such as fingerprints and voice prints, which would make it almost impossible for anyone to fraudulently use cards designed for security and financial applications. The high security and large memory capacity of such cards means that they will open up many new applications for smartcards, such as storage of personal information, for example medical records.

Thus, not too many years in the future, we could all have two or three smartcards in our pockets starting with a money card such as Mondex, which we could use to pay for goods and services in the same way that we use cash today. Then there could be a medical record/identity/passport card. Finally, there could be an assortment of smart travel cards, motorway toll payment cards, and security access cards. But one thing that we can be absolutely certain of, smartcards are with us to stay, we are only just seeing the beginning of applications to which they can be applied.

Send Your Data By *Laser Beam*

In part 2 of this fascinating project, Ken Gill shows how to link two computers and transfer data between them using no wires or cables, just a beam of infra-red light

Last month we looked at the design and construction of the circuitry for this project, this month we conclude with a look at the construction and setting up of an infra-red data communications link.

The range expected with this type of system is greater than that of a domestic television infra red system. The drive currents used here in this system should be capable of increasing the range over the prototype's distance of ten metres, which is the distance required to cover the ground between the two buildings. Here, using commonly available components, a peak pulsed current of 2A can be used to increase the range of the system considerably. With sense prevailing, it was thought best to have the current limited to a value considered appropriate to the range, so it is reduced to just under 1A peak. The current used in the prototype covers the required distance well, in fact the range during tests was found to exceed the original working distance of ten metres.

What does it do?

The object of this system is to replace a conventional or optic cable system causing minimum disruption to property.

An AC mains supply carrier system could have been used to convey the data between the two buildings, but consider the case where the two ends of the system are on different phases. In such a circumstance, the carrier system would not work.

This system provides a full duplex serial data link at 1200 baud ASCII between two buildings at least ten metres apart. The proviso is that an optical system which is in use here has no permanent structures placed in the way of the Infra Red beam to attenuate the flow of data which will pass between the two halves of the system. The effects of temporary obstacles, i.e. passing structures, ladders for example, or flying birds, should have little effect on the performance of the system's

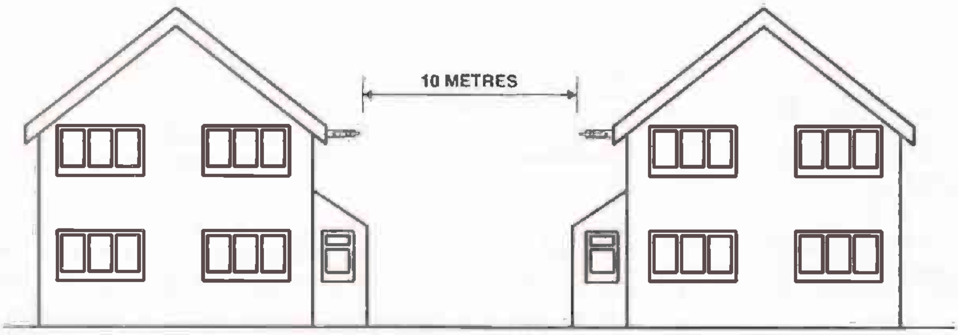
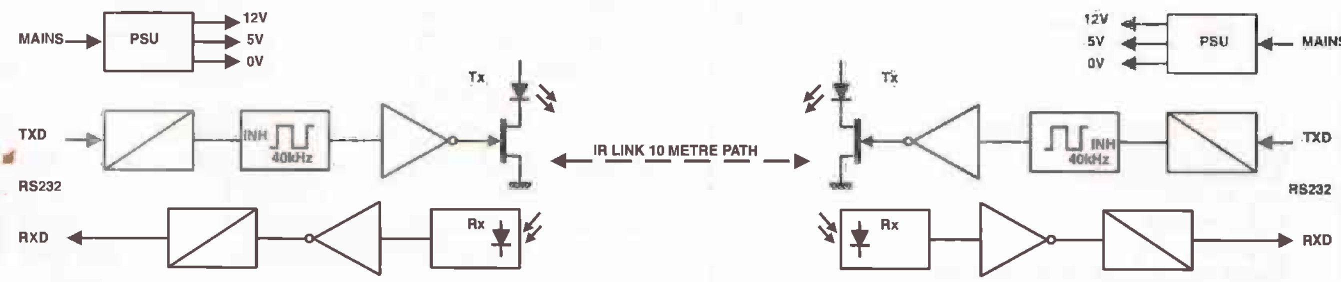


Figure 1 showing overall idea of system. Range of models should not be greater than 10m. There should be no obstacles in the beam's way to cause reflections from one transmitter back to the adjacent receiver. This will cause an echo to occur and slow down the data transfer.

Figure 2: Basic Block Diagram.



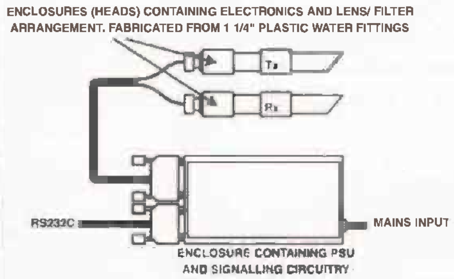
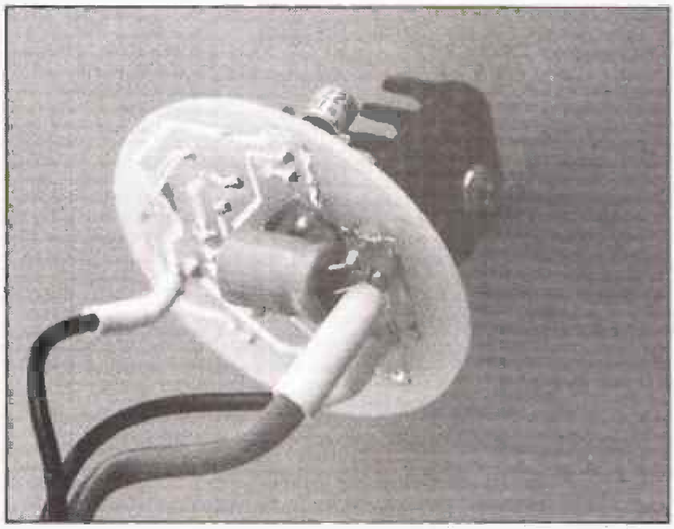


Figure 3. Rough outline of construction of project.



data transfer from one end to the other. Also, the effects of atmospheric conditions should have little, even in conditions of rain, snow and fog.

Errors may result from such conditions but tests have shown that these are small when the received IR power levels are high enough to overcome the absorption due to local atmospheric conditions.

The Mechanical Side

The same set of equipment can be found at either end of this serial link. It comprises a mains power supply and associated circuitry, and two remote heads, one head for the IR transmitter and optics, the second enclosing the IR receiver circuitry and optics. This makes for easy construction of the optical system, using mainly 1.1/2in plastic waste pipe and fittings to fabricate water tight enclosures which need to withstand the variations in weather. Additional metalwork is needed to make the supports for the optical assemblies, which is minimal. The power supplies and signal processing circuitry, including the serial equipment interface, are housed within a separate enclosure, making a total of three parts at each end of the system. Each end has to be duplicated, doubling the equipment, work and cost.

