ETI

ELECTRONICS TODAY INTERNATIONAL

TOMORROW'S TECHNOLOGY TODAY

THE MAGAZINE FOR PRACTICAL ELECTRONICS & ELECTRICAL COMPUTING

SHAPE MEMORY ALLOYS

Technology behind the robot muscles of the future

Designing and building switch regulator PSUs

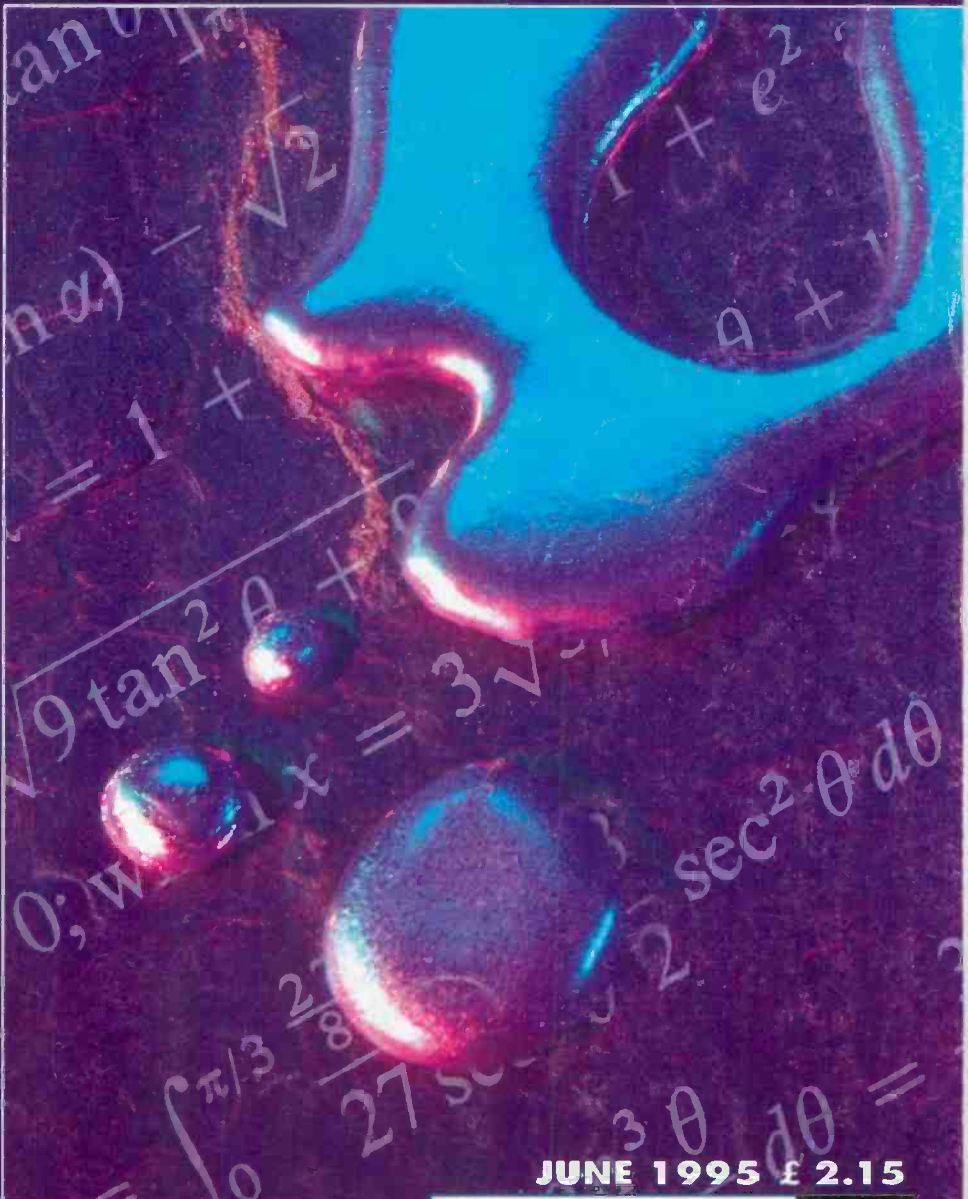
4 channel touch switch for the ETI 80188 SBC

