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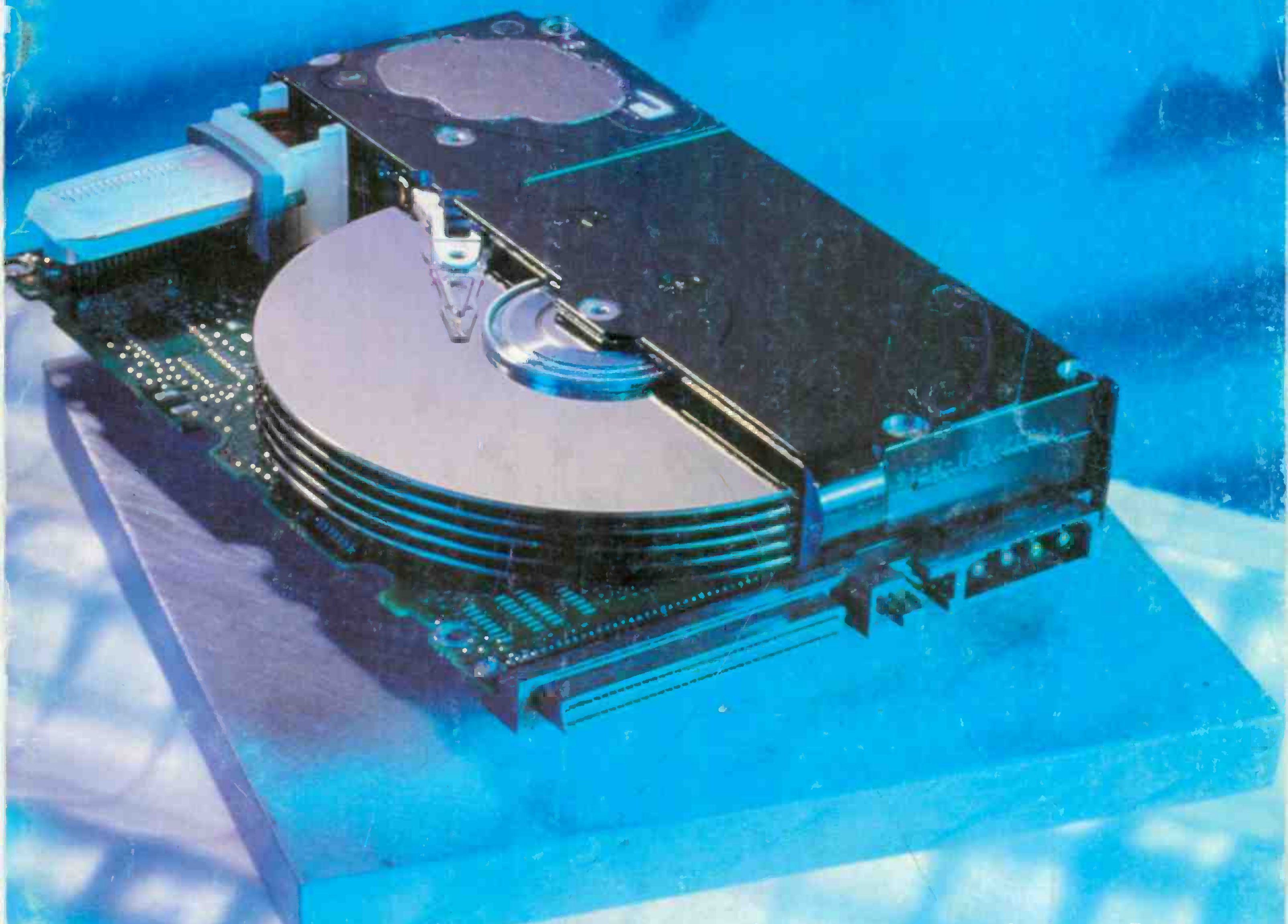

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# Integrated PCB & Schematic Design System for Windows™

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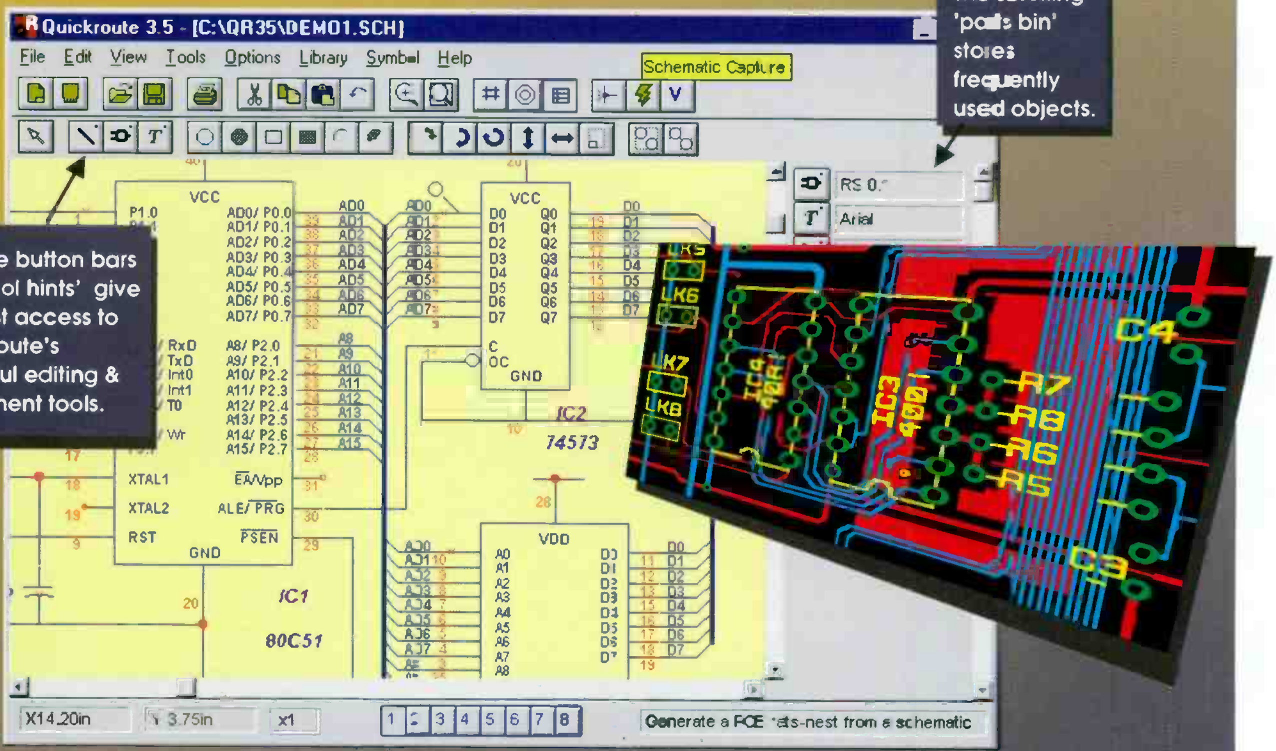


"..of all the products included here, this is my personal favourite... Really, thats all I have to say about Quickroute - it certainly gets my vote!" Review of QR 3.0 & other products Computer Shopper Nov 95

EASY TO USE
Quickroute 3.5 is a powerful, affordable and easy to use Integrated schematic & PCB design system for Windows.™ With its multiple button bars, 'tool hints' and 'parts bin', Quickroute helps you to design quickly and efficiently

POWERFUL
There are four different versions of Quickroute giving you a choice of features & price. Quickroute is available with multi-sheet schematic capture, auto-routing, 'engineering change' (modification of a PCB from a schematic), copper fill, and a range of file import/export options. See the table for a selection of features.

AFFORDABLE
Prices are Designer (£149), PRO (£249) and PRO+ (£399). The Personal edition is available for just £68, but has the manual provided on disk as on-line help. Post & Packing is £5 (UK), £8 (EC), £12 (World). VAT must be added to the total price.

| | Personal | Designer | PRO | PRO+ |
|---|---|---|---|---|
| PCB & Schematic Design | ✓ | ✓ | ✓ | ✓ |
| Schematic Capture | | ✓ | ✓ | ✓ |
| Auto router | | | ✓ | ✓ |
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| Copper Fill | | | | ✓ |

QUICKROUTE SYSTEMS

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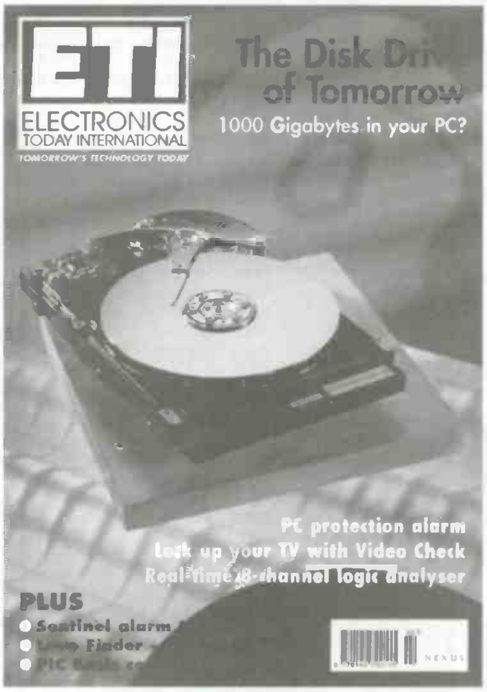



**Volume 25 No.2**

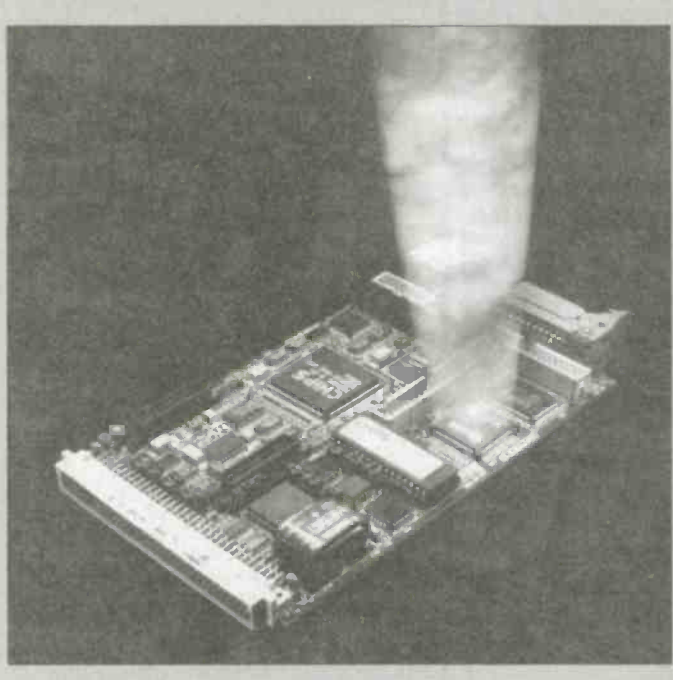
## & Features Projects





## Regulars

# New from Arcom



Arcom has launched the fastest Eurocard STEbus PC AT-compatible available. Called SCIM486SX, it is based on the power 486sxlc processor and provides a single-board solution to the most demanding embedded DOS and Windows applications.

The new board packs a 50MHz CPU with over lOMbytes of RAM and Flash EPROM onto a compact l00 x l60mm single Eurocard. The hardware architecture delivers computational performance benchmarked at up to 40% faster than a full 32-bit 486DX CPU running at 33MHz - but at a price designed to attract OEMs and control system designers.

In addition to offering a powerful and economic foundation for a host of realtime and embedded industrial control and instrumentation applications, the board provides a rugged platform for running advanced software applications - such as Visual BASIC - in aggressive environments.

The Texas Instruments 486sxlc CPU at the heart of SCIM486SX delivers exceptional Intel 486-compatible performance thanks to design features such as five pipelined stages in the instruction execution path, and an 8kbyte, 32-bit, 2-way set-associative cache. The processor is combined with a Chips & Technologies, chipset to provide full PC AT compatibility.

The memory array offers IC sites for populations of up to 8Mbytes of zero wait-state dynamic RAM, l28kbytes of battery-backed static RAM and 2Mbytes of Flash EPROM. This can be extended by a further 8Mbytes of RAM using the board's SCIM mezzanine local bus expansion facility - providing the capacity to run very large applications efficiently and/or operating systems such as UNIX. Other onboard hardware includes a site for a maths co-processor, IDE and floppy disk controllers, keyboard interface, real-time clock and watchdog timer, loudspeaker output, and COMI, COM2 and LPT1 ports. A serial-organised 256-byte E2PROM is additionally provided for fail-safe retention of BIOS configuration data and other information such as hardware/software version and issue.

SCIM86SX's combination of PC functionality and realtime-oriented hardware is more than adequate for many embedded DOS/Windows applications. But if greater functionality is required, then three expansion routes provide exceptional configuration flexibility.

The main STEbus interface - implemented via the reliable 2-part DIN41612 connector -includes full multi-master arbitration, allowing the construction of very high performance systems with parallel processing using up to 21 backplane slots.

The SCIM local expansion interface bus provides a means of closely matching the onboard hardware to the industrial requirement, to minimise system board count and costs. I/O is routed via a 50-way ribbon-cable header connector with a pin-out conforming to the industry-standard SCS signal-conditioning system. This secondary expansion route is a de-facto standard and offers access to a range of heavy-duty, real-world interfaces with features such as screwdriver-connect terminations, allowing users to integrate the isolation and conditioning functions essential for 'true' industrial computer systems.

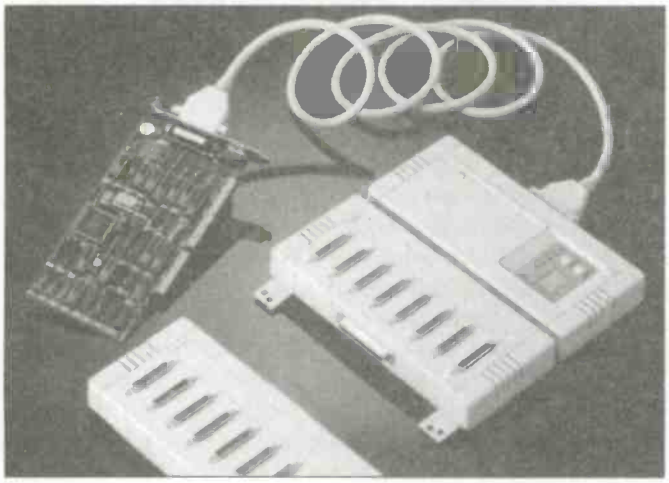
SVGA graphics is available in the form of a plug-on mezzanine module. This approach provides cost and flexibility advantages, minimising board costs for systems which do not require a man-machine interface, or allowing users to select the optimum form of display driver for the industrial application rather than being restricted to the usual CRT output. Arcom offers a choice of LCD, plasma or electro-luminescent SVGA drivers.

Because SCIM486SX is fully PC AT-compatible, applications software can be developed on the board itself. This greatly speeds the real-time systems design process, allowing debug to take place directly on the target hardware. When development is complete, Arcom offers a support package called SiliconDrive which allows software to be blown into ROMdisk/RAMdisk, for operation in harsh industrial environments where conventional disks are unsuitable.

The new board uses the same core architecture as a number of earlier 486slc- and 386sx- based STEbus modules, Arcom's most popular target boards over the last 3-4 years, and will also run code developed for Arcom's range of low-cost 80188-based controllers. This compatibility provides a plug-in upgrade path for more than 5,000 systems throughout the UK and Europe.

For further details contact Arcom Control Systems Ltd, on +44 1223 411200.

# Latest from IMS



IMS has announced a new generation of PC multi-function data acquisition and control cards. Codenamed the PCL-818 Series, these cards incorporate multiple functions on a compact, half-size PC plug-in card. This high level of functional Integration has been achieved by merging the board's functionality on a single ASIC chip which combines high accuracy and reliability with low cost, size and power consumption.

The 818 series spans a number of cards ranging from 4OHz up to 33OKHz sampling speeds, with features including 16 channels of 12-bit A/D conversion, D/A conversion, 16 digital inputs, 16 digital outputs and a counter/timer. The range is specifically designed to suit users' requirements from low-cost applications to high-speed, high performance applications.

All the cards include on-board ACS (Automatic Channel Scanning) enabling full-speed, multi-channel DMA controlled sampling. At the high end of the range the cards also incorporate on-board 1KB FIFO buffers for high throughput sampling, particularly for Windows applications. A high gain card (l000x amplification) is also included in the range for direct sensor connection to low signal sensors, such as thermocouples, thereby dispensing with the need for an external signal amplifier. On board CJC is also provided specifically for thermocouple measurement.

IMS also announced a new multi channel intelligent sensor-to-computer interface module for remote measurement and control. Codenamed the ADAM-4017, this module can be supervised by a host computer over a standard RS-232/485 network. Fitted with an on-board microprocessor, the module is also able to monitor sensors autonomously and report back measured readings or interrupt under alarm conditions.

The 4017 module provides 8 channels of differential analogue inputs with a high precision 16-Bit A/D converter suitable for measuring both voltage and current sensor outputs. The module is ideal for applications where the measurement/sensing points are some distance away from the supervisory computer. By digitising the measurement at the sensorpoint the module avoids the common shortfalls of long cable runs carrying sensor signals back to a central supervisory computer. Furthermore, by operating over an RS485 link this further simplifies cabling down to a single pair of wires which can be daisy-chained from module to module.

The 4017 module is enclosed in a rugged hardened plastic shell, with various mounting configurations supported, including panel or DIN rail mounting, with plug-in, screw-terminal connectors simplifying installation, expansion and repair. The Module is designed to accommodate unregulated power supplies, commonly used in the industry, from +10 to +30 VDC.

Last but not least, IMS has also introduced a new intelligent PC-based multi-port RS232 serial controller. Codenamed the PCL-747, this comprises a PC Bus (ISA) plug-in card with an associated external CPU module. The 747 provides modular expansion upto 32 RS232 serial ports, offering unprecedented serial port expansion for a desktop PC normally limited to standard PC COM1..COM4 serial ports.

The 747 and its associated CPU module incorporate an on-board 40Mhz TMS320C25 processor to handle the processor intensive serial communications, supporting baud rates of up to 38,400 bps on every port. An integral 1/2 Megabyte memory buffer provides temporary buffering of transmit and receive data to and from the host PC. The 747 modular design allows expansion in 8 port steps by the addition of UART modules which plug directly into the external CPU module. Up to 4 UART modules may be connected, providing 32 serial ports in total. The 747 is supplied with the PC-ComLIB utility software which includes DOS and Windows drivers, as well as programming library supporting most of the common high level languages (C, Pascal, Basic, Assembly, Clipper, etc.)

The 747 is ideal for applications requiring communications with multiple serial devices such as PLC interfacing, remote instrumentation and display, data communications modems, point of sale terminals and many more.

For further information, contact IMS on 01703 771143.

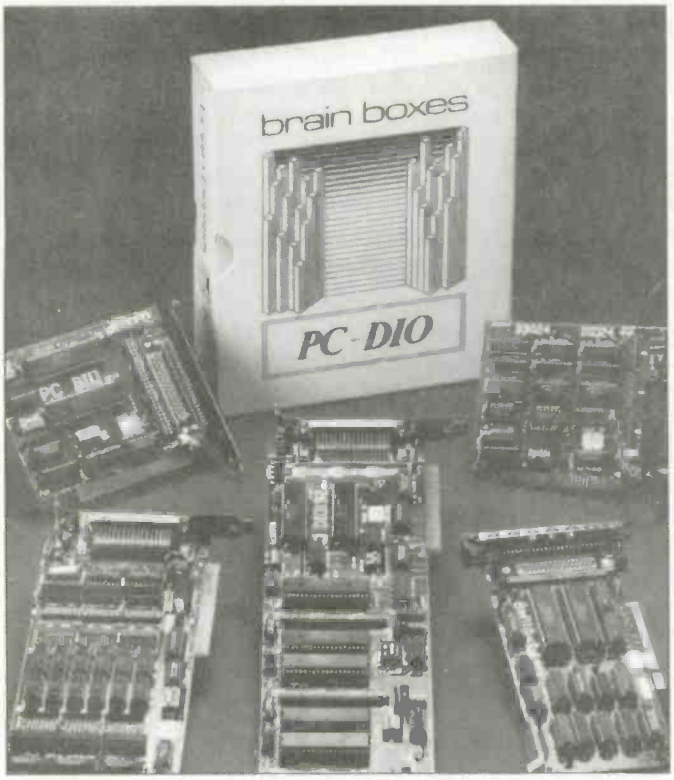
# New PCI/C44 addresses new markets for board-level DSP

The new PCI/C44 from Loughborough Sound Images is a fast, multi-processing DSP engine. It combines the power of Texas Instruments' TMS320C4x floating point DSP with the high throughput of the PCIbus. This allows the PCI/C44 to address pre-press and medical imaging applications, multi-channel telecom products and high performance instrumentation. The board can be populated with up to four TMS320C44 processors, to operate at 50 or 60 MHz.

The PCI/C44 sports 2 MByte of shared SRAM. This enables high-speed data transfers between the host and the DSPs. In addition, each processor has up to 4 MByte of local, zero wait state SRAM. The PCI/C44 also features LSI's open standard DSPLink-2 interface. This allows off-board 1/0 expansion through a range of multi-channel analogue and digital 1/0 boards. Interprocessor communication links operating in excess of 80 MByte/s per processor simplify multiprocessor system implementation. An on-board JTAG test bus controller is mapped to the PCI Local Bus to provide a comprehensive debug facility.

Much development and application software is already available for the PCI/C44. Software from LSI's existing C40 ISA boards is upwards compatible with the new board, and a wide range of off the shelf DSP algorithms are available. Texas Instruments' TMS320C44 DSP itself is well supported, with application development software available from TI and other parties.

For further information contact: Loughborough Sound Images, on Tel:+44 1509 634444




# DIO with DLL!

Responding to customer demand from Windows users, Brain Boxes have announced that they will bundle their Windows DLL with all their digital input output PC interfaces from 1st October.

The range of cards offer up to 192 high-speed, high-current TTL compatible, digital input/output lines; they use the popular Intel 8255 P.P.I. chip, which provides the core I/O logic for the interfaces. Each chip has 24 input output lines that are controlled by reading and writing data to the chip's four registers.

Every card has a choice of base addresses, dip switch selectable, and a range of interrupts.

These high-speed interfaces are now fully available to Windows users, priced from as little as £79, which includes 270pp of informative advice and suggestions, disks, example circuits, and fully explained sample programs in the most popular languages.

Uses include high-output current control applications such as driving relays or LEDs, interfacing BCD inputs or outputs, detecting key presses or contact closures, generating fast TTL pulses, driving non-standard parallel devices etc.

The 48 and 192 line cards offer a choice of IDC or 'D' type connector.

Opto isolated versions of the card are also available.

For further information, contact Brain Boxes on 0151 220 2500

# 60 Million Samples per Second

Strategic Test recently announced the availability of the CompuScope 6012, an IBM PC/AT compatible ISA bus card capable of performing a 12 bit A/D conversion on one input at sampling rates up to 60 MSPS (Million Samples Per Second) and two simultaneous inputs at 30MSPS with a bandwidth of 30MHz.

Manufactured by Gage Applied Sciences of Canada, the CompuScope 6012 is supplied with free GageScope software which enables users to operate the card like an oscilloscope without writing a single line of programming code. As a low-cost alternative to digital oscilloscopes, it allows users to store, analyse and print their data and convert it to an ASCII format for export to spreadsheets and mathematical software packages without the traditional inconvenience of data transfer via RS232 or GP-IB interfaces provided by stand-alone instruments.

Applications for the CompuScope 6012 include cellular communications, receivers, LIDAR, imaging, non-destructive testing, ultrasonic testing, laser doppler anemometry, high end video, CCD testing, vibration analysis, laser diode characterisation, impact testing, etc.

Software drivers for C, Pascal, BASIC, LabWindows and LabView are available, together with a Windows 3.1 DLL, for users who want to integrate the CompuScope 6012 as part of a custom test system. Data can be transferred from the 6012 to the PC's extended memory at rates up to 1.5 MWord per second on a 80486 based system using the software drivers provided by Gage.

The standard card is supplied with 512k of on-board SRAM for signal storage; however this can be expanded to 8M samples which is a feature unique to the CompuScope 6012 and allows recording of long transient signals or fast repetitive acquisitions.

Other key specifications of the compuScope 6012 include 62dB SNR, -61dB THD, programmable input gain, auto-calibration, programmable input coupling, internal or external trigger capability and an ergonomic human interface. Multiple cards can be used in a Master/Slave configuration to achieve 60MSPS, 12 bit sampling on up to 8 simultaneous channels, with a common clock and trigger.

Auto-calibration is an essential feature of any multi-MHz waveform capture system. Temperature changes on the A/D board can cause offset and gain drift due to the relatively high thermal coefficients of resistors and trimpots. Gage have developed an auto-calibration method with a very low (20 ppm/C) thermal coefficient which allows the offset and gain of each input channel to be controlled in real-time, under software control.

For further information contact: Strategic Test & Measurement Systems Ltd on Tel: 01734 795950

# Intelligent I/O & PLC

Cambridge Microprocessor Systems Ltd has introduced a new low-cost industrial controller which provides full signal conditioning on each of 12 opto-isolated, non-polarised inputs and 4 isolated voltage-free outputs. The card can be programmed in Ladder Logic, 'C', or both, the latter offering full deterministic control of the I/0 but providing the flexibility of 'C'. When used as a PLC, the user can select the scan time required - for fast applications this can be as low as 500 µs - and still provide full communications and networking; the default is 10 ms.

The makers claim that, at £95 in quantity, this is the highest spec'ed lowest cost controller available today. The specification includes: 16/32 bit CPU 68000 compatible up to 1 Mbyte of EPROM and 512 Kbytes of SRAM plus EEROM, two fast hardware timer/counters, on-board PSU, expansion options, I2C or Mbus, RS232 or RS485 with full networking and remote I/0 protocols such as MODBUS etc. The latter can also be used for remote programming and re-programming as well as interfacing to most SCADA packages and Visual Basic. A low-cost radio option is also available for remote locations and remote networking.

For more information contact CMS on 01371 875644

**PORTABLE X RAY MACHINE PLANS** Easy to construct plans on a simple and cheap way to build a home X-ray machine! Effective device, X-ray sealed assemblies, can be used for experimental purposes. Not a toy or for minors! £6/set. Ref F/XP1.

**TELEKINETIC ENHANCER PLANS** Mystify and amaze your friends by creating motion with no known apparent means or cause. Uses no electrical or mechanical connections, no special gimmicks yet produces positive motion and effect. Excellent for science projects, magic shows, party demonstrations or serious research & development of this strange and amazing phychic phenomenon. £4/set Ref F/TKE1.

**ELECTRONIC HYPNOSIS PLANS & DATA** This data shows several ways to put subjects under your control. Included is a full volume reference text and several construction plans that when assembled can produce highly effective stimuli. This material must be used cautiously. It is for use as entertainment at parties etc only, by those experienced in its use. £15/set. Ref F/EH2.

**GRAVITY GENERATOR PLANS** This unique plan demonstrates a simple electrical phenomena that produces an anti-gravity effect. You can actually build a small mock spaceship out of simple materials and without any visible means- cause it to levitate. £10/set Ref F/GRA1.

**WORLDS SMALLEST TESLA COIL/LIGHTENING DISPLAY GLOBE PLANS** Produces up to 750,000 volts of discharge, experiment with extraordinary HV effects, 'Plasma in a jar', St Elmo's fire, Corona, excellent science project or conversation piece. £5/set Ref F/BTC1/LG5.

**COPPER VAPOUR LASER PLANS** Produces 100mw of visible green light. High coherency and spectral quality similar to Argon laser but easier and less costly to build yet far more efficient. This particular design was developed at the Atomic Energy Commision of NEGEV in Israel. £10/set Ref F/CVL1.

**VOICE SCRAMBLER PLANS** Miniature solid state system turns speech sound into indecipherable noise that cannot be understood without a second matching unit. Use on telephone to prevent third party listening and bugging. £6/set Ref F/VS9.

**PULSED TV JOKER PLANS** Little hand held device utilises pulse techniques that will completely disrupt TV picture and sound! works on FM too! DISCRETION ADVISED. £8/set Ref F/TJ5.

**BODYHEAT TELESCOPE PLANS** Highly directional long range device uses recent technology to detect the presence of living bodies, warm and hot spots, heat leaks etc. Intended for security, law enforcement, research and development, etc. Excellent security device or very interesting science project. £8/set Ref F/BHT1.

**BURNING, CUTTING CO2 LASER PLANS** Projects an invisible beam of heat capable of burning and melting materials over a considerable distance. This laser is one of the most efficient, converting 10% input power into useful output. Not only is this device a workhorse in welding, cutting and heat processing materials but it is also a likely candidate as an effective directed energy beam weapon against missiles, aircraft, ground-to-ground, etc. Particle beams may very well utilize a laser of this type to blast a channel in the atmosphere for a high energy stream of neutrons or other particles. The device is easily applicable to burning and etching wood, cutting, plastics, textiles etc £12/set Ref F/LC7.

**MYSTERY ANTI GRAVITY DEVICE PLANS** Uses simple concept. Objects float in air and move to the touch. Defies gravity, amazing gift, conversation piece, magic trick or science project. £6/ set Ref F/ANT1K.

**ULTRASONIC BLASTER PLANS** Laboratory source of sonic shock waves. Blow holes in metal, produce 'cold' steam, atomize liquides. Many cleaning uses for PC boards, jewllery, coins, small parts etc. £6/set Ref F/ULB1.

**ULTRAHIGH GAIN AMP/STETHOSCOPIC MIKE/SOUND AND VIBRATION DETECTOR PLANS** Ultrasensitive device enables one to hear a whole new world of sounds. Listen through walls, windows, floors etc. Many applications shown, from law enforcement, nature listening, medical heartbeat, to mechanical devices. £6/set Ref F/HGA7

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**PARABOLIC DISH MICROPHONE PLANS** Listen to distant sounds and voices, open windows, sound sources in 'hard to get' or hostile premises. Uses satellite technology to gather distant sounds and focus them to our ultra sensitive electronics. Plans also show an optional wireless link system. £8/set ref F/PM5

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**ELECTRONIC SIREN KIT** Impressive 5 watt power output. Ideal for car/bike alarm etc. 6-12v dc max current 1A, 1.2khz £6 Ref 1003.

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**1 WATT FM TRANSMITTER KIT** Supplied with piezo electric microphone 8-30vdc. At 25-30v you will get nearly 2 watts! £12 ref 1009.

**FM/AM SCANNER KIT** Well not quite, you have to turn the knob your self but you will hear things on this radio that you would not hear on an ordinary radio (even TV). Covers 50-160mhz on both AM and FM. Built in 5 watt amplifier, inc speaker. £15 ref 1013.

**MOSQUITO REPELLER KIT** Modern way to keep midges at bay! Runs for about a month on one 1.5v battery. £7 Ref 1015.

**3 CHANNEL SOUND TO LIGHT KIT** Wireless system, mains operated, separate sensitivity adjustment for each channel, 1,200 w power handling, microphone included. £14 Ref 1014.

**MOTORBIKE/CYCLE TREMBLER ALARM KIT** Adjustable sensitivity, preset alarm time, auto reset. Could be connected to horn etc. £12 Ref 1011.

**0-5 MINUTE TIMER KIT** adjustable, will switch up to 2A mains. Perfect for alarms, photography, etc. £7 Ref 1020.

**4 WATT FM TRANSMITTER KIT** Small but powerful FM transmitter, 3 RF stages, microphone and audio preamp included. £20 Ref 1028.

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**PHONE BUG DETECTOR KIT** This device will warn you if somebody is eavesdropping on your line. £6 ref 1130.

**ROBOT VOICE KIT** Interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £9 ref 1131

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**VOX SWITCH KIT** Sound activated switch ideal for making bugging tape recorders etc, adjustable sensitivity. £8 ref 1073.

**INCAR SOUND TO LIGHT KIT** Put some atmosphere in your car with this mini 3 channel sound to light. Each channel has 6 led's. £10 ref 1086.

**7W HI FI AMPLIFIER KIT** Useful, powerful, ideal for audio systems, intercoms etc. 12-18vdc £7 ref 1025.

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**http://www.pavilion.co.uk/bull-electrical**

**PREAMP MIXER KIT** 3 input mono mixer, sep bass and treble controls plus individual level controls, 18vdc, input sens 100mA. £15 ref 1052.

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**SOUND EFFECTS GENERATOR KIT** Produces sounds ranging from bird chips to sirens. Complete with speaker, add sound effects to your projects for just £9 ref 1045.

**GUITAR PREAMP KIT** Complete with tone controls, small enough to fit in any guitar, based on TL082 IC, 9-12vdc £8 Ref 1091.

**15 WATT FM TRANSMITTER (BUILT)** 4 stage high power, preamp required 12-18vdc, can use ground plane, yagi or open dipole. £69 ref 1021.

**TELEPHONE AMPLIFIER KIT** Very sensitive amplifier which uses a pickup coil (supplied) will let you follow a conversation with out holding the 'phone. £11 ref 1059.

**HUMIDITY METER KIT** Builds into a precision LCD humidity meter, 9 ic design, pcb, lcd display and all components included. £49

**PC TIMER KIT** Four channel output controlled by your PC, will switch high current mains with relays (supplied). Software supplied so you can program the channels to do what you want whenever you want. Minimum system configeration is 286, VGA, 4.1,640k, serial port, hard drive with min 100k free. £24.99

**DIVINING RODS** Expensive technology cannot challenge the fool proof art of water divining, passed down from generation to generation. Seeing is believing. Use in the home, garden, countryside or desert. It's divinely simple! £4.99 a pair ref E/3.

**HUGE BUBBLE MAKING KIT** You'll be amazed at the the size of the bubbles you can acheive with this bubble making kit. Once you have got the knack it is possible to make bubbles of up to 40 feet long. £11.99 ref E/9.

**FM CORDLESS MICROPHONE** This unit is an FM broadcasting station in minature, 3 transistor transmitter with electret condenser mic+fet amp design result in maximum sensitivity and broad frequency response. 90-105mhz, 50-1500hz, 500 foot range in open country! PP3 battery required. £15.00 ref 15P42A.

**MAGNETIC MARBLES** They have been around for a number of years but still give rise to curiosity and amazement. A pack of 12 is just £3.99 ref GI/R20

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# Digital Hard Drives

***Nick Hampshire takes a look at how new technologies being developed by IBM are rapidly expanding data storage capacities***

Everyone who owns and uses a PC will be familiar with the fact that data and programmes are primarily stored on magnetic disk. There are two basic types of magnetic disk data storage systems; the so-called floppy or removable disk and the fixed or hard disk. Both basically function in the same way, but the fixed disk has much larger capacity.

Floppy disks usually have data capacities ranging from a few hundred kilobytes to a couple of megabytes. The average hard disk on a brand new PC will, on the other hand, probably now have a capacity of about 540Megabytes. In this article, we will be concentrating on hard disks; however, the basic recording technology is the same for both types of drive.

The hard disk drive was first developed by IBM in 1956 and was known as the RAMAC (or Random Access Method of Accounting and Control). This massive floor-standing drive unit contained no less that 50 disks, each 24 inches in diameter and capable of storing 100Kbytes of data, thus giving RAMAC what was, at the time, the enormous total storage capacity of 5Mbytes.

Hard disk drive technology continued to develop at a steady rate until the late 1970s when another IBM development, the Winchester drive, was used with early microprocessor-based computer systems to create the forerunners of today's personal computers. Since then, PC hard disk capacity has steadily grown from 10Mb to 20Mb, 100Mb, and now 500Mb plus is commonplace.

Today, every PC sold, whether a portable or a desktop, will have an inbuilt hard drive, creating a global demand for well over 100million such drives per annum. The mass production of such drives, coupled with the relentless application of technology, has meant that the unit price of a drive has remained virtually unchanged despite an enormous increase in average drive capacity.