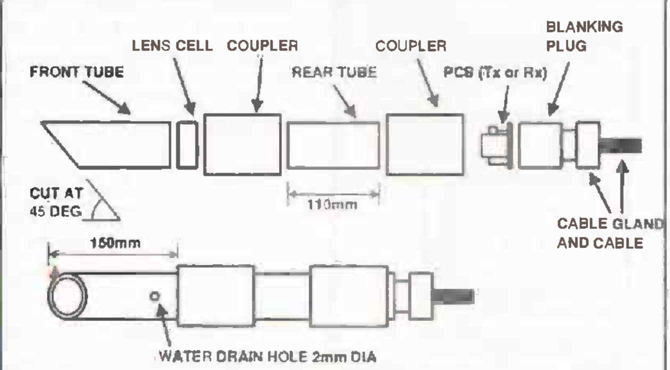


Figure 4
Component parts and completed assembly of optical transducers.

Mechanical Construction

Optics

The optical assemblies are fabricated from PVC waste pipe and fittings, available from most DIY outlets. This actually makes a convenient and water tight assembly for the electronics and the optics.

A number of components have to be manufactured prior to fitting, including the four lens cells - these are made from four 1 1/2in to 1 1/4in reducers cut down as shown in Figure 7. In addition, four 1.1/4in blanking plugs are used to complete the cell.

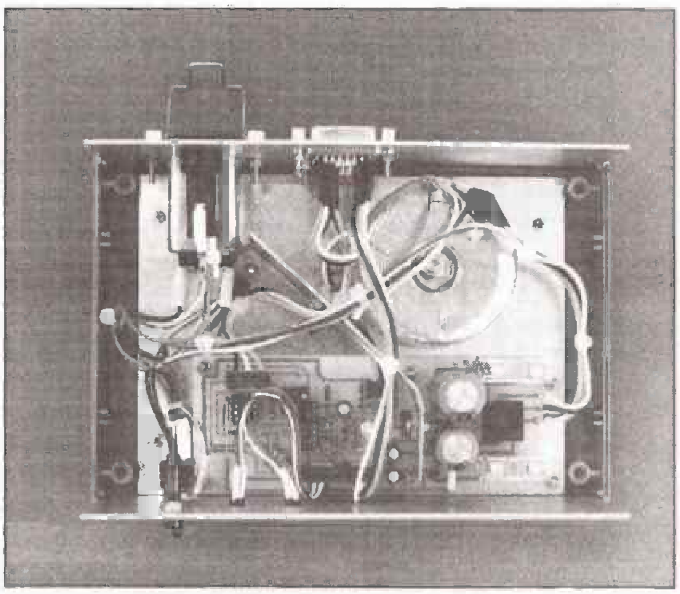
Both the reducer and the blanking plug, as shown in Figure 15, are cut down to 6mm in length. Any rough edges are removed at this stage, which will facilitate easy assembly prior to glueing the parts together.

Transmitter Lens Cell

The diameter of the lens has to been reduced to fit the internal diameter of the plastic reducer. It can be dropped into the reducer convex side up. The ring cut from the 1.1/4in blanking plug is now dropped on top of lens. This will retain the lens in the cell assembly. Check to see that all is well at this stage. Take these components apart, and re-assemble them once satisfied they are a good fit. A small amount of glue is applied to the internal surface of the reducer with the lens in situ. Push the lens retaining ring down the tube to secure the lens firmly and squarely in place. Follow the same technique for the other transmitter lens cell. The receiver lens cell has an addition, a filter, so the construction is slightly different. Remove any excess of the protruding inner lens retaining ring with fine sand paper or emery, which will make the inner ring flush with the outer ring.

Receiver Lens Cell

The remaining two lens cells have filters incorporated which reduces any effects of visible light on the IR receiver modules. The material needed for the filters is cut from a black plastic bin liner and is cut to the same diameter as the Maplin lens. A circle of 1mm plastic (Perspex) sheet is also required to hold the filter element in place. This second sheet of transparent



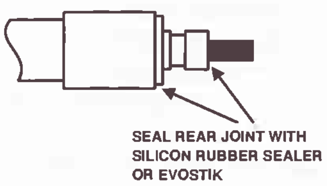
plastic sandwiches the filter between itself and the lens. The filter will reject visible light to a large degree and admit IR with very little loss.

Optical Head Construction

The remaining optical system is constructed from 1.1/2in grey PVC waste pipe and fittings. The waste components are all cut to length, as shown in Figure 4, before assembly. All burrs are removed and all cut ends cleaned with fine sand paper or Emery paper. Try fitting the optical components together before final assembly, as in the construction of the four lens cells, because any problems after this stage cannot be rectified and are best put to rights now, before the glue is applied.

Each of the lens cells is located in the front portion of the front tube coupler and is glued in place. The front tube cowling is therefore glued ahead of the lens cell and the rear tube behind the front coupler. The second (i.e. rear) tube couplers are glued in place at the rear of the second tube. The assembly is shown in Figure 7. The circular PCBs are located in the rear portion of this second coupler and are held in place with a 1.1/2in blanking plug. This is secured in place, once the electronics have been assembled and tested, with a silicon rubber type compound or an alternative adhesive such as Evo-stik - something which will seal against the weather but not as secure as the proprietary glue advised for the tubing. This is to help in the maintenance aspect should a fault occur. To gain access to either of the IR head's electronics may prove disastrous and may damage the housing for the sake perhaps of a broken wire.

Figure 5. Details of rear of optics assembly weather proofing. The optics and electronics.



Leave the PCB installation until last, that is after full circuit testing. When fitted into the lens cell, the flat surface of the Maplin plano-convex lens is facing outwards, away from the electronics. The convex surface of the lens is closest to the IR transducers. This is so for both the transmitter and the receiver optics.

PCB Construction

The system is made from two identical halves, two identical sets of boards need to be populated.

The round boards associated with the optics may need trimming to a small degree to fit the pipe used in this project. There should only be a tiny amount removed, certainly no more than a millimetre and this is best done before any of the round boards are populated with components.

Encapsulating

When the final assembly of the optics and testing of all the units is complete, the end plug which secures the cable into the gland is fixed with a silicon rubber sealing compound. Prior to securing the assembly and during testing, the boards can be put in place and the end plugs secured with PVC insulating tape. Weather proofing the unit comes later.

Final Checks

Check all the units for correct values and position of components and wiring prior to switching on. Once the unit has been powered, check all the regulator outputs for correct values. This includes the regulators in the main unit and those associated with the optics. Even the independent 5V supply for IC2 and Q1. The voltages should be well within the tolerance for these devices. Quiescent current drawn through either side of the power supply will be low, certainly no greater than 70mA.

Connect pin 1 and pin 2 together on PL1 and monitor pin 11 of IC2. There should be a square wave present at 5V amplitude when the multivibrator is enabled. This frequency should now be adjusted with RV1 to suit the frequency of the IR receiver components used, 38KHz for the RS chip and 40KHz for the Tandy module. RV1 will provide more than enough adjustment to accommodate the different IR receiver. Monitor the square wave at PL4 pin 1, a 12V square should now be observed when the multivibrator is again enabled.

Remove the link and ensure the subcarrier is disabled.