Adding circuitry to a PC's parallel port

Build a PC controlled PIC programmer

PLUS

- *Exploring Saturn with Cassini*
- *Stamp based analog input*
- *Build a bicycle loop alarm*
- *The laser tag controller*



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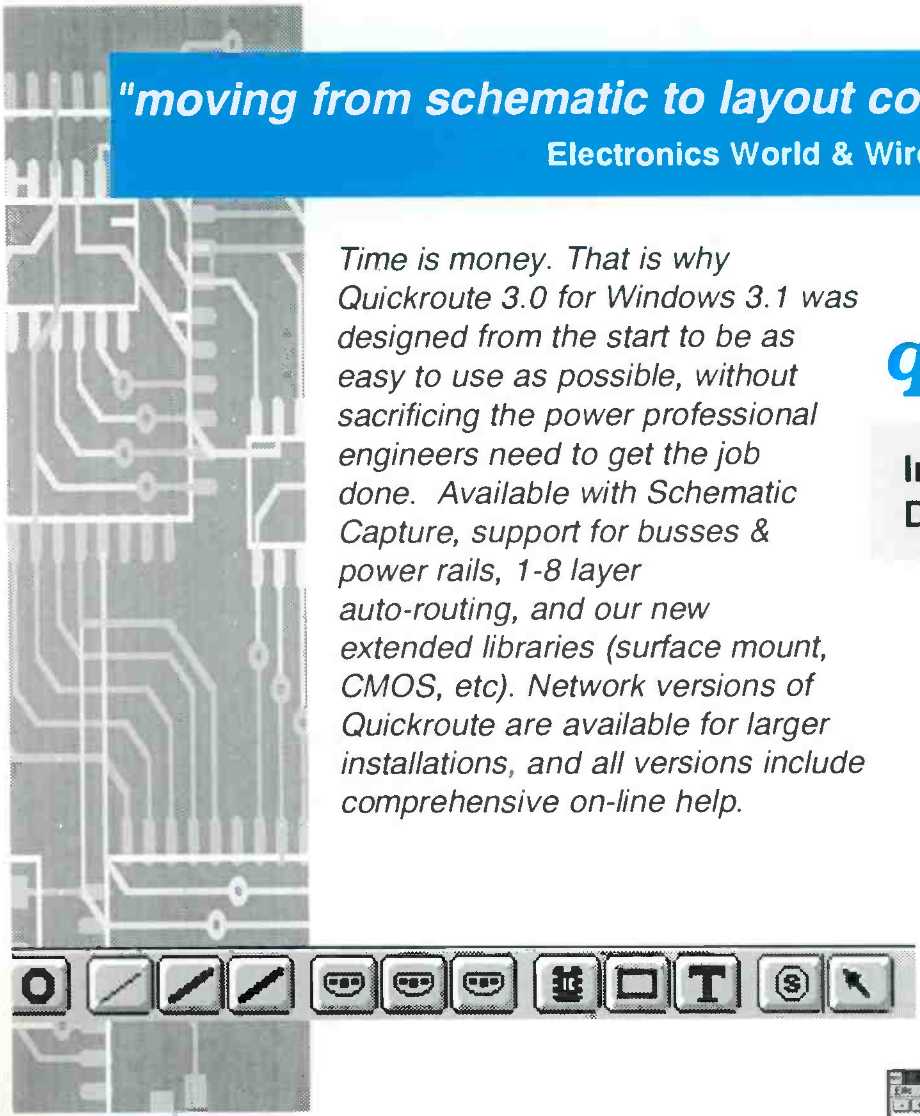


"moving from schematic to layout could not be easier"