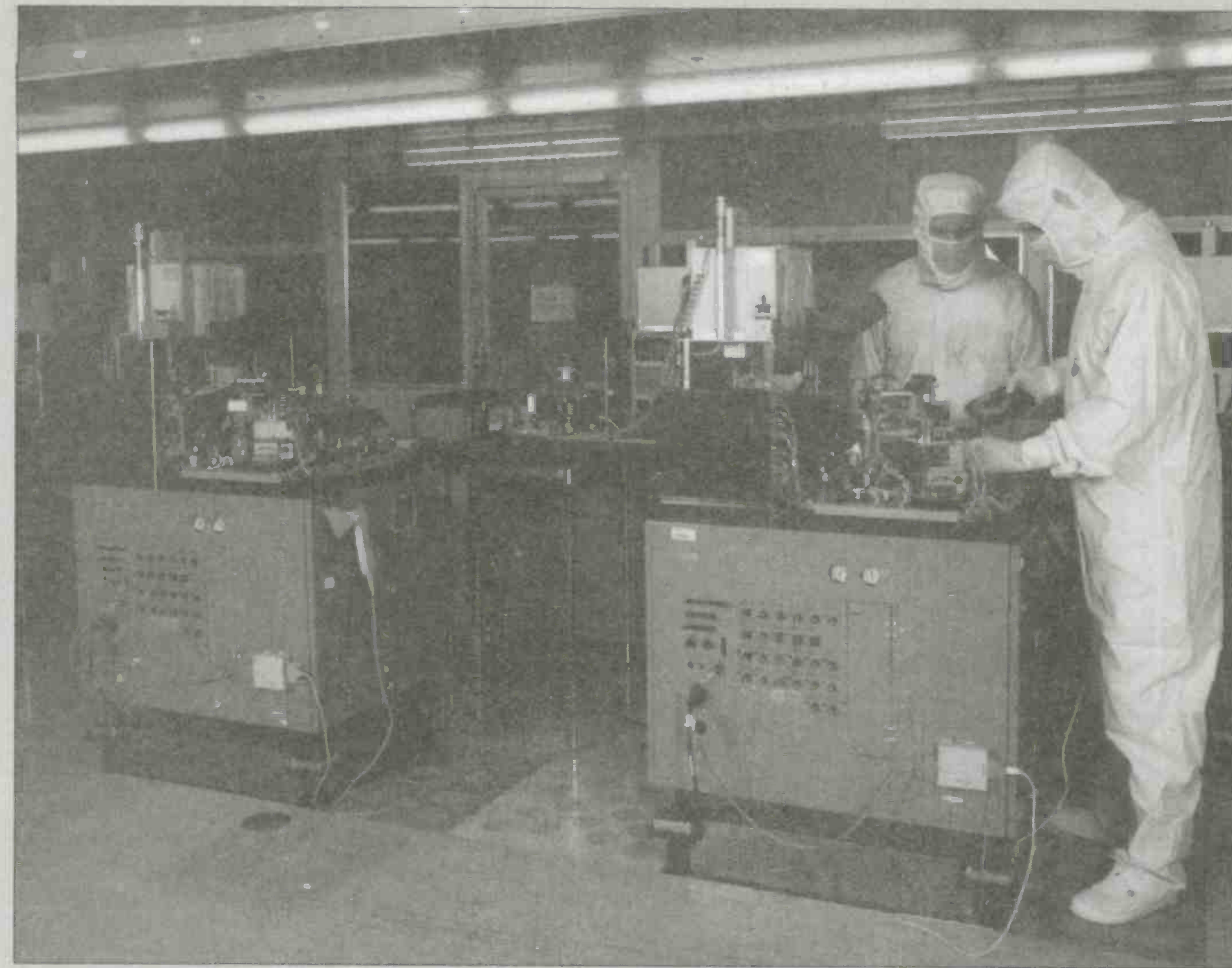
This means that if we look at a graph of hard disk storage capacity over time we can see that between 1956 and 1990 the maximum drive capacity was increasing at about 30% per annum but, in 1991, this suddenly increased to an annual rate of over 60% per annum. Today, companies like IBM are already producing 3.5 inch disk drives, the same physical size as those used in the average PC but, with a capacity of 10Gigabytes, at this rate you could have a 100Gigabyte drive in your PC by the year 2000 at no more cost than a current generation 1Gigabyte drive.

If you are wondering how much data storage that actually is, then just think that you can store one hour of full motion video in about 850Mbytes, so that is enough storage for over 117 hours of your favourite films. Furthermore, the technology will not stop there; already under development are techniques which will push the increase in drive storage capacities forward at this rate until well into the next century. In the rest of this article, we will take a look at some of these technologies.

## The basics of hard drive operation

To understand some of the problems involved in designing and building very high capacity disk drives, it is essential to begin

**IBM disk drive manufacture in an A100 clean room**



**Automated testing of IBM disk drives**

with a look at the basic physics employed in every magnetic disk drive. All drives consist of a rapidly rotating disk coated with a magnetically sensitive coating, such as a very thin film of finely powdered iron oxide.

Writing data on the disk involves the use of an electromagnet mounted on a moveable arm that can track back and forth across the surface of the disk in a radial direction. This electromagnet is then used to generate a magnetic field on a very small area of the disk. This field will align the magnetically sensitive particles in the coating in a particular direction, a direction which can be reversed by altering the direction of current flow in the electromagnet. The magnetic domain will remain set in a particular direction until altered by another write operation.

The data can be read from the disk by simply reversing the process. When the small magnetic domains on the disk coating pass under the coils of the electromagnet they will generate a very small current, the direction of which depends on the polarity of the domain.

This process is fundamentally the same as that employed to record music on a common magnetic tape, but with one major difference; the bits recorded on a disk are small spots where the magnetic field has totally saturated the area. In other words, it is either off or on. But on a tape, the level of saturation varies with the wave form being recorded, thus allowing it to store a variable analogue level rather than small dots. This technique is not used on disk drives because small dots are easier to precisely read and write at very high speed.

Having said this, all the early disk drives used basically the same type of analogue electronics as a tape recorder, with the exception of driving the record head in a way which totally saturated the coating. Such drives are usually referred to as analogue disk drives.

However, in order to increase the amount of data stored on a disk, without actually increasing the disk size or the number of disks in a drive, it is necessary to decrease the spot size and thus pack more spots onto a given area. This is known as the areal density and we have seen this figure increase by a factor of ten in the last five years to a current level of 0.86Gigabits per square inch of disk surface and, by the year 2000, this figure should be in the region of 10Gigabits per square inch.

Greater areal densities mean smaller spots that are closer together, and to achieve this has meant reducing the head size and the distance between the head and the platter. This, in addition to increasing the sensitivity of the read head because smaller spots mean weaker induced fields. In order to increase areal density, research has thus concentrated in three areas - head miniaturisation, better disk coatings and improved read electronics.

The result has been the development of what is generically known as the digital disk drive.

## Reliably storing data on disk

If there is one thing a magnetic disk drive must do, it is to store

both used to store data bits with a logic '1' value, the areas with no defined polarity store the logic '0' bits. This technique has two virtues; it permits higher data density, but most importantly it allows the disk to be self-timing. This is possible because two successive logic '1' bits will be stored as two successive domains of opposite polarity (though, in practice, special RLL coding ensures that every '1' is separated by at least one '0' and up to seven '0's).

This self timing allows servo-control techniques to ensure that variations in disk spin speed will not cause any slewing of the points on a track where the signal coming from the read head is sampled. It also allows the system to automatically compensate for the fact that the amount of track occupied by a given domain on an outer track is much longer than that occupied by a similar domain on an inner track (this is because fast random access of data is very important on magnetic disk drives and this requires the use of what is referred to as constant angular velocity. This means the use of concentric tracks which, in a very simplified system, would each store the same number of bits, as opposed to the spiral constant linear velocity track found on a record or CD where the bit spacing along the track is always the same).

The system electronics connected to the read head is designed to sample each domain area twice as the disk rotates. The servo control mechanism which is part of that circuitry will adjust the sampling rate to closely match the domain spacing on the track. This saves any complex control of drive motor speed and rotational position, and also ensures that the sampling electronics can accurately detect the peak of any magnetic domain and thus count the bits along the track.

data reliably over a long period and with repeated access. Nobody will want to use a drive which loses a percentage of the data stored on it. Nobody wants to try retrieving some important document that has been the result of hours of slaving away over a hot computer only to find that every few words there is a letter which has mysteriously changed.

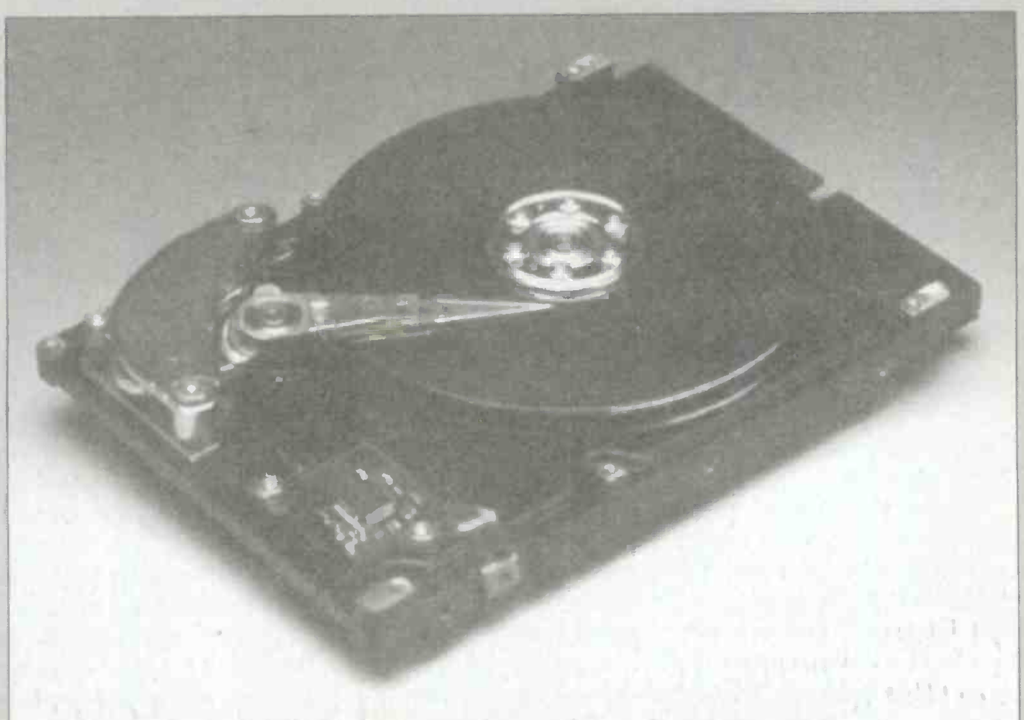
What users demand from their disk drive is very high reliability over several years of continuous use. Given the enormous amount of data which is being stored on modern disk drives, ensuring this reliability is no easy task for the designers.

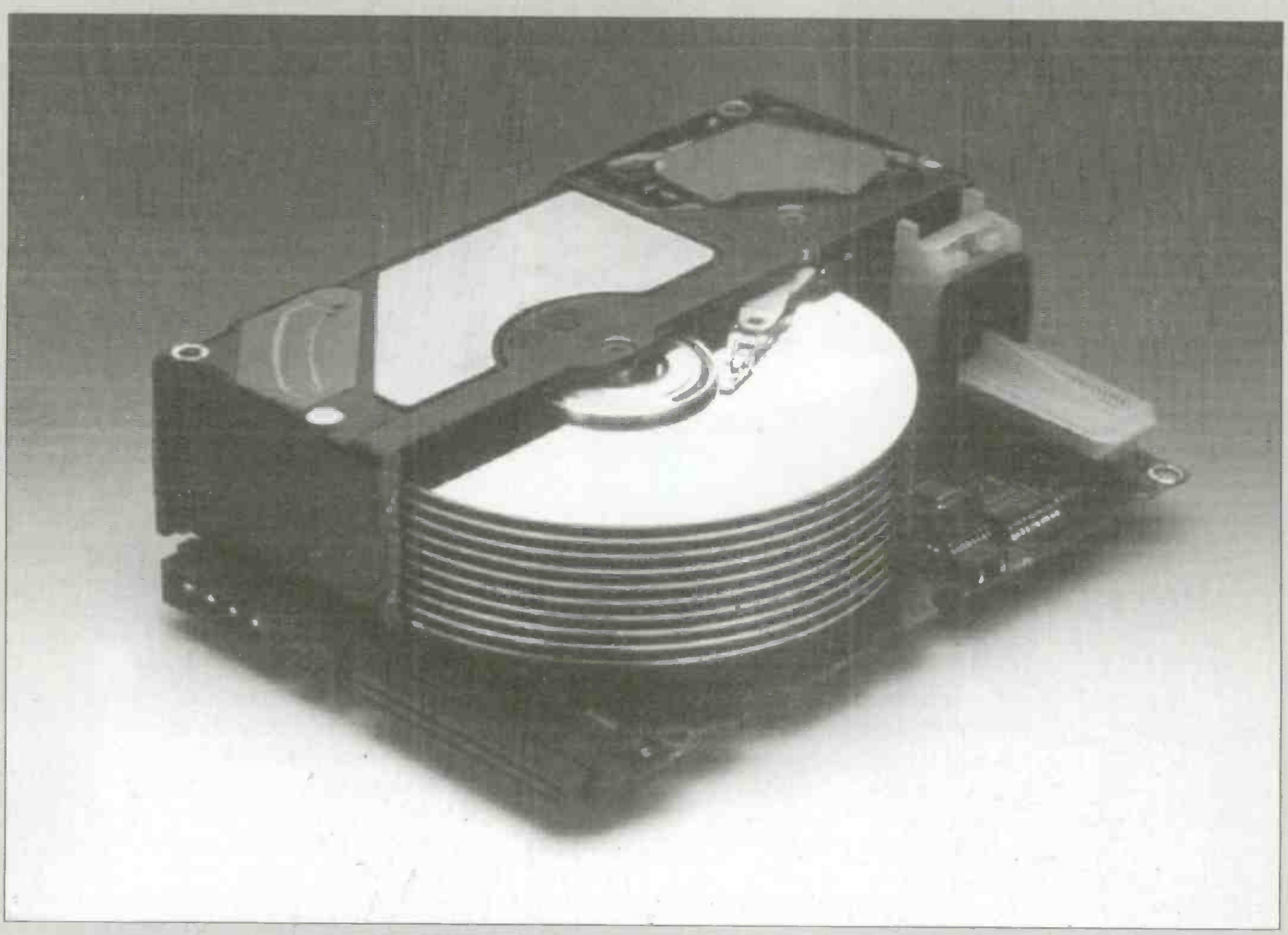
The data is stored on a disk drive as tiny magnetic domains located in a series of concentric tracks. Rotation of the disk allows every domain on a given track to pass under the head and, by moving the head across the radius of the disk, it is possible to position the track, and thus read/write data on every track on the disk.

The magnetic domains on each track are created by the electromagnet in the write head. When current flows through this electromagnet coil in one direction, the domain written on the disk's magnetic coating is aligned one way. By switching the direction of current flow in the coil, the domain that is written will have the opposite magnetic polarity.

This means that the magnetic coating on the disk can have three states; one with no defined magnetic polarity, and the other two with defined but opposite magnetic polarities. Intuitively, one would think that it was the two opposite magnetic polarity domains that are used to store logic 1, and 0 bits but ,in practice, this is not the case

In modern disk drives, the two opposite polarity domains are





## Encoding data

As areal densities increase, the size of individual magnetic domains has to decrease. This means weaker induced fields in the read head and the probability that domains can start to overlap one another. The result can be a certain ambiguity as to whether the data stored at a particular point is a logical zero or a logical one. This increasing level of 'noise' within the data is one of the major problems facing magnetic disk drive designers as they attempt to put more and more data onto a disk.

The earliest techniques revolved around the use of error correction codes, or ECCs, such as the very widely used Reed Solomon code. The function of these codes was to help the hardware to reconstruct the original data where any errors resulting from 'noise' had occurred.

On later generations of drive, this technique was improved by use of a further level of coding referred to as Run Length Limited, or RLL, coding. This is, as we have already seen, used to ensure that not too many '1's or '0's fall in succession. To do this, extra bits are added where necessary, in accordance with the coding formulae of the specific RLL method being used. It is a technique which greatly increases reliability, particularly with respect to the elimination of clock drift, but it does have the drawback that it can increase the amount of data stored on a disk by up to 50%.

The read electronics attempt to sample each domain twice (the minimum practical sampling rate). These samples are then used by so-called 'peak detection' circuits to determine whether the resultant bit is a logical '1' or '0'. However, as one puts the domains closer and closer together, there is the additional problem of domains overlapping and thus trying to get the electronics to determine exactly which peak a particular sample belongs to. As can be seen from the accompanying diagram (Fig.1.), the wave form coming from the read head is no longer smooth, but disjointed.

The solution to this problem lay in a computational technique which was first developed by mathematicians working for NASA in order to clean up very weak signals coming from interplanetary spacecraft. It is a technique known as Partial Response Maximum Likelihood, or PRML, it has revolutionised disk drive technology and made possible the multigigabyte drives of today - and the even higher capacity drives of the coming decade.

## PRML and the digital drive

In PRML systems the data from the read channel is output as a sequence of 6-bit digital values which corresponds to the sampling voltages. This sequence of digital values is then fed into a special purpose processor chip which applies the PRML algorithm and outputs the data to the drive's data channel. This use of digital electronics is the reason why such drives are referred to as 'digital disk drives' as opposed to the older technology 'analogue disk drives'.

Simply, the PRML algorithm is designed to look at a sequence of samples and then determine whether each pair of samples belongs to the same peak or to two separate peaks. This in itself is not that revolutionary; what is, is the fact that the algorithms can adjust themselves when errors occur, a very important feature because noise will often add false peaks as a result of skewing the samples.

To more closely understand how PRML works, look at Fig.2. This shows the rather noisy sequence of samples obtained from the read wave form shown in Fig.1. In this system, normal

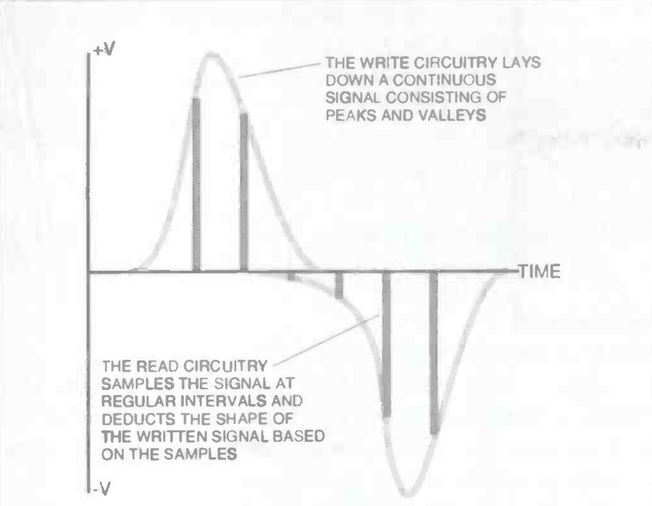


Fig.1 'Read signal sampling'

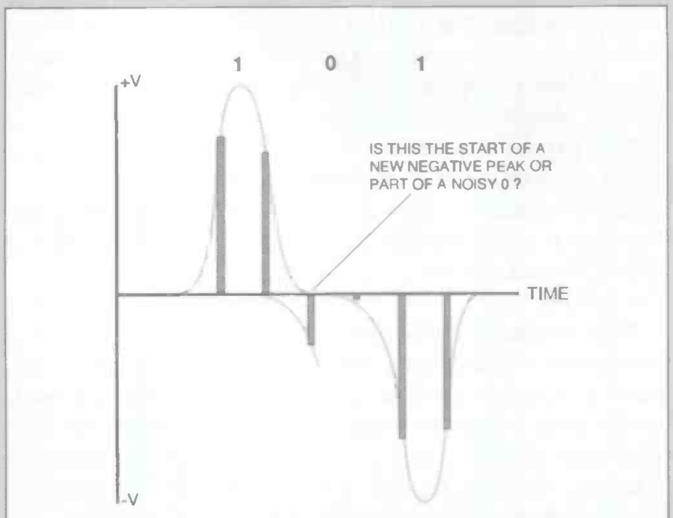


Fig.2 PRML sampling with noise

detectable peak values for a logical '1' would be either +3.5volts or -3.5volts with a permissible error of about 0.5 volts. Whilst a logical '0' would be 0volts again with a permissible error of 0.5volt.

The samples shown in this diagram actually represents a '101' bit pattern but, as can be seen, the third sample has rather an ambiguous value of -1.5volts, more than '0' but less than '1'. The question is: is this sample the beginning of a new negative peak which has been attenuated? Or is it a noisy sample caused by overlapping peaks? In other words, is the bit pattern '101' or '1101'? (of course, the system would reject this interpretation because the peaks will always alternate between positive and negative, but this would still not ensure that the correct bit sequence could be determined).

Whereas the analogue peak detection system simply matched voltages to thresholds in order to determine the presence or absence of peaks, PRML will not determine whether a given sample is a peak until it has received perhaps five or six subsequent samples. Only then will it compute the peaks by means of a method involving calculating the partial errors which occur with the interpretation of each sample as well as those preceding and following it.

The addition of very high-speed PRML processing electronics into modern disk drives has thus enabled areal density to be increased enormously and should, given improvements in both processing hardware and PRML software, allow continued increases in density at 60% per annum for at least another ten years.

However, this is not the only advantage of using PRML. The fact that the software can be made to be self-adaptive means that it can be individually tuned to optimise the behaviour of each drive. This overcomes the slight variations between units that are inevitably introduced during manufacturing. This factor should help minimise failure rates, much to the users' delight, and manufacturing reject rates which should not only please manufacturers but also help keep drive prices down.

## The year 2000 and technology limitations

Researchers at companies like IBM are confident that they can continue increasing areal densities on magnetic disk drives using current technology until about the year 2000. By then we should see densities of up to 10Gigabits per square inch and maximum 3.5inch format disk drive capacities of around 100Gigabytes.

However, as the heads get smaller to match the smaller magnetic dot size, the read back signal also decreases. As it gets smaller, it eventually reaches a level where the amount of noise in relation to the signal makes it impossible to accurately extract the data. With conventional MR head technology, engineers expect to reach this point in about four years' time.

The acceleration in development of technology means that there is less and less time to develop new technologies if the momentum is to be continued. It is not surprising therefore that IBM, who are probably the world's technology leaders in hard disk drives, have already designed a new head which overcomes these problems and will allow continued development until about 2005.

The new head technology developed at IBM's huge Almaden Research Centre in San Jose, California, is known as the Giant MR, or Spin Valve Head. This head is based upon very advanced physics and is at least five times more sensitive than the MR head, thus allowing a further considerable decrease in both head dimensions and magnetic dot size.

The Giant MR head should, according to current research, enable engineers to produce-drives with areal densities of between 20 and 30Gigabits per square inch, which will equate with 3.5inch format drives having a capacity of about 1000Gigabytes. Not surprisingly there is an enormous R&D effort currently being expended by the major disk drive producers to achieve this target.

This research is also looking at improving the PRML techniques, the read electronics and the magnetic coating on the disks. Already, as far as the disks are concerned, designers are moving away from aluminium disks to glass disks which - surprisingly - are more robust and permit a much smoother and thinner magnetic coating.

However, as we approach about 2005/6, disk drive designers will, assuming a continued 60% annual increase in areal density between now and then, reach a physical limit to any further increase. This limit is known as the super paramagnetic limit and is reached when the bit size equals the smallest magnetic domain in any known material. This means that magnetic disk drives will not be able to have areal densities above about 80Gigabits per square inch.

Of course, in order to produce magnetic disk drives with areal densities as high as 30Gigabits per square inch will require - in addition to further development of existing technologies - the creation of a lot of new technologies, such as new types of spindle motor and head actuators.

As the distance between tracks, and the individual bits on a track, becomes smaller, so conventional motors and actuators will prove unable to deliver the very smooth and fine movements necessary. The solution lies in an entirely new technology known as micro-mechanics. A technology which uses semiconductor manufacturing techniques to construct mechanical devices - indeed whole machines which are truly microscopic in size.

Micro-mechanical components for the disk drives of the future are already being developed by IBM and others. Probably the first application will be the use of an actuator mounted on the head arm which will finely adjust the position of the head and thus allow it to be very accurately positioned over very narrow tracks on the disk.

The ultimate goal is to use micro-mechanics for virtually all the mechanical components of a disk drive, including drive motor, head actuator and even the disk itself. The aim is the production of ultra-miniature drives, with very high capacity, which are little bigger than a conventional IC package.

Indeed, IBM are already some way down the line in developing such drives and, at the recent Comdex show in Las Vegas, they unveiled a prototype one inch disk drive that made extensive use of micro-mechanics. Within a few years, such drives, capable of storing at least several hundred Magabytes of data, will be commercially available. It is envisaged that they will be used in devices such as digital cameras, personal digital assistants, Internet connectable mobile phones, etc.

## Beyond the magnetic disk.

The super-paramagnetic limit may impose an upper boundary on the areal density, and thus the total storage capacity, of magnetic disk drives, but there are plenty of other data storage technologies waiting in the wings. Contenders are multi-layer optical disks, 3-D holographic memories and, right at the very top, the ability of the atomic force microscope to store data by moving individual atoms.

The AFM is probably a very long way off from any practical implementation, but we could well see multi-layer optical disks and holographic memories in use commercially within the next couple of years.

Already we are familiar with CD-ROMs; these hold about 640Megabytes of data but, by stacking two or more layers of data containing tracks one above the other and then reading them using an optical system which can focus on one layer at a time, it is possible to greatly increase the storage capacity of such disks. It is also possible to decrease the spot size, and thus increase the amount of data stored on a disk, if we can also decrease the wavelength of the light beam used to read the data. Hence the quest for a blue, or ultra-violet, semi-conductor laser.

IBM have demonstrated a blue semiconductor laser based around a frequency doubler crystal and have also recently demonstrated a multi-layer disk. These two technologies should make it possible to store tens of Gigabytes of data on a CD-ROM type disk by the end of the century. These are technologies which are applicable to both read only and read/write type disks.

However, there is a practical limit to the number of layers and also a limit on dot size imposed by the wavelength of light. This means that, as with magnetic disks, there is an upper limit to the data storage capacity of optical disks which employ conventional storage techniques. But this limit can be overcome by taking a fundamentally different approach; the use of holography.

Holographic data storage devices, whether based on a rotating disk or an optically scanned block should, in theory, be capable of storing hundreds of gigabytes of data, and what is even more important randomly accessing and retrieving that data at rates of Gigabits per second.

At the moment, holographic memories only exist as experimental systems and there are still problems with finding a reliable storage medium which is stable enough to keep the data for a long time, not to mention the development of a sensitive enough read detector. However, a couple of small California start-up companies are expected to launch holographic memories within the next year. These are 3-D holographic disks based around a 100 micron thick polymer film and capable of storing data at a density ten times that of a CD. One of them is even working on a trillion bit storage device - that's 200 times the data stored on a conventional CD-ROM.

**All photos courtesy of IBM**

## MR heads

The MR or magneto resistive head was one of the key technologies behind the introduction in the early 1990s of the first 1Gigabyte 3.5inch hard disk drive. It has enabled designers to greatly increase areal densities while at the same time substantially reducing the number of head and disk components.

Higher areal densities and fewer components have made it possible to produce very small disk drives for use in portables (these are usually 2.5inch format drives). This is because fewer components mean that the drive needs less power to operate and, of course, can be made much smaller. These factors have brought about an explosion in demand for both portable systems and high capacity desktop systems.

The MR head was developed by IBM at their Almaden Research Centre in San Jose, California, and first used in a commercial product in 1991. Such heads are now used in all very high capacity drives and IBM are currently producing over 100 million MR heads per annum all of which go into IBM manufactured drives.

The individual head measures no more than a few square millimetres and is less than a millimetre thick. It is mounted at the end of a thin and very flexible actuator arm which moves the head radially across the surface of the rotating disk. The flat area of the head is very carefully machined with special grooves to create an air bearing which ensures that the head floats at just 2 or 3 micro inches above the surface of the disk (this is very close and equivalent to between 200 and 300 atomic spacings).

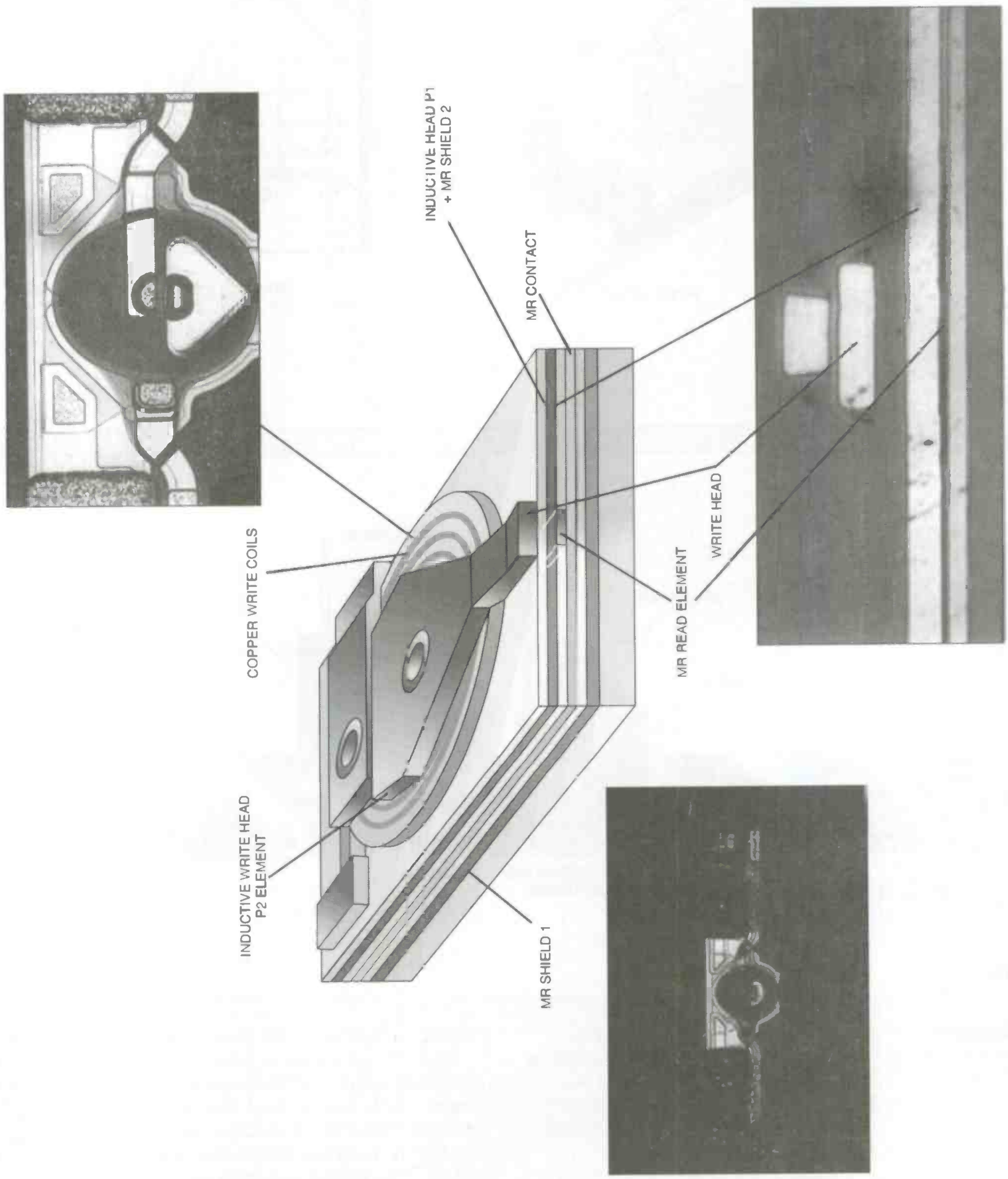
The actual read/write heads are fabricated using thin film technology on the vertical face at one end of the head (see the photomicrograph on this page). The MR head's basic design consists of a separate read and write element which are formed over each other and sharing common material layers. The write element is a thin film inductive head. The read element is a thin alloy film, usually NiFe, which exhibits a change in resistance in the presence of a magnetic field, the MR effect.

This optimised design not only has the smaller geometry required for high areal density disks but it is also much easier to build than conventional inductive heads that must perform both read and write functions. This is because the design requires fewer copper coils, material layers, photolithographic masking operations, and head tolerance controls. The result is higher processing yields, greater reliability and reduced cost.

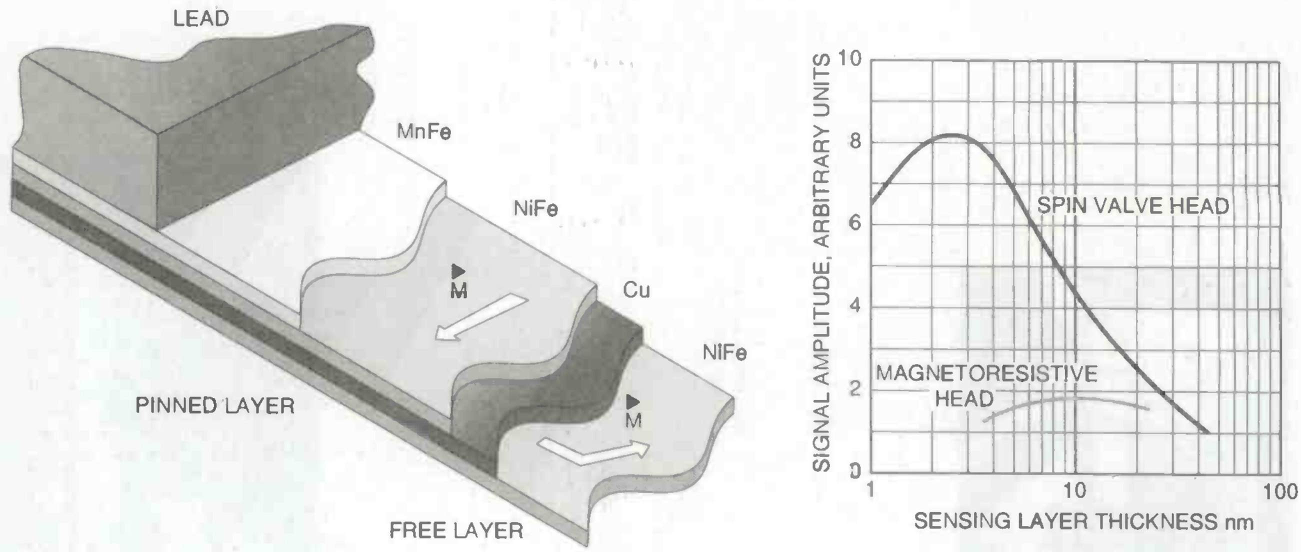
Note that the shielding layers are used to protect the MR element from other magnetic fields. The second shield also functions as one pole of the inductive read head, thus giving rise to the term 'merged MR head'.

The main diagram (fig.3) accompanying this text box is an idealised 3-D representation of a merged MR head. The bulk of the head with its air bearing grooves is not shown; what the diagram represents is the end of the head with the thin film read and write structures. The 3-D view is looking at the head from the plane of the rotating disk.