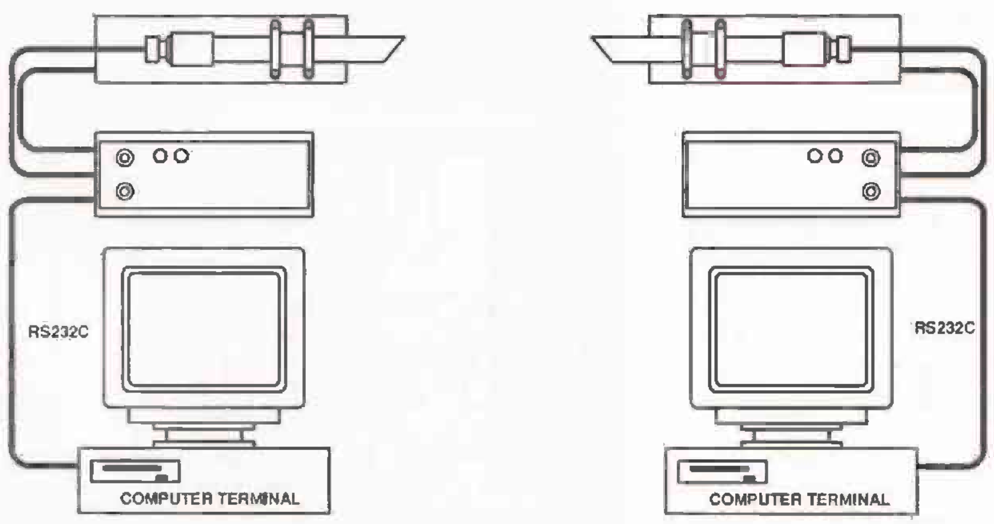


Figure 6. Ideal test system using two computers to check out the modem link using one computer and a link between pins 2 and 3 on the 9 pin D-type would provide a remote loop back test, remote echo.

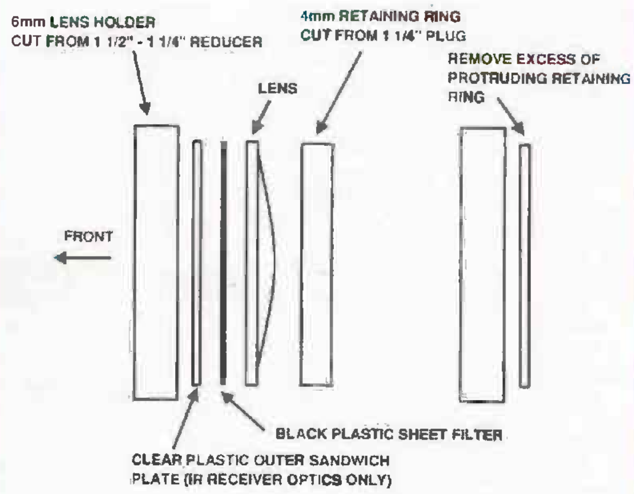
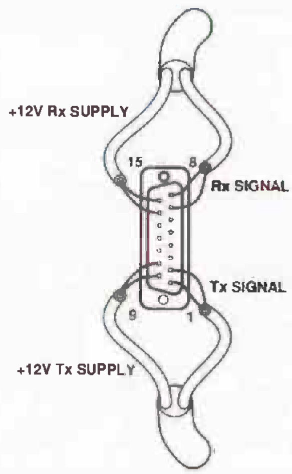


Figure 7. Construction of lens cell.

Figure 8. Rear view of PL6, connection of shielded cable to connector.



Set the two modules apart at a distance of about five metres and facing each other. Ensure there are no obstacles within a metre each side of the IR beam, otherwise reflections will occur and a local echo will arise.

Connect the system up as shown in Figure 6, using a suitable terminal program at one end with a data rate of 1200 baud. Parity, Stop Bits and Data Bits are of little consequence. Using an obstacle to obstruct the beam, you can now perform a local loop test, which is similar to an analogue loop test of a conventional modem. A large card, 12in from the units to be tested, will be sufficient. The characters sent out and shown on the transmit window of the terminal software should be echoed back on the received screen.

Perform the same test on the second part of the system and the same results should occur.

Now, with a clear path between the two ends of the system, a remote test can be initiated. Link pins two and three of the nine way D-type on the far modem. Link the computer with the terminal software to one modem. There should be only one echo (i.e. remote), two would indicate both a local and remote echo. If this occurs, then it should be possible to spot what obstacle is causing this, and remove it.

The system should now be ready for final installation.

Alignment

The entire optical system alignment is of great importance to ensure reliable performance of both modems. It is essential to ensure the axes of both optical systems are in line and form a common axis, transmitter to receiver and back. This will mean that as much power as possible is received at the remote end, assuming that the optical components have been correctly positioned within their housings.

Considering Figure 1 it can be seen that the two parts of the system are in plain view of each other and that they have no obstacles within thirty degrees of the axis of either transmitter, otherwise this would cause problems with echoes. This would ultimately slow the rate of data transfer considerably. The echo problem can be easily seen at each end of the modem link, with an instantaneous repeat of the transmitted data.

Notes for operation

Fluorescent lighting interference

When conducting various tests with the system, it was found that fluorescent lighting was a problem. Even though the IR receivers are designed to overcome it, they seem to be sensitive to this type of lighting. The IR radiation, however small, from these light sources was sufficient to introduce considerable errors in the optical chain. Therefore, direct or strong areas of radiation should be avoided at all costs.

The lens/filter arrangement used attenuates this problem to a large degree, but it would be wise to avoid aiming any of the optical paths along the line of any other strong IR emissions, for example the Sun.

One word of warning which has to be considered when the system is set up. Other people will be using IR controllers and it would be best not to have optical paths along an axis which is possibly going to correspond with an innocent source of IR radiation, such as a television remote controller.

This could either cause problems with the television remote controller being received with the link equipment or the link's data controlling the television or video. Avoid broadcasting the link IR into windows.

MIDI Explained

In part two of this series, Robert Penfold continues his look at the Musical Instrument Digital Interface

MIDI is basically just a means of sending rigidly coded messages from a master unit to one or more slave devices. These messages break down into two broad groups, which are the channel and system messages. Both types of message are important, but the channel messages are definitely the more important of the two. You can utilise MIDI fairly extensively just using the channel messages, but it would be difficult to get MIDI to do anything worthwhile using only the system messages. The channel messages are the ones that are used all the time in the everyday use of MIDI systems.

In order to use MIDI effectively it is essential to have at least a fundamental understanding of the system messages. If you are intending to undertake the design of MIDI hardware or MIDI software programming, a detailed understanding of these messages and their coding is absolutely essential. In this second article of the series we will look at the basics of channel messages and consider the related subject of MIDI operating modes.

Significant Nibbles

The primary difference between channel messages and system types is that the former are directed at one particular device in the system, or even one voice of one device, whereas system messages are directed to every slave unit. This is not to say that everything in the system will respond to system messages, or even that something in the system will respond to every channel message.

MIDI is a framework within which every MIDI equipped unit must operate, but the MIDI specification does not lay down any minimum requirements. Some MIDI units respond to no more than a few of the more basic messages, while others have quite full implementations. There is probably no piece of MIDI equipment, apart perhaps from a few MIDI testing devices, which respond to every possible MIDI message. You have to consult the MIDI implementation charts in the manuals in order to determine which particular messages your instruments will recognise. These charts should also show which messages the units can transmit and it is quite normal for there to be some differences between the sending and receiving capabilities.