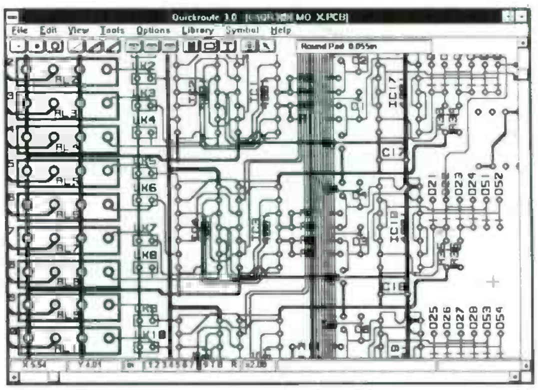
Electronics World & Wireless World Jan 1995

NEW Extended Library Pack Just £39.00!

Time is money. That is why Quickroute 3.0 for Windows 3.1 was designed from the start to be as easy to use as possible, without sacrificing the power professional engineers need to get the job done. Available with Schematic Capture, support for busses & power rails, 1-8 layer auto-routing, and our new extended libraries (surface mount, CMOS, etc). Network versions of Quickroute are available for larger installations, and all versions include comprehensive on-line help.

quickroute 3.0

Integrated Schematic and PCB Design for Windows 3.1



DESIGNER £99

*Schematic & PCB Drawing *1/2 layer auto-router *Supports Windows printers/plotters *Full set of libraries *Clipboard support *Designer Special (manual on disk) also available.

PRO £199

*Schematic & PCB Design *Schematic Capture *Integrated Rats-Nest Generation *1-8 layer Auto-router (faster than Designer) *Net-List Export *Supports Windows printers/plotters *CAD-CAM outputs.

PRO+ £299

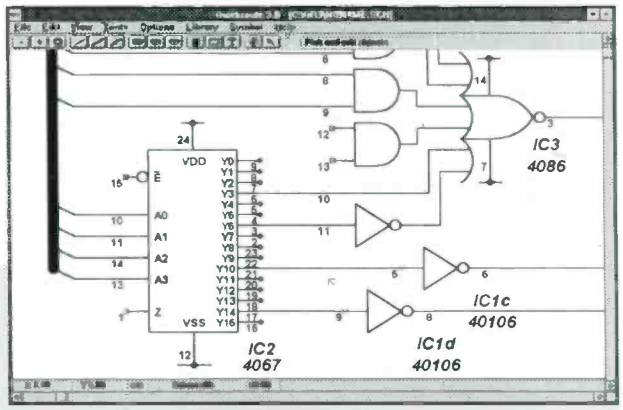
As the PRO but also includes *Advanced Schematic Capture (Busses,Power rails,etc) *Larger Schematic & PCB Designs *Gerber file IMPORT for File Exchange *Extended libraries including SMT, CMOS, etc.

**Prices exclude P+P and V.A.T. VISA/MasterCard Accepted *Network versions available.*

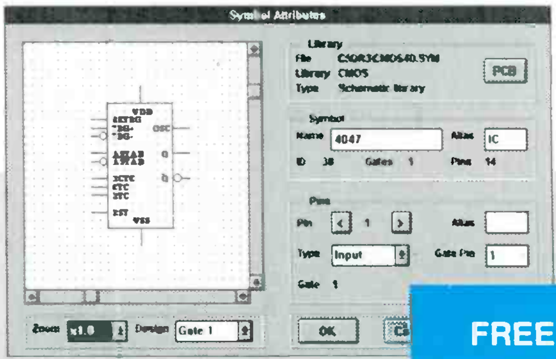
POWERware, 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD, U.K.