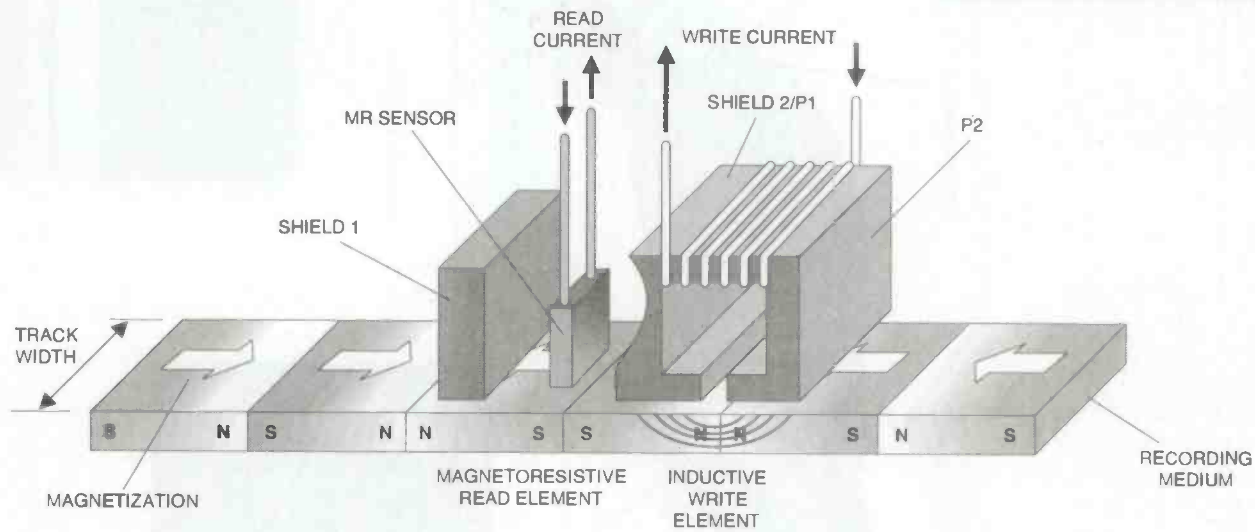
The way that this head works is shown in the diagram above (fig.5). It shows the inductive element writing bits of


INDUCTIVE HEAD P1
+ MR SHIELD 2
MR CONTACT
COPPER WRITE COILS
WRITE HEAD
MR READ ELEMENT
INDUCTIVE WRITE HEAD
P2 ELEMENT
MR SHIELD 1

(fig.3)




(fig.4)

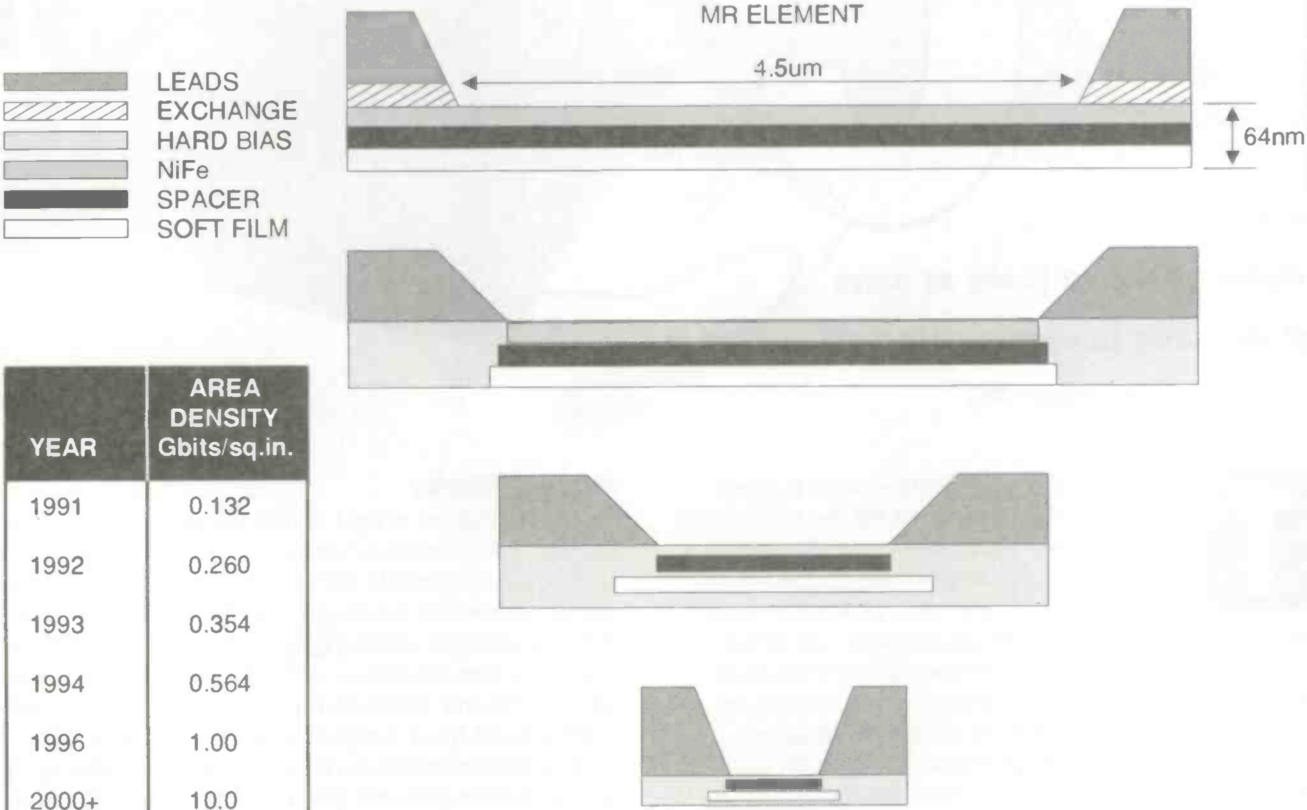



(fig.5)

information as magnetically biased regions within radially concentric areas, or tracks, that are subsequently read by the MR sensor. The presence of a magnetic transition, or flux reversal, between bits causes the magnetisation in the MR sensor to rotate. This rotation can be detected directly as a resistance change by a precision amplifier, which then produces a stronger signal that relays the information to the disk drive's electronics channel.

As areal densities approach 1Gigabit read head noise starts to become a problem. In the current top range drives produced by IBM, the MR element is a strip of Nickel Ferrite just 300Angastroms thick. The problem with making such a head is how to stabilise the magnetic domains so as to produce a clean, noise-free read back signal.

What IBM have done, in a patented technique, is produce what is known as a 'soft adjacent layer', or SAL, biased MR sensor structure. What this means is that by passing electricity through the MR sensor they can create a magnetic field that interacts with the magnetisation of the underlying soft film. This transverse biasing ensures that the magnetic rotation of the MR film occurs at an optimum angle with respect to the sense current, producing the preferred linear-responsive MR signal. To maintain the MR sensor's stability and to suppress magnetic domain noise, a longitudinal bias is also applied by an additional structure, the exchange-bias, or hard-bias, layer.




| YEAR | AREA DENSITY Gbits/sq.in. |
|---|---|
| 1991 | 0.132 |
| 1992 | 0.260 |
| 1993 | 0.354 |
| 1994 | 0.564 |
| 1996 | 1.00 |
| 2000+ | 10.0 |

**(fig.6) Reduction in MR head size**

By scaling down MR heads (fig.6), it should be possible to increase areal densities to about 10Gigabits per square inch. This will be achieved by using progressively thinner magnetic films together with narrower MR elements. However, around the year 2000, designers expect to reach a limit to further reduction in size and thus a limit to further increase in areal densities.

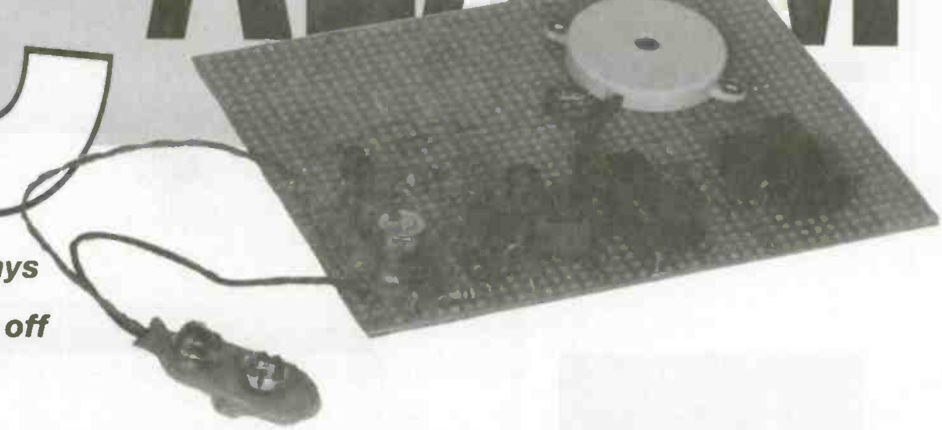
The year 2000 is less than 2000 days away; little enough time to develop a new technology, so it is hardly surprising that IBM have already developed their technology which will succeed MR and allow them to push towards the ultimate boundary in magnetic disk technology, the so-called super paramagnetic limit. This is dictated by the physics of magnetic recording and lies at an areal density of just over 100Gigabits per square inch. A limit which developers expect to reach in about 2010.

The IBM technology designed to succeed MR is known as a 'Giant MR' or 'spin valve head' (fig.4), where spin valve refers to the direction of electron spin. In this type of head, the MR stripe is replaced with a multi-layer structure which form two MR stripes, a cobalt layer whose magnetic domains are firmly pinned in one direction by the bias film, a very thin copper spacer, and a second MR layer made from nickel ferrite whose magnetic domains are free to rotate one way or the other as the transitions pass under the head.

If the magnetic domains in the pinned layer are aligned in opposite directions to the free layer, the electrical resistance is high. If they are aligned in the same direction, it is much lower. Therefore, as the transitions pass under the head, the magnetic vector in the free layer rotates one way or the other, thus changing the resistance. Read back signals from the Giant MR head are some five times higher than current MR heads and thus able to cope with the very small magnetic domains found in high areal density disks.

The above short review of disk drive head technology shows how the creation of the head unit is a fusion of advanced physics, and some really leading edge manufacturing technologies. It is this fusion coupled with an ongoing enormous investment in research, development and manufacturing capabilities which will ensure that the data storage capacity of magnetic disks will continue to increase at a compound growth rate of 60% until at least the year 2010. After that, we are probably looking at the use of entirely new technologies such as bulk holographic memories.

# PC ALARM



***Robert Penfold looks at ways of stopping thieves making off with your PC***

Theft of all sorts seems to have been a growth industry in recent years, but the rise in computer thefts has been particularly steep. Sometimes a large number of computers are stripped of their memory modules and micro-processors in well planned raids. More usually though, complete computers are removed, together with any expensive peripherals such as laser printers and modems, in relatively quick, small-scale raids. Some disappear as a result of opportunist crime.

Any premises which contain expensive computer equipment should obviously have the usual security measures to make life difficult for would-be burglars. With larger electronic goods such as computers, it is possible to provide increased security by fitting them with their own built-in alarm. Thieves could still make off with the goods, but they would presumably be reluctant to carry off computers that were producing a loud alarm sound! A built-in alarm should certainly be sufficient to see off opportunist thefts.

The simple alarm featured here is intended for use with PCs and it simply plugs into any unused expansion slot. However, as the circuit is completely self-contained, and is not dependent on the PC for power, there should be no difficulty in adapting it to suit other computers and (possibly) other major items of computer equipment.

Under standby conditions, the alarm consumes no significant power, and it can therefore be powered from a PP3 size battery for the "shelf-life" of the battery. For modern high-quality batteries, this is usually a few years. If the PC is moved, the alarm is triggered by a "trembler" switch, which is a form of mercury switch. Once triggered, the alarm can only be switched off by opening up the computer and disconnecting the alarm circuit from the battery. The alarm sound is a piercing frequency modulated tone provided by a ceramic resonator.

## How It Works

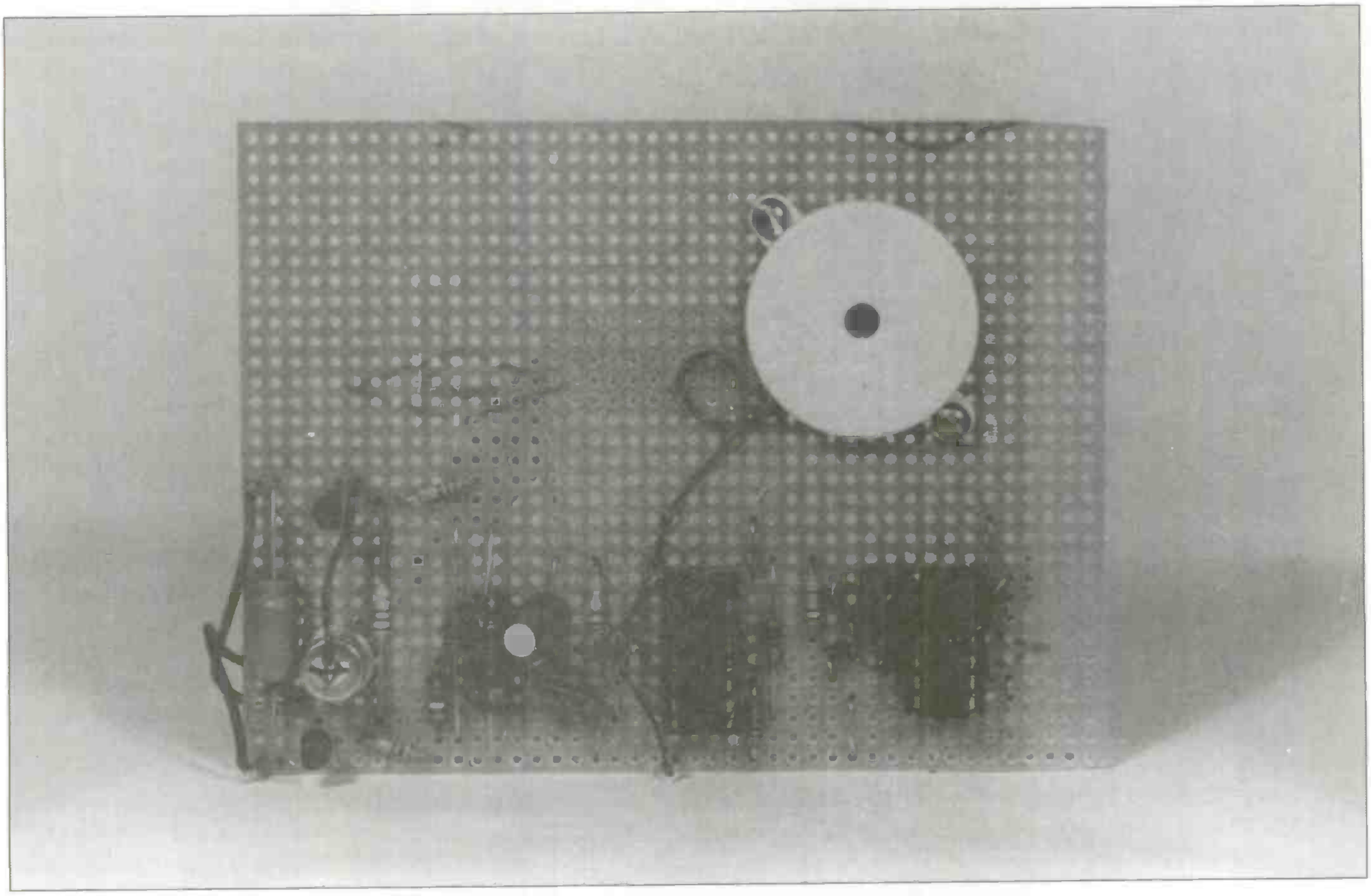
The block diagram of Fig.1 shows the general make-up of the PC alarm. As pointed out previously, the trembler switch is a form of mercury switch. With a normal mercury switch there are two electrodes in a roughly half-filled reservoir of mercury. With the switch at some angles the mercury touches both electrodes and provides a contact between them. At other angles, only one electrode is touched by the mercury and there is no electrical connection between the electrodes.

A trembler switch is a variation on this arrangement. They vary somewhat from one type to another, but the general scheme of things is to have two intricately shaped electrodes at the centre of a slightly less than half-filled reservoir of mercury. If the switch is held still, the mercury will fail to touch both electrodes, regardless of the switch's orientation. However, the mercury only just fails to bridge the electrodes when the switch is stationary, and it only takes slight movement to send waves through the mercury that result in the switch closing momentarily.

Although this alarm will work properly using an ordinary mercury switch, a trembler switch is the more convenient in use. With an ordinary mercury switch it essential to mount the switch so that it is switched off, but only just. Then, hopefully, any movement will cause it to close at least momentarily. A trembler switch can be mounted with any orientation, and will give the desired effect.

The trembler switch drives a simple latch circuit. A momentary switching action from the trembler switch results in the latch being activated, and it then turns on an electronic switch. Even when the trembler switch returns to the "off" state, the electronic switch remains switched on. The electronic switch is used to activate a simple audio alarm generator circuit which provides a frequency modulated


**Fig.1. The PC alarm block diagram**



(warbling) alarm sound.

A low frequency oscillator provides the frequency modulation. The output signal from this oscillator is a roughly squarewave type, which would switch the tone generator between two frequencies. This would give a reasonably effective alarm sound, but better results are obtained if the pitch of the tone is swept up and down. This is achieved by feeding the modulation signal to the tone generator via a lowpass filter. This filters the squarewave signal to produce a roughly triangular modulation signal.

The basic audio tone is produced by a v.c.o. (voltage controlled oscillator). As the modulation voltage varies up and down, the output frequency of the v.c.o. varies up and down in sympathy with it, generating the required alarm sound. The available output current from the v.c.o. is quite small, but it is adequate to produce high volume levels from a cased ceramic resonator.

Fig.2 shows the circuit diagram for the PC alarm. The latch is based on TR1 and TR2, and as TR2 provides an open collector output, it also acts as the electronic switch. Under standby conditions there is no base bias to TR1, and it is therefore fully switched off. TR2 does not receive a base current either, since it can only be switched on via a current from the collector of TR1. S1 is the vibration switch and, when this is activated, it provides a strong base current to TR1. TR1 then switches on and, in turn, provides a strong base current to TR2. TR2 supplies virtually the full supply potential to the alarm generator circuit connected in its collector circuit.

The latching is provided by R5. Under standby conditions R5 cannot provide a base current to TR1 because TR2 is

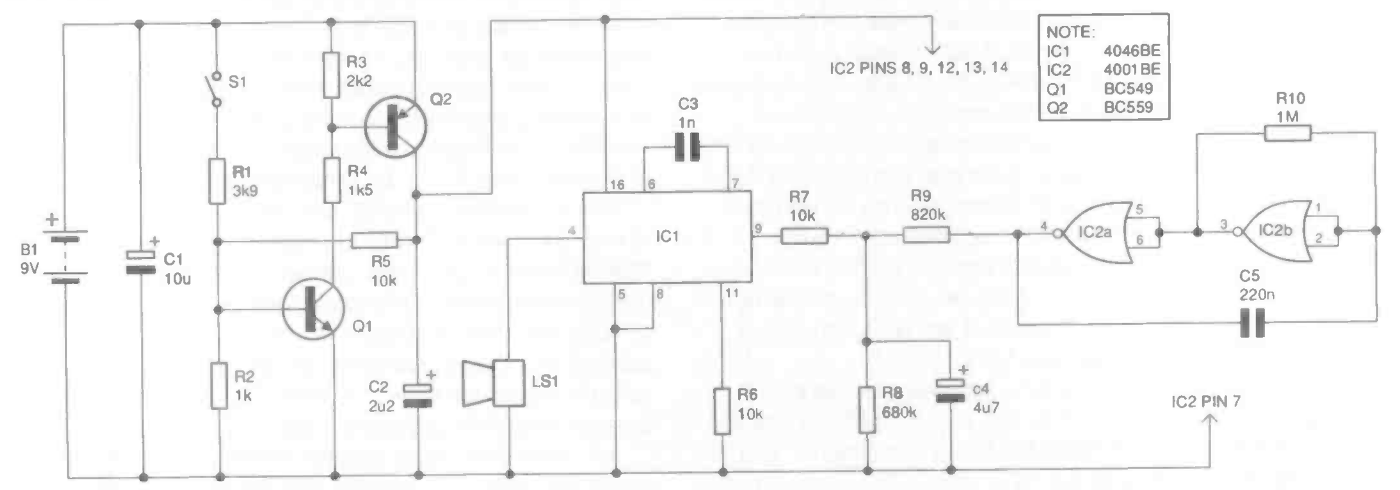



**Fig.2. The PC alarm circuit diagram**

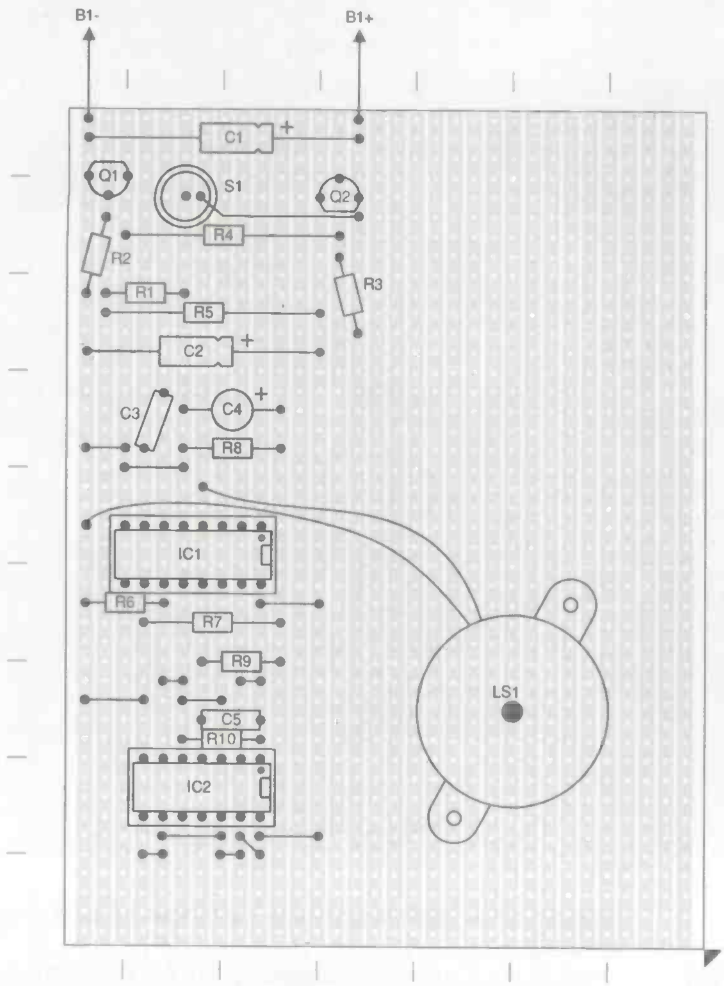



**Fig.3. Component layout for the stripboard panel**

switched off. R5 does provide a base current to TR1 when S1 is activated and TR2 switches on. R2 will hold TR1 in the "on" state even when S1 opens again and TR1 is no longer supplied with a base current via S1 and R1. Thus, TR1 and TR2 hold each other in the "on" state, and the required latching action is obtained.

There is a potential problem with this type of latch circuit in that it is extremely sensitive, and easily triggered by electrical noise. Inside the average computer there is likely to be quite a high level of electrical noise. The values of the resistors in the circuit, particularly R2 and R3, have been made quite low in value in order to keep the sensitivity of the latch quite low. This should avoid problems with spurious triggering each time the computer is switched on or a disk drive is accessed!

A CMOS 4046BE "micro-power" phase locked loop (IC1) is used as the basis of the alarm generator. In this case only the v.c.o. section of the 4046BE is utilized, and no connections are made to the other stages. C3 and R6 are the timing components, and the modulation signal is applied to the v.c.o.s control input at pin 9. LS1 is the ceramic resonator, which provides very high efficiency at the fairly high output frequency range of IC1 (around 1.5 to 4kHz).

The low frequency modulation signal is provided by a simple astable circuit based on two of the four 2 input NOR gates in IC2. C5 and R10 are the timing components, and they set the operating frequency at around three to four hertz. The other two gates of IC2 are unused, but their inputs are connected to the positive supply rail to prevent spurious operations. The lowpass filtering is provided by R9 and C4. R8 attenuates the modulation signal slightly, and prevents an excessive amount of modulation. The modulation signal is coupled to IC1 via protection resistor R7.

The alarm generator should work quite well with the specified component values, but it is often worthwhile "tweaking" one or two circuit values in order to obtain optimum results from the particular ceramic resonator you are using. In this case it might be possible to obtain a higher sound level by altering the value of R6 so as the give an output frequency range that precisely matches the optimum response of the resonator.

The quiescent current consumption of the unit is negligible, since the only current flow is leakage through C1, TR1, and TR2. This should be less than one microamp. Only about 8 milliamps is consumed when the alarm is activated. A PP3 size battery is able to supply these modest needs. The battery life is equal to the battery's shelf life, and it might be worthwhile using one of the "high power" varieties which have very long shelf lives.

## Construction

The stripboard component layout for the PC alarm is shown in Fig.3. The board has 43 holes by 32 copper strips. This must be cut from one of the larger standard sizes in which the board is sold. Cut along rows of holes and then file the rough edges to a neat finish. Then make the 24 breaks in the copper strips, as detailed in the underside view of the board (Fig.4). The breaks can be made using the special tool, or using a hand-held twist drill bit of about 5 millimetres in diameter. Make sure that the tracks are properly cut across their full widths, but do not cut so deeply into the board that it becomes damaged.

Then start adding the components and link-wires, working methodically across the board. The link-wires are made from 22 or 24 s.w.g. tinned copper wire or, as they are all quite short, the trimmings from the resistor and capacitor leadout wires may well suffice.

S1 is an unusual component which has just one leadout wire. This wire is soldered to the board in the normal way. The other connection is made to S1's metal casing and a short insulated lead is used to connect the case to the appropriate point on the stripboard panel. The case seems to be made from a metal that readily accepts solder and there should be no difficulty making this connection provided the case and the end of the leadout wire are tinned with solder first.

The 4001BE and 4046BE are CMOS integrated circuits, and as such are vulnerable to static charges. They must be fitted in holders, but should not be plugged into their holders until all the soldered connections have been completed. Both devices should be supplied in some form of anti-static packing and they should be left in their packing until it is time to fit them onto the board. Try to handle the pins as little as possible and avoid any obvious sources of static electricity.

LS1 must be a cased ceramic resonator, and not a non-cased resonator or an ordinary moving coil loudspeaker. A non- cased resonator will give too little sound output and the circuit has insufficient output current to drive an ordinary

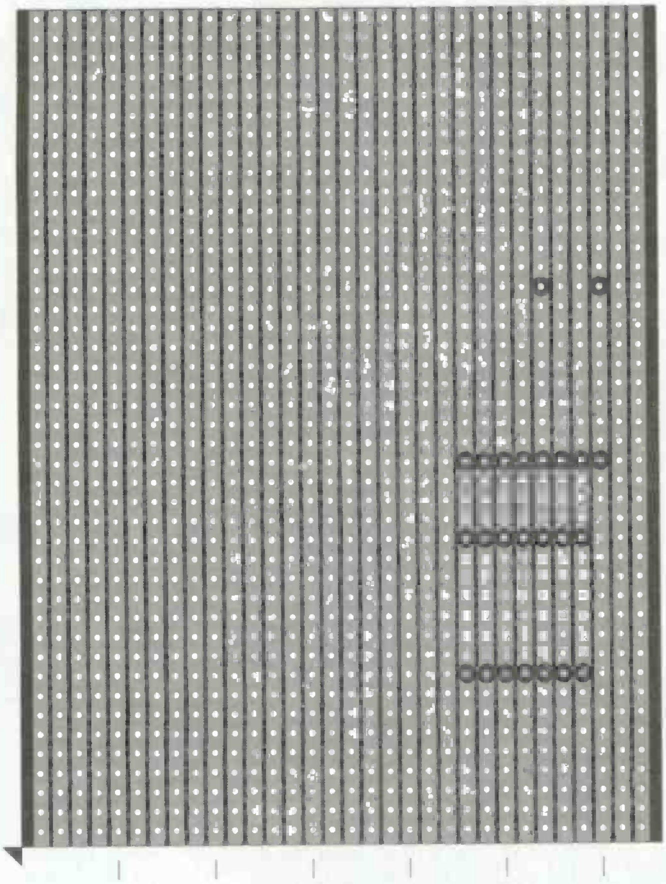


Fig.4. Underside of the stripboard panel

loudspeaker at reasonable volume. The leadout wires will probably red and black, but this is not a polarised component and it can be connected to the board either way round.

On the prototype LS1 is mounted to the circuit board. Most type require 8BA fixings, but some take 6BA bolts. The retailer's literature should give details of the mounting requirements. Obviously there will be some loss of sound level with the resonator inside the computer. Many computers have fairly open cases which still allow plenty of sound to pass through to the outside world. With computers that have cases which are largely sealed-up it would be better to mount LS1 on the exterior of the case. A couple of insulated extension leads will then be needed in order to connect LS1 to the circuit board.

The board is designed to plug into an unused expansion slot. The columns of holes on the right-hand side of the board (as viewed in Fig.3) fit into the expansion slot, but it might be necessary to file the board down slightly in order to get it to fit into the edge connector. Also, the copper strips must be removed from the part of the board which fits into the edge connector. This can be done by carefully cutting them away with a modelling knife. Alternatively, the board can simply be "Blu-Tacked" to (say) one side of the power supply box.

The battery can be fitted to the circuit board in the vacant area to the side of LS1. It can be fixed in place with a blob of "Blu-Tack" or a double-sided adhesive pad. Obviously, care has to be taken when connecting the battery, or you might vibrate the board and trigger the alarm. The vibration switch is not highly sensitive, and I found it quite easy to get the alarm up and running.

There is potentially a more difficult problem in that some computers require a fair amount of wrestling in order to get the outer casing back on. With such computers it could be difficult to get the outer casing in place without triggering the alarm. Also, some computers are used in positions where they tend to get the occasional knock, which could obviously result in a lot of false alarms. Having to occasionally remove the computer's outer casing, reset the alarm by disconnecting the battery and then reconnecting it again and then replace the outer casing is clearly not a very satisfactory state of affairs.

The solution to the problem is to fit an on/off switch on the rear of the case. Most PCs have some blanking plates on the rear panel, covering unused cutouts for D type connectors. It should be possible to mount a small switch on one of these. For obvious reasons, a key-switch is preferable to ordinary slider switches, toggle types, etc.

## Testing

Initially the unit should be tested outside the computer. When the battery is connected the alarm should not sound, but it should do so almost immediately if the unit is moved. Note that it takes a second or so for the capacitor in the lowpass filter to get up to its normal working charge voltages and for the alarm sound to settle down properly. If the unit works properly, install it in the computer and give it a final check before replacing the computer's outer casing.

## PARTS LIST

### Resistors

(0.25 watt 5% carbon film)

| | |
|---|---|
| R1 | 3k9 |
| R2 | 1k |
| R3 | 2k2 |
| R4 | 1k5 |
| R5,R6,R7 | 10k (3 off) |
| R8 | 680k |
| R9 | 820k |
| R10 | 1M |

### Capacitors

| | |
|---|---|
| C1 | 10u 25V axial elect |
| C2 | 2u2 50V axial elect |
| C3 | 1n polyester |
| C4 | 4u7 50V radial elect |
| C5 | 220n polyester |

### Semiconductors

:

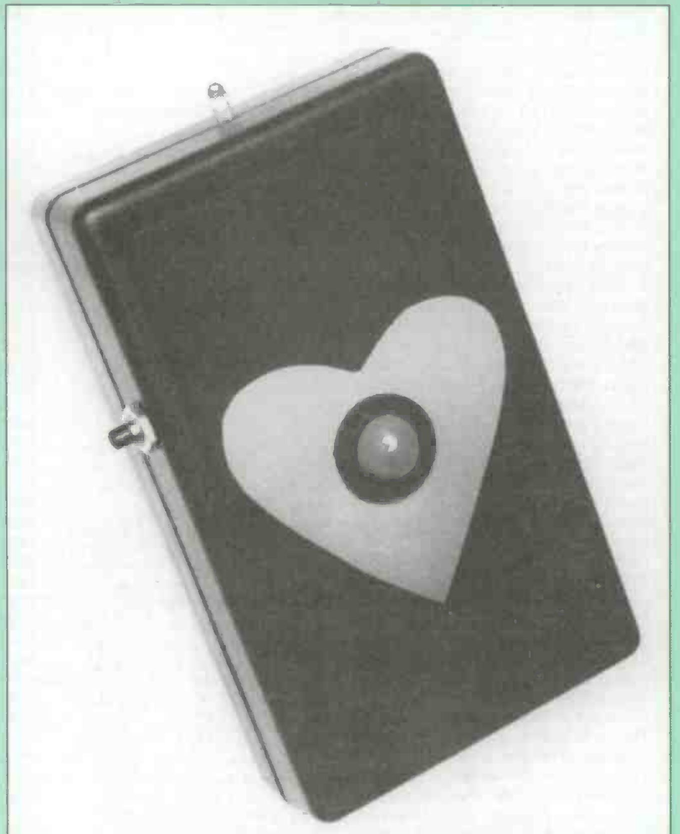
| | |
|---|---|
| TR1 | BC549 |
| TR2 | BC559 |
| IC1 | 4046BE |
| IC2 | 4001BE |

### Miscellaneous

| | |
|---|---|
| S1 | Vibration switch (Maplin UK57M) |
| B1 | 9 volt (PP3 size) |
| LS1 | Cased ceramic resonator |
| | 0.1 inch pitch stripboard 43 holes by 32 strips,battery connector, 14-pin d.i.l. i.c. holder, 16-pin d.i.l. i.c. holder, wire, solder, etc. |

# Love FINDER

***With St Valentine's day on its way, here is a project from Terry Balbirnie that will deduce your passion ration***



This device will probably not tell you how much someone loves you. However, it 'seems' to do so and this can make it great fun to use at a Valentine's Day party.

The circuit is housed in a small box with a red heart motif on the front (see photograph). The plastic case has a clip which enables it to be attached to the clothing so that it may be carried prominently while walking around. It also has a convenient battery compartment accessible from the outside. In the centre of the "heart" is a large LED (light-emitting diode). There is also a push-to-make switch and a small sensor protruding through a hole in the side.

When the push-button switch is operated, the LED glows green - this indicates "cold heart". The sensor is held against the palm of the person to be "tested". After a while, the colour may remain green (with the obvious message which this conveys) or it may become slowly yellow, orange - or even red!

## Be truthful

In reality, the device works by responding to the subject's skin temperature. There is probably some truth in the observation that, when tested, a loving subject would become hot and flustered with a rising skin temperature. The uncaring one will remain cool and collected. However, the response is likely to be clouded by various unpredictable external factors. The sensitivity is such that the entire transition from green to red occurs over a very narrow temperature range which may be adjusted between 1 degrees C and 3 degrees C approximately.

@B:The LED at the centre of the "heart" is a tri-colour device. Although it appears as a single unit, it actually contains two LEDs side by side - one red and one green - housed in a milky white translucent package. With the correct operating current flowing through the green section only, the appearance will be obviously green. As a little current is now allowed to flow though the red one, the colour "warms" and becomes yellowish. With equal current in both sections, the appearance will be yellow. This is because red and green are primary colours. When light of these colours are mixed in the translucent plastic, they produce light of the secondary colour, yellow. When the current in the green LED is reduced, the yellow colour becomes orange and, with no current flowing in the green one and normal current in the red, the display will be red.

## Circuit description

The circuit diagram for the Love Finder circuit is shown in figure 1. The sensor itself consists of negative temperature coefficient thermistor R1. This component has a resistance which falls as its

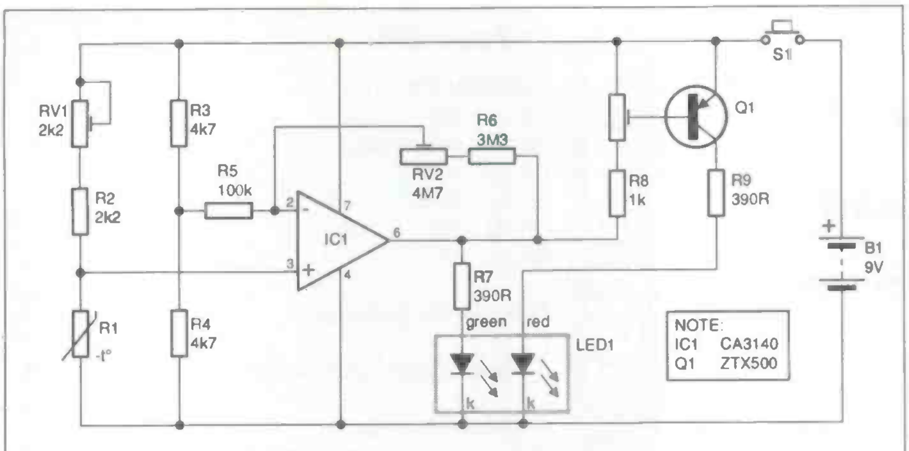



Fig.1 Circuit diagram

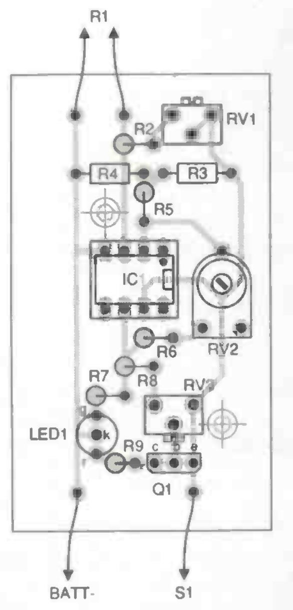



Fig 2 PCB Component overlay

temperature rises and vice-versa. The average skin temperature is likely to be a little below blood temperature - probably around 34 degrees C. Under these conditions, the thermistor will have a resistance of some 3kW. Although the temperature-resistance response is non-linear, over the small range considered, the change will be 130 ohms per degree Celsius approximately.

The main section of the circuit is based on operational amplifier IC1 and associated components. This is connected as a form of differential amplifier. Thus, it will amplify the difference in voltage which exists between the inverting (-) and non-inverting (+) inputs. The amplifying factor is set by the values of fixed resistor R6 in conjunction with preset potentiometer RV2 and, with the values specified, may be adjusted between 30 and 80 times approximately. Adjustment to RV2 will determine the range of temperature over which the LED will go through the entire colour change. At minimum adjustment this will be 1 degree and, at maximum, 3 degrees approximately.

Thermistor R1 forms the lower arm of a potential divider. The upper arm consists of fixed resistor R2 in conjunction with preset potentiometer RV1. This combination of resistors is connected across the 9V battery B1. The potential divider action provides a certain voltage around one-half that of the battery at the op amp non-inverting (+) input, pin 3, with RV1 sliding contact adjusted to mid-track position. As the temperature of R1 rises, its resistance will fall and this will be reflected in a falling voltage across it and hence at IC1 pin 3. At the same time, a fixed voltage is applied via R5 to the inverting input, pin 2, by the potential divider consisting of equal-value resistors R3 and R4. This will be nominally one-half of supply voltage - that is, 4.5V. Note that R5, R6 and RV2 will have little effect on this voltage.