A simple method of software channelling is used for channel messages. In other words, all the messages are sent down the same pair of wires and the channel numbers are contained within the code numbers of the messages. A MIDI device can operate on up to sixteen channels, which are simply numbered 1 to 16. All MIDI messages start

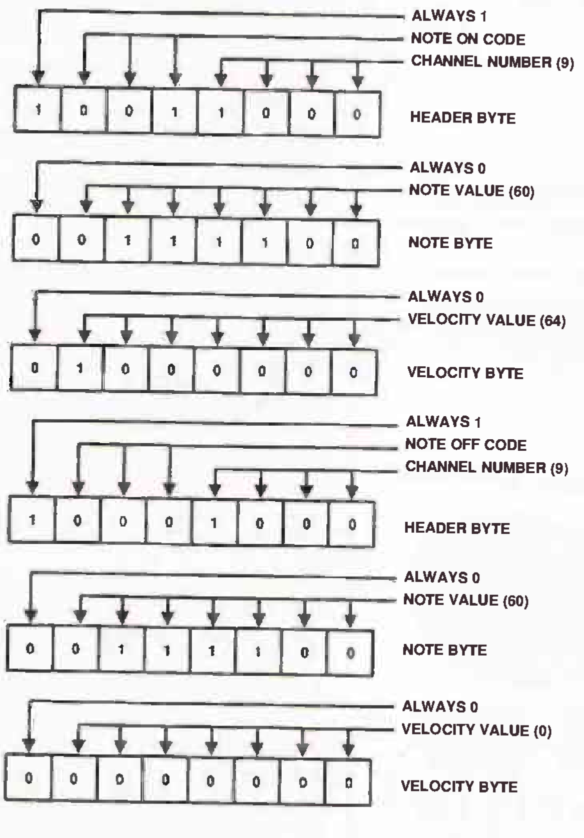


Figure 2: A note on – note off sequence is six bytes long.

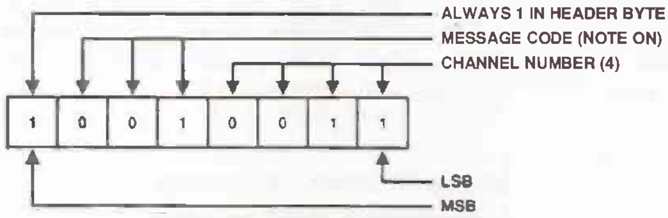


Figure 1: An example MIDI channel message header byte.

with a header byte that contains two vital pieces of information. For channel messages these are the channel number and the message type (note on, note off, etc.). In some cases the header byte is all that is needed, but with most messages some further bytes of information must be sent. These contain data, such as which note to switch on or off, or the amount of 'bend' to apply to a note.

MIDI sends messages as a series of 8 bit binary codes, or bytes as they are termed. Each header byte has to be considered as two separate four bit codes. In computer terminology, believe it or not, a four bit code (half a byte) is known as a 'nibble'. In standard serial interface fashion, MIDI sends the least significant bit first, working through in sequence to the most significant bit. The first four bits received (the least significant nibble) contain the channel number.

For those working on the design of MIDI hardware and software it is important to remember that there is a discrepancy between the value used in a MIDI message and the actual channel number. The binary codes run from 0000 to 1111, which is the decimal equivalent of 0 to 15. The convention is for MIDI channel numbers to run from 1 to 16. Therefore, the channel value used in the header byte is one less than the conventional MIDI channel number.

The most significant nibble in a header byte indicates the message type. In fact, the most significant bit is always set to 1 in a header byte and to 0 in a data byte, so that there is no risk of receiving devices mistaking one type for the other. There are then three bits to indicate the message type. Although this gives eight possible message codes, one of these is used to for system messages, limiting MIDI to seven types of channel message. Figure 1 shows the function of each bit in a header byte and it should help to clarify the coding method used. This example header byte is a note-on type on channel 4.

Exchanging Notes

Although MIDI can be used to control just about any aspect of an instrument, or any other piece of electronic music equipment (digital effects unit, audio mixer, etc.), its primary function is to play notes on the slave instruments. Notes are normally switched on and off via separate messages which take the same basic form. They consist of the header byte followed by two data bytes. The first data byte is the note value. All data bytes have the most significant bit set to 0, so only seven bits are available to carry the note value. In decimal terms, the note value is in the range 0 to 127. Middle C is at a value of 60 and there is an interval of one semitone from one value to the next.

This gives a range of over ten octaves, which should be sufficient for anything from ancient music to the latest avant-garde creations. MIDI accommodates a range of over ten octaves, but it is only fair to point out that most MIDI instruments have a somewhat narrower compass. The way in which out-of-range notes are treated varies from instrument to instrument and in some cases they are simply ignored, but with most instruments the right note will be played, but in the nearest octave that the instrument can manage. This minimises the disruption to the reproduced music. Many instruments actually cover a wider note range via MIDI than that available by way of their keyboards.

The second data byte is the velocity value. For keyboards that are not touch sensitive a 'dummy' value (usually 64) is used here. For touch sensitive keyboards the velocity value reflects how hard the key was pressed. Slave units that implement touch sensitivity use these values to control the volume levels of the notes, and the filter circuits might also respond to them. Although rare at one time, virtually all new MIDI instruments implement touch sensitivity, although many only seem to have about half a dozen different velocity levels, not the full 128 supported by MIDI.

In note off messages, most keyboards simply use a velocity value of 0. Most slave units do not respond to velocity values in note off messages. Clearly the decay characteristic of a note could be related to this value, but as yet few 'real world' instruments have this feature. Figure 2 shows an example note on - note off sequence.

One of the less well understood aspects of MIDI is the use of note on messages to switch notes off. A note on message will act as a note off type if it has a velocity value of 0. MIDI permits somewhat streamlined operation where a single note on header byte can be followed by numerous pairs of data bytes. Using this system, plus velocity values of 0 to switch notes off, it is possible to play complete sequences using just one note on header byte plus numerous pairs of data bytes. In practice this method is limited by the fact that each change to a different channel requires a new header byte to be sent. This method is used in an increasing number of sequencers though, and it can help to reduce MIDI 'choke'.

In The Mode

MIDI receiving devices must operate in one of four modes. MIDI modes govern the way in which system messages are handled, and this is their sole function. They can sometimes seem like an unnecessary complication, but they enable a system to be organised in ways which fully exploit its capabilities. By changing modes it is possible to reconfigure the system to suit different pieces of music. The four official MIDI modes are identified by mode numbers and mode names, but in some cases old mode names as well.

Mode 1; Omni On/Poly (Previously Omni Mode)

Mode 1 is one of the most basic MIDI modes, and as such it is little used these days. The Omni On part of the name indicates that channel numbers are not implemented in this mode. A device in Mode 1 will respond to any channel message regardless of its channel number. The Poly part of the name means that polyphonic operation is possible. In other words, more than one note at a time can be played. In a Poly mode, MIDI supports any number of notes playing simultaneously, but few MIDI instruments can have all their notes operating at once. It is up to the user of the system to ensure that each slave unit can cope with the notes it receives. This is a slight drawback to the MIDI version of multi-track recording as with the traditional method you can use one instrument to build up finished pieces of any complexity. The same is true when putting together MIDI sequences, but it is only possible to playback the finished piece if you have sufficient hardware to produce every note on every channel!

The other MIDI modes are optional, but all MIDI equipped units should include mode 1 and should default to this mode at switch-on. It is probable that all commercially produced MIDI equipment includes mode 1, but it is now quite rare for anything to default to this mode at switch-on. Usually, a modern MIDI equipped device will have built-in memory circuits which store a wide range of settings while the unit is switched off. Once switched on again, these settings are used as the defaults. At switch-on, a modern MIDI instrument is therefore likely to take up where it left off rather than simply defaulting to mode 1.