Tel/Fax 0161 449 7101

email info@powrware.demon.co.uk



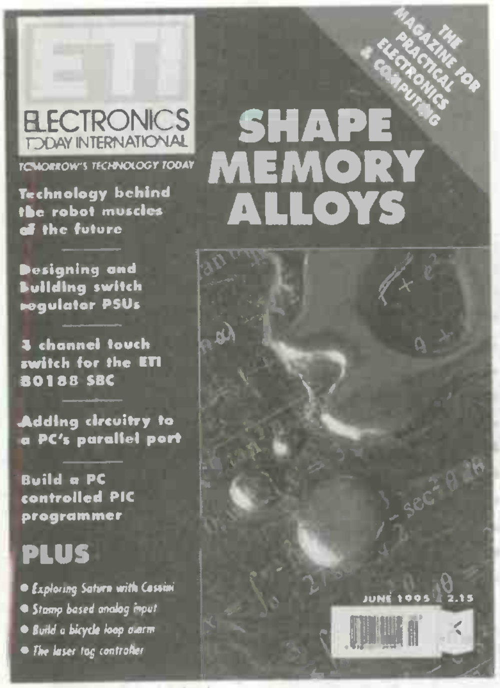
Busses and Power rails handled easily using Global Nets on PRO+



Design your own Schematic and PCB symbols

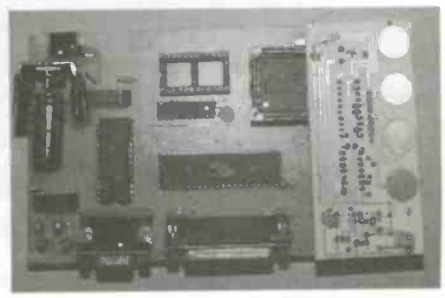
FREE Demo Pack Available.

Contents



Volume 24 No.6

& Features Projects



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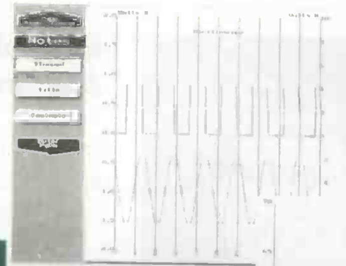
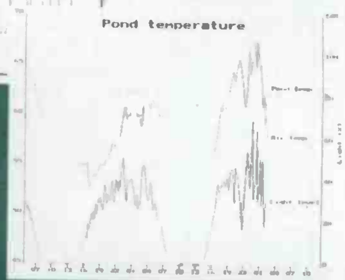
Pico Releases PC Potential

Pico's Virtual Instrumentation enable you to use your computer as a variety of useful test and measurement instruments or as an advanced data logger.



PicoScope
'Virtual instrument' software.



Hardware and software are supplied together as a package - no more worries about incompatibility or complex set-up procedures. Unlike traditional 'plug in' data acquisition cards, they simply plug into the PC's parallel or serial port, making them ideal for use with portable PC's.

Call for your Guide on 'Virtual Instrumentation'.

PicoLog
Advanced data logging software.

New from Pico TC-08 Thermocouple to PC Converter

8 channel Thermocouple Amplifier

- **Connects to your serial port - no power supply required.**
- **Supplied with PicoLog datalogging software** for advanced temperature processing, min/max detection and alarm.
- **8 Thermocouple inputs (B,E,J,K,R,S and T types)**
- **Resolution and accuracy dependant on thermocouple type.** For type K the resolution is better than 0.1°C and accurate to ±0.1°C over -270°C to +1300°C.

TC-08 **£ 199**
complete with PicoLog, software drivers and connecting cable.
A range of thermocouple probes is available.

SLA-16 Logic Analyser

Pocket sized 16 channel Logic Analyser

- Connects to PC serial port.
- Up to 50MHz sampling.
- Internal and external clock modes.
- 8K Trace Buffer.

SLA-16
with software, power supply and cables **£ 219**

ADC-100 Virtual Instrument

Dual Channel 12 bit resolution

- Digital Storage Scope
- Spectrum Analyser
- Frequency Meter
- Chart Recorder
- Data Logger
- Voltmeter

The ADC-100 offers both a high sampling rate (100kHz) and a high resolution. It is ideal as a general purpose test instrument either in the lab or in the field. Flexible input ranges (±200mV to ±20V) allows the unit to connect directly to a wide variety of signals.