Preset potentiometer RV1 will be adjusted so that when the thermistor is cool, the voltage at pin 3 will lie some way above that at pin 2. The difference in voltage (probably in the region of 200mV) which is amplified by IC1 will therefore be relatively large and the voltage provided at the op amp output, pin 6, will be correspondingly high. The green LED section connected to it via current-limiting resistor R7 will therefore be lit. At higher temperatures, the differences between the inverting and non-inverting input voltage will decrease and this will be reflected in a reduced voltage appearing at pin 6. The green LED will therefore turn off gradually. Since the voltages applied to both inverting and non-inverting inputs are derived from potential dividers, they will fall in sympathy as the battery ages. Thus, the operating conditions will remain unchanged.

## Smooth changes

On rising temperature, the falling voltage gap referred to above will result in a rising voltage between the positive rail and IC1 pin 6. This voltage is scaled down by the potential divider action of fixed resistor R8 and preset potentiometer RV3 and applied between base and emitter of transistor Q1. Since Q1 is a pnp transistor (rather than the more usual npn type), at a certain temperature it will turn on and the red LED section in the collector circuit will begin to operate through current-limiting resistor R9. With suitable adjustment to RV3, there will be an overlap where both red and green LED sections are on simultaneously. The effect is that, on rising temperature, the colour changes smoothly through green, yellow, orange and red.

Some readers may wish to test the wise saying 'cold hands, warm heart'. For this, the colour changes need to occur in the opposite sense - that is, red to green on rising temperature. To do this it is only necessary to reverse the LED connections so that the red section operates as the green one and vice-versa.

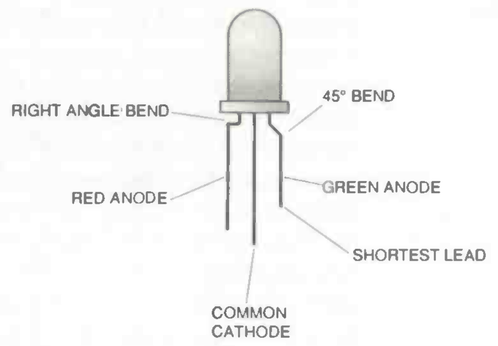



Fig.3 LED connections

## Construction

Construction of the Love Finder uses a single-sided printed circuit board (pcb) The topside component layout for this is shown in figure 2.

Begin by drilling the two mounting holes in the positions indicated (these will probably not be needed if the specified box is used). Next, solder the i.c. socket in place but do not insert the i.c. itself yet. Follow with the resistors including the preset potentiometers. Note that some resistors are mounted flat on the board while others are soldered vertically. Solder the thermistor end leads to the pads marked "R1". Bend them so that the thermistor lies horizontally and pointing away from the circuit panel (see photograph).

Add the transistor Q1, observing the orientation - the "flat" faces RV3 position i.e. the emitter connects to the positive line. Those used to working with npn transistors will find this strange. Take note of the lengths of the LED leads - the green (g) anode (positive) has the shortest one while the common cathode (k) is in the centre. Cut them all to a length of 15 mm and solder them in position so that the base stands 10 mm above the circuit panel. If the identification of the red and green anode leads is "lost", note that they are bent differently near the body - see figure 3. For "standard" operation, the orientation is as shown in figure 2. For the 'cold hands, warm heart' mode of operation, this should be reversed - that is, the green (g) and red (r) anode leads should be connected in the opposite sense. Shorten the PP3 battery connector leads to a length of 5 cm and solder the negative (black) one to the position marked "Batt -" on the circuit panel. Solder a 5 cm piece of light-duty, stranded, connecting wire to the point labelled "S1".

## Preparing to box

If using the specified box and the rear-mounted clip is to be used, begin by drilling the holes to attach it. Pilot holes, partially drilled, will be found on the inside rear panel. Drill these to the correct size and mount the clip using the two self-tapping screws provided. Measure the position of the thermistor and file a groove in the centre between the upper and lower sections of the box so that the leads may pass to the outside (see photograph). Drill a hole in the side for the push-to-make switch. If using the specified box, the clip-type battery terminals should be discarded and the battery snap connector used instead. This will avoid problems with possible polarity-reversal.

Taking note of the LED position on the pcb, drill the hole in the front panel for the clip which will secure it. This should be somewhere along the centre line of the box. Decorate the lid of the box around this hole with the heart motif or some alternative as desired. In the prototype unit, a heart was cut out of thin red card. When the LED clip is engaged, this should be sufficient to hold the circuit panel and motif in position. If the circuit panel is not

# PARTS LIST

## Components

### Resistors

| | |
|---|---|
| R2 | 2k2 |
| R3, R4 | 4k7 (2 off) |
| R5 | 100k |
| R6 | 3M3 |
| R7, R9 | 390 |
| R8 | 1k |

All 0.25W 5% carbon film.

R1 Bead thermistor resistance at 25 degrees C, 4k7.

PH:Potentiometers

| | |
|---|---|
| RV1 | 2k2 min. vert. preset. |
| RV2 | 4M7 min. horiz. preset. |
| RV3 | 22k min. vert. preset . |

## Semiconductors

| | |
|---|---|
| IC1 | CA3140 op. amp |
| Q1 | ZTX500 pnp silicon transistor. |
| D1 | 10 mm Tri-Colour LED |

## Miscellaneous

| | |
|---|---|
| B1 | 9V PP3 alkaline battery |
| S1 | Sub-miniature push-to-make switch. |

Printed circuit board.
Case size 103 x 62 x 23 mm
8-pin d.i.l. socket,
PP3-type battery clip
Stranded connecting wire
Solder m
Materials for heart motif etc.

## BUY LINES

Most o' the components for the Love Finder are readily available. The thermistor was obtained from Maplin, order code FX21X. The LED was also a Maplin stock item, order code UK29G. The switch used must be a sub-miniature type or it may be difficult to mount it in the side of the box. These are also available from Maplin, order code JM01B. The special case referred to in the text is a Maplin item, order code KC95D although other plastic boxes could be used providing they are of sufficient size.

reasonably secure, drill holes and use thin fixings through the holes in the circuit panel. Use a little glue on the motif if necessary. Make small adjustments to the LED and thermistor leads so that, when the LED snaps into its clip, the two sections of the case will fit together correctly with the thermistor end leads passing through the slot filed for the purpose. Make any adjustments as necessary. If there is any possibility of the thermistor leads touching, use some insulation on them.

Before unpacking the i.c. and handling its pins, touch something which is earthed - a water tap, for example. This will remove any static charge which may have accumulated on the body. This could otherwise damage IC1 because it is a CMOS component. Insert IC1 with the correct orientation. Refer to figure 4, mount the switch and complete the internal wiring.

## Getting started

It is now necessary to adjust presets, RV1, 2 and 3 for correct operation. It will be helpful to have an assistant available when doing this. With the circuit panel removed again, adjust RV1 fully

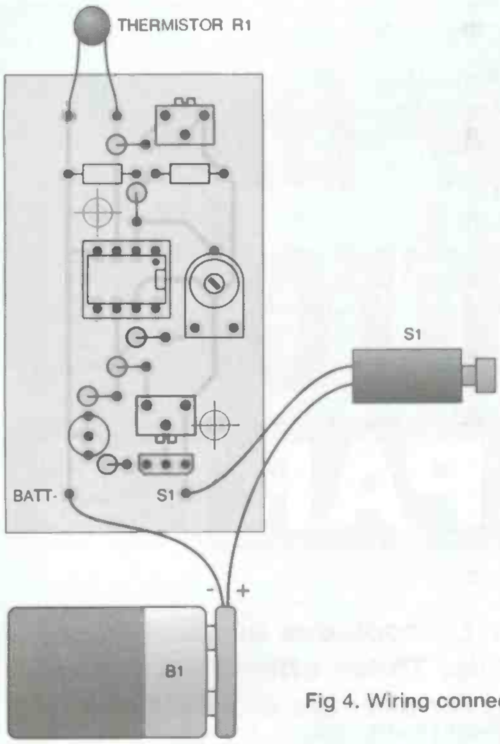


Fig 4. Wiring connections

clockwise (as viewed from the left-hand edge), adjust RV2 to mid-track position and RV3 fully-clockwise (as viewed from the right-hand edge). Connect the battery.

Use an elastic band or piece of Sellotape to keep S1 pressed so that both hands are free. The green LED section should now be on. If the hands are not already hot, rinse them in warm water so that they feel as warm as they could be naturally and dry them carefully. Press the palm against the thermistor and wait for two minutes for the temperature to stabilise. Now, adjust RV1 slowly anti-clockwise until the green LED just goes off - there should be no other colour showing. This should occur with RV1 sliding contact adjusted to approximately mid-track position (RV1 provides a range of 25 degrees to 35 degrees C approximately). Next, keeping the thermistor warm, adjust RV3 anti-clockwise until the red LED comes on and adjust it a little further. This "little further" will determine the degree of overlap between green and red operation - that is, the range over which yellow shows. Remove the palm and observe how the LED returns smoothly through red, orange, yellow and green. Repeat this a few times and make small adjustments as necessary. Replace the circuit panel and assemble the two sections of the case using the self-tapping screws.

## I need you

Before using the device at a party, it will be best to give it a short period of trial using a few "dummy" subjects and make further small adjustments for best effect. It may be necessary to adjust RV2 to provide a wider or smaller operating temperature range Fully-clockwise will provide a range of about 1 degree C and fully anti-clockwise, about 3 degrees . However, mid-track position was found to work well in tests using the prototype unit.

When operated from cold, the first test may take a long time - this may be regarded as part of the fun. If subsequent tests are made in fairly quick succession, the warm thermistor will need less time to reach its final temperature.

This device may not help you to find your perfect partner but it will certainly be fun to use. Good luck!

# BASIC for the PIC controller PART 5

***The developer of this unique project, Robin Abbott, concludes his look at some other versions of the ETI PIC based controller module. These offer the user a range of additional options which make them ideal for specific applications***

In this final part of the ETI PIC BASIC series, we'll take a look at the most advanced PIC used for the BASIC language so far. This is the PIC16C64.and PIC16C74. Throughout this article we'll look at the 16C64 but all the features of the 16C64 are also available in the 16C74. Enhancements for the 16C74 to cover its serial port capabilities and A/D converters will be available in later software upgrades. The 16C74 is a superset of the 16C64. Enhancements for the 16C74 to cover its serial port capabilities (using interrupt driven asynchronous communications) and A/D converters will be available in later software upgrades. Again, the circuit board used for the 16C64 is suitable not only for running ETI PIC BASIC, but also as a general purpose controller board for a wide variety of applications.

## The PIC16C64

The 16C64 is one of the more recent PIC devices. It contains 2K words of program memory, 128 bytes of RAM for user programs and a wide range of peripheral devices. These are as follows:

* 8-bit real time clock counter
* 16-bit real time clock counter
* Pulse width modulation output
* Event timer
* 8 -bit interface to external microprocessor
* Synchronous serial port/I2C interface

Note that the I2C interface on the 16C64 only offers slave support and so unfortunately does not offer an enhancement to performance for driving the I2C EEPROM used in ETI PIC BASIC.

## 16C64 BASIC General features

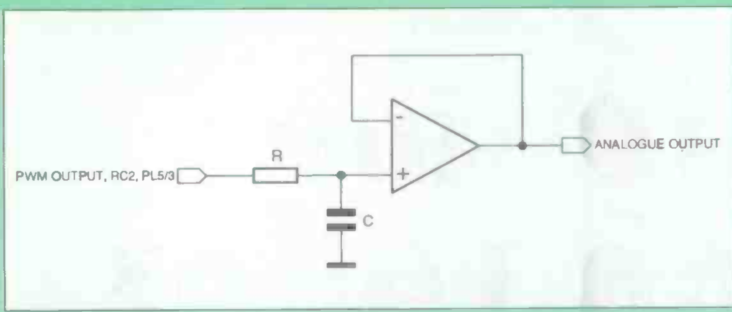
The 16C64 version supports all the features of the 16C57 and 16C58 shown in the last two articles, as well as some additional commands and facilities. The circuit board supports two 8-pin I2C devices, and the additional socket is used for an optional static RAM device which allows an extra 256 bytes of space for variables (which may be stored in arrays). The internal architecture of the 24LC16 device which is supported by the other ETI PIC BASIC versions prevents use of the extra I2C device, and so the 16C64 version only supports the 24LC65 (8Kx8) EEPROM. External I2C devices are supported on a peripheral I2C bus and two new commands IIREAD and IIWRITE. The PWM output of the 16C64 may be used for D/A conversion at up to 10-bit resolution and the extended 16-bit timer is available for use with internal clocks, or with an external crystal. The other peripheral devices of the 16C64 are also supported, with the exception of the synchronous serial port which uses the same pins as those used by the EEPROM and static RAM.

## Circuit Diagram

Figure 1 shows the circuit diagram of the 16C64 version of BASIC. Port C is used on the processor for BASIC's support circuitry, as this is the port used by most of the peripherals on the 16C64. The same serial port circuit as that used for previous versions of BASIC is also used for the 16C64 on the upper bits of port C. R3 is provided for future programming of modes and should be left open circuit for current BASIC versions. The EEPROM and static RAM are supported on port C pins RC3 and RC4. The static RAM is an 8-pin device, the Philips 8570, 256 x 8 static RAM. Although at around 2p per byte this must be one of the most expensive RAM devices currently available, it does have the advantage of the I2C interface. The RAM is optional.

The EEPROM IC2 is connected to be at address 0 on the IIC bus and the static RAM is at address 1. This is achieved by using the A0, A1 and A2 pins of the I2C devices. As these devices are specifically supported by the EEPROM and RAM support routines of PIC BASIC then only the LC65 and 8570 or compatible devices may be used in these sockets at present.

The brown out reset circuit now has an external reset capability. If the reset pin is taken high then the MCLR pin of the processor will drop to ground and reset the processor. If



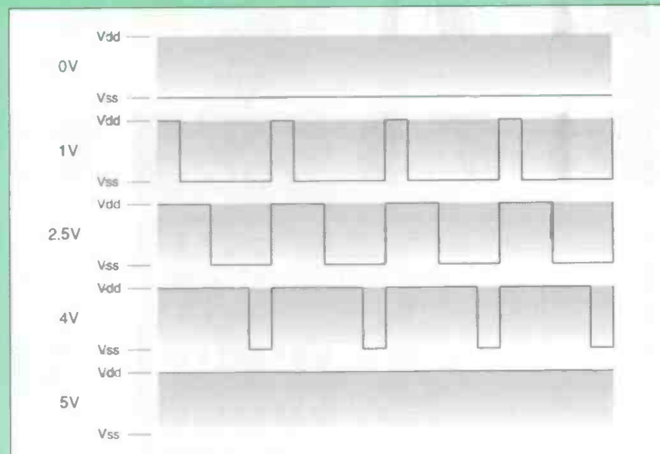




Fig.5 PWM waveforms

the pin is taken low then the brown out reset circuit will be disabled. This latter mode must not be used when running the BASIC version of the 16C64

The peripheral I2C bus is supported on pins RA3 and RA4 for SCL and SDA respectively. These are further described below. RC0 and RC1 are the external oscillator pins and may be connected to an additional low frequency crystal as described in the time section below. RC2 is the PWM output pin which may be used as a digital to analogue converter. This is also described below.

There are three external connectors for I/O. PL3 is a 16-pin DIL socket which hosts port A and port E together with the external reset line. PL4 is the 20-pin IDC connector which hosts port B and port D together with the external RTCC input for the 8-bit internal timer. This connector is pin compatible with the connector on the 16C57 version (although that connector hosts port B and port C). Finally, a 3-pin header supports the bottom three bits of port C.

## Construction and testing

Figure 2 shows the PCB overlay. Use sockets for IC1, IC2

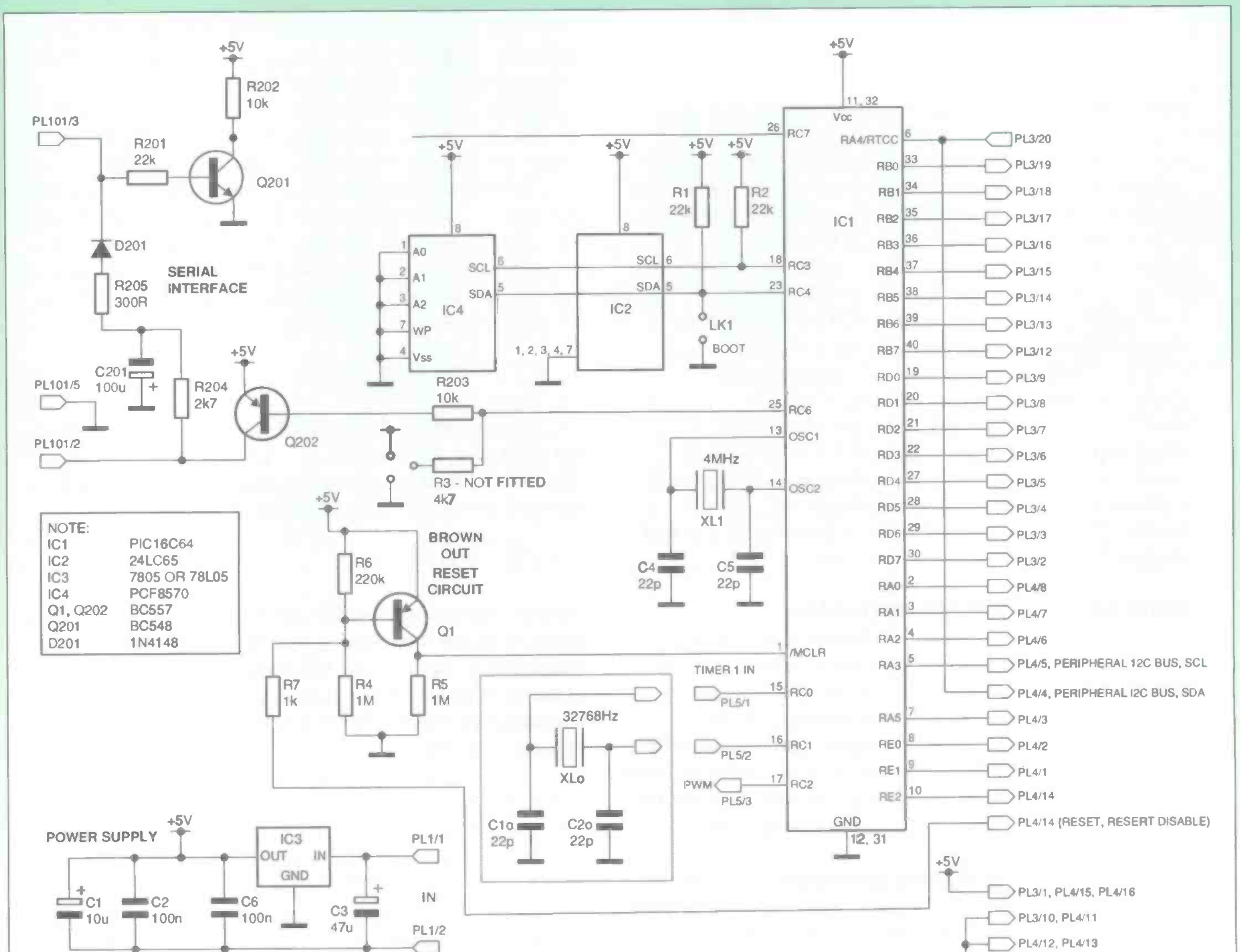



Fig.1. Circuit diagram

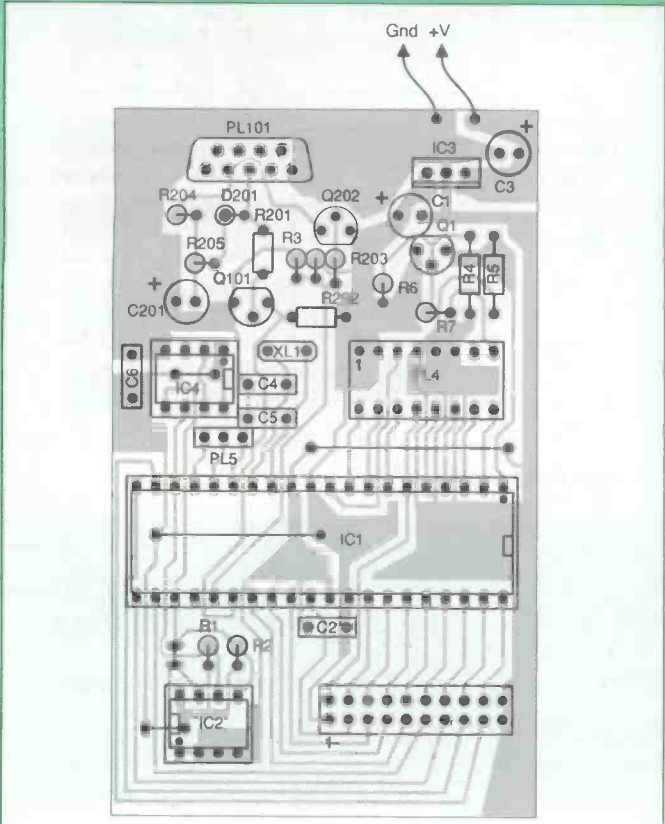



Fig.2. PCB overlay

and IC4. There are only two links to be fitted, one under IC1 and one to the left of IC1; fit these first. Follow the links with the horizontally mounted resistors, then the IC sockets, the other resistors, capacitors, IC3, and the remaining components and connectors. IC3 is the power regulator; a 78L05 or 7805 may be used dependant on power consumption of peripheral circuitry. IC3 may be removed altogether if an external regulated supply is available.

Before inserting any ICs, connect the power supply and check the voltages on the power supply pins of IC1, IC2 and IC3. Power down and insert these ICs (note that the orientation of IC2 is opposite to that of IC4), power up, connect to the PC as shown in previous articles and use the development software to confirm the operation of the module. The module will check for the presence of IC4 and will report it to the development program.

## External static RAM variables

I considered using an automatic scheme for allocating external RAM variables (when the internal RAM is used up then the external RAM is used automatically). However, I rejected this idea because it is not sufficiently flexible. External RAM variables are much slower than internal RAM variables and so the user should decide which variables need the speed. Such variables are likely to be index counters for loops (for I=1 to 20 : next I), or other frequently used variables.

An external static RAM variable is declared using the DIM statement with a .X after the variable name. All external static RAM variable is always 16 bits long. For example:

```
dim a.X,b[8].X
```

This declares a as being a 16-bit variable using external RAM, and b as being an array of eight 16-bit variables. a and b may now be used in the same way as any other variable.

## Use of the Peripheral I2C bus

The peripheral I$^2$C bus is supported on port A. Figure 3 shows an example connection to an IIC device, the A/D and D/A converter chip, PCF8591. In this case, the 8591 has been wired to be at address 0 on this bus by connecting pins A0, A1 and A2 to ground. Please note that the I$^2$C bus is likely to be on a length of several centimetres of cable and so the pull up resistors are specified as 4K7. If operation is unreliable (if acknowledgement bits cannot be read from devices on the bus), then these resistors may be reduced to 1K.

There are two new functions to support the I$^2$C bus.

These are the IIREAD and IIWRITE functions. Each of these commands takes a definition value. The definition value specifies whether a start bit, stop bit and acknowledgement are to be sent, and is made up of any combination of the following values:

START - Sends a start bit before any transfer
STOP - Send a stop bit after the transfer
ACK - Sends an acknowledgement bit (low) at bit 9 of the transfer.

If no stop bit is specified, then the bus will be left in a state where SDA is high and SCL is low. If a stop bit is specified, then both SDA and SCL will be left high.

The IIWRITE function has the syntax IIWRITE(value,def). value is the 8-bit value which will be written to the device; def is the combination of values which specify the actions described above. The IIWRITE function returns the state of the acknowledgement bit returned by the I$^2$C device, which will be 0 for an acknowledgement or 1 otherwise. For example, the following line will write the value 90hex to the bus and put the returned acknowledgement into the variable ack. A start bit will be sent before the value, and no stop bit will be sent.

```
ack=IIWRITE(90h,START)
```

The IIREAD command reads 8 bits from the bus and returns the value read. For example, to read 8 bits into the variable data, and to send an acknowledgement and a stop bit, the following line of BASIC could be used:

```
data=iiread(STOP+ACK)
```

Detailed operation of the 8591 is beyond the scope of this article; however, the following lines of BASIC show a function called AREAD which reads A/D converter channel number 1 of the 8591 connected in figure 3 and returns this value. This routine leaves the peripheral I$^2$C bus in the idle state with both SCL and SDA high.

```
func aread()
    dim r.8
    porta=0ffh
    trisa=27h                ; 0
    iiwrite(90h,START)       ; 1
    iiwrite(0,0)             ; 2
    iiwrite(91h,START)       ; 3
    r=iiread(ACK)            ; 4
    r=iiread(STOP)           ; 5
    return r                 ; 6
end
```

Line 1 addresses the 8591 with a start bit and its address. Line 2 sets the control byte of the 8591 to read channel 1 as a single ended input with the analogue output disabled. Line 3 writes another start bit and the read address of the 8591. Line 4 reads the A/D converter and line 5 reads it again. The reason for this dual read is that each read access to the 8591 returns the value last converted by the A/D converter on the previous read access. Finally, the value read is returned.

This routine is a simple example of the use of the peripheral $I^2C$ bus, a realistic use of the 8591 could be written far more efficiently; interested readers are referred to the 8591 data sheet which is available from Farnell.

## Overview of operation of 16-bit timer

The PIC16C64 has three timers. Timer 0 is similar to that on other PICs and can be read or written through the RTCC variable. Timer 2 is used for the PWM module and the event capture module.

Timer 1 is a 16-bit timer which is extremely flexible. It offers the facilities for counting from an external source, or using the internal microprocessor clock divided by 4. In addition, the PIC16C64 contains the oscillator circuitry to enable a crystal to be directly connected to the chip for timer1. The variable timer1 represents the current value of the timer and may be assigned or read. Thus, to reset timer1, the following line may be used :

```
timer1=0
```

The variable t1con is used to control the timer. There are a number of values which may be added together to control the timer. These are as follows:

tmr1on - This value must be specified to turn the timer on.
tmr1cs - This selects the source for the timer. If this value is specified then the source of the timer will be the external input on pin RC0, otherwise the internal oscillator will be used which is the microcontroller clock divided by 4.
t1insync - This value, if specified, disables the synchronisation circuitry. Normally, it should not be specified; it is only provided for advanced users.
t1oscen - This value, if specified, enables the external crystal oscillator circuitry; see the description below.
t1ps1, t1ps2, t1ps4, t1ps8 - These values specify the prescalar for the timer. If t1ps2 is specified, for instance, then the clock is divided by 4 before being applied to timer1.

Thus to enable timer1 and to set it to use the external crystal oscillator and, to divide its frequency by 4, the following line should be used:

```
t1con=tmr1on+tmr1cs+t1oscen+t1ps4
```

The external crystal oscillator uses the RC0 and RC1 pins. It is intended for crystals of less than 200KHz frequency, such as 32768Hz watch crystals. Figure 1 shows how to connect a crystal to these pins, only an additional two capacitors are required.

An interrupt is generated when the timer1 register overflows. To action this interrupt then interrupts must be enabled. In the 16C64 the intcon variable is used to enable interrupts as shown for the 16C84 in the earlier article. However, as the 16C64 has a wide range of interrupt sources, then two variables are used to control them. The first is the intcon variable controlled by the ei() function as

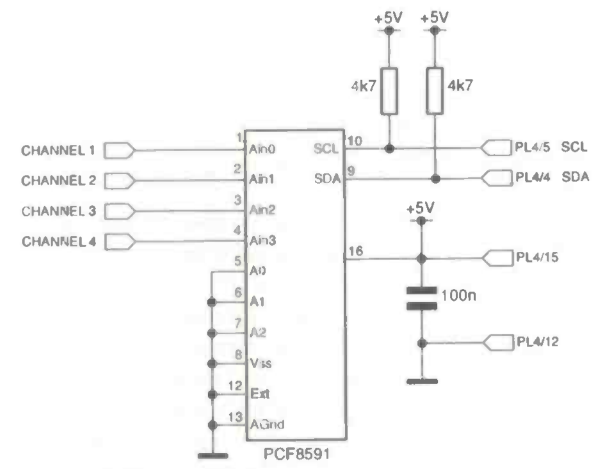



Fig.3. Sample $I^2C$ circuit

before; the second is the peripheral interrrupt enable variable pie1. To set interrupts on a peripheral device, the interrupt must be enabled by setting pie1, followed by the ei ( ) function. This can be done using the following code :

```
 pie1=tmr1ie              ; Enable timer 1
interrupts
 ei(peie+gie)             ; Enable peripheral
interrupts
```

The use of interrupts is shown in more detail in the documentation supplied on disk.

The example code in Figure 4 shows a complete stop watch which prints minutes and seconds on the terminal. It uses a 32768KHz watch crystal as shown in Figure 1. It is stopped by pressing the Escape key when the terminal window is open.

## Use of Pulse Width Modulation

Pulse Width Modulation or PWM is a technique for control of analogue devices from digital circuitry. This is achieved on a single output pin which has a digital clock which is of much greater frequency than the rate of change of the desired output voltage. The duty cycle of this clock is then changed so, for an output voltage which is half the digital high voltage, the duty cycle is 50% high to 50% low. For a voltage which is 10% of the digital high voltage, the duty cycle is 10% high to 90% low. This is illustrated in Figure 5a.

The digital clock may now be filtered and buffered to drive an analogue output. In the 16C64, the digital output pin for PWM is RC2. This can drive low current devices directly (for example, an LED), but is best used through a filter, or can drive devices such as small motors with no additional filtering; however, buffering must be provided in this case.

The 16C64 supports PWM to a resolution of 8 or 10 bits. The control of the PWM mode involves five variables in the 16C64 and can be quite complex to program. Fortunately most of these variables can be set to default values for simple applications. We'll look at the simple use of PWM in this article. This will offer 8-bit resolution and a set frequency of 3.91KHz to provide an output voltage which can vary between 0 and 5V in 0.02 Volt steps.

PWM mode uses timer 2 and requires the 16C64 capture/pwm control register to be set to PWM mode. The frequency of the PWM output is set with the period register PR2. The RC2 pin must be set to drive as an output. This can all be achieved in four lines of BASIC code at the top of the program as follows:

```
trisc=trisc&0fbh            ; 1
pr2=0ffh                    ; 2
t2con=trm2on                ; 3
ccp1con=ppwmmode            ; 4
```

Line 1 sets the drivers on port C to be their current values, except for bit 2 which is set low to drive on pin RC2. Line 2 sets the frequency of output of timer 2 to its maximum value which gives 8-bit resolution. Line 3 turns timer 2 on in the same way as the control register for timer 1. Finally, line 4 sets the 16C64 capture/compare/pwm module to PWM mode. Following this, the output voltage will be set to 0V.

Now to set the output voltage. Set this to a value between 0 and 255 to set the PWM output voltage between 0 and 5V. For example, the following code loop will generate a 10-step ramp waveform with a period of 1S. The 4 lines shown above should be included before this loop.

```
while(1)
    for i=0 to 9
        wait(100)
        ccpr1l=28*i
    nextw
end
```

## Other peripheral devices

The other peripheral devices of the 16C64 are supported by variables in BASIC which represent the registers in the device. These are not documented here, but the data sheet for the 16C64 should be consulted for further details. The only peripheral not supported is the synchronous communications and I²C module.

## Device sourcing

The PCF8591 is available from FARNELL on 0113 263 6311.

The author is prepared to program 16C64 devices for £15.00, or can provide a programmed 16C64 (4MHz) for £28.00. The latest version of PICBASDE will also be required for these devices which handles extended BASIC and the extra variable types needed for the 64/74 series. Please send payment, an SAE, a blank FORMATTED disk (if the latest version of PICBASDE is required) and a blank device (if required) to Robin Abbott, 37 Plantation Drive, Christchurch, Dorset. BH23 5SG.

The author can be contacted by e-mail on CIS at 100023,535, or via the internet at robin.abbott@dial.pipex.com

There is a support interest group for ETI PIC Controller BASIC on a bulletin board called the Astronomers' Den which is on 01942-831925.

## Program

```
include "util.inc"
typesub interrupt()
dim secs.8,mins.8,tflag.1

timer1=0                    ; Reset timer
tflag=0                     ; Flag to show 2 seconds
has passed
piel=tmr1ie                 ; Enable timer 1
interrupts
ei(peie+gie)                ; Enable peripheral
interrupts
t1con=tmr1on+tmr1cs+t1oscen+t1ps1          ; Enable
timer 1
secs=0
mins=0
tflag=1

while(serin(defserin,100)27)    ; Run until the
escape key
    if (tflag) then
        serout('\r',ds)
        prtnum(mins) : serout(':',ds)
        prtnum(secs)
        tflag=0
    endif
wend
ei(0) ; Disable interrupts
monitor()                   ; and return to monitor

; Interrupt subroutine, called every 2 seconds

sub interrupt()
    secs=secs+2
    if (secs=60) then secs=0 : mins=mins+1
    tflag=1
    pir1=0                  ; Clear interrupt in
software
end
```

## PARTS LIST

### Resistors

| | |
|---|---|
| R1,2 | 22K |
| R3 (not fitted) | 4K7 |
| R4,5 | 1M |
| R6 | 220K |
| R7 | 1K |
| R201 | 22K |
| R202 | 10K |
| R203 | 22K |
| R204 | 2K7 |
| R205 | 300R |

### Capacitors

| | |
|---|---|
| C1 | 10uF 16V Electrolytic |
| C2,6 | 100n, Ceramic |
| C3 | 47uF 10V Electrolytic |
| C4,5 | 15pF, Ceramic |
| C201 | 100F 10V Electrolytic |

### Semiconductors

| | |
|---|---|
| IC1 | PIC16C64 |
| IC2 | 24LC65 or compatible |
| IC3 | 7805 or 78L05 |
| IC4(optional) | PCF8570 |
| TR201 | BC548 |
| TR1,TR202 | BC557 |
| D201 | 1N4148 |

### Other

| | |
|---|---|
| XL1 | 4.000MHz crystal or ceramic resonator |
| PCB | |
| PL101 | 9 Pin D socket |
| PL3 | 20 Pin IDC connector |
| PL4 | 16 Pin DIL socket |
| PL5 | 3 Pin header link |
| LK1 | 0.1" link with jumper |
| IC sockets | 8 Pin x2, 40 pin x1 |
| Veropins | 2 |
| Heatsink | IC3, optional |

**Next Month....**
**Robin Abbott takes detailed look at the I²C bus and its use.**

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A module is available for the 16C57 version which features a 9600bps serial interface, 16 lines of programmable I/O, 4MHz crystal, and 24LC16 2Kx8 EEPROM on a small PCB (55 mm x 80 mm).

**16C57 module kit - £27.00**
**16C57 pre-built module - £33.00**
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**16C64 chip programmed with enhanced level 2 BASIC £25.00**

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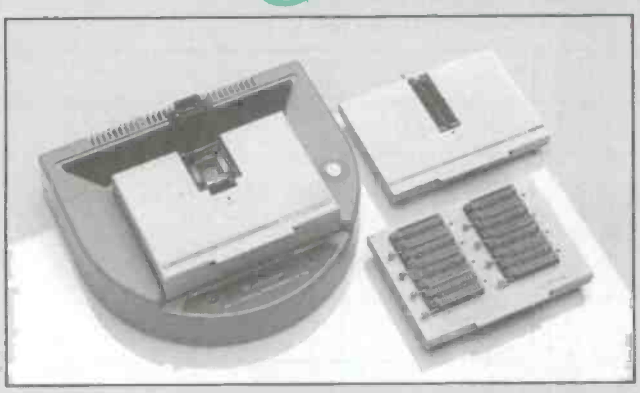

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***Bart Trepak's project will stop your children watching too much T.V.***

Until quite recently, the domestic television was regarded by most people as a pleasent diversion from everyday cares and a source of relaxation or, at worst, a waste of time which could be better spent reading books, pursuing sports or simply talking to other people. The steady increase in the number of available channels due to the introduction of satellite and the longer broadcasting hours of the terrestrial channels, however, seems to have been acompanied by a steady decline in the number of worthwhile programs to watch; so much so, that some MPs and at least one minister have expressed their concern at the declining standards, especially of children's programmes. One has only to watch some of the offerings on children's TV, with the seeming concentration on third-rate cartoons introduced by moronic presenters trying to act like kids ,to see what they mean.

With the introduction of cable TV, it is quite possible that the standard of programmes will decline further as hard-pressed producers will have to scrape the bottom of the programme barrel to fill an ever-growing number of channels for even longer periods at lower and lower cost. No matter how bad or boring the programmes get, however, they seem to have a mesmerising effect on some children (and adults) who seem to become quite incapable of finding anything else to do other than watching TV once it is switched on.

Those that do, often substitute the video game for the cartoon or game show and can easily spend hours making one of the Mario Brothers jump various obstacles to the sound of a mind-numbing tune. This activity has also attracted its share of condemnation from phsycologists andr doctors who fear that the repetitive images may cause epilepsy in some children not to mention other less obvious phsycological or sociological problems.