This mode is primarily intended to act as a sort of universal mode which will enable any MIDI device to communicate with any other. If you only wish to use MIDI in a fairly basic fashion, then Mode 1 might suffice and if it will, then it is the best choice. Whereas some of the other modes require some careful setting up in order to get the system operating properly, with Mode 1 you should need to do nothing more than set the right mode. Its easy going nature makes it a good choice when things are going wrong and you need to go back to basics in order to get the system functioning to some degree again.

The problem with Mode 1 is that it does not implement channel numbers. In effect, all messages become system types. If you simply wish to have one or two slave instruments following the notes played on a master instrument, it may do the job perfectly well but even with a set up as basic as this, Mode 1 might impose some limitations. Many MIDI keyboard instruments can have some form of split keyboard operation. Different parts of the keyboard can be assigned to different MIDI channels and can produce different sounds on both the master and slave instruments. However, if the slave instruments are set to Mode 1, they will ignore the fact that the note messages are on two or more channels and will play all notes using the same sound generator settings. For anything beyond simple slaving it is necessary to use one of the other modes.

Mode 2; Omni On/Mono (No Previous Name)

This mode does not implement channel numbers and it only permits monophonic operation. In other words, it provides what is effectively a single channel system that can only handle one note at a time. It provides such an elementary link that it would seem to be of no real practical value, but presumably it was included in the MIDI specification to accommodate monophonic synthesisers. These were quite common when MIDI was being formulated, but they have now been out of commercial production for many years. Few monophonic synthesisers equipped with MIDI interfaces were ever built and it would seem that this mode no longer has any practical significance, and it is one that a modern MIDI user can simply disregard.

Mode 3; Omni Off/Poly (Previously Poly Mode)

This is one of the most useful MIDI modes. As the Omni Off part of the name indicates, it does implement channelling. An instrument in this mode must therefore be assigned to a particular MIDI channel and it will only respond to channel messages which are on that particular channel. It is also a Poly mode, which means that it supports polyphonic operation. If you only have one slave instrument, this mode is not really a great advance on Mode 1 but the situation is very different for a system which has several slave instruments. With this mode you can have up to sixteen different instruments operating polyphonically, with each one on its own channel and playing its own completely independent track. You can have what is effectively a MIDI controlled orchestra playing very complex sequences. Mode 3 is therefore a popular one for use in sequencing set-ups.

Its potential in 'live' performances should not be overlooked either. With a master unit set for split keyboard operation it is possible to have two or three slave instruments following different parts of the keyboard and playing different sounds. Although MIDI tends to be mainly associated with sequencing, it has a lot to offer the 'live' performer.

A modern instrument can usually be assigned to any MIDI channel when it is set to operate in mode 3. Many older instruments are far less accommodating. In some cases it is a case of any channel you like, provided it is Mode 1. If there is only one instrument of this type in the system there is no problem, since the other instruments can be assigned to something other than channel 1. With two or more instruments of this type in the system, it will not be possible to fully exploit mode 3.

Mode 4; Omni Off/Mono (Previously Mono Mode)

This is another powerful and useful MIDI mode. It is one which many regard as the most powerful, but I think it is true to say that it is slightly inferior to Mode 3. Channels are implemented in Mode 4, but only monophonic operation is possible. On the face of it, this makes Mode 4 of limited value, but the important point to bear in mind here is that Mode 4 is only monophonic in the sense that one note at a time can be played per channel. It is polyphonic in that up to sixteen channels can be used at once, giving sixteen note polyphony across all the channels. You do not necessarily need sixteen instruments to occupy all sixteen channels. In theory it is possible to have one instrument in Mode 4 occupying all sixteen channels, but in practice there are few instruments that can do this. Nevertheless, two modern MIDI instruments are usually enough to cover all or most of the available channels.

Mode 4 clearly has great potential for those who are into multi-track sequencing. Using a couple of fairly advanced instruments set to this mode you can sequence sixteen independent monophonic tracks, with each one using a different voice. This gives you a MIDI controlled orchestra of sorts. It is not equal to sixteen Mode 3 instruments as it provides only monophonic operation on each track. A number of instruments in Mode 3 provide polyphonic operation on each channel and it is for this reason that Mode 3 has to be regarded as ultimately more powerful than Mode 4. Being realistic however, few musicians can afford the luxury of sixteen instruments in Mode 3. A couple of synthesisers operating in Mode 4 is a much more affordable option.

When selecting MIDI operating modes you should always bear in mind that the slave units do not have to operate in the same mode. A mixture of Modes 3 and 4 will often provide the greatest versatility. For example, you could have an electronic piano in mode 3 reproducing a polyphonic track, plus a Mode 4 instrument providing an eight track monophonic (per track) accompaniment. Most music consists of one or two polyphonic parts plus several monophonic parts and is well suited to a combination of Modes 3 and 4. With complex sequencing it is essential to give careful thought to the track assignments, as well as to the mode used for each instrument.

In theory, each channel of a Mode 4 instrument is independent of the other channels. In practice, particularly with older instruments, the channels might not always be completely separate. It is as well to read the fine print in the equipment manuals, particularly any notes in the MIDI implementation chart. Some instruments support Mode 4, but with certain types of message affecting all channels, not just the one they were transmitted on. For example, pitch bending on one channel might actually affect every channel. If my understanding of the MIDI specification is correct, this sort of thing is not actually within the MIDI standard. It means that the instrument is mainly operating in Mode 4, but that with certain types of channel message it operates in Mode 1! Although not strictly legitimate, I suppose it is better to have an instrument which supports a 'strings attached' version of Mode 4, rather than one which does not implement this mode at all.

Multi-Modes

The four official MIDI modes were barely adequate at the time MIDI came into being and they soon started to look more than a little inadequate. Suppose that you have a twenty four note polyphonic instrument. Using Modes 3 or 4 this instrument could provide twenty four note polyphonic operation on one channel, or monophonic operation on sixteen channels. In some circumstances twenty four note polyphonic operation could be very worthwhile, but in many situations it would be wasteful with no more than a few notes ever playing at the same time. In Mode 4 no more than sixteen notes could be played at once, meaning that eight sound generator circuits would be left totally unused.

In order to accommodate increasingly sophisticated instruments, a new and more powerful mode was badly needed. No MIDI Mode 5 has ever been introduced, but most modern instruments have what is effectively an additional mode. This additional mode has been given various names by the equipment manufacturers, but it is now generally known as 'multi-mode'. In points of detail multi-mode varies somewhat from one instrument to another and some instruments have more than one multi-mode available. All multi-modes have one basic property in common. They enable an instrument to operate polyphonically on two or more channels.

For example, a sixteen voice instrument could have multi-modes which permit eight note polyphonic operation on two channels, four note polyphonic operation on four channels, or two note polyphonic operation on eight channels. In each case a sort of polyphonic Mode 4 is being provided and it might seem as though instruments offering multi-modes fall outside the MIDI standard specification. I suppose that this is really a matter of opinion, but multi-modes can be legitimised on the basis that they are really just Mode 3. With a multi-mode instrument you have what are effectively two or more instruments working in Mode 3, which just happen to be in the same case. These notional instruments are usually termed 'virtual' instruments.

As multi-modes have not been standardised, the only way to determine the exact multi-mode capabilities of a given instrument is to carefully read the relevant section of the instruction manual. In some cases, there may be only one fairly basic mode offering something like four note polyphonic operation on three channels. Most instruments seem to offer various modes, splitting the voices across (say) two, four, six, or eight MIDI channels in assorted ways.