ADC-100 with PicoScope **£199**
with PicoScope & PicoLog **£209**

ADC-10

1 Channel 8 bit

- Lowest cost in the Pico range
- Up to 22kHz sampling
- 0 -5V input range

The ADC-10 gives your computer a single channel of analog input. Simply plug into the parallel port.

ADC-10 **with PicoScope £49**
PicoScope & PicoLog £59

Carriage UK **free**, Overseas £9 Oscilloscope Probes (x1, x10) £10

PICO TECHNOLOGY

VISA

Pico Technology Ltd. Broadway House, 149-151 St Neots Rd, Hardwick, Cambridge. CB3 7QJ
Tel: 01954 - 211716 Fax: 01954 - 211880

Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT

MONO VGA MONITORS
Some with slight screen burns but OK at £19.95 Ref EF40 and some without burns at £29.95 Ref EF39.

A4 DTP MONITORS Brand new, 300 DPI. Complete with diagram but no interface details.(so you will have to work it out!) Bargain at just £12.99 each!!!!

OPD MONITORS 9" mono monitor, fully cased complete with rasterboard, switched mode psu etc. CGA/TTL input (15way D), IEC mains. £15.99 ref DEC23. Price including kit to convert to composite monitor for CCTV use etc is £21.99 ref DEC24

PC CONTROLLED 4 CHANNEL TIMER Control (on/off times etc) up to 4 items (8A 240v each) with this kit. Complete with Software, relays, PCB etc. £25.99 Ref 95/26

COMPLETE PC 300 WATT UPS SYSTEM Top of the range UPS system providing protection for your computer system and valuable software against mains power fluctuations and cuts.New and boxed, UK made Provides up to 5 mins running time in the event of complete power failure to allow you to run your system down correctly. SALE PRICE just £119.00.

RACAL MODEM BONANZA! 1 Racal MPS1223 1200/75 modem, telephone lead, mains lead, manual and comms software, the cheapest way onto the net! all this for just £13 ref DEC13.

HOW LOW ARE YOUR FLOPPIES? 3.5" (1.44) unbranded. We have sold 100,000+ so ok! Pack of 50 £24.99 ref DEC16

BRITISH TELECOMM MULTIMETERS SA9083 These are 'returns' so they may have faults but look ok. Complete with new leads and leather case. Price for two meters & 1 case is £10 ref DEC89.

5mw LASER POINTER. Supplied in kit form, complete with power adjuster, 1-5mw, and beam divergence adjuster. Runs on 2 AAA batteries. Produces thin red beam ideal for levels, gun sights, experiments etc. Cheapest in the UK! just £39.95 ref DEC49

SHOP WOBBLERS! Small assemblies designed to take D size batteries and 'wobble' cardboard model signs about in shop windows! £3.99 Ref SEP4P2.

RADIO PAGERS Brand new, UK made pocket pagers clearance price is just £4.99 each 100x40x15mm packed with bits! Ref SEP5.

BULL TENS UNIT Fully built and tested TENS (Transcutaneous Electrical Nerve Stimulation) unit, complete with electrodes and full instructions. TENS is used for the relief of pain etc in up to 70% of sufferers. Drug free pain relief, safe and easy to use, can be used in conjunction with analgesics etc. £49 Ref TEN/1

COMPUTER RS232 TERMINALS. (LIBERTY) Excellent quality modem units,(like wyse 50,s) 2xRS232, 20 function keys, 50 thro to 38,400 baud, menu driven port, screen, cursor, and keyboard setup menus (18 menu's). £29 REF NOV4.

OMRON TEMPERATURE CONTROLLERS (E5C2). Brand new controllers, adjustable from -50 deg C to +1,200 deg C using graduated dial, 2% accuracy, thermocouple input, long life relay output ,3A 240v o/p contacts. Perfect for exactly controlling a temperature, Normal trade £50+, ours £15. Ref E5C2.