Most worrying of all, perhaps, is the problem, highlighted by the James Bulger murder, of youngsters watching so-called "adult" movies from video tapes, some of which, it could be argued, are even unsuitable for many adults and which some researchers believe can give rise to copycat behaviour.

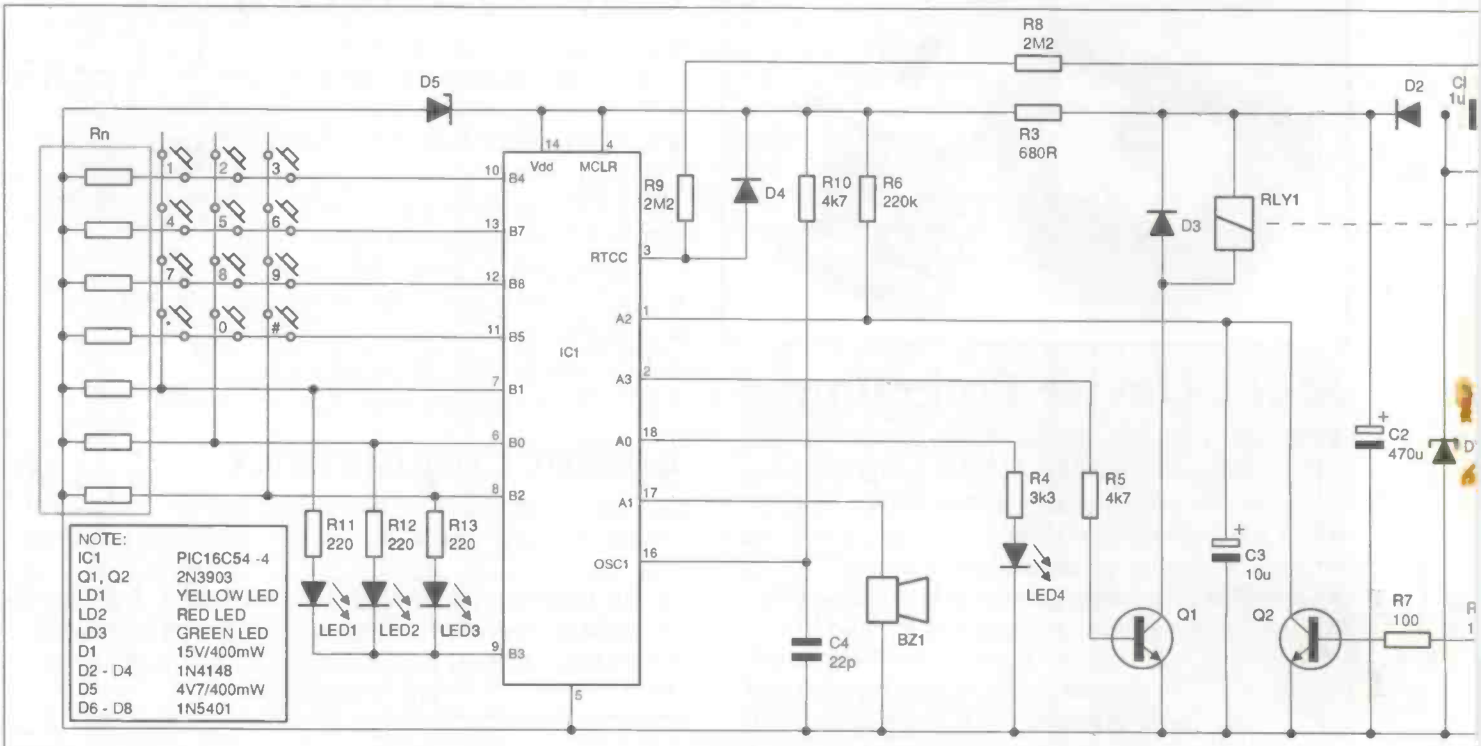


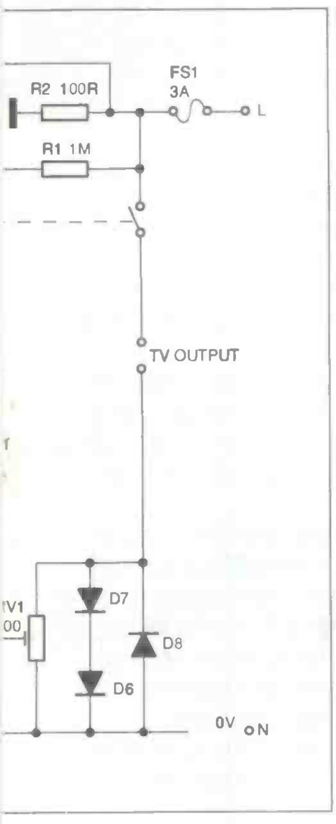

Fig.1 Circuit Diagram

Children, as every parent knows, seem to have a talent for circumventing authority and it is often difficult for parents to supervise what their childeren are watching or how long they spend in front of the TV. Experience has shown that once the TV is on, it is often difficult to switch it off without arguments breaking out or endless negotiations about when the evening's homework will be done if only the programme which is now on, can be watched. Often the current programme is followed by one which is even more "interesting" and the negotiations have to start all over again.

Various products have appeared on the market from time to time for disabling the video recorder by means of a lockable dummy cassette which prevents the insertion of another but this only tackles one of the problems outlined above and is more suitable as an anti-theft deterrent. A far better method would be to disable the television itself as this would make it impossible to play video games or watch unsuitable material from whatever source. The idea for this project came to me when I decided to try to wean my eight year-old son off of watching too much TV during the school holidays by simply removing the fuse from the mains plug one evening. It took him about five minutes the next morning to locate this "fault" and, helping himself to some spare fuses from my toolbox, repaired it and was watching TV before I knew what had happened! realised that something more sophisticated was required.

## The Psychology

What was needed was a device which could be switched on and off and could control the mains supply to the television set by the parent but not by the children. Fitting a key operated switch to the TV seemed like a very low-tech idea and not all that inexpensive and when added to the inconvenience of having to carry/hide/misplace keys, it was quickly discounted. Having recently designed a digital lock using a microcontroller, I felt that this was the obvious answer to the above problem. This could easily be adapted to control a relay which could be inserted into the mains lead to prevent the TV from being switched on unless the correct code was entered. A slight modification would be needed to ensure that once the TV was switched off, the relay would also open so that the code would need to be entered again before the TV could be switched on again. This would save the bother of having to remember to enter the code each time the TV was switched off and eliminate the possibility of forgetting to do this and leaving the TV enabled by mistake.




Unfortunately, because it is usually easier to agree on when the homework has to be done and how much time can be spent in front of the TV before the TV is switched on, rather than try to switch the TV off in the middle or even at the end of a programme, this simple scheme would do little to stop the arguments or relieve the parent from having to time the children's viewing. A timer would therefore be useful so that the viewing time could be preset with the prior agreement of all concerned after which the TV would switch off automatically without intervention.

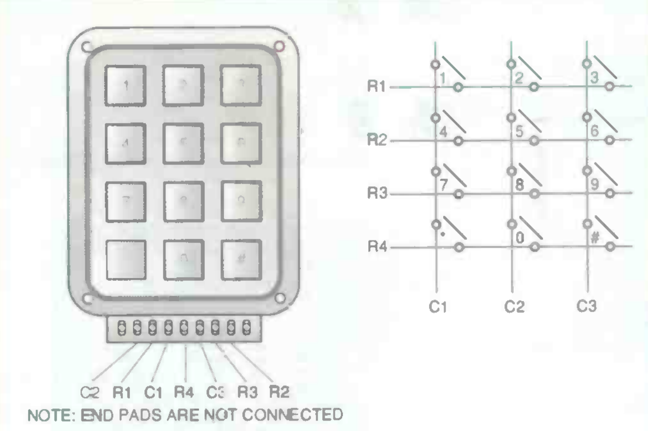



Fig.3 Keyboard connections

A further improvement could be obtained by fitting a clock instead of a simple timer. This would permit the TV to be enabled for a pre-programmed period of time between the hours of say 3.00pm and 9.00pm and leave the choice of what to watch up to the children, thus preventing the almost round the clock TV viewing which can occur during the school holidays.

Thus, if, say, a two-hour period was programmed into the unit, the TV could be used from 3.00pm to 5.00pm or from say 3.30pm to 4.00pm and again from 6.00pm to 7.30pm or any combination of times up to two hours with the unit switching off at 9.00pm even if the TV had not been on for the full two hours. This would also have the added bonus of making bed-time easier to organise. The 9.00pm deadline was chosen because this is the time before which the terrestrial channels have agreed not to broadcast programmes which may be considered unsuitable for children.

Being a responsible adult myself, I still wanted to be able to switch on the TV outside these times (so that I could monitor the programmes the TV companies were putting out and check out their suitability for children - of course) so provision for this would also have to be made. The unit has therfore been designed so that it can be switched on and off at any time simply by entering the correct code while still permitting the children to watch TV only for the allowed period.

## The electronics

So much for the physchology - now for the electronics. A keyboard would obviously be required to enable the "on" code to be entered as well as the allowed viewing period and the time of day so that the unit could keep track of the time and switch the mains supply to the TV at the appropriate times as well as automatically enabling the TV the next day. A display was also considered but it was felt that this would not really be much use other than in showing how much time had elapsed. It would also add yet another display of the time to the existing battery of displays on the video recorder, TV etc which already showed this. So, to keep the unit simple and reduce cost, this was rejected.

The time would be set as a four-digit number in the standard 24-hour format, while the allowed viewing time as a three-digit number of minutes. A display for this was not essential either. To prevent errors, the programme has been designed to accept only valid times and a maximum allowed time of 359 minutes (6 hours). The "on code" is also a four-digit number which gives good security and is short enough to

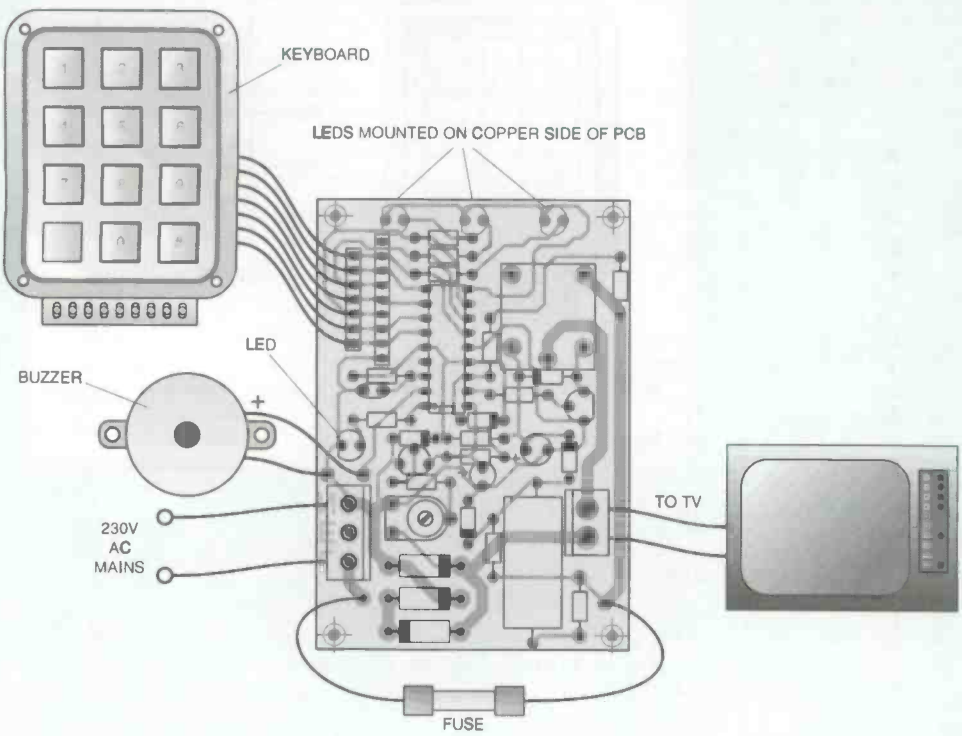



Fig.4 Videocheck wiring diagram

for this was considered but was felt to be an unnecessary addition, especially as most children would be unaware of this possibility of defeating the system.

As the circuit would be mounted in the mains lead, it could obviously be mains powered and a simple power supply would suffice. Because there would then be no real need to maintain isolation from the mains, therefore opto isolators for the mains inputs to the micro-controller would not be used.

## The circuit

The circuit diagram is shown in Fig 1. As we are using a micro-controller, all the clever stuff is done by this, leaving the mundane things like driving the relay and seeing if the TV is on to TR1 and TR2, resulting in a relatively simple circuit.

C1, R2, D1, D2 and C2 form a 12 V DC supply for the relay which is further reduced to 5 V for IC1 by R3 and D5. The unit needs to "know" if the TV is switched on, to enable the period for which the TV is used to be timed. The only way of sensing this without tampering with the TV set is to sense the mains current drawn. A simple mains current detector is used, which utilises the voltage drop in two power diodes D6 and D7 to turn on transistor TR2 which keeps capacitor C3 discharged and holds input A2 of the micro-controller low when the set is switched on. The value of R6 is chosen so that the capacitor does not have time to charge up during the negative mains half-cycle when TR2 is turned off so that A2 remains low until the power is cut or the TV is switched off. D8 is necessary to allow AC to flow to the load. The voltage across the two diodes can be reduced by VR1, allowing the current level at which the TV is considered to be on, to be adjusted to enable the TV to be set to standby (when it will still be drawing some current) without the timing being continued.

The on chip oscillator frequency is defined by resistor R10 and capacitor C4. Because this is not stable enough for a clock, the mains frequency is used as a timebase and this is connected to the RTCC input via resistors R8 and R9. Diode D4 is included to prevent the voltage at this pin from exceeding the supply voltage which could damage the chip.

Most of port A is programmed as an output and is used for controlling the buzzer BZ1, the TIME RUNNING indicator LED4 and the relay RLY1 via the transistor TR1. Only port A2 is configured as an input to read the "TV on" signal from TR2 as described above.

Port B is used for reading the keyboard (arranged as a row and column matrix) and driving the PROGRAMME INDICATOR LEDs LED1 to LED3. For this, B0, B1 and B2 are programmed as outputs and are driven high in turn. B4, B5, B6 and B7 are configured as inputs and are read by the programme. If B1 is high and key 4 happens to be pressed, the read operation will result in B7 being read as high while, if key 7 had been pressed, B6 would have been read as high. Similar routines are used with the other columns driven by B0 and B2 and in this

remember easily. All of these parameters (ie. code, viewing time and time of day) can be varied and reprogrammed at will (provided, of course, that the correct "code" is entered first) and, as long as power is maintained, they will be stored. To enable the user to ascertain which parameter is being changed during programming, three LEDs are included, together with an LED which stays on, flashes at 1Hz or goes out to indicate that the unit is working, timing or in the programme mode.

A buzzer was also considered desirable because it is apparently vitally important not to have the unit switch off without warning at a crucial point when playing some video games, especially when a high "level" has been reached. The unit has therefore been designed to give a warning bleep ten minutes before the time is due to run out and then every minute during the final five minutes so that the user is not caught unawares. The buzzer is also used to indicate that an error in setting the unit had been made such as attempting to enter a time of, for example, 26:78 or a viewing time of 475 minutes.

Since the unit is to be mounted in the mains lead, the voltage across the TV mains switch cannot be used to determine if the TV is on, so a line current sensor is required to monitor the current taken by the set. The 50Hz mains signal can, however, be utilised as a timebase for the clock and timer. Unplugging the unit from the mains socket would, of course, stop the clock and timer, so that any times set would be lost, so the unit is designed to sound the buzzer continuously when the power is re-applied to signal that there has been a power failure and any times set will have been lost. To prevent this from being turned to advantage by enterprising "young engineers", the output is switched off and the allowed viewing time is also reset to zero when the power is restored. Unfortunatly, the "on code" is also lost and reverts back to the pre-programmed number so this must be kept secret to prevent the circuit being activated by switching the mains off and re-programming it with a new number. An EEPROM store way, the processor can determine which key, if any, has been pressed. The LEDs LED1-LED3 are driven in a similar way with B0, B1 and B2 being made high in turn and output B3 going high (+5V) when the LED is to stay off and low if it is to light.

## Programming

In its basic operation, the unit can be regarded as a simple digital clock (albeit without a digital display), with a built-in timer, which can be programmed to give an "allowed viewing time" of up to a maximum of 359 minutes (six hours). At 15:00 (3pm), the timer is loaded with the previously set "allowed viewing time" and if the TV set is switched on, the timer will count down every minute. If the TV is switched off or the code entered to permit unrestricted viewing, the counting will cease until either the set is switched on again or the code is entered again. When the count reaches zero or the time in the clock reaches 21:00 (9pm), assuming that the code has not been entered to permit unrestricted viewing, the output will switch off, cutting the mains supply to the set.

The software has been designed to enable the output to be over-ridden at any time by entering the 4-digit code, so that the TV can be enabled at any time of the day. Thus, the timing can be suspended ,as can the 9:00pm switch off, by entering the preprogrammed 4-digit code to allow for special eventualities such as a TV programme over-running the 9.00pm deadline or if longer viewing times are to be permitted, without the need to re-programme the device each time. Normally, when the output is on (i.e. between 3:00pm and 9:00pm and the timer has not timed out), the TV can be switched on and off at will but, once outside the allowed time (i.e. between 9:00pm and 3:00pm the next day or when the timer has timed out), the output and hence the TV can only be switched on by entering the code first. In this case, the TV must be switched on within five seconds of entering the code because otherwise the output will turn off again, as it will if the TV is subsequently switched off. Entering the code again when the output is on will also switch the output (and the TV) off whereas, during the allowed viewing time, the output will remain on and only the timer will be switched off, allowing the TV to be watched beyond the 9:00pm deadline or when the timer would normally have timed out.

The digits must be entered within five seconds of each other, otherwise they will be considered to be separate entries. Thus if the "code" is 1056, for example, and 105 is entered followed by a gap of more than five seconds, the unit will not switch on when the final "6" is keyed as it will regard the "6" as the first digit of a new attempt at entering the code. Any errors are ignored and there is no keyboard lockout, so any sequence of numbers which includes 1056 with no incorrect digits inbetween will switch the unit on.

At power up, the unit will start with the relay off, the time set to 21:00 (i.e. 9pm) and an initial code (1111) which must be entered to enable the output to be switched on and the unit programmed. (NOTE: The pre-programmed PIC for this project will normally be supplied with this default 4-digit code. If you require another code number, please specify at the time of ordering.) The CLOCK/TIMER RUNNING LED will be on continuously to indicate that the clock is running and the buzzer will emit ten bleeps, followed by a continuous sound.

To enter the programme mode, the 4-digit code must be followed by the "*" key (within five seconds) which will cause the PROGRAMME CODE LED indicator to light and the CLOCK/TIMER RUNNING LED to go out, signifying that the clock has been stopped. The new 4-digit code (or the old one if no change to this is required) must now be entered followed by the "*" key which will cause the indicator to go out returning the unit to the normal mode. Note that if more than four digits are entered, only the last four will form the new code. If fewer than four digits are entered before the * key is pressed, the buzzer will sound an alarm and the unit will remain in the programme mode until the remaining digits have been entered and the "*" key pressed. All keys are valid except * and # and there is no time restriction on the entry of digits in the programming mode.

If the allowable viewing time is also to be entered/altered, then instead of pressing the "*" key, the "#" key should be pressed. This will store the code, switching off the PROGRAMME CODE indicator but, instead of returning the unit to the RUN mode, will light the PROGRAMME VIEWING TIME LED. Here a 3-digit number can be entered, representing the number of minutes for which viewing will be permitted, with the maximum time being 359. Again, only the last three digits are accepted and any attempt to enter a time greater than 359 minutes will cause an error consisting of three bleeps, in which case another digit will have to be entered. Thus, if the first entry is 5, this will be ignored and an error signalled until a digit of 3 or less is keyed in. Any digit of 5 or less is acceptable for the second digit. If a time of less than 100 is to be entered, a zero should be keyed first (e.g. 058 or 005 if only five minutes are to be allowed, although, in this case, a better solution may be to sell the TV!).

Note that although the allowed time entered is stored as soon as the "#" key is pressed, it is only loaded into the timer counter when the clock reaches 15:00 or is set to a time between 15:00 and 21:00.

If the time of day is also to be altered, then again instead of entering "*", the "#" key should be pressed. This will cause the PROGRAMME CLOCK LED to light. A 4-digit number representing the time of day in the 24 hour clock format (i.e. 0916 for 9:16 am or 1723 for 5:23pm) can then be entered and, assuming that a valid time has been entered, pressing the "*" key will put the unit back to the running mode with the CLOCK/TIMER RUNNING LED on. If the # key is pressed, the PROGRAMME CODE LED will light again, allowing this to be

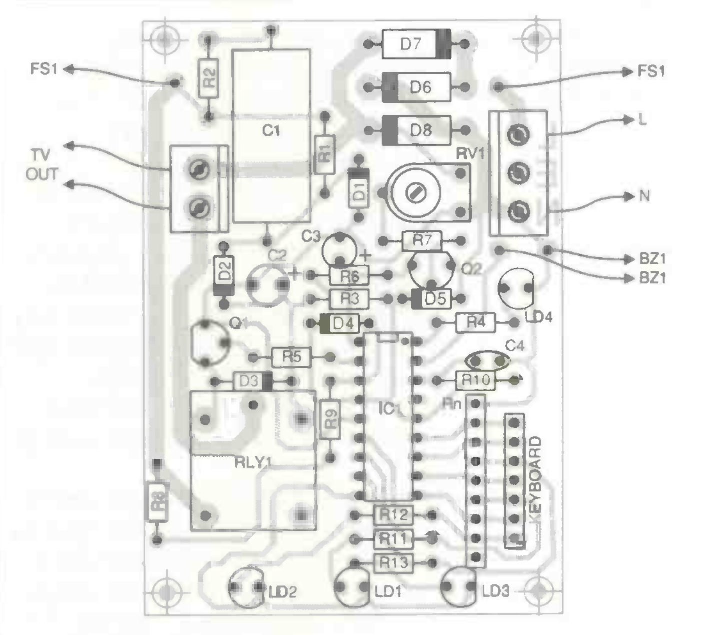



Fig.2 PCB component overlay

altered again if required.

If an allowed viewing time greater than zero (i.e. 000) has been entered and the time set is between 15:00 and 21:00 then the output relay will remain on when the "*" key is pressed to enter the RUN or normal mode. In this case, assuming that the TV is on, the CLOCK/TIMER RUNNING LED will flash once per second to indicate that the timer is also counting. In other cases, the output will switch off and become active only when a time of 15:00 is reached.

Note that during the programme mode, the output is switched on and the CLOCK/TIMER RUNNING LED goes out to indicate that the unit is not counting. It switches on or resumes flashing only when the "*" key is entered and the unit reverts to the RUN mode. This can be used to set the clock precisely by setting the time one minute ahead of the current time pressing the "*" key when the time entered is reached.

## Construction

Although, at a pinch, the circuit could be built on stripboard, a printed circuit board will make construction quicker and much less error-prone which is very important, especially as there are mains voltages present on the board. A suitable printed circuit board layout is shown in Fig 2. Whatever method of construction is chosen, care should be taken to ensure that all diodes, transistors, electrolytic capacitors and the integrated circuit are fitted to the board the correct way around, otherwise component damage may occur. Note also that the resistor network Rn which consists of 7 resistors with a common connection must be fitted the correct way around, the common connection usually being indicated by a dot on the component. The board is laid out to accept a 7- or 8-way resistor network depending on what is available. The microprocessor is a CMOS type and although the input circuitry at the pins has been designed to protect the device from electrostatic damage it is best to fit a suitable ic. socket to the board and fit the chip to this when assembly is complete.

The order in which the circuit is assembled is, of course, unimportant but it is usually best to begin with the low profile components such as resistors and diodes and then progress to the taller ones (capacitors, transistors, LED and terminal blocks).

The circuit is designed to operate with virtually any keyboard as long as it has matrix connections (ie. Rows and Columns) and is not one with a common connection. The connections for the keyboard used are shown in Fig 3. However, if your keyboard does not have the same connections, this is not too important as long as the column connections of the keyboard are connected to the column connections on the printed circuit board. The same applies to the rows. The circuit will work although the numbers will be different and in particular the functions of the * and # keys may be performed by two of the numbered keys. It is therefore best to adhere to the connections as shown in order to avoid confusion. The keyboard may be wired to the printed circuit board using a short piece of ribbon cable or individual wires as preffered.

Depending on the box chosen, the LEDs may also need to be mounted on the box and connected to the printed circuit by means of short pieces of wire. The fuse is best mounted in a panel-mounted fuse holder so that it may be changed, should the need arise, without having to open the box. This, too, should be connected to the appropriate points on the printed board with suitable wire. The circuit can then be built into the box and, after testing, the lid glued permanently so that no attempt can be made by "budding engineers" to try to open the box in an effort to by-pass the internal relay. This would not only defeat all the clever electronics inside but could also be extremely dangerous.

## TESTING

REMEMBER THAT THIS CIRCUIT OPERATES AT MAINS POTENTIAL AND DANGEROUS VOLTAGES EXIST AT VARIOUS POINTS IN THE CIRCUIT. SWITCH OFF AND DISCONNECT THE CIRCUIT FROM THE MAINS BEFORE ATTEMPTING ANY MODIFICATIONS OR SOLDERING.

Since the circuit uses a microprocessor to define the logic, then assuming all the external connections to the chip are correct there is very little to go wrong and there is virtually no "setting up" other than to check that the circuit is working and familiarise yourself with its operation. The unit should be connected to the mains and the TV as shown in Fig 4. Before plugging in the chip, switch on and check that you have 5V between pins 5(-) and 14(+) of the i.c. socket with a voltmeter. If this is not the case, check the polarity of the Zener diodes D1 and D4 as well as diode D2 and capacitor C2. If all is well, switch off and insert the chip into its socket with the notch marking pins 1 and 18 nearest the mains input and output terminals and switch the power back on, ensuring that the TV is switched off.

The circuit should produce ten bleeps followed by a continuous sound and the CLOCK/TIMER RUNNING LED (LED4) should be on with the relay remaining off. Enter the code 1111 and check that the relay is energised and switched off again after five seconds. Enter the code again but, this time, press the "*" key before the relay switches off. LED2 should now light and the relay will remain energised with LED4 going out.

Connect a voltmeter set to measure 5 Volts across C3 and switch on your TV. The voltage should drop to zero or less than 1 Volt. If your TV has a standby mode, switch it to this and adjust VR1 for a reading of at least 2 Volts. Any setting of VR1 which gives a voltage of less than 1 volt when the TV is on and greater than 2 Volts when it is off or on standby is correct. Switch off the TV or set it to standby.

You may now enter a new code or the same one if you do not want to change it. Initially, key in only two numbers and then press "#" or "*". The unit will respond with three bleeps to indicate an error and LED2 will remain lit. Only after entering at least four numbers (a new valid code), will LED2 go out and LED1 light if "#" is pressed, or all the LEDs go out and LED4 switch on if "*" is entered to return the unit to the RUN mode.

If LED1 is lit, you may enter a suitable "Viewing Time" up to a maximum of 359 minutes. Again, try making some "errors" like pressing 4 first and note the error warning which is given. Eventually, enter a "viewing time" of 1 minute (001) before pressing the "#" key to go into the SET TIME mode. If you make a mistake, continue entering (valid) numbers and press "#" each time until the entry is accepted - LED1 goes out and LED3 lights. Press the "#" key three times to return the unit to the "Programme Viewing Time" mode again with LED1 lit and enter the correct time. Note that invalid entries are ignored so that if you want to set a time of, say, 120 minutes but key in 4,1,2,0 then the 4 will not be stored. If you enter 1,4,2,0 however, this will be accepted as 0 (the 142 being discarded because a fourth digit had been entered which will be regarded as the first digit of a new number) and the unit will not allow you to exit from this mode until two more valid digits have been entered. The above procedure of entering numbers until accepted and then re-entering the required number should therefore be adopted if a mistake is made or you are unsure of which numbers you have entered.

In the SET TIME mode, with LED3 lit, again only valid entries will be accpted. These should be in the 24-hour format (e.g. 2358, 0936, 1343 etc) and each four digit group of valid numbers will be accepted when the "#" or "*" key is pressed. If an invalid digit is entered, a warning will be generated and the entry ignored while if a fifth (valid) digit is entered, it will be regarded as the first digit of a new entry and in the case of confusion, the procedure described in setting the "Allowed Viewing Time" should be adopted. Initially, enter the time to 1459 and press the "*" key.

The unit will resume counting, switching on LED4 to show that the clock is running and the relay will switch off. After one minute, the relay will switch on (i.e. when the time reaches 15:00). Leave the unit in this state for a few minutes with the TV off and check the the relay is still energised after this time by switching on the TV which should now remain on for the allowed one minute. Note that this time may be somewhat less than one minute, depending on the precise point in the clock minute cycle when the TV was switched on as the clock and timer are incremented at the same time. LED4 will now flash at a rate of once per second to indicate that the timer is running. Switching off the TV or entering the code will disable the timer which will cause LED4 to stop flashing and light continuously.

The above procedure may be repeated but, this time, set the "Allowed Viewing Time" to 11 minutes (011) and the time to 15:00 or any other time between 15:00 and 21:00. This time when the "*" key is pressed, the relay will remain energised and allow the TV to be left on for 11 minutes. Switch on the TV (LED4 flashing) and after the first minute, the unit will emit five bleeps to signify that there are ten minutes of viewing left. After five minutes, another warning (five beeps) will be given and thereafter each minute will be marked by four, three or two beeps depending on the number of minutes left. When only one minute is left, ten beeps will be sounded to warn the viewer in no uncertain terms, that "Mario" is about to be zapped, no matter how expertly the joystick is manipulated or how great a score has been reached. Only if the code is entered (by a relenting parent) before the minute is up will play be allowed to continue.

Similar checks can be made to ensure that the relay will switch off at 21:00 even if the timer has not timed out, or that the unit can be switched on and off outside the allowed viewing time by entering the correct code.

Although the programming may appear complicated, it is quite logical and certainly more so than many video recorders on the market. If you still cannot figure it out, then, as with video recorders you can always get the children to do it, but make sure that you keep the initial code number a secret!

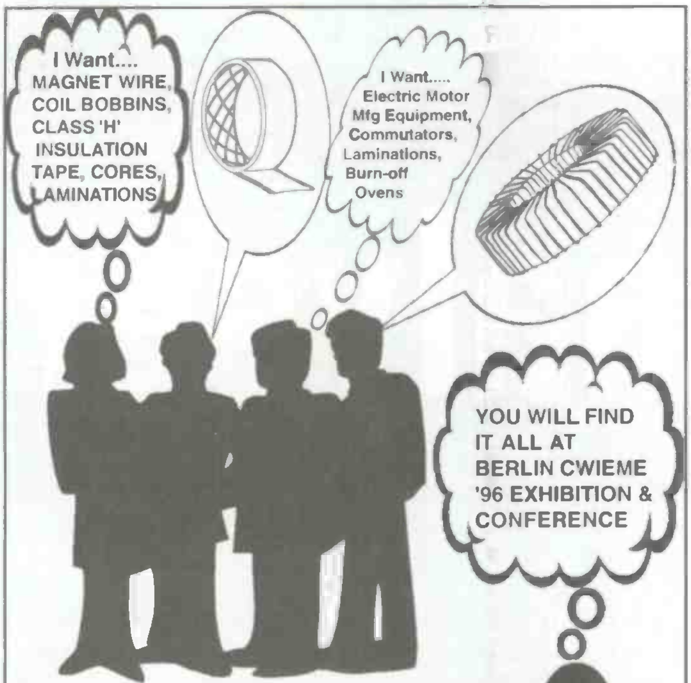
## PARTS LIST

| | | | |
|---|---|---|---|
| **R1** | **1MOhm** | **C1** | **1uF/400V** |
| **R2** | **100 Ohms1W** | **C2** | **470uF/16V** |
| **R3** | **680 Ohms** | **C3** | **10uF/16V** |
| **R4** | **3.3kOhms** | **C4** | **22pF Ceramic** |
| **R5** | **4.7kOhms** | | |
| **R6** | **220kOhms** | **D1** | **15V/400mW Zener** |
| **R7** | **100 Ohms** | **D2, D3, D4** | **1N4148 Diode** |
| **R8, R92.2M** | **Ohms** | **D5** | **4V7/400mW Zener** |
| **R10** | **4.7kOhms** | **D6, D7, D8** | **1N5401 Diodes** |
| **R11, R12, R13** | **220Ohms** | | |
| **Rn** | **7 or 8x 10kohm SIL Resistor network** | **LD1** | **Yellow LED** |
| | | **LD2, LD4** | **Red LED** |
| **VR1** | **100 Ohm pre-set (horizontal)** | **LD3** | **Green LED** |
| | | **TR1, TR2** | **2N3903 NPN Transistor** |
| **IC1** | **PIC16C54-4 Programmed*** | | |

**RLY1 12V/400 Ohm coil 3A/240Vac contacts, 12-way (4x3) Matrix Keyboard, 2-Way and 3-Way pcb terminal blocks, 18 pin dil ic socket, 20mm Panel mounting Fuse holder, 20mm 3Amp Fuse, Miniature 6 Volt Piezo Buzzer, Printed circuit board, Box to suit.**

*** A pre-programmed PIC16C54-4/F for this project is available from the author at £9.50 each. Customers outside UK please add £2.00 postage. Send orders to: B. Trepack, 20 The Avenue, London W13 8PH enclosing a cheque or Postal Order. Please state "VIDEOCHECK" on your order.**

**Next month, the complete Videocheck Assembler Code**

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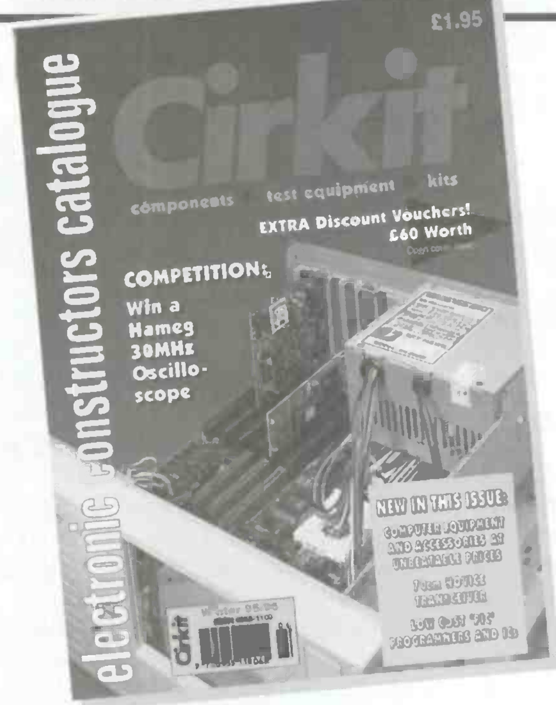
# WINTER 1995/6 CATALOGUE

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# Real Time 8 channel Logic Analyser

***A handy piece of test equipment for electronic engineers designed by Richard Grodzik***

Prototyping a microprocessor/microcontroller-based project is a precise science where luck does not get a look in. Unlike analogue electronics where component tolerance or even component failure could still produce a functioning circuit, no allowance for a single error is permitted in the art of microelectronics. A single corrupted bit in a Megabyte program will cause a software 'crash'. Similarly, one logic gate malfunction will render a computer kaput.

Once the hardware has been built and verified for connections, the next step is to write a small program to test the system. The prototype circuit may well mirror the hardware precisely, but what if data bus contention arises when two or more peripheral devices are being accessed at the same time?.

This is a situation where the logic analyser is an invaluable piece of test equipment. Quite simply, it allows the capture of 8 bit wide data (data/address/control) bus at the system clock speed in real time, and then to be examined at leisure on the PC's screen.

Consider the following scenario which often happens when a newly constructed prototype board has been built. A small piece of software is written to, say, toggle a port pin. It doesn't work. Has the processor even got further than the reset stage when the first address is placed on the address bus to access the first operational code in ROM?.

The solution is to attach the logic analyser probes, press the switch to arm the unit; 256 bytes will then be automatically captured. Press the switch again, and these bytes are then transferred via a standard RS232 serial data stream link to the PC's screen.

If the board being analysed uses a 8031 controller, then this has a reset address of 0000H and it is this address that first appears on the address bus. If we examine the captured data on the screen and find that the first address captured is 80H (10000000b) and succeeding bytes have the 8th bit held at logic 1, then there is obviously a fault with the A7 line. Close examination of the print on the PCB will probably reveal that address line A7 has a short to the 5 volt supply line.