The most versatile multi-modes use dynamic allocation of the voices. With a mode of this type you are offered something like eight channel operation with up to sixteen notes per channel. This might seem to be too good to be true, and it is. The usual flaw in a mode of this type is that there is a limit of perhaps sixteen notes playing simultaneously. If you use the full sixteen note polyphony on one channel, nothing can be played on any of the other channels.

Although this might seem to be no better than a normal multi-mode, it definitely offers greater versatility. You can change instantly from one extreme to another, such as sixteen notes on one channel to one note each on sixteen channels. It is possible to use endless chopping and changing of this type without having to change from one multi-mode to another. You just have to make sure that sequences stay within the limit of sixteen notes at once. Without dynamic note allocation, frequent mode changes would be required, which might not be a practical proposition

It is perhaps worth making the point that MIDI modes only apply to receiving devices. You may sometimes find them applied to MIDI master units, particularly sequencers. I suppose a device that transmits polyphonically on one channel could be regarded as being in Mode 3, but this is not a strictly accurate way of looking at things. Modes govern the way received channel messages are handled, and should only be applied to slave units.

Summary Of Modes

Mode 1 - Polyphonic operation, but does not implement channels. Useful for troubleshooting or where very basic slaving is all that is needed.
Mode 2 - Monophonic operation with no channelling. Probably has no practical value.
Mode 3 - Polyphonic operation on one MIDI channel. A powerful mode, particularly in a system which has several instruments. Mode 4 - Monophonic operation on several channels. Ultimately less potent than Mode 3, but it can make very effective use of one or two instruments.
Multi-modes - Provide polyphonic operation on several channels. Unofficial modes, but more powerful than the standard modes. Ideal for complex sequencing with a few instruments.

Practically Speaking

by Terry Balbirnie

This is the first in a monthly series about general workshop matters. Over the months ahead it will take various forms - sometimes we will look at repair jobs which the electronics hobbyist is asked to carry out and, at other times, health and safety aspects or the use of test instruments. Theory will be introduced where it helps, but the maths will be kept as light as possible. Occasionally, there will be a link with a constructional project in a future issue.

Although chiefly aimed at the electronics enthusiast, much of Practically Speaking will be useful to anyone interested in electronics, whether educationalists or those engaged in industry, while some of the theory will be of value to those preparing for examinations. We begin by looking at the workshop itself and we'll be pursuing this theme over the next two months.

Working Environment

Some readers will be lucky enough to have a real workshop - perhaps using a spare bedroom, garden shed or section of the garage. However, to many, the 'workshop' will be a table in the kitchen and a cupboard or set of drawers.

Having to do electronics in the living room is far from ideal. Apart from the likelihood of distractions from the TV, wife and children, there is the necessity to clear everything away at the end of a session. Flashing lights and bleeps from experimental circuits - not to mention the smell of soldering flux - are all likely to make you very unpopular.

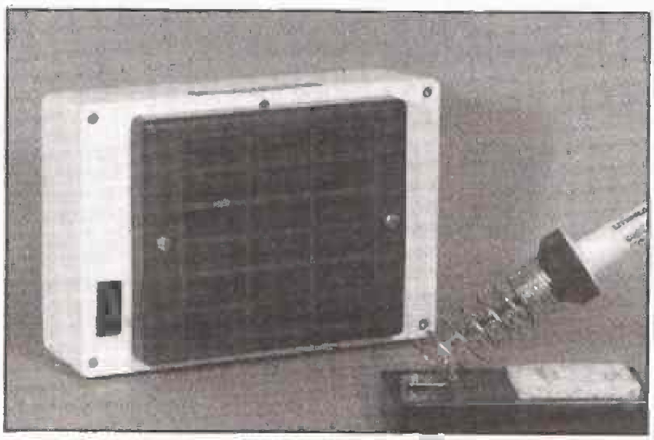
Using a spare room is much better, but this will rarely be possible. If you do have one, it will be necessary to up-rate the lighting and make the power supply more accessible and safe. A stable work bench is essential and for this it is better to use a sturdy old table or desk rather than modern furniture. An old sideboard with a heavy top surface and plenty of storage space underneath for test instruments, small tools, etc., is ideal.

Components may be stored in a set of small drawers, which can be bought in DIY stores. Components which are too large for the drawers can be stored in plastic lunch boxes. Plenty of shelving is useful for often-used test instruments, tools and reference books.

The workbench should be placed close to a wall socket. A four-way extension board may then be used so that a soldering iron, power supply unit, test instruments, etc., can be used at the same time. Keep the lead itself as short as possible for safety.

It is essential to fit extension sockets with an RCD (residual current device). This greatly reduces the chances of receiving an electric shock. The easiest way is to use one which replaces a standard mains plug and the illustration shows the H72 PowerBreaker Safety RCD Plug - these are available from DIY stores. The fuse in the RCD plug, individual plugs and in the extension board should be of 3A rating, which should be adequate for experimental equipment.

Illumination can be improved by using a fluorescent light. The type which plugs directly into the ceiling fitting is a good idea because it can be instantly removed if the need arises. You will need to provide ventilation to remove soldering flux fumes or the smell will soon permeate the house. A soldering iron station with fume extraction facility will be beyond the means of most readers, but a cheaper alternative is to use the free-standing Solder Fume Captor from Light Soldering Developments. This mains-operated unit sucks fumes into a filter and removes the tarry deposits. It costs about £50 and the address of the company is given at the end of the page.



The Litesold Solder Fume Captor

Be sure to fit a smoke detector on the ceiling, but check that it can be heard around the house when the workshop door is closed. It will be triggered by such things as burning insulation if the soldering iron has been left switched on and in contact with a length of connecting wire.

Finally, but very importantly, there is the necessity to lock the door when the room is not in use. It could be disastrous for a child to play with equipment whether it be a soldering iron, high-voltage supply unit or sharp tools. Even certain types of battery and low-voltage power pack can provide sufficient current to cause nasty burns, if short-circuited with a piece of wire.

That's all for this month. Next time we will look at using a shed or outbuilding as a workshop.