ELECTRIC MOTOR BONANZA! 110x60mm. Brand new precision, cap start (or spin to start), virtually silent and features a moving outer case that acts as a fly wheel. Because of their unusual design we think that 2 of these in a tube with some homemade fan blades could form the basis for a wind tunnel etc. Clearance price is just £4.99 FOR A PAIR! (note- these will have to be wired in series for 240v operation Ref NOV1.

MOTOR NO 2 BARGAIN 110x90mm. Similar to the above motor but more suitable for mounting vertically (ie turntable etc). Again you will have to wire 2 in series for 240v use. Bargain price is just £4.99 FOR A PAIR!! Ref NOV3.

OMRON ELECTRONIC INTERVAL TIMERS.
Minature adjustable timers, 4 pole c/o output 3A 240v,

HY1230S,	12vDC	adjustable	from	0-30 secs.	£9.99
HY1210M,	12vDC	adjustable	from	0-10 mins.	£9.99
HY1260M,	12vDC	adjustable	from	0-60 mins.	£9.99
HY2460M,	24vAC	adjustable	from	0-60 mins.	£5.99
HY241S,	24vAC	adjustable	from	0-1 secs.	£5.99
HY2460S,	24vAC	adjustable	from	0-60 secs.	£5.99
HY243H,	24vAC	adjustable	from	0-3 hours.	£8.99
HY2401S,	240v	adjustable	from	0-1 secs.	£9.99
HY2405S,	240v	adjustable	from	0-5 secs.	£9.99
HY24060m,	240v	adjustable	from	0-60 mins.	£12.99

PC PAL VGA TO TV CONVERTER Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware. £49.95. Ideal for laptops or a cheap upgrade. We also can supply this in kit form for home assembly at £34.95 ref EF54.

DRINKING BIRD Remember these? hook onto wine glass (supplied) and they drink, standup,drink, standup ETC! £4 each Ref EF1

EMERGENCY LIGHTING UNIT Complete unit with 2 double bulb floodlights, built in charger and auto switch. Fully cased. 6v 8AH lead acid req'd. (secondhand) £4 ref MAG4P11.

GUIDED MISSILE WIRE. 4,200 metre reel of ultra thin 4 core insulated cable, 28lbs breaking strain, less than 1mm thick! Ideal alarms, intercoms, fishing, dolls house's etc. £14.99 ref MAG15P5

300v PANELMETER 70X60X50MM, AC, 90 degree scale. Good quality meter. £5.99 ref MAG 6P14. Ideal for monitoring mains etc.

ASTEC SWITCHED MODE PSU BM41012 Gives +5 @ 3.75A, +12@1.5A, -12@.4A. 230/110, cased, BM41012 £5.99 ref AUG6P3.

TORRODIAL TX 30-0-30 480VA. Perfect for Mosfet amplifiers etc. 120mm dia 55mm thick. £18.99 ref APR19.

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £9.99 ea ref AUG10P3.

FLOPPY DISCS DSDD Top quality 5.25" discs, these have been written to once and are unused. Pack of 20 is £4 ref AUG4P1.

ECLATRON FLASH TUBE As used in police car flashing lights etc, full spec supplied, 60-100 flashes a min. £9.99 ref APR10P5.

24v AC 96WATT Cased power supply. New. £13.99 ref APR14.

MILITARY SPEC GEIGER COUNTERS Unused anstraightfrom Her majesty's forces. £50 ref MAG 50P3.

STETHOSCOPE Fully functioning stethoscope, ideal for listening to hearts, pipes, motors etc. £6 ref MAR6P6.

OUTDOOR SOLAR PATH LIGHT Captures sunlight during the day and automatically switches on a built in lamp at dusk. Complete with sealed lead acid battery etc £19.99 ref MAR20P1.

ALARM VERSION Of above unit comes with built in alarm and