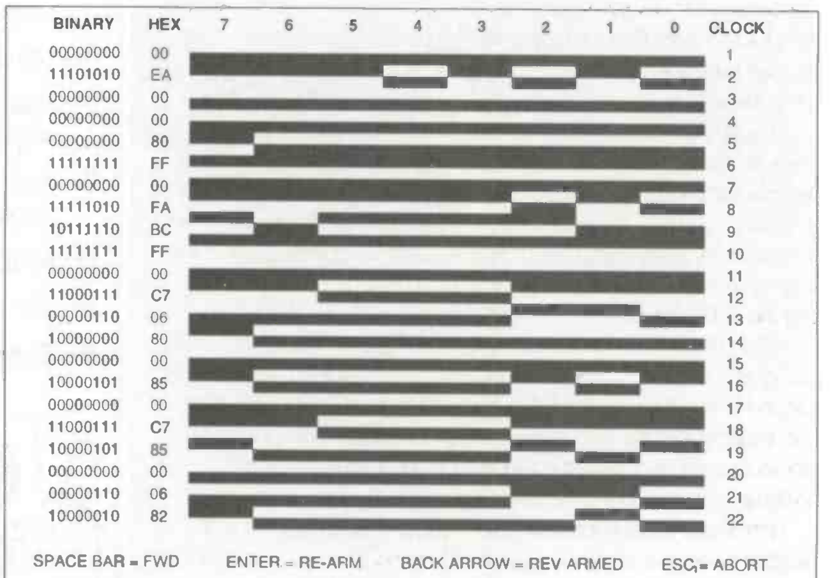
So there we have it. A very effective way to locate a hardware fault.

The logic analyser can also be used to determine the correct execution of software. Connect the analyser probes to the data bus, and press the reset switch on the target board. Arm the analyser and capture the data. Every single OPCODE/OPERAND on the data bus will then be captured as the program is being executed by the processor. Perhaps the operation of a conditional jump was misinterpreted when you wrote the software. A close examination of the captured data will verify if this is the case.

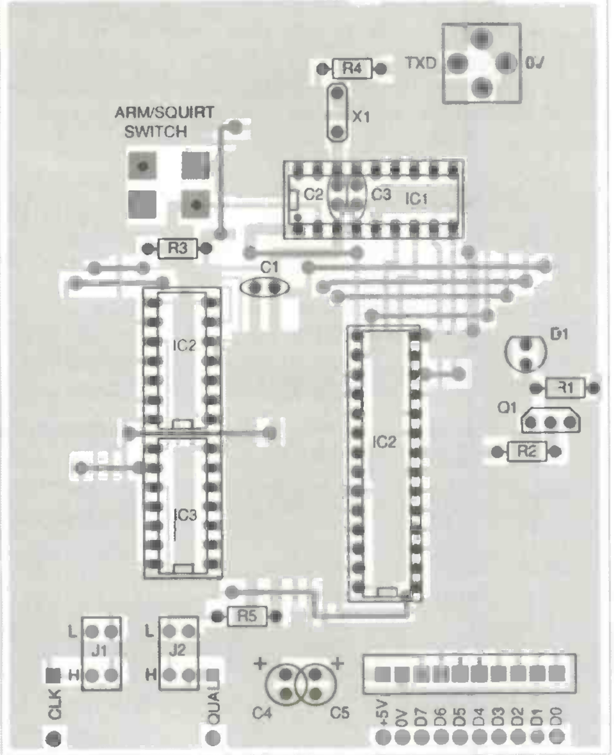
A typical microprocessor's instruction cycle will consist of a number of 'T' states or machine instruction cycles, which usually vary in number dependent on the type of instruction being executed. A multiplication instruction may take as many as five clock cycle/machine cycles. The clock cycle time is either a function of the crystal frequency or, more usually, an exact sub-multiple of the system clock.

The 'PIC' microchip is revolutionary compared to most other microcontrollers in that all instructions take one machine time cycle of 1/4 of the system clock. This means that if the xtal frequency is 4 MHz, a single instruction will be executed in 1 microsecond. In conventional microprocessor-based systems, the OPCODE may persist on the data bus for several clock cycles so that, when the logic analyser data is viewed, the same byte will have been captured several times. This is normal and doesn't mean that the processor is 'stuck'.

Many processors such as the 8088/8031 have a multiplexed low order address/data bus where the same 8 pins share data and address information; a latching D-type (74573) or (74373) is used to demultiplex data/address bytes. A control line (ALE in the case of the 8031) latches through the addresses on an active high pulse. When the pulse is at a logic low level, data is present on the input




Typical PC display from analyser




PCB component overlay

pins of the D-type.

This is where the 'Qualifier' control probe from the logic analyser comes in. If we attach it to the ALE line of the processor and move jumper J2 to the H (active low) position, address information will be captured by the analyser. Conversely, moving the jumper to position 'L' will allow the capture of data information. Jumper J1 allows the analyser to capture the bytes on the leading (active high) or trailing edge (active low) of the clock pulse. The CLK (clock) probe lead is usually attached to one side of the crystal, or to any high frequency TTL source.

## How it works

The basis of the analyser's functionality is the Advanced Micro Devices AM7200 FIFO (First-In First-Out) 256 byte CMOS memory. As the name suggests, data that first enters the memory on a write cycle is the first data that comes out on the first read cycle; an exact opposite to the operation of a 'stack' in a processor system where the LIFO (Last-In, First-Out) operation pops off (reads) the last byte pushed (write) on the stack. Pressing the ARM/SQUIRT button arms the analyser.

The AM7200 has an access time of 50 nanoseconds which means that the analyser is capable of catching data on all but the very fastest processor systems. No firmware intervention (the PIC's software) occurs in the data capture process, since this would slow things down somewhat. Capture is completely hardware driven, the target processor providing the high speed clock to drive 256 bytes into the 7200's buffer.

When the RAM is full, further writes are inhibited and the FF (full) pin lights the LED. Pressing the analyser's ARM/SQUIRT button a second time will cause the PIC's firmware to read the RAM's data and transmit it to the PC via the serial port. Further 256 byte deep blocks of sample data can now be captured by re-arming the analyser i.e. pressing the switch button once.

Note that it is suggested to hold the target system in the rest position (keep the reset button pressed) when arming the analyser. Then release the target system's reset button i.e. data/address information will then be captured from processor reset (the start of OPCODE execution).

The 7408 and 74132 consist of simple logic gates to multiplex clock and qualifier signals to the write pin of the 7200. When pin 9 of the 74132 Schmidt trigger NAND gate is low, the analyser is disabled and data will not be captured. When armed, this logic level changes to logic 1 permitting the target board's clock to write in successive bytes of data. If things appear to be happening rapidly, remember that with a clock of 1 MHz, it will take approximately 0.25 milliseconds to clock in 256 bytes of data!

## Construction

The unit is built on a double-sided PCB. This is not a formidable task as may at first appear. The following method has been used successfully by the author: make a 'sandwich' consisting of the double-sided photo resist board and the copper layer and component layer artwork, ensuring that the component layer is print side up.

The artwork dimensions must be exactly the same as that of the finished board, but at this stage cut the board with a 1 inch overlap at the sides to allow tape to keep the artwork in position. To ensure correct registration between both sides of the board, two 0.8 mm holes are drilled diagonally opposite at the edges through the board and the artwork. By holding the 'sandwich' up to a bright light source, a pinhole camera effect allows the artwork to be aligned.

With board and artwork aligned it is a simple matter of following the usual processing procedure i.e. exposure of both sides of the board to U.V. light and then developing and etching. Finally, the dried board is cut to final shape and the 'pin through' holes are made with short lengths of wire or by using special purpose PCB through connecting pins.

## System firmware

A PIC - 16C54 contains the logic analyser software for capturing the 256 bytes of data and transmitting them in binary form to the PC at 9600 baud 8 data bits 1 stop bit.

The source code listing is shown below:

```
MPASM 01.02.05 Intermediate   LOGICBIN.ASM
9-2-1995   15:6:0    PAGE  1

LOC       OBJECT CODE      LINE SOURCE TEXT
               0001
               0002           ;LOGIC ANALYSER
               0003           ;'LOGICBIN.ASM'
               0004
               0005           LISTp=16C54
               0006           ;
               0007
0020           0008 BAUD_1    EQU .32;9600 BAUD
               0009
0000           0010 TXD       EQU 0        ;RA0
0001           0011 RTCC      EQU 1        ;RTCC
0002           0012 PC        EQU 2
0003           0013 STATUS    EQU 3        ;STATUS
                                           REGISTER
0005           0014 PORT_A    EQU 5        ;PORT A
0006           0015 PORT_B    EQU 6        ;PORT B
0008           0016 DLYCNT    EQU 8
0009           0017 COUNT     EQU 9
000A           0018 BUFFER    EQU 0AH      ;TRANSMIT
                                           BUFFER
000B           0019 COUNTR    EQU 0BH      ;TIMING
                                           COUNTER
000D           0020 INVERT    EQU 0DH
0010           0021 BLOW      EQU 010H
0011           0022 BHIGH     EQU 011H
               0023
               0024
;*****************************************************************
********
               0025           ORG 0
0000           0026           start
               0027
```

```
0000        0028          NOP
0001 0000   0029          NOP
0002 0948   0030          CALL INIT
                          ;INITIALISE PORTS
            0031
0003        0032          CYCLE
0003 0C40   0033          MOVLW 040H
0004 0030   0034          MOVWF BLOW
0005 0C04   0035          MOVLW .4
0006 0031   0036          MOVWF BHIGH
            0037
0007        0038          POLL
0007 0004   0039          CLRWDT
0008 0665   0040          BTFSC PORT_A,3;GO SWITCH
                                      LOW?
0009 0A07   0041          GOTO POLL
            0042
000A 0C07   0043          MOVLW B'00000111'
                                 ;DEBOUNCE
000B 0002   0044          OPTION
000C        0045          RELEASE
            0046
000C 0061   0047          CLRF RTCC
000D 0004   0048          DEBOUNCE CLRWDT
000E 07E1   0049          BTFSS RTCC,7
000F 0A0D   0050          GOTO DEBOUNCE
            0051
0010 0765   0052          BTFSS PORT_A,3
0011 0A0C   0053          GOTO RELEASE;STILL
            LOW?THEN GOBACK

MPASM 01.02.05 Intermediate  LOGICBIN.ASM
9-2-1995  15:6:0 PAGE  2
LOC   OBJECT CODE     LINE SOURCE TEXTVALUE

            0054
0012 0525   0055      BSF PORT_A,1     ;ARM ON
            0056
0013        0057      FLUSH
0013 0665   0058      BTFSC PORT_A,3  ;PRESS 2ND TIME
                                           TO;READ

0014 0A13   0059      GOTO FLUSH
            0060
0015 0425   0061      BCF PORT_A,1     ;ARM OFF
            062
0016 0C07   0063      MOVLW B'00000111'
            ;DEBOUNCE
0017 0002   0064      OPTION
0018        0065      RE_LEASE
            0066
0018 0061   0067      CLRF RTCC
0019 0004   0068      DE_BOUNCE CLRWDT
001A 07E1   0069      BTFSS RTCC,7
001B 0A19   0070      GOTO DE_BOUNCE
            0071
001C 0765   0072      BTFSS PORT_A,3  ;STILL LOW?
                                       THEN;GOBACK
001D 0A18   0073      GOTO RE_LEASE
            0074
001E        0075      EMPTY
001E 0445   0076      BCF PORT_A,2;READ LINE LOW
001F 0206   0077      MOVF PORT_B,0;READ DATA INTO W
            0078      ;DATA IN W
            0079
0020 092C   0080      CALL CONVERT;INVERT ALL BITS
0021 0931   0081      CALL TRANSMIT   ;AND TRANSMIT
                                          AT 9600
0022 0004   0082      CLRWDT
            0083
0023 0545   0084      BSF PORT_A,2;READ LINE HIGH
            0085
0024 02F0   0086      DECFSZ BLOW,1
0025 0A1E   0087      GOTO EMPTY
0026 0C40   0088      MOVLW 040H
0027 0030   0089      MOVWF BLOW
0028 02F1   0090      DECFSZ BHIGH,1
0029 0A1E   0091      GOTO EMPTY
            0092
002A 0004   0093      CLRWDT
002B 0A03   0094      GOTO CYCLE
            0095
            0096
002C        0097      CONVERT
002C 0FFF   0098      XORLW 0FFH
002D 002A   0099      MOVWF BUFFER;IN FILE REGISTER A
002E 0C08   0100      MOVLW 8;8 DATA BITS
002F 002B   0101      MOVWF COUNTR
0030 0800   0102      RETLW 0
            0103
0031        0104      TRANSMIT
0031 0505   0105      BSF PORT_A,TXD
0032 0942   0106      NEXT CALL DELAY   ;104 uS DELAY

MPASM 01.02.05 Intermediate  LOGICBIN.ASM
9-2-1995  15:6:0 PAGE  3

LOC   OBJECT CODE  LINE SOURCE TEXT VALUE

0033 032A   0107      RRF BUFFER       ;ROTATE BUFFER
0034 0603   0108      BTFSC STATUS,0   ;TEST CARRY
                                            FLAG
0035 0505   0109      BSF PORT_A,TXD
0036 0703   0110      BTFSS STATUS,0   ;TEST AND
                                        TRANSMIT BIT
0037 0405   0111      BCF PORT_A,TXD
0038 02EB   0112      DECFSZ COUNTR
                       ;UNTIL ALL 8 BITS
                       ;TRANSMITTED
0039 0A32   0113      GOTO NEXT
            0114
003A 0942   0115      CALL DELAY
003B 0405   0116      BCF PORT_A,TXD   ;STOP BIT
            0117
003C 0942   0118      CALL DELAY
003D 0942   0119      CALL DELAY
003E 0942   0120      CALL DELAY
003F 0942   0121      CALL DELAY
0040 0942   0122      CALL DELAY
            0123
0041 0800   0124      RETLW 0
            0125
0042        0126      DELAY;104 uS DELAY
0042 0C20   0127      MOVLW BAUD_1
0043 0028   0128      MOVWF DLYCNT
0044 02E8   0129      REDO DECFSZ DLYCNT,1
0045 0A44   0130      goto REDO
0046 0004   0131      CLRWDT
0047 0800   0132      retlw 0
            0133
0048        0134      INIT
0048 0004   0135      CLRWDT
0049 0CFF   0136      MOVLW 0FFH
004A 0006   0137      TRIS PORT_B;PB0 - PB7 INPUTS
004B 0C08   0138      MOVLW 8;
004C 0005   0139      TRIS PORT_A;RA0 SERIAL OUTPUT
            0140
            0141      ;RA1 OUTPUT ARM
            0142      ;RA2 OUTPUT READ
            0143      ;RA3 INPUT  GO
            0144
004D 0405   0145      BCF PORT_A,TXD   ;START WITH
                       STOP BIT;LOW
004E 0425   0146      BCF PORT_A,1     ;ARM OFF
004F 0545   0147      BSF PORT_A,2     ;READ LINE HIGH
            0148
            0149
0050 0800   0150      RETLW 0
            0151
            0152      org      01FFh
01FF 0A00   0153      goto     start
            0154      END


MPASM 01.02.05 Intermediate  LOGICBIN.ASM
9-2-1995  15:6:0 PAGE  4

SYMBOL TABLE

LABEL         VALUE
BAUD_1        0020
BHIGH         0011
```

```
BLOW          0010
BUFFER        000A
CONVERT       002C
COUNT         0009
COUNTR        000B
CYCLE         0003
DEBOUNCE      000D
DELAY         0042
DE_BOUNCE     0019
DLYCNT        0008
EMPTY         001E
FLUSH         0013
INIT          0048
INVERT        000D
NEXT          0032
PC            0002
POLL          0007
PORT_A        0005
PORT_B        0006
REDO          0044
RELEASE       000C
RE_LEASE      0018
RTCC          0001
STATUS        0003
TRANSMIT      0031
TXD           0000
__16C54       0001
start         0000

Errors   :  0
Warnings :  0
Messages :  0
```

## Operating

The power for the analyser is taken from the target board and must be +5 volts (+- 0.25 volts). Connect the eight data leads to the target's address or data bus via a chip glomper. If no qualifying signal is required, remove jumper J2. Jumper J1 selects between an active low or active high signal and can be selected by experiment according to the processor type.

Connect the serial link (i.e. the PC's serial port - either COM1 or COM2). The receive data pin of the serial port is pin 2 (pin 5 0v). Strap together pins 4, 6, 7, 8 together. Press the analyser switch once. The system is now armed. When 256 bytes have been captured, press the same switch again. The data will then be presented on the PC's screen for inspection and analysis.

The DOS software driver was written by the author to be used with the Logic Analyser. The software gives the user a better representation of the captured data than does a Terminal Emulator. An example of the driver graphics is shown below:

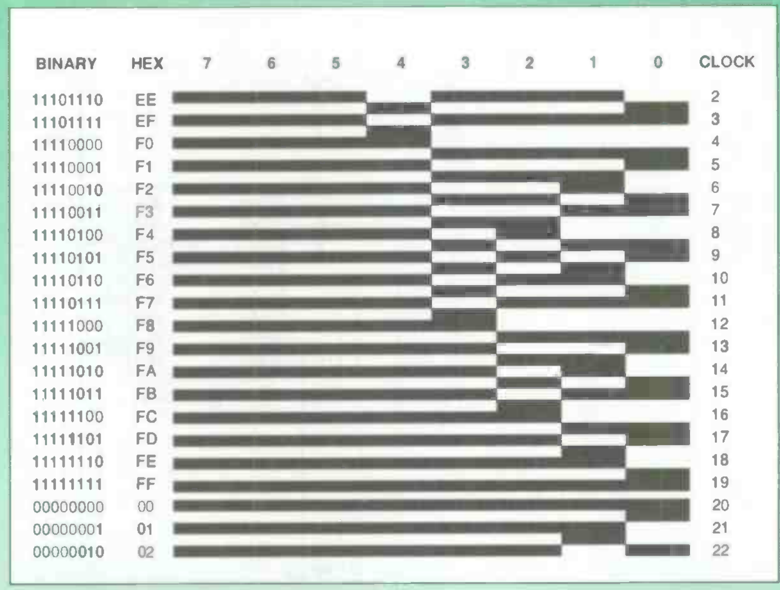
The data is shown in pure binary format, it's hexadecimal equivalent, a 'bar-chart' representation of logic levels and the clock cycle associated with each captured byte. In addition, the ASCII printable character is displayed alongside each byte.

## Operating the software driver

One can quite easily write a simple software driver and data display programme for the analyser using in any computer language, even Basic. However, if you don't want to do this, a programme is available free from the author with the purchase of a programmed PIC chip; see below for details.

Install either 'LOGCOM1.EXE' or 'LOGCOM2.EXE' file onto the hard disk and connect in the Logic Analyser to the COM1/COM2 serial port of the PC. Arm the logic analyser board by pressing the ARM switch once. A flashing 'ARMED' message on the PC screen display will show that the system is operational. The Full buffer LED will light showing that the FIFO buffer is full.

Pressing the switch a second time will stream the captured data to the PC. 256 bytes will be saved in a buffer and written to disk in file 'Logic_a'. To view the data, press the space bar to increment the viewing window and, similarly, the back-arrow key will decrement the clock cycle number. The driver may be re-armed at any time by pressing the ENTER key. To abort, simply hit the ESCAPE key. Screen contents can be printed by using the PrtSc button on the keyboard.




A pre-programmed PIC is available from the author:

Mr.R.Grodzik (MICROS)
53 Chelmsford Road,
Bradford BD3 8QN
West Yorkshire
United Kingdom

Price £29 (p&p inc). Includes free PC logic analyser software driver on disk.

Tel.01274 662085 for further details.

Also available: AM7200-50RC FIFO £10 (p&p inc).

## PARTS LIST

### Capacitors

| | |
|---|---|
| C1 | 100n |
| C2 | 33p |
| C3 | 33p |
| C4 | 100u |
| C5 | 10u |

### Resistors

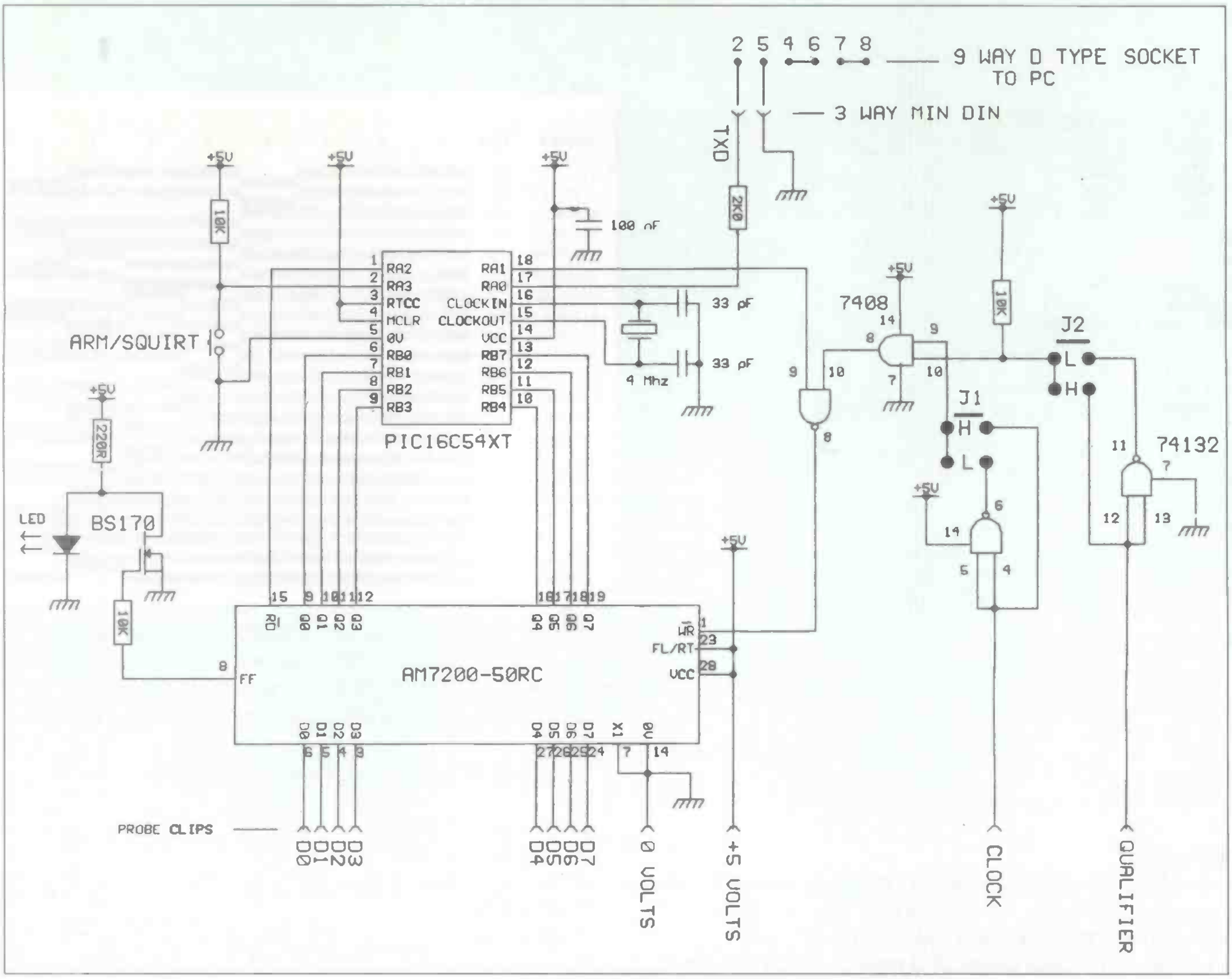
| | |
|---|---|
| R1 | 220R |
| R2 | 10k |
| R3 | 10k |
| R4 | 2k |
| R5 | 10k |

### Semiconductors

| | |
|---|---|
| IC1 | PIC16C54XT |
| IC2 | AM7200-50RC |
| IC3 | 7408 |
| IC4 | 74132 |
| Q1 | BS170 |
| D1 | LED |

### Miscellaneous

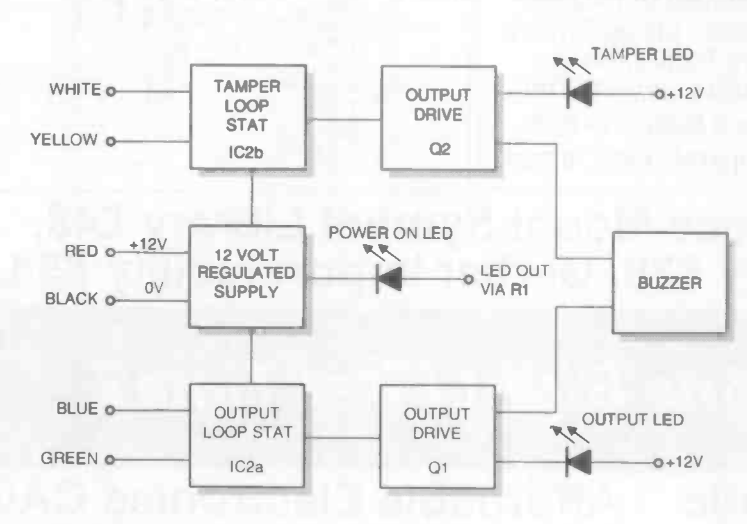
X1 4MHz crystal
9-way D-type socket
3-way miniature DIN
Pushbutton switch
0.1in connector pins



2 5 4 6 7 8
9 WAY D TYPE SOCKET TO PC
3 WAY MIN DIN
TXD
+5V
10K
2K0
100 nF
33 pF
33 pF
4 Mhz
7408
J2
J1
74132
ARM/SQUIRT
RA2
RA3
RTCC
MCLR
0V
RB0
RB1
RB2
RB3
RA1
RA0
CLOCKIN
CLOCKOUT
VCC
RB7
RB6
RB5
RB4
PIC16C54XT
LED
BS170
220R
AM7200-50RC
FF
WR
FL/RT
VCC
PROBE CLIPS
D0 D1 D2 D3
D4 D5 D6 D7
0 VOLTS
+5 VOLTS
CLOCK
QUALIFIER

# SENTINEL (Alarm Sensor Watchdog)

***A useful piece of equipment designed by Bob Noyes for testing and setting up alarm systems***



Sentinel block diagram

The DIY home security systems market is booming, alarm systems are forever coming down in price as a result of keen competition between manufacturers and, as a result, both quality and reliability are suffering.

A typical example of this is the tamper loop provision on PIR (passive infra red) sensors; in the past this has consisted of a microswitch mounted in such a position that if the alarm cover is removed, the tamper trip Is activated and the alarm sounds. This has worked extremely well for many years, but now, with all the cost-cutting, the microswitch in several systems has been replaced by a bent piece of metal that touches a contact when the lid is in place but springs up when the alarm cover is removed, thereby breaking the circuit. This seems OK but, when subjected to vibration, smoke or condensation, it fails after only a few months, setting the alarm off when no actual intrusion has taken place. The two different metals become tarnished or, in some extreme cases, corroded, causing a bad connection.

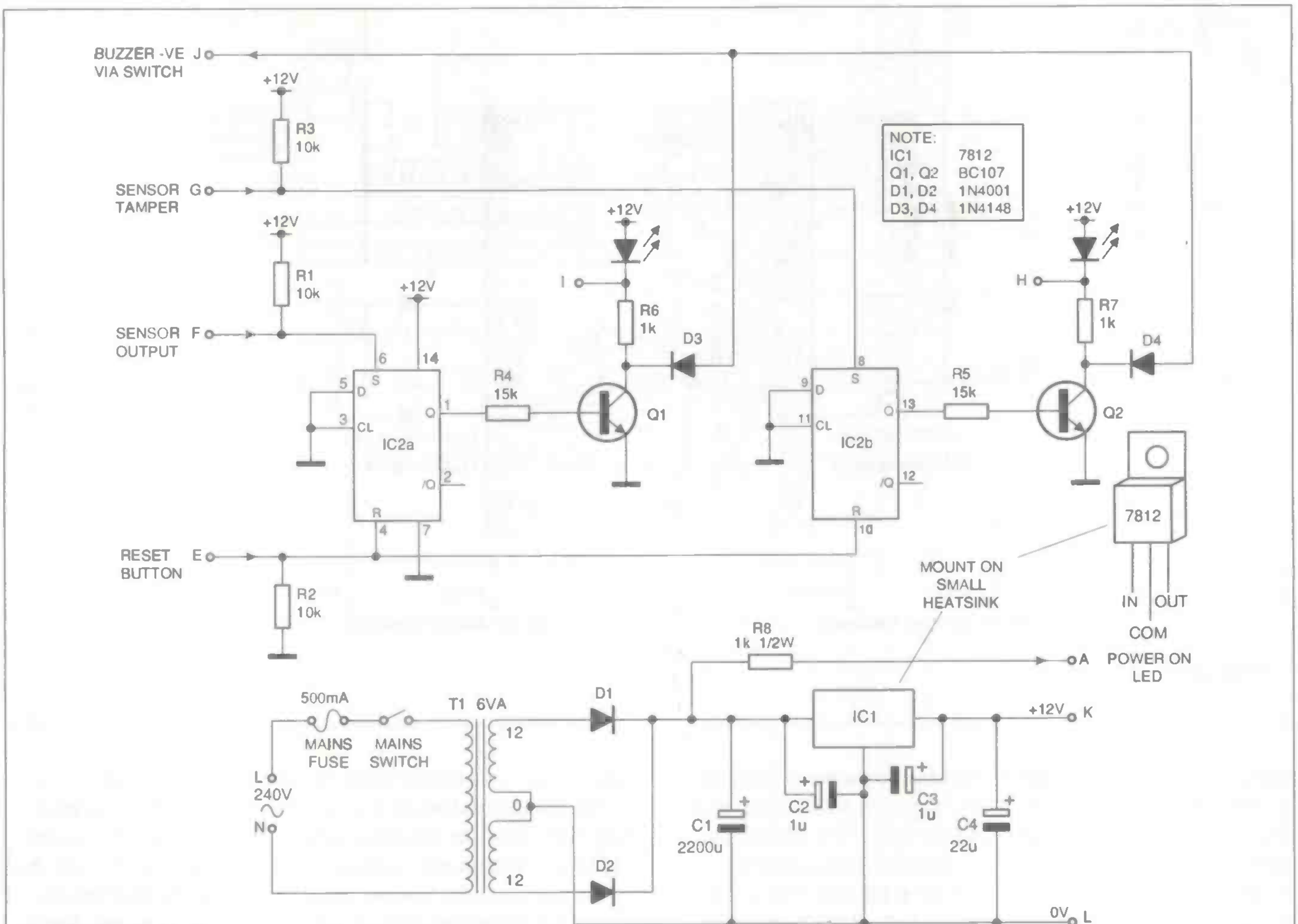
Another shortcoming in certain cheaper PIR detectors is that the PCB is no longer screwed to the case but held in place by a plastic clip or clips made from the moulding of the case. These clips either bend out of place or, in some extreme cases, snap off altogether when the PCB is connected to the wires and pressed back into position; because it is not being held firm, it is free to move about, albeit slightly. Vibration from heavy traffic or even a slamming door can cause a false alarm because the PCB containing the PIR sensor moves rather than a heat source moving, and so the alarm 'sees' it as an intrusion and sets off the alarm.

In most alarms it is possible to see which zone loop has activated the alarm but if several PIR detectors are connected to this zone it is impossible to say which one is giving the false signal. This problem is more prevalent in certain alarm systems' tamper loops where all sensor switches and detectors share one common loop and any break anywhere only shows on the alarm panel's LEDs as a tamper problem - one LED for maybe six or seven detectors. Although a break, i.e. a permanent open circuit, is easy enough to find with a meter, an intermittent break is far harder to find as it may only happen under certain conditions such as a cold night or when subjected to vibration. This Is where Sentinel comes into its own; if any break occurs, the corresponding LED will come on and stay on even if the loop breaks and connects itself again - the most common type of problem. Sentinel doesn't need feeding so it is always vigilant and any failure will activate the LED or sound the buzzer.

If several detectors are to be tested they must be done one at a time and for long enough so that any possible fault can show. If only one area of fault is being looked at, the other one can be looped out. For instance, if the tamper loop is the area of fault in a unit, the output loop terminals of Sentinel can be shorted out; in the prototype these are the blue and green. This means the PIR unit can be handled and although it would trip due to handling, it does not cause Sentinel to activate because of the added loop. The other loop, i.e. the tamper, can then be tested fully by exposing the PIR to vibration etc. If this fails to show the problem, it can be left and the sound switched on. As soon as it fails, the buzzer sounds, indicating exactly when the failure occurs. If you are out of earshot at the time, the LED and buzzer remain on until reset

## How the circuit works

Sentinel must be able to power the sensor under test so, to accomodate this, a regulated 12 volt supply is provided. This is a standard supply consisting of two diodes (D1, D2) producing DC from a 12-0-12 volt tap on the transformer; this is smoothed by a reservoir capacitor C1. The voltage access C1 is around 17 volts off load which is the feed to IC1 a 7812 the standard +12 volt 1 amp regulator. In order to suppress any high frequency present,



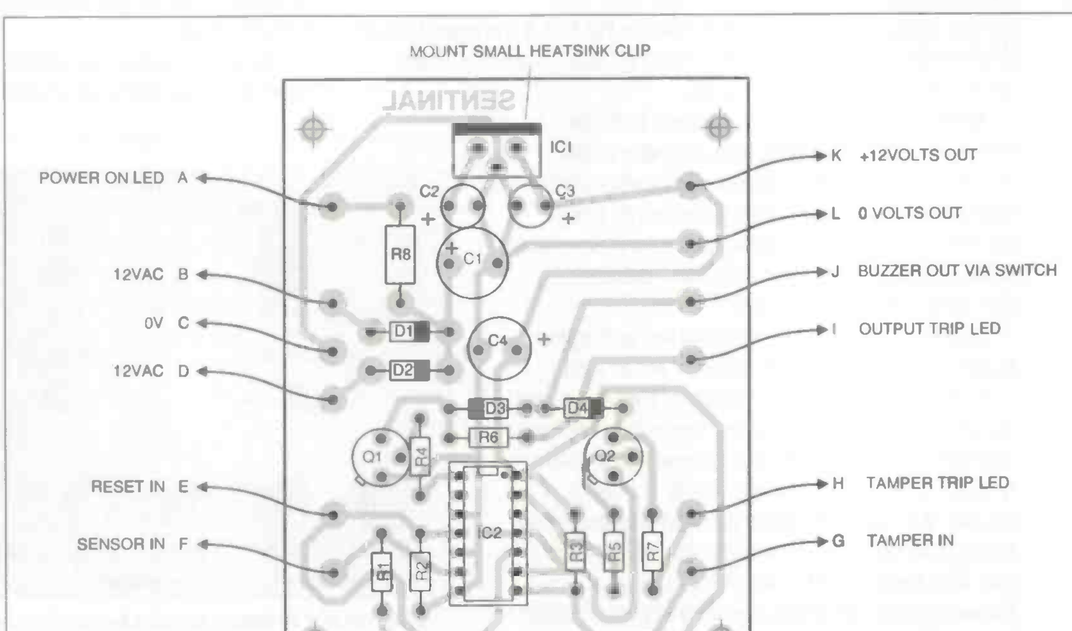

The Sentinal circuit

C2 and C3 are mounted as close to IC1 as practicably possible. This +12 volt supply is used to power Sentinel's electronics as well as provide the +12 volts for the sensor under test, +12 volts to the red terminal, 0V to the black terminal.

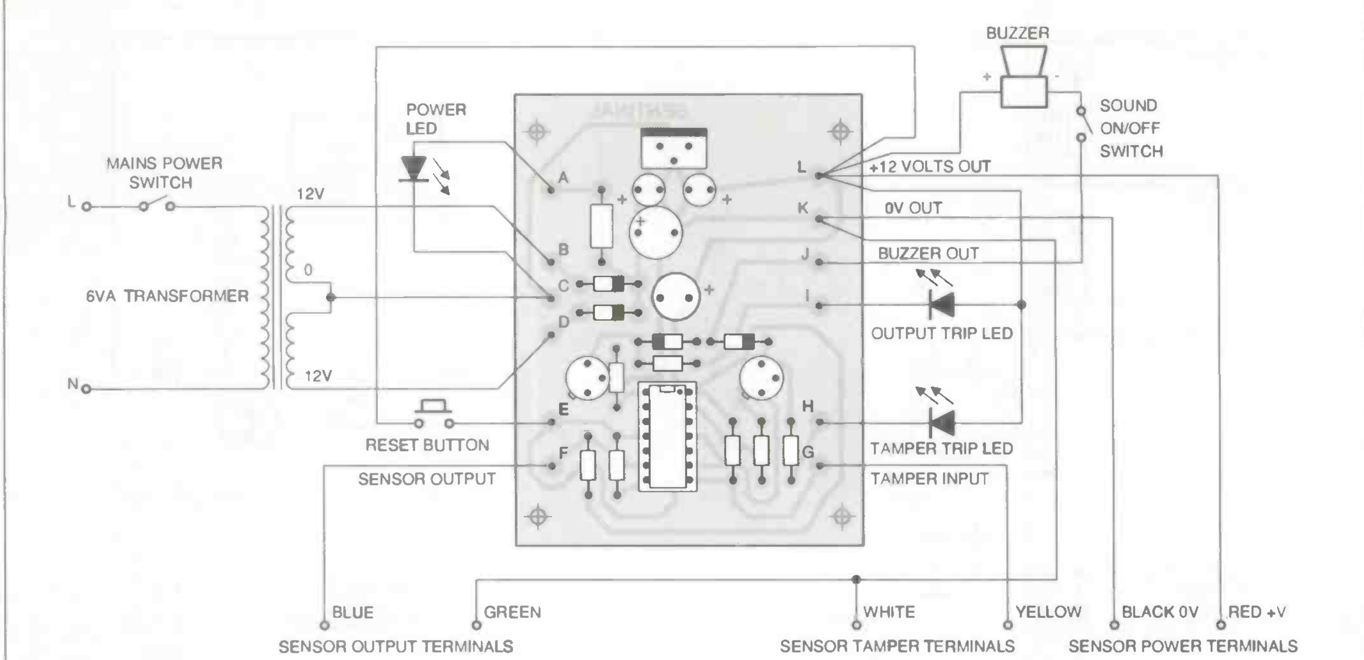
The principle of the tamper loop test circuit is identical to that of the output alarm circuit except it uses the other half of IC2.