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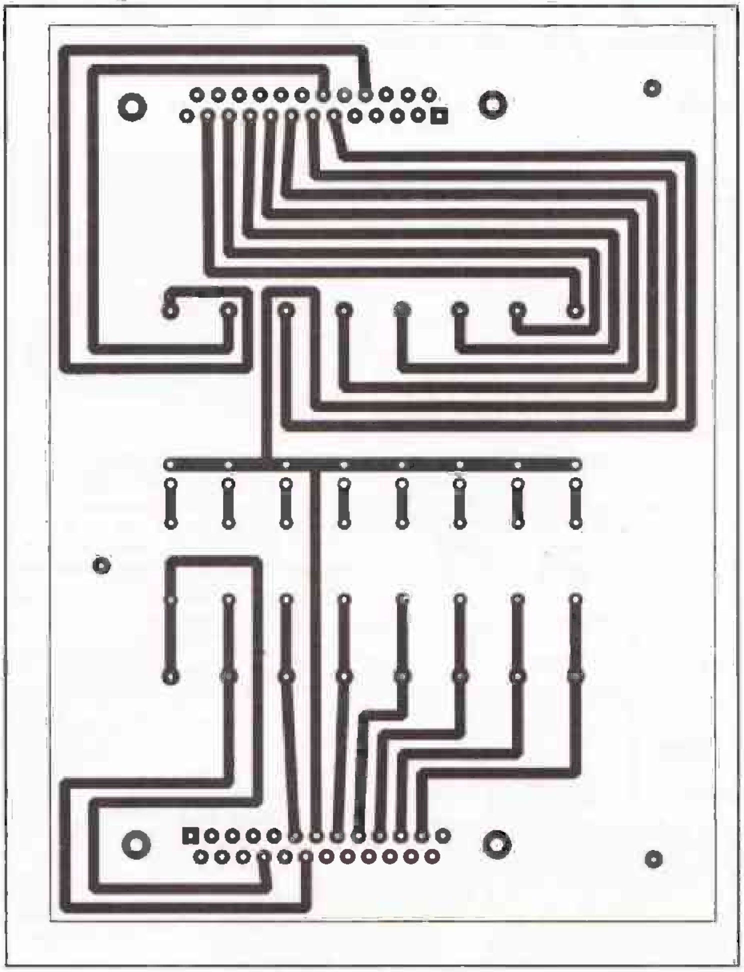
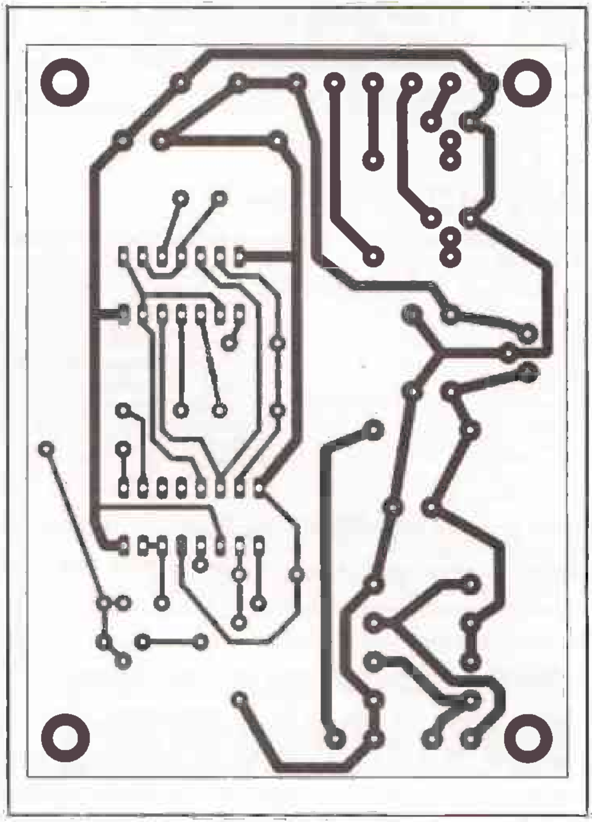
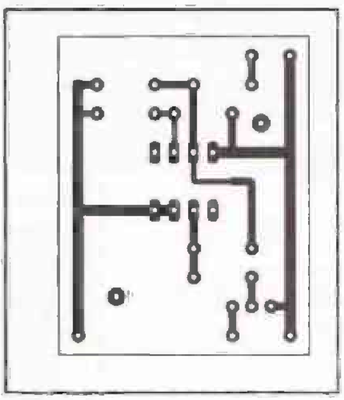
Foils for this issue



Breakout Box

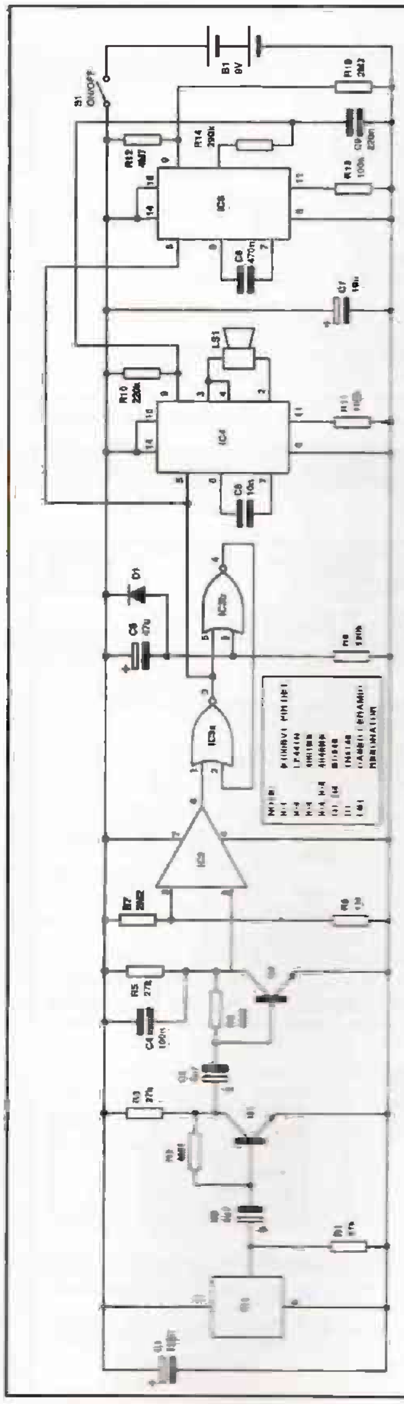


Killjoy



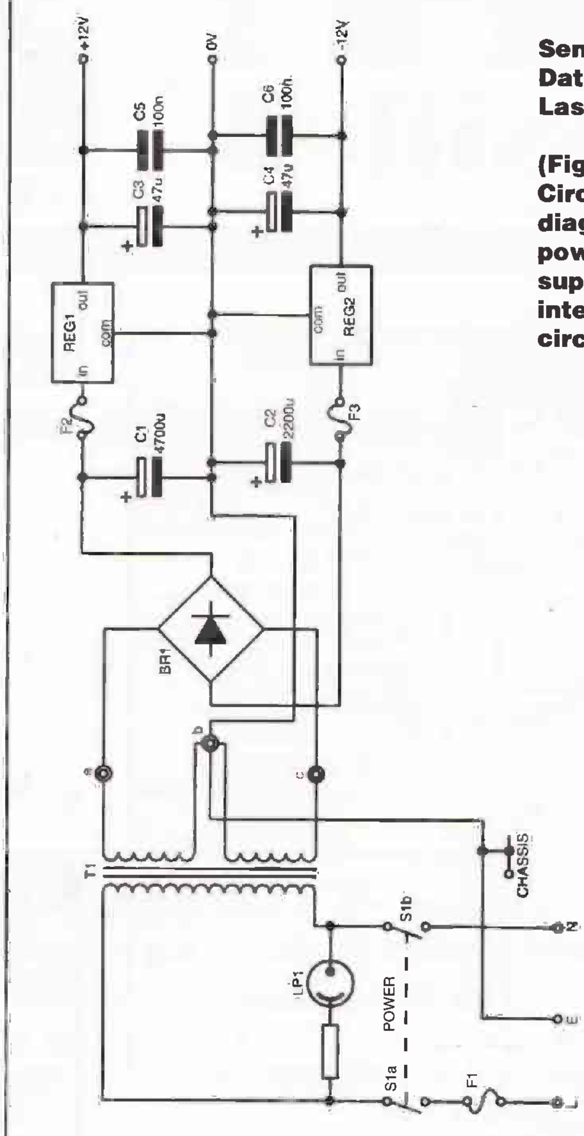
Loop Alarm

Corrected diagrams for JUNE issue:



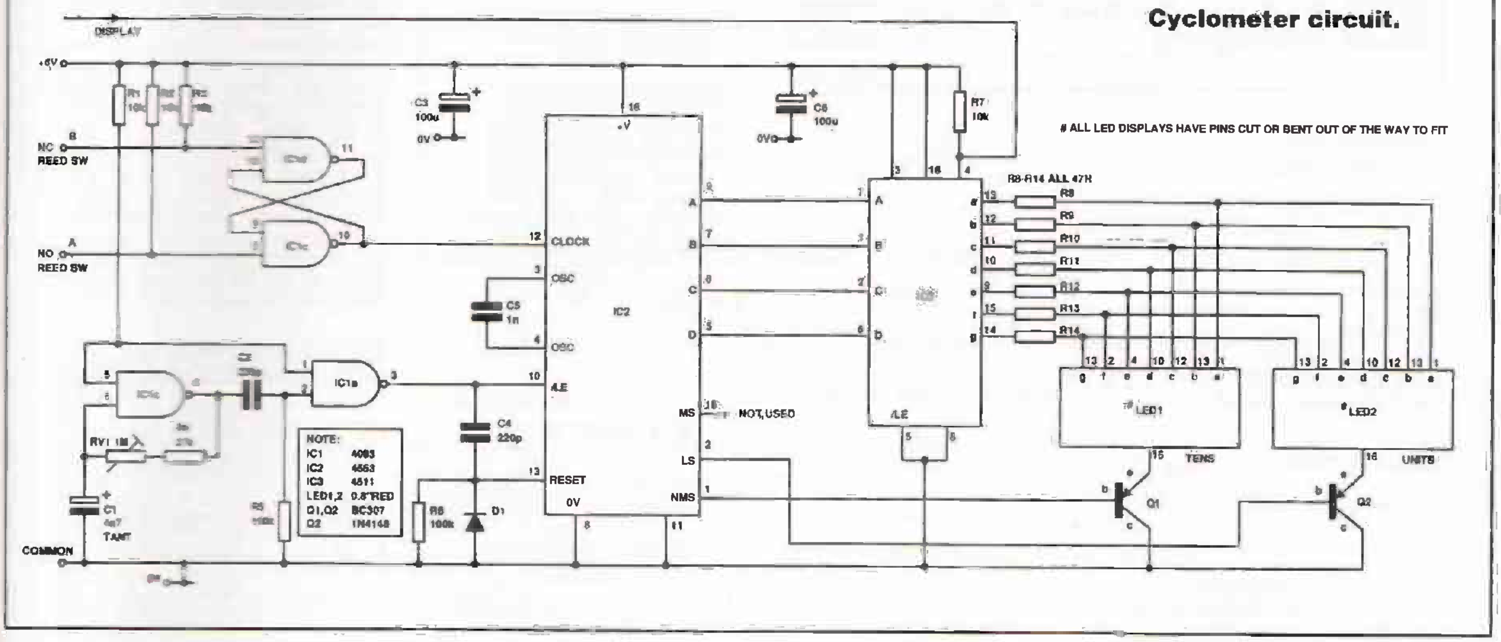
The Passive Infra-red Intruder Alarm (Figure 3)

The passive infra-red alarm circuit.



Send Your Data by Laser Beam

(Figure 4) Circuit diagram of power supply and interface circuitry.



Cyclometer circuit.

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About nine months, ago a friend of mine was made redundant. Now aged forty-three, he had worked for the same bank since he left university. He is one of about 100,000 people who have been made redundant in the UK banking industry, about a quarter of the industry's entire workforce.

In a middle management position and with a comfortable lifestyle, my friend now faces the fact that he is probably unemployable. The job he once thought would be a job for life is now just a memory, he has no alternative but to start all over again.

The reason that he and countless others in a whole range of different professions have lost their jobs is not just the recession in the UK., not just a turn down in world business. Although these factors have not helped, the truth is that most owe their unemployment to advances in technology.

The shake out of staff in the financial industries was inevitable, indeed I went on record predicting it nearly twenty years ago. Neither will it stop here as once the path to automation has begun it can not be easily stopped.

The same will happen to people with 'secure' jobs in the civil service, in retailing, in civil engineering and construction, in fact virtually every area of human activity with the exception of a handful of people in the creative professions, artists, writers and the designers of advanced technology.

All this points to the simple fact that advances in technology have eliminated the concept of the lifetime career, of the safe occupation which will carry one from the cradle to the grave. As observers like myself have said for years, people will have to learn to be flexible, to be prepared to change careers several times in their lives.

But one can only successfully do this if one is aware of what is happening around one, of the currents and eddies produced by the forward motion of that great engine of progress, technology. Despite what I had been telling him for years, my friend's redundancy came as a great shock to him. He and those around him had not seen, or chose to ignore, the creeping advance of the technology that was to take away their jobs.

Of course, some will take a crude Luddite view and insist that the progress of technology must be halted, or even reversed. Such views are futile and invariably self destructive. If society adopts such attitudes then it will inevitably hurl itself backwards into a bleak and miserable third world existence.

If we want the benefits of technology, then we must learn to live with it. If we are to live with an ever changing technology then we must understand that technology and learn to chart its future development so that we, unlike my friend, are not caught unawares by some technology driven change.

In my opinion, this is one overwhelming reason for the importance of teaching science and technology in schools, and teaching it well. If we know something about science and technology then we are no longer afraid of, or in awe of, the products of science and technology - those products become our tools rather than our masters.

In this way we can, to a degree, control the course of technological development as it affects us and, at the very least, indulge in that rather pleasant game of predicting the future. If you have a keen observation and a good grounding in general technology then such prediction for the next ten, or even twenty, years is not hard and could protect you from many a nasty surprise.

We must all accept that the products of science and technology are so all pervasive that none of us can ignore them. This is despite the seeming protestations to the contrary of a former editor of the Times, Simon Jenkins, in a recent column in that paper discussing the merits or otherwise of the new national curriculum. He boldly states that 'there is nothing here that justifies the extraordinary status of maths and science' and continues 'there is no shred of evidence that Britain "needs" more mathematicians and scientists.' Sad comments indeed.

Even sadder was his conclusion - 'I believe that trying now to train a nation of mathematicians and scientists is like Thomas Arnold training a nation of clerks and clerics. The new curriculum seeks to push children out of school with a store of learning they are certain to forget and with precious little to prepare them for work or life.'

It is all right for Mr Jenkins, he is one of that small fortunate handful who are relatively immune to technological change. But for the rest of society, how wrong he is!

Science and technology is stimulating, exciting and creative. But like other stimulating, exciting and creative pursuits if you approach it with ignorance it can be dangerous and, when ignored, it can be dangerous, as my unemployed friend has found out to his cost.

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In next month;s issue of ETI we will be continuing our PC Clinic series with a look at processor and co-processor chips, plus cache memory, the BIOS routines, POST codes and how to use them. For PC owners who want to know how fast their processor is running, there is a project to build a simple little display which shows the current turbo speed setting.

B:The main feature in the next issue will examine the technology behind and the future for global positioning systems. Systems which can accurately tell you where you are in the world to within a few metres.

Among the projects we will be running next month are a number of useful little devices - a car lights on tester, an angler's bite detector, a video light meter and, for the electronics workbench, a constant current transistor tester. We will also be continuing our series on an introduction to MIDI.

For the more experimentally inclined reader we will be looking at the design and construction of magnetometers, devices sufficiently sensitive to detect the change in the earth's magnetic field.

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