The white and yellow terminal are used on the front panel to bring the two tamper wires from the PIR sensor under test to Sentinel. The tamper wires may be connected either way round as this is an isolated loop, as per diagram. The white terminal goes to 0 volts while the yellow goes to pin G on the PCB. From here, it goes to the set (pin8) of a D type stat IC2 as well as a pull up resistor.

The D type is at the heart of the memory circuit; when a fault - in our case, a break in the loop - occurs, it is remembered, even if the break connects again - an intermittent fault. The clock and "D" inputs are grounded in IC2 leaving only the set and reset input pins in use. In such a circuit when a positive or 12 volts is detected on the set, pin 8, the "Q" pin 13, goes high and stays high until reset by a high or 12 volts on the reset, assuming the set is not still high. Although this sounds a bit of a mouthful it all fits in rather well because if there is a "high" on the set the PIR's fault is showing itself i.e. the loop is broken - a permanent fault. These types of fault are easy to detect and can be confirmed on a meter. However, the type of




TCB component overlay




PCB Wiring connections

fault Sentinel has been designed to detect is the intermittent one.

Normally, the tamper loop on the alarm is a short circuit i.e. a loop in through a closed switch and out again. This means that, when working, the white and yellow terminals are connected together on Sentinel via the tamper loop in the PIR. This means that pin G on Sentinel is at 0V which, in turn, puts 0V on the set input of IC2. If, however, this loop fails i.e. a break occurs, the set input of IC2 is pulled high via R3. This high, no matter how fast, turns the "Q" pin high; this via R5 turns on TR2. The collector of TR2 goes low and in turn illuminates the monitor LED on the front panel. D4 now becomes forward biased and, if the sound switch is on, will sound the buzzer - very handy when Sentinel is used on test for a long time as you can be getting on with something else. D4 and D3 are required to prevent the tamper loop interfering with the ouput loop LEDs and vice versa.

The rest pin 10 of IC2 is held low via R2 but, if the reset button is pressed, pin 10 becomes high as the other side of the reset switch is connected to +12 volts.

Under normal working conditions both the tamper connectors (white and yellow) and the ouput loop connectors (green and blue) are two separate closed loops (not connected to one another). So all the unit does is constantly monitor both loops and indicate if a break is detected by illuminating the relevant LED.

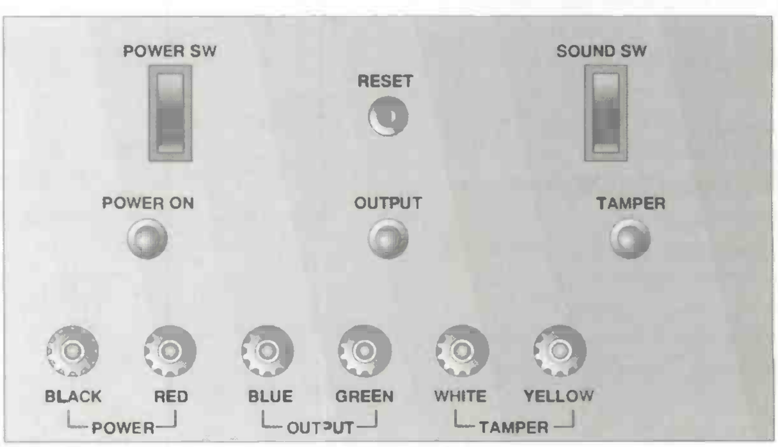
A little more care is required when testing the output loop of, say, a PIR detector as, to start with, they normally take a couple of minutes to get settled down. During this time, the output LED will illuminate so it's a good idea to have the sound turned off as it can get a little irritating. After a couple of minutes, it will be working and the reset button can be pressed; the monitor LED will go out. But, being a PIR, it will detect body movement so it must be placed firmly so it cannot move of its own accord and facing away from you, otherwise it will detect you and give an output. While on test it must face away from any heat source such as a human body, radiator, powerful light etc.

Ideally, it should be left in an unattended room. If the room is fairly dark, it can be left some distance from an open door as the LEDs can be seen from outside. If this is not convenient, then the sound can be used. This will indicate when the PIR has tripped, as a result of the slamming of a door, heavy traffic, a plane flying overhead, the fridge motor starting up, etc.

As well as Sentinel being an extremely useful fault finding aid, it is also of benefit for setting up the PIR in its actual position. It may not be practicable to energise the whole alarm system to power up the PIR but, by using Sentinel, the PIR can be tested and positioned during installation.

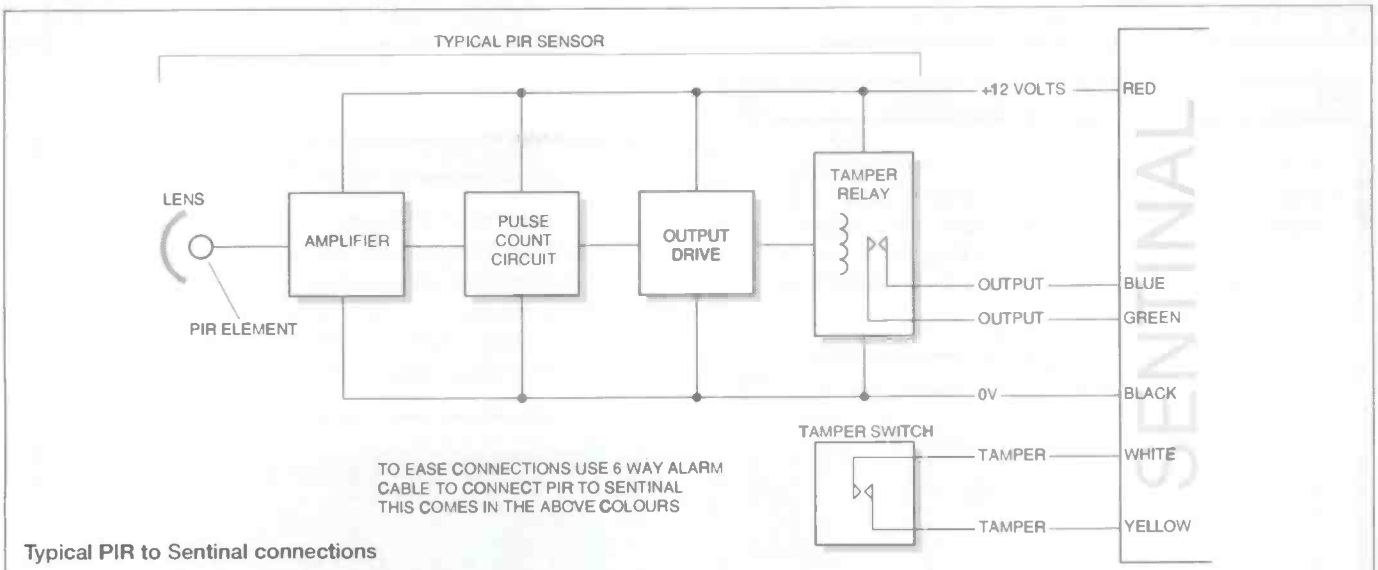
Although PIRs are by far the most common type of sensor, other types can be tested such as Doppler, ultrasonic, radar etc. They must be 12 volt devices and have closed loop outputs when not activated.

As well as electronic detectors, even simple switches such as reed switches, commonly used on doors etc, can be monitored




NOTE: COLOUR OF TERMINAL POSTS MATCH COLOUR OF STANDARD 6 WAY ALARM CABLE

Layout of standard vero box




Typical PIR to Sentinal connections

## PARTS LIST

**Resistors**

| | |
|---|---|
| R1 | 10K |
| R2 | 10K |
| R3 | 10K |
| R4 | 15K |
| R5 | 15K |
| R6 | 1K |
| R7 | 1K |
| R8 | 1K 1/2W |

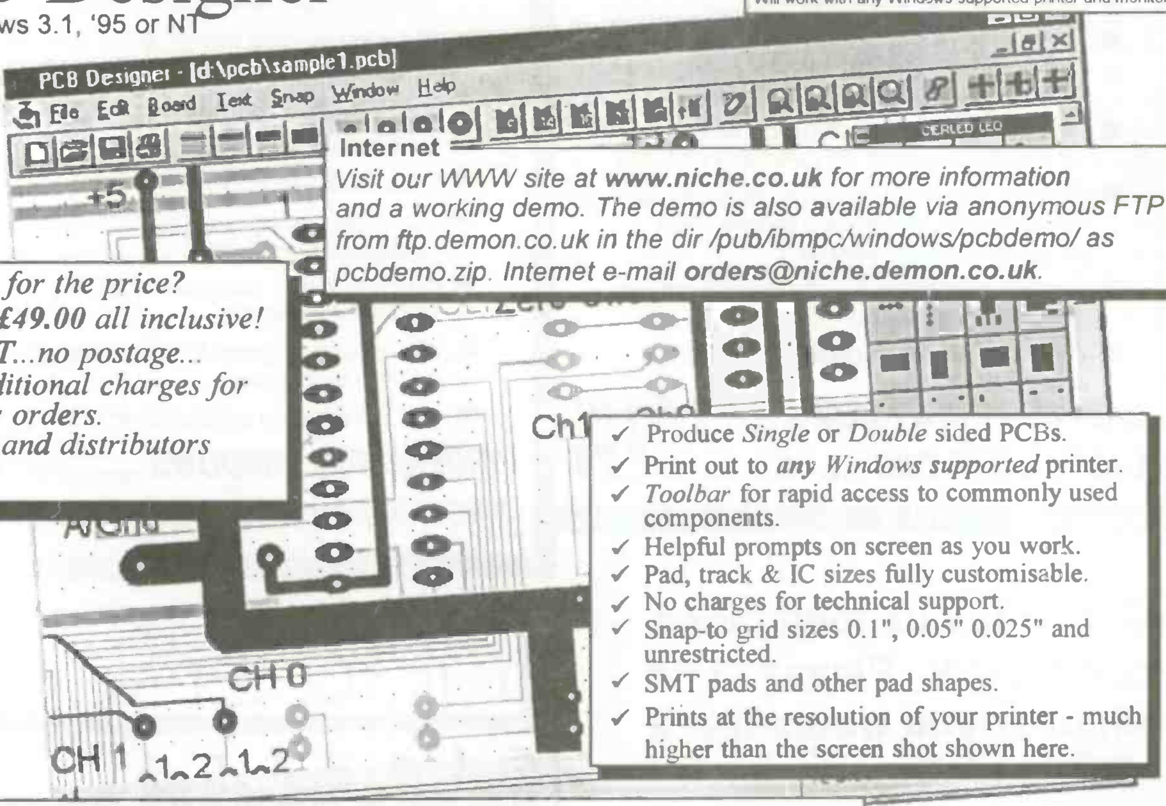
**Capacitors**

| | |
|---|---|
| C1 | 2.200nF 25V Rad |
| C2 | 1nF 25V Rad |
| C3 | 1nF 25V Rad |
| C4 22n | F 25V Rad |
| IC1 | 7812 +12 V Reg |
| IC2 | 4013 CMOS "D" type stat |
| D1, D2 | IN4001 |

**Miscellaneous**

1 x 2-0-12V 6VA transformer
Red LEDs 0.2" (2 off), Green LED 0.2"
12V buzzer
Switches single pole on-off (2 off)
Coloured terminal posts (red, black, green, blue, white, yellow) (2 off)
Box to suit (Vero type used)
Press to make switch
14-pin IC holder
TO220 Heat sink clip
Fuse (max 1 Amp)





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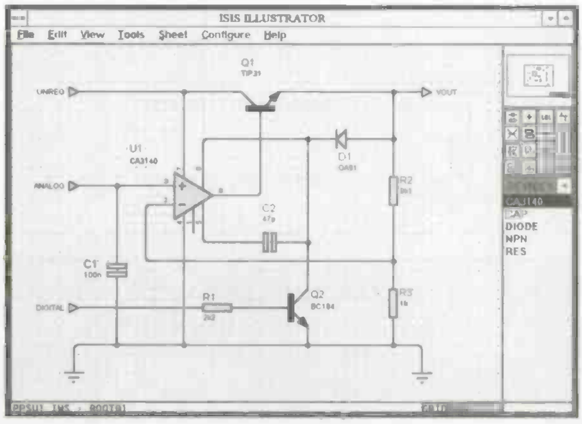


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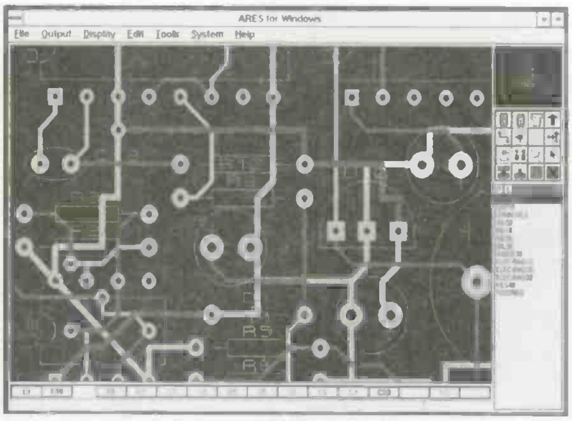


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# Software review

***Continuing our look at software for the engineer's PC, Frank Guaschi delves into the intricacies of Mathplus***

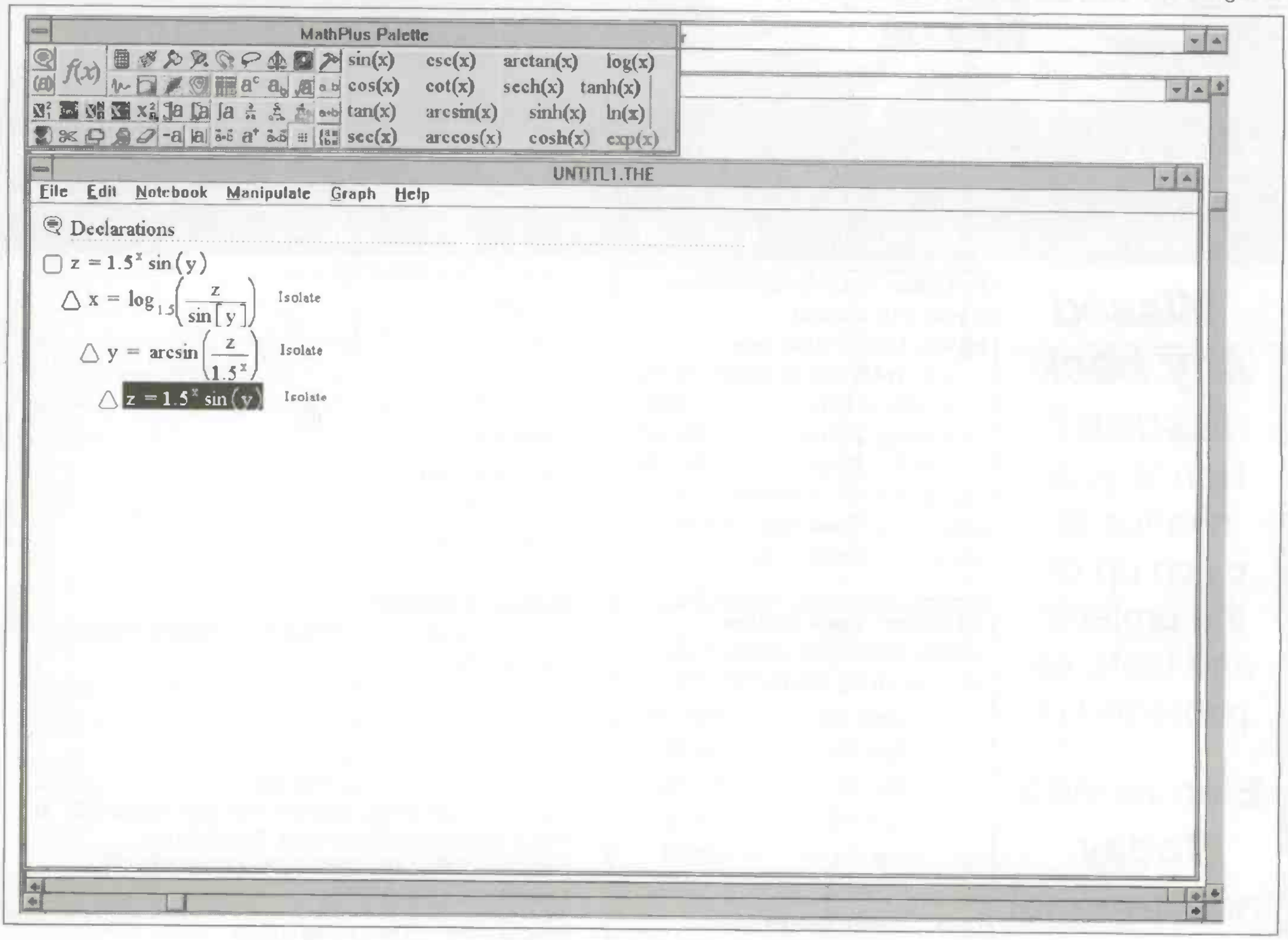
Computers and mathematicians have always gone together. Indeed, if we go back to the last century, the original derivation of the word computer was none other than a mathematician whose job it was to 'compute' some complex and usually repetitious formulae. So it seems only right that the mathematician of today should enjoy the assistance of an electronic 'computer' to perform, amongst other things, those same complex and repetitious formulae.

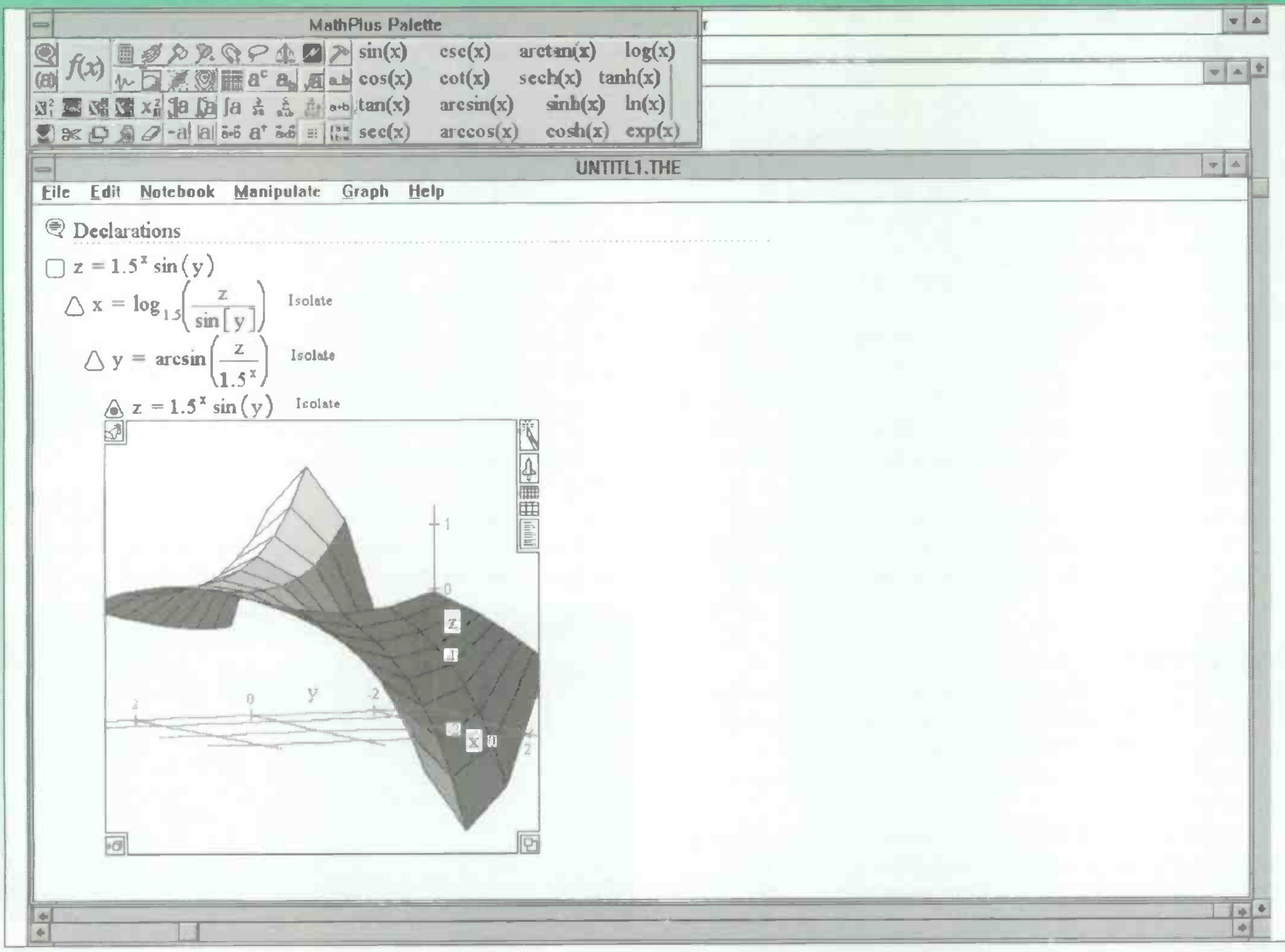
Of course mathematicians have been using computers since the very first system was constructed. But it is only in the last few years that very powerful personal computers have made it possible to write software that can form the basis of a practical real time tool to aid mathematicians in a wide range of different procedures. Procedures ranging from multi-dimensional graph plotting of a complex polynomial to solving problems with differential calculus.

There are several such programmes available commercially today, and the one we are going to look at in this article is Mathplus from the Canadian software house Waterloo Maple.

## Mathplus

Mathplus has been produced for mathematicians and scientists with particular emphasis on its use as a teaching and






learning tool in secondary schools, colleges and universities. It has been designed to run on a standard personal computer and sports a graphical user interface that makes it very easy to use. This is in contrast to some of the other packages on the market, such as Maple V, which require the user to learn a programming language before being able to use it.

Mathplus is, in fact, an improved Windows version of a programme called Theorist. This has been a very popular computer algebra package which has been available for the Apple Macintosh for several years.

The review version which I looked at ran under Windows. Installation was a matter of just a few minutes thanks to the install routine initiated through Window's Programme Manager. The installation copy was on two 3.5inch disks that came with two thick and very comprehensive manuals. (It should be noted that Maple publish a whole range of books on using this programme that form an invaluable library of associated information; a list of these books was provided in the box.)

## Using the programme.

Mathplus comes with a fully illustrated 320-page learning guide that is quite easy to follow with plenty of examples to help the user to get familiar with the different procedures. This is supplemented by a handy and extensive 350-page reference manual that expands on many of the things in the learning guide. These were both essential given the enormous range of features and functions supported by this package.

With Mathplus, one simply creates a mathematical equation by entering symbols and figures using the keyboard, or selecting from a palette using the mouse. Solving such equations is made very easy thanks to the use of 'click and solve' techniques, highlighting the expression with the mouse, and choosing a host of manipulative icons from the palette.

Built into the Mathplus software are over 250 maths functions with instructive live notebooks illustrating finite and infinite series, Laplace transforms, 2-D and 3-D graphics, 15-digit arithmetic precision, remanipulation, vectors, matrices, trigonometry, polynomials, etc.

The Graph feature is particularly good and, indeed, one can very easily get quite carried away with entering a wide range of polynomial and trigonometric functions and experimenting with the differently shaped curves produced by modifying the parameters. It is also possible to extract tables from the graphs so that values of y can be tabulated for a range of values of x in the function y= f(x). Three-dimensional representations of graphs can be shown for bi-variate functions.

The program makes it possible to do very simple mathematics like basic addition and subtraction etc, although most users will probably find it easier to get out their hand calculators. However, when it comes to Algebra, the program is much more useful. The program readily deals with the manipulation of quite complicated expressions. It can cope with the solution of quadratic equations, and of polynomial equations of higher degree using graphical methods. There are also neat methods of handling Non-linear equations.

The program's ability to handle the Calculus is an attractive feature. The program takes in its stride the straightforward problems in differential calculus such as differentiation of algebraic and trigonometric functions, slopes and tangents, and maxima and minima. Similarly, it is equally impressive in handling the integral calculus. Simple definite and indefinite integrals, integration by parts, or by substitution, can be done although, with some of the difficult problems, care has to be taken to follow through the steps. This is especially true of Multiple or other complicated integrals that require intelligent intervention by the operator. In other words, the program is no mere robot.

The rest of the program's abilities in the Calculus is taken up with the solution of differential calculus. Because this is a vast and complicated field requiring great ingenuity in the solution of many equations, the program could not be expected to cope with other than the more simple ones. Even so, its use of graphs to solve numerical equations of first, second, and higher degrees makes a very useful contribution.

The program's capability in dealing with Matrices is a definite advantage. The basic matrix operations of multiplication and inversion that are often a bit of a chore are carried out with great speed. The program's ability to handle General linear systems, determinants and the solution of simultaneous equations is similarly impressive.

Finally, the Mathplus program gives the mathematician a demonstration of the way in which it can be at home with more advanced techniques like Fourier transforms, Bessel, and the Gamma functions.

### In Conclusion

I found the Mathplus program very attractive and well laid out. The palette of icons makes it easy to become familiar with the various facilities. Many mathematicians, and especially mathematical students, will find this a very useful package to have on their PCs.

The package is well suited to the needs of students studying maths, the sciences and information technology within the National Curriculum, as well as higher level students and professionals, particularly those in the sciences and technology who are not specialist mathematicians.

### Supplier Details

Product: (MATH)plus version 2

Publisher: Waterloo Maple, 450 Phillip Street, Waterloo, Ontario, Canada, N2L5J2. Tel (from UK) 001 519 747 2373. Fax 001 519 747 5284 or electronically on:
info@maplesoft.on.ca
and World Wide Web:
http://www.maplesoft.on.ca.
UK Distributor - Robinson Marshall (Europe) plc, Nadella Building, Progress Close, Leofric Business Park, Coventry, Warwickshire, CV3 2TF. Tel 01203 233216. Fax 01203 233210.
email: RME@cityscape.co.uk

Price: £199 per single user, network licences begin at £1000.00 for 10 users (there is a special schools version with an unlimited user site licence fee of £995.00)

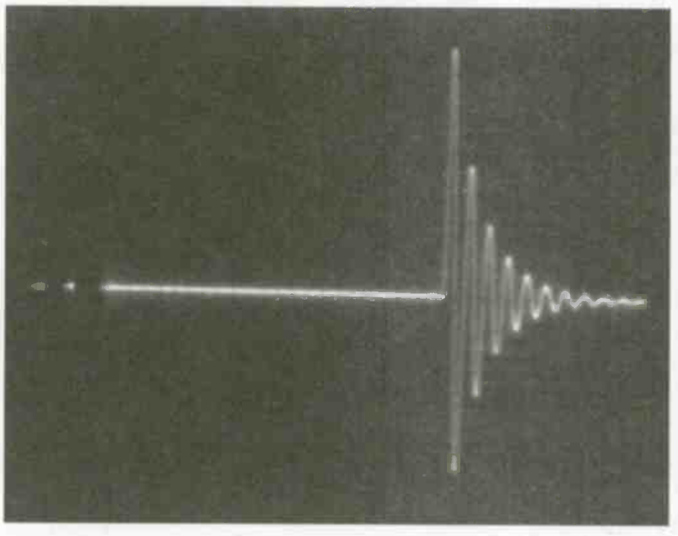
### System Requirements

PC version: 386 or higher processor, 4MB+ of RAM, 3MB+ hard disk space, VGA display, and Windows 3.1 or NT

Macintosh version: Apple Mac Plus and above including Quadras, 2MB+ RAM, 2MB+ hard disk space, System 6, 7 and A/UX compatible. Math co-processor support version included.

# HUGHES MICROPHONES

*George Pickworth delves into some very early electronic devices - how and why did they work?*



The Hughes microphone or loose-joint was the first device able to detect electrical pulses that were too feeble or of too short duration to be detected directly by a galvanometer or a telephone earpiece. Until then these were the most sensitive device available to experimenters; the Hughes Microphone was infinitely more sensitive than the minute spark gap detector later employed by Hertz.

Its great sensitivity made it possible for the first time to detect minute pulses induced in an antenna by early spark transmitters and this played a leading role in the evolution of a practical "wireless" system.

The loose-joint type detector was the simplest device imaginable; it was essentially a pair of minute metal/metal or metal/carbon electrodes just making physical contact with each other. See Figure 1.

## Microphones

Hughes' used the term "microphones" for his loose-joints presumably because its peculiar characteristics were first noticed with early telephone microphones; indeed, the loose-joint was basically the same as an early telephone microphone.

So in respect to Hughes, the term "microphones" is used in this study; moreover, the term is easy to use and differentiates the detector as a whole from its component electrodes.

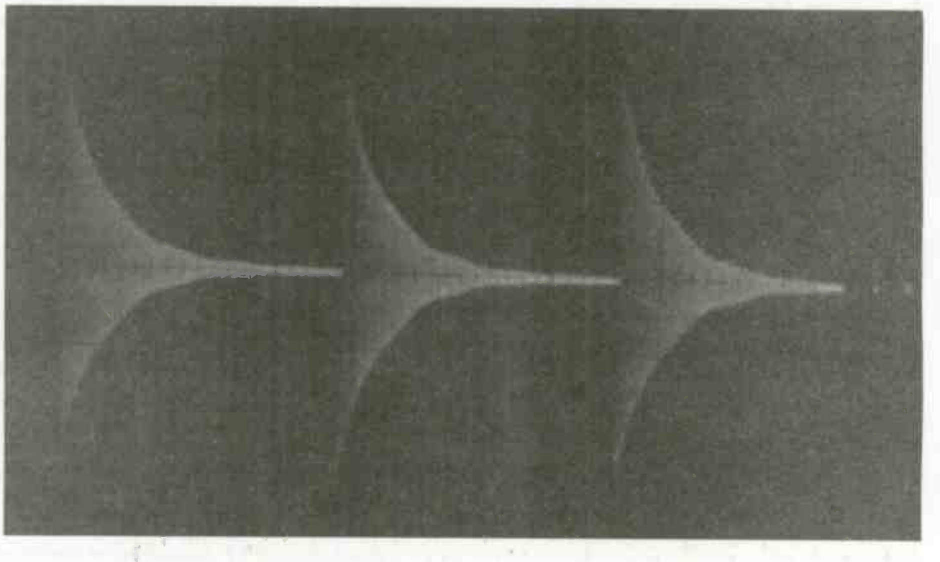
## Relay

Ordinarily, the joint presents almost infinite resistance, but when subjected to a voltage pulse with a very fast rise-time, referred to as a trigger pulse, its resistance instantly drops to a low level, generally less than 10Ω.

Current from a local DC source can then flow across the joint to deflect the needle of a galvanometer or cause a "click" to be heard in a telephone earpiece. However, I used an Ohmmeter for most of my experiments and to avoid damaging the joint's electrodes and of course the meter, the local DC was limited by a resistor to about 500μA.

In effect, the microphone behaves as an extremely sensitive, high-speed, latching-relay and, when used as a detector with early radio systems, the trigger pulse was the first half-wave of an exponentially-declining wave-train induced in the receiver antenna by a spark transmitter (see Photo A).

Paradoxically, the trigger pulse needs to have a peak potential in the order or 20V compared with about 0.5V for the local DC and at first sight this would indicate very poor sensitivity. However, sensitivity is not simply related to voltage but to the amount of energy required to trigger a microphone and this was exceedingly small; indeed, the static charge on a small screwdriver driver was more than



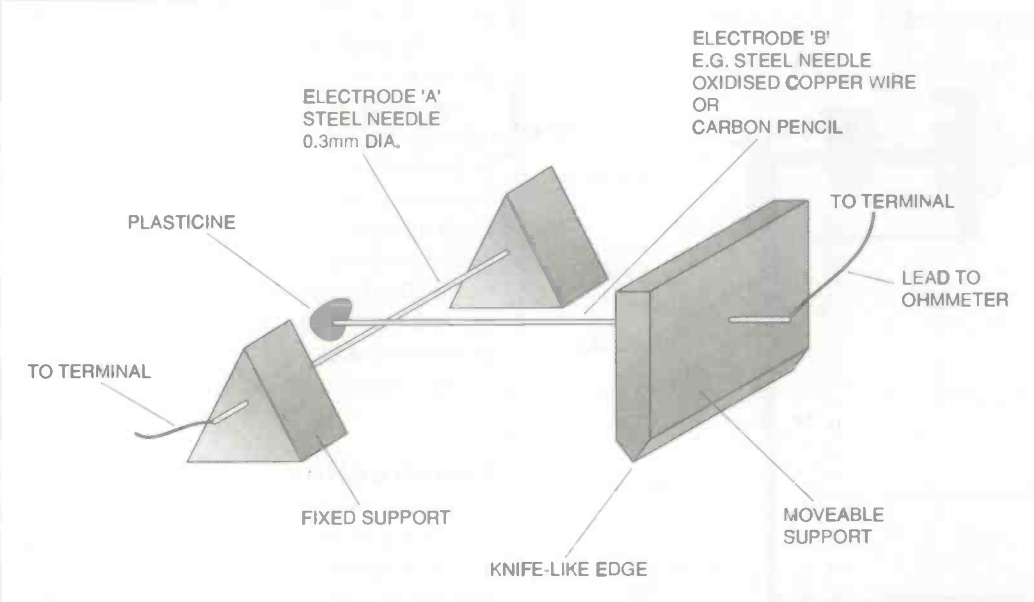



**Fig.1 Experimental loose-joint based on a design used by Branly**

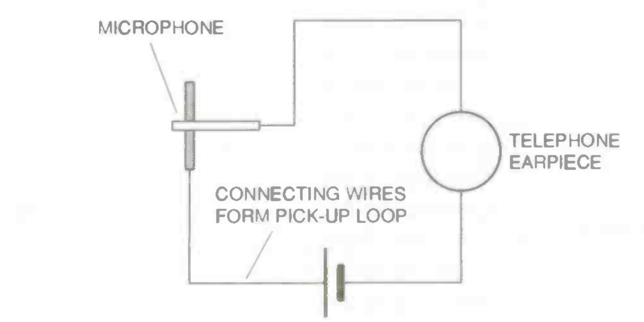



**Fig.2 Representation of a Hughes Hand-held receiver**

adequate. Moreover, its almost infinitely high resistance allows high potentials to develop across the electrodes.

The microphones also respond to pulses induced by natural phenomena. Indeed, I have employed my replicas to detect mysterious earth currents and distant lightning strikes.

## Restoring

As the microphone behaves like a latching relay, it needs to be restored to its high resistance state after each operation; this simply requires slight vibration. Some types of microphones were restored by ambient vibration and were known as self-restoring detectors. Other types were restored by mechanical arrangements (more about that later). However, fairly fast restoration was, of course, vital when the device was used in a signalling system.

## Evolution

The earliest reference I have found to the peculiar characteristics of a loose-joint is in a paper entitled "On Unilateral Conductivity" read by Arthur Schuster before the British Association in 1874. The effects were described by Schuster as a new discovery in electricity but he did not continue his research.

In 1878, Prof. D E Hughes successfully developed loose-joint as a detector for his "aerial-wave" wireless telegraph system, which according to some authorities was an Hertzian wave system before Hertz. However, I am rather sceptical if it was an Hertzian wave system but this in no way detracts from Hughes' pioneering work with detectors. Indeed, as far as the microphone was concerned, it was immaterial whether energy was induced in the receiver circuitry by Hertzian waves or by em induction.

Hughes was a Professor of Music and not a member of the scientific fraternity, so he was probably unaware of Schuster's work The professor's perception was that the loose-joint responded directly to aerial waves radiated by his transmitter.

However, the scientific establishment led by Professor Stokes rejected the concept of "aerial" waves and dismissed Hughes' system as being based on the "well know principles of induction". Disenchanted, Hughes abandoned his research.

## Sir William Crookes

Sir William Crookes had observed Hughes' demonstration when his hand-held receiver responded to pulses emitted by his transmitter over a distance of several hundred metres along Great Portland Street, London, where he conducted the "long range" experiments. Hughes' receiver was simply a microphone, a small cell and a telephone earpiece connected in series (incidentally, this seems to be the first record of a hand-held radio receiver). See Figure 2.

After Hertz had actually demonstrated the existence of em waves, Crookes reviewed Hughes' aerial-wave system, which he then believed to have been an Hertzian-wave system before Hertz, but as I have said, I remain sceptical.

Crookes wrote to technical writer J J Fahie to ask if he could persuade Hughes to publish his research. Hughes responded with a series of letters to Fahie and these provide the background material for this study. Indeed, had it not been for Crookes, the pioneering work of Hughes

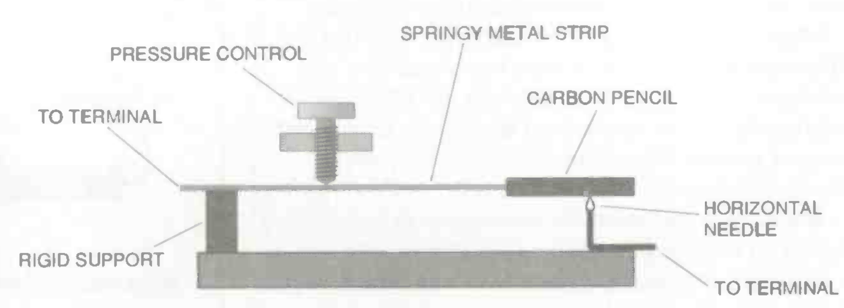



**Fig 3. Reproduction of Prof Hughes' carbon/steel detector**

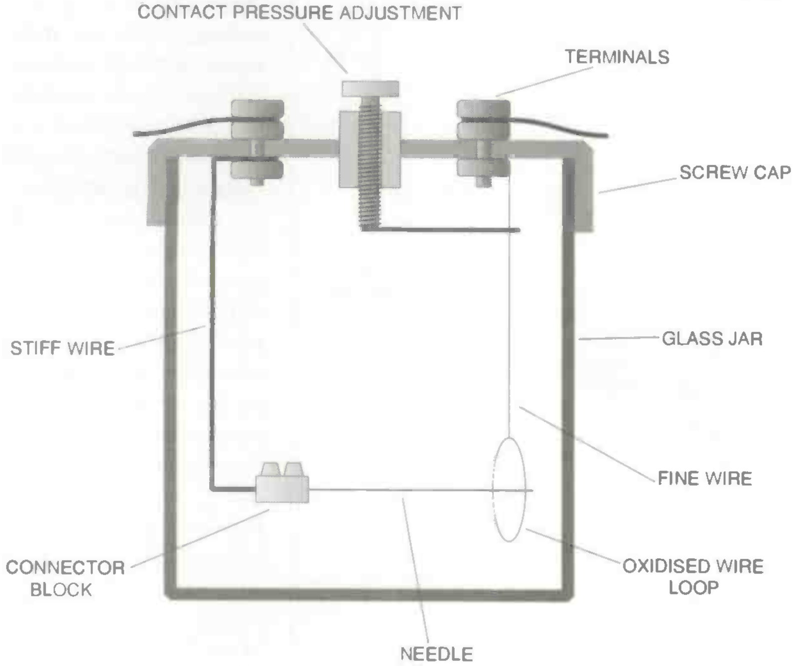



Fig.4 Reproduction of Prof Hughes' oxydised-wire-loop detector

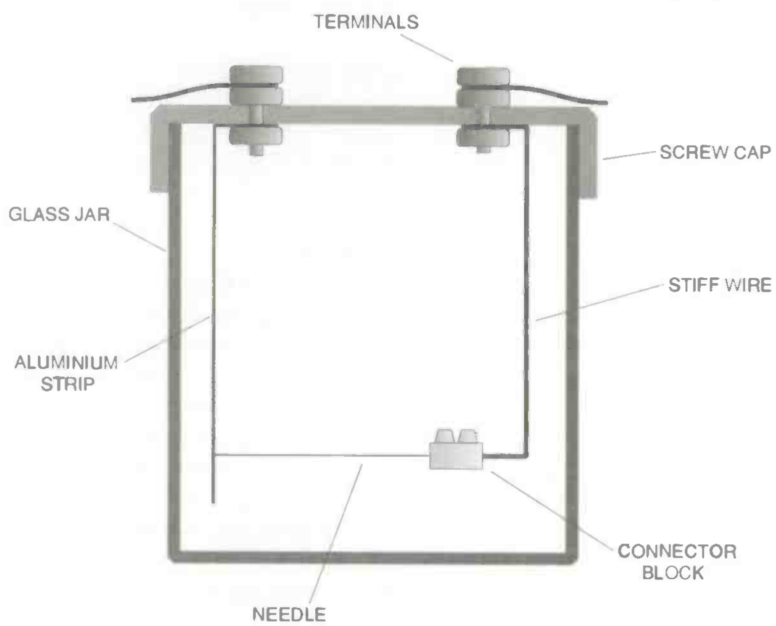



Fig.5 Reproduction of Lodges steel point/aluminium detector

would almost certainly have been consigned to oblivion.

Unfortunately, space only allows a brief mention of Hughes' senders; indeed little seem to be known about them, so this study concentrates on his detectors.

Hughes' primary objective seems to have been to detect aerial-waves rather than investigate the behaviour of his detectors; this was left to Prof. E Branly, who in 1891 published the results of his study in a paper entitled "Variations of Conductivity under Electrical Influence".

Branly too, perceived the loose-joint as responding directly to electrical influence. (See Part 2) Indeed, during my reproduction of Branly's experiments, it did at first sight seem as if my replica microphone responded directly to em waves. However, my experiments demonstrated that microphones were triggered by current induced in the circuitry.

Radiation of em waves by my reproduction of Hughes' sender was found to be minimal and, for this reason, I am not convinced that his system was a true em wave system though obviously some em waves were radiated. Hughes connected his transmitter to gas and water mains and I am inclined to believe that energy was propagated along metal pipes buried under Great Portland Street.

## Construction

As already mentioned, the microphone's electrodes were arranged so as to be in actual physical contact, but for now let us assume that contact pressure was so low that the oxide film present on the metal electrodes, which can be considered as a dielectric, was not ruptured. As there was no actual metallic contact, the joint presented almost infinite resistance.

Nonetheless, my experiments showed contact pressure to be critical and that contact area must be almost microscopic. Optimum contact pressure was experimentally found to be between 0.3 and 0.5g with the device shown in Figure 1.

My experiments also showed the oxide film to have a dielectric strength of about 10V. So, when a pulse with a peak potential greater than 10V was applied across the electrodes, the dielectric was presumably punctured and metal/metal or metal/carbon contact occurred.

## Vibration

With my replicas, vibration caused by walking across my study caused immediate restoration of the replica microphone; indeed, this extreme sensitivity to vibration made the experiments difficult.

Hughes claimed that his microphones were instantly restored by ambient vibration but I found ambient restoration too unpredictable for my experiments so I isolated the microphone on rubber sponge and adopted manual-restoration by gently tapping the case with a pencil.

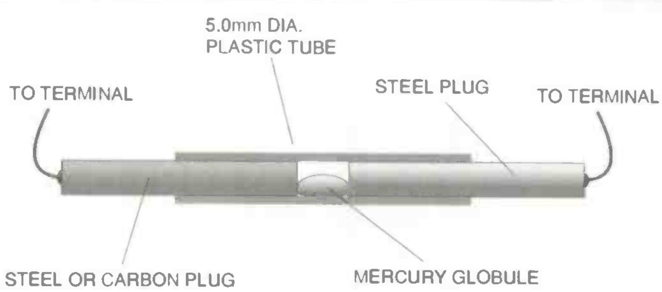



Fig.6 Reproduction of Italian Navy detector

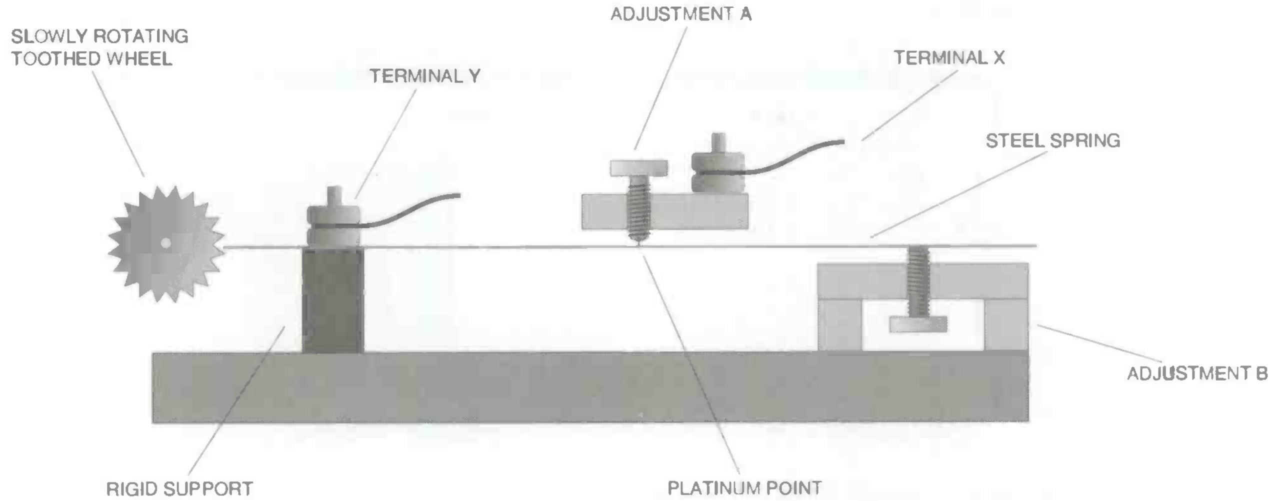



Fig.8 Lodges mechanically restored loose contact detector

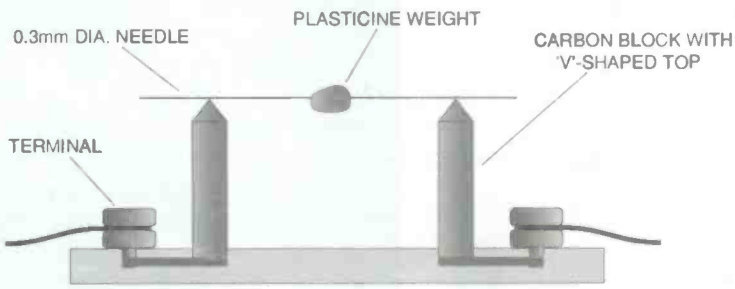



Fig.7 The Massie oscillophone detector

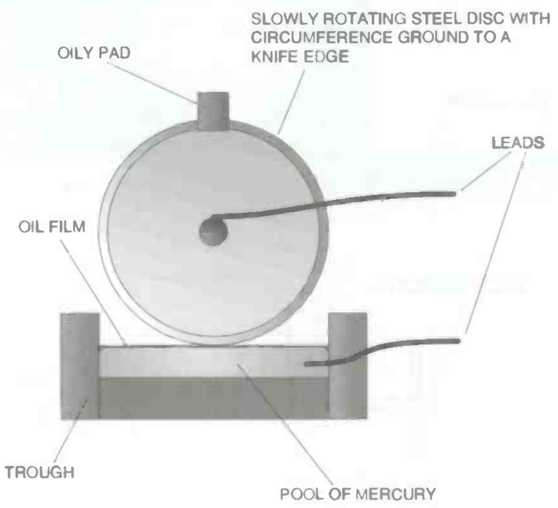



Fig.9 Simplified representation of the Logde-Muirhead detector

## Sensitivity

As already mentioned, my experiments showed that pulses with a peak potential of more than 20V were necessary for reliable triggering. Nonetheless, my very low power Hertz-type transmitter (Figure 11) was able to trigger my replica of Hughes' hand-held receiver at a distance of 25m. See Graph A.

All the replicas were readily triggered by lightning discharges up to 10km away but range was dramatically increased by increasing the length of connecting wires to form a large loop-type antenna.

Like Branly, I also found that sensitivity of a new microphone increased to a maximum after being subjected to a number of trigger pulses and, thereafter, sensitivity remained at maximum level. Presumably, some reaction occurred on the surface of the electrodes during the first few operations.

Remarkably, sensitivity was significantly increased by triggering the microphones with a strong, locally generated pulse and restoring immediately before the distant transmitter radiated a wave-train.

## Signalling

At the time of Hughes' research, much land-line telegraphy was still by observing the deflection of a galvanometer needle, or by listening to "clicks" produced by a sounding board; the microphone detector was therefore well adapted to a "wireless" system using this form of signalling. (See Photo B)

Notwithstanding claims made by users of self-restoring microphones, the pioneers found that for signalling, some form of automatic restoration was highly desirable. One of the first mechanically restored microphones was made by Lodge but this was a failure. (See Figure 8)

However, the Lodge-Muirhead detector (Figure 9) was the most successful of all relay type detectors and was reported to respond to individual trigger pulses with a repetition rate greater than 50kHz per second (Photo B) but, being a relay device, it could not produce a musical note. It was more generally used with a paper-tape type Morse-register.

## Behaving as a rectifier

It was, however, claimed that some later self-restoring microphones, particularly the Massie oscillophone (Figure 7) and the Italian Navy Detector (Figure 6) restored themselves so quickly that they responded to individual trigger pulses with a repetition rate in the order of several hundred kHz and were therefore used as a detector in

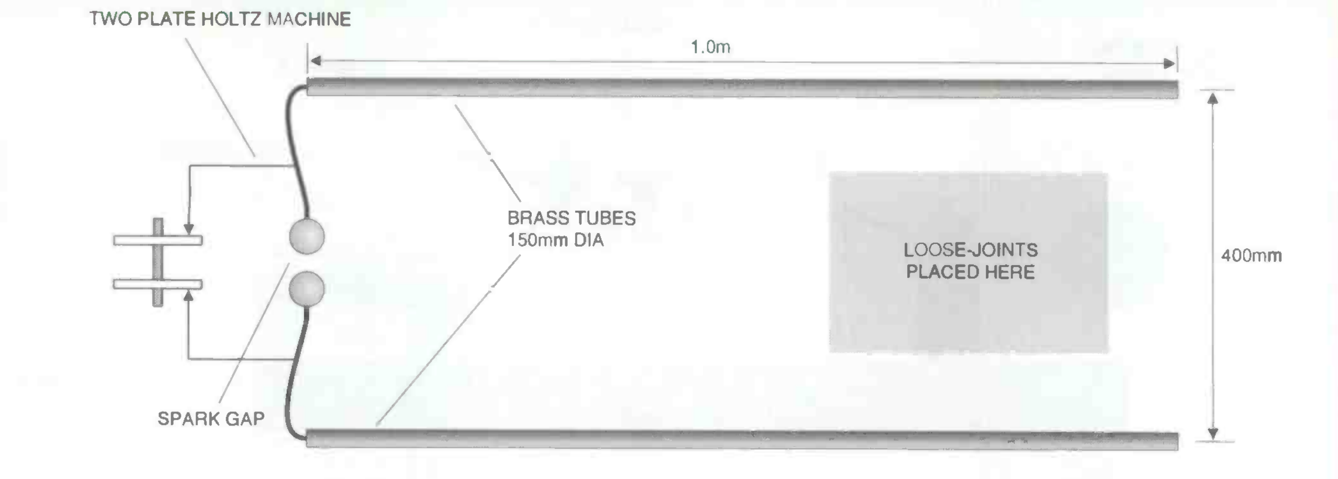



Fig.10 Simplified representation of Branly's "Influence Generator"

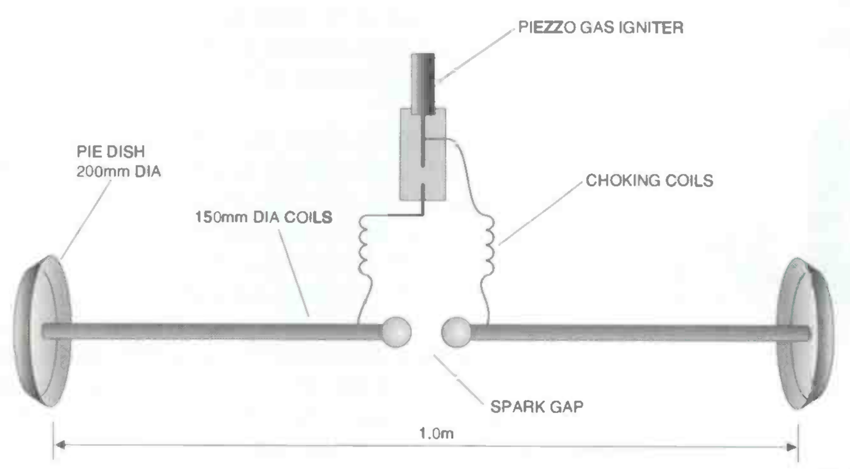



Fig.11 Representation of the Hertz-Type transmitter employing the Piezo gas igniter

presumably, the devices must also have been capable of operating as rectifier type detectors.

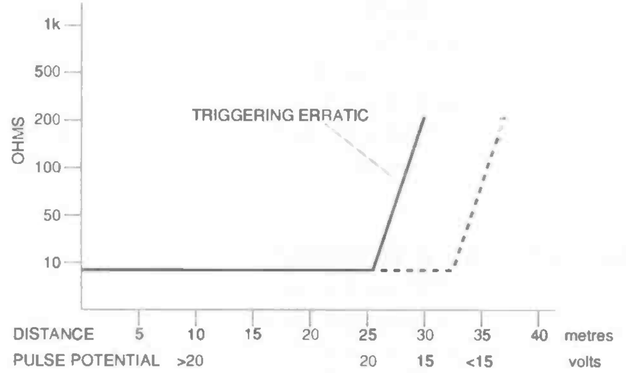
Indeed, my research showed that under certain conditions the Italian Navy Detector could be made to behave as arectifier similarly to Fessenden's Liquid Detector; this dissipated positive-going half cycles but blocked negative-going half cycles which were then diverted through the telephone earpiece. My experiments seem to be the first to actually demonstrate this rectifier effect.

Unfortunately, so far I have been unable to made the Massie Oscillophone respond to radio frequencies. Obviously I am missing something here!

**In part 2 we look at microphone type detectors in more detail.**

practical wireless systems.

Indeed, both the Massie Oscillophone and the Italian Navy Detector were used in practical "wireless" systems shortly after the turn of the century, but mechanical restoration would have been impossible at radio frequencies. So,




Graph A Range with receiver employing steel/aluminium strip microphone Fig5 and Piezo excited transmitter Fig.11

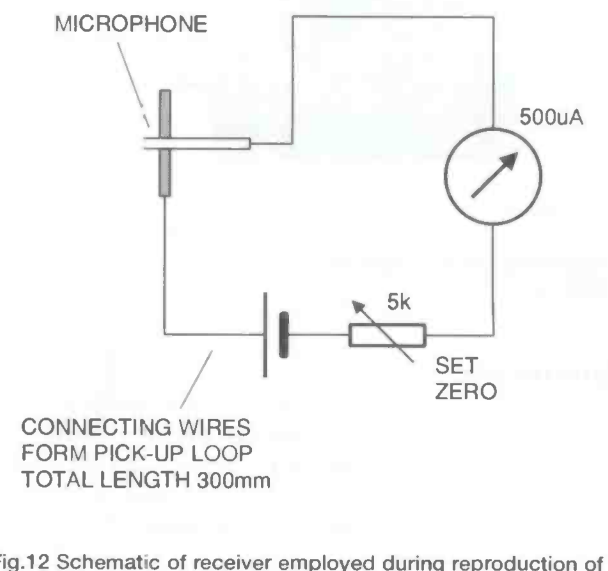



Fig.12 Schematic of receiver employed during reproduction of Branly's experiments and Far-field experiments

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NEXUS

# Practically SPEAKING

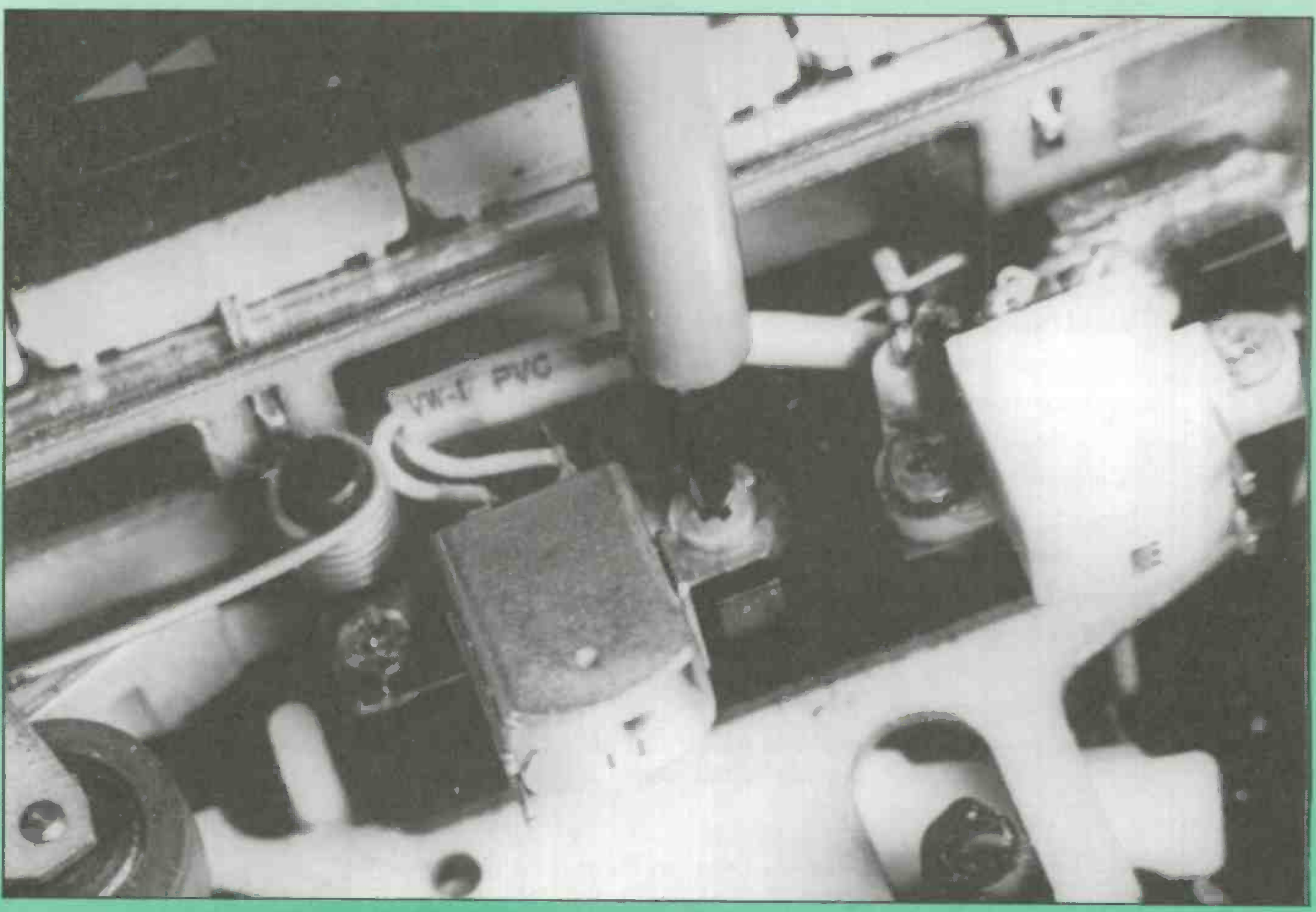
## CASSETTE RECORDERS

## BY TERRY BALBIRNIE PART 2

Last month we discussed methods of cleaning a cassette player's tape transport mechanism. If this does not cure problems of poor high-frequency response (often described as "muffled" sound) it may be that the record/playback head is misaligned. There may be further problems of permanent head magnetisation or possibly the head itself could be worn out. Fortunately, all these problems may be corrected cheaply and easily. If the head is worn, you will need to work very carefully and, depending on the size of the machine, in a confined space. Head replacement will be described next month.

### Special cassette

Record/playback head demagnetisation should be carried out regularly as a matter of routine. Over a period of time, the material it is made of tends to become permanently magnetised. This, again, will result in poor-quality sound.



Demagnetisation is easily carried out using a special cassette which is inserted in the machine like an ordinary one. The machine is then operated according to the manufacturer's instructions. There are two types of demagnetising cassette - one contains a rotating magnet, the other is more sophisticated and houses an electronic oscillator circuit. However, both types do the same job. Do not confuse a demagnetising cassette with a cleaning cassette. However, combination cassettes can be bought which perform both functions (Maplin catalogue P88).

## Adjusting the azimuth

If these measures do not improve the sound quality, suspect misalignment of the record/playback head. This is referred to as incorrect "azimuth". The magnetic information on the tape is "read" as it passes a very narrow gap in the head. This gap must always be maintained at right angles to the direction of movement of the tape. Over a period of time, the setting tends to fall out of adjustment. A maintenance engineer will tell you that special equipment is needed to re-set the azimuth exactly and this is probably true. However, the initial setting is often so bad that even a reasonable re-adjustment will give a dramatic improvement in sound quality. If you are lucky, there will be a small hole drilled in the case at the position of the head. Through this hole, a small screwdriver (such as a watchmakers' screwdriver) may be used to adjust the azimuth. Often, the cassette door has to be removed or moved out of the way to expose this hole. If you are unlucky, some dismantling will be needed to expose the head.

The head is usually held in position with two screws. One bears down on a small fork on the body and there will be a small spring beneath this to hold it in position. It is this latter screw which adjusts the alignment. It is very important to understand that only minute adjustments to the screw are required. You may find that the position of the screw is sealed against movement using a little coloured varnish. This will not interfere with the adjustment process. It could be re-sealed using a little nail varnish if this is thought necessary.

## Best sound

Adjustment may be made while playing a commercially-recorded tape with plenty of high frequency sounds (very high-pitched notes) in it. Listen carefully and very slowly adjust the screw one way and then the other. You will hear the sound improve and then deteriorate again. Do this a few times so that you know what you are listening for and to get a feel for the process. Make small adjustments until the best sound is obtained.

Setting may be carried out more quickly by using a cassette specially made for the purpose. These tapes are often made with a variety of diagnostic sounds but the most important one here is a steady tone of a very high pitch (about 8kHz). It is played and the azimuth adjusted for optimum sound quality. These tapes are available from Hart Electronic Kits Ltd, at £9.99. Tel: 01691 652894

If problems persist, it could be that the record/playback head is worn out. Worn out heads sometimes show themselves by periods of good and bad sound at unpredictable intervals. Sometimes the sound on one channel sounds good while that on the other is poor. Fortunately, replacement heads are easily obtained and this will be discussed further next month.

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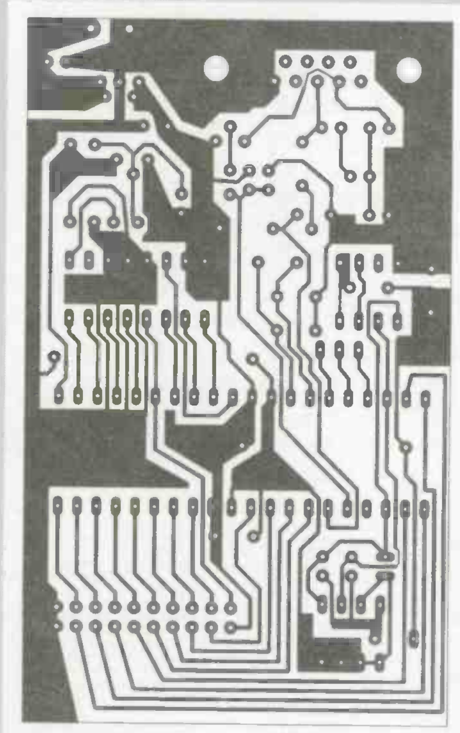

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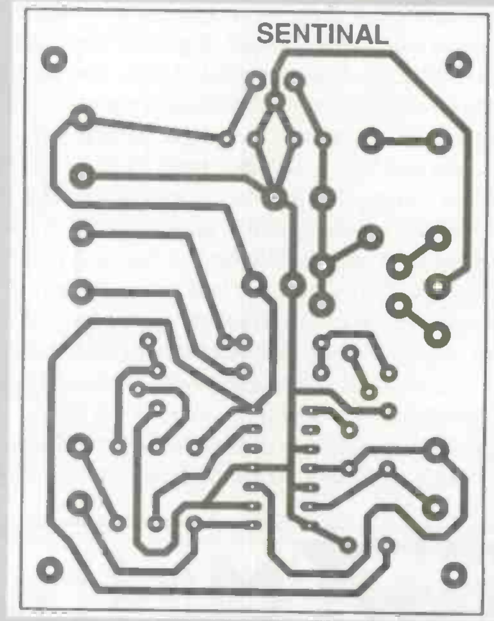


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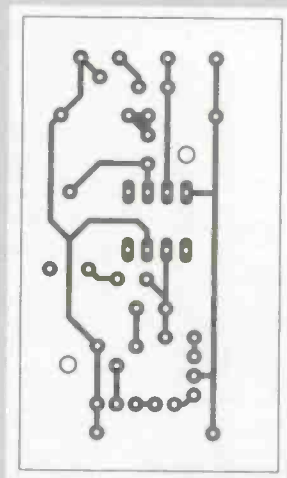

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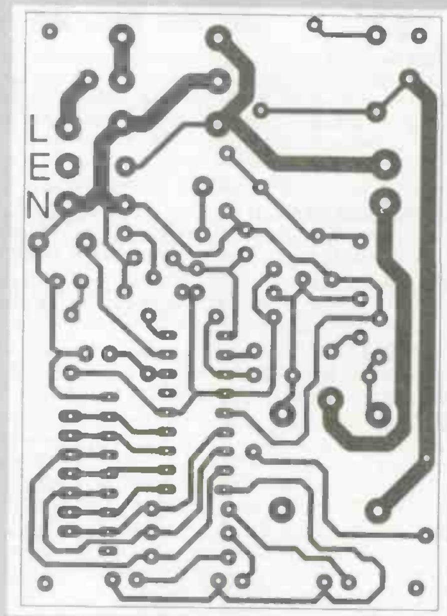


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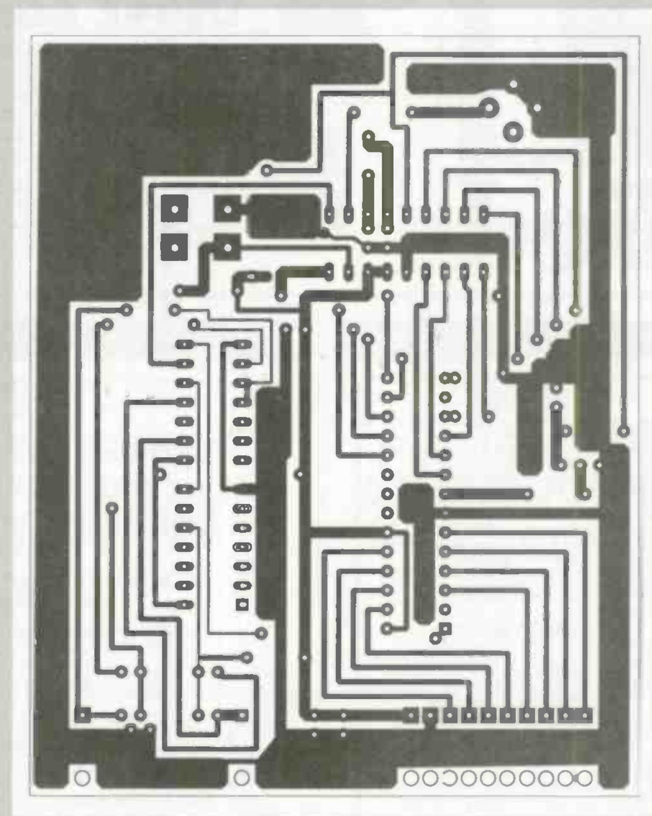

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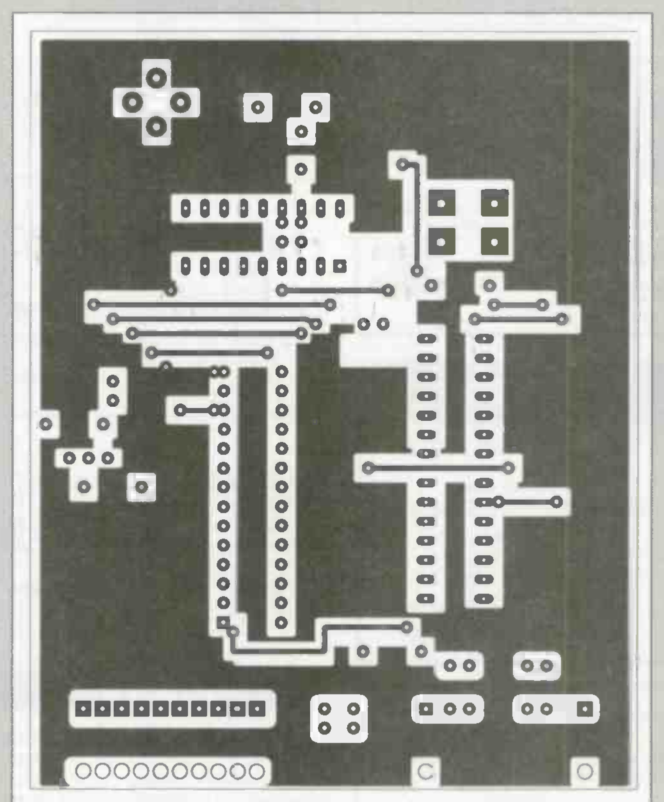

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# Around the Corner

***Nick Hampshire takes a look at the technology of tomorrow***

Computer networks are very much the technology of today. Indeed, if we are to go by the number of times they are mentioned in the newspapers and on TV, it seems as if everyone is talking about the Internet and the World Wide Web. These systems are revolutionary and are already starting to have a major impact on the way we work, on business, and in our leisure hours.

Companies worth billions have sprung up overnight and, in a recent poll, nearly half the population of the UK wanted a multimedia, Internet-compatible PC as their number one choice of Christmas present.

But for one American company, network pioneers Novell, this is not enough. They have already developed a technology which will not only allow users to send e-mail and access the Net but will also allow them to control household devices, all without the need for a conventional PC.

The technology unveiled by Novell is a tiny software 'agent', known as Novell Embedded Systems Technology, or NEST. It can be installed in any processor, whether it is in a conventional computer, the controller in your central heating system, a burglar alarm, even your washing machine, or your car.

This tiny piece of software can be incorporated by the manufacturers into the processor chip of any product that employs an embedded microcontroller. It will then allow that product to be connected to the Internet via a phone line or even the power cable. With NEST, it would be feasible to phone your home, turn on the washing machine, or even phone up your car and check whether it has enough petrol for the journey you intend taking.

In some ways, this may all sound rather far-fetched, but a lot of companies are taking it very seriously. In fact, over 300 different electronic devices from some of the biggest US, European and Japanese companies will incorporate NEST and be commercially available by the end of the year.

However, the odds are that one of the first implementations of this technology will be in the UK. It is understood that at least one of the electricity companies is working with Novell to develop a system for broadcasting commands over the power cables.

The power company's primary interest in NEST is that it will allow them to encourage users to use electricity at times when the demand is lowest, and it will also enable them to develop remotely readable electricity meters, thus eliminating the quarterly call of the meter man.

Novell are not the only company to be looking at ways of expanding the market for networks without having to have lots of PCs with their very expensive Intel processors and Microsoft software. The British computer company Acorn and its subsidiaries, chip maker ARM and interactive TV company Online Media, are understood to be working with the database software giant Oracle to develop a very low-cost Internet box.

According to reports, this box will cost just a couple of hundred pounds and come with a full keyboard and modem. It will use a standard domestic TV as the monitor and be connected directly to any standard domestic phone line. The user will be able to send and receive e-mail, download software for applications such as wordprocessing, access the Internet and World Wide Web, play interactive games and, in the near future, download video and music.

This is an interesting concept that should expand the potential market for access to the Internet by encouraging people to become involved who would not have otherwise bought a full featured PC. It will also be of interest to the cable and telephone companies since it offers yet another way of selling telecommunications services.

No one can really know how successful any of these products will be, particularly in the face of very rapid technology development. But, one thing is certain - the future will be filled with increasingly complex and ever larger networks of processors.

Networks are here to stay!

## Next Month...

In the March 1996 issue of Electronics Today International, Robin Abbott takes a close look at using the I²C bus and, from Terry Balbimie, there is a miniature sound recorder which can store and replay ten seconds of speech, which could form an interesting addition to many projects

Digital thermometers are the subject of a piece by Graham Reith, Bart Trepak examines ways of controlling power devices with the PIC microcontroller, and Tony Sercombe introduces a project to build a portable audio mixer.

The feature articles will include a look at advances in solar energy power systems by Dave Clarkeson and George Pickworth will conclude his delving into the technology behind early electronics.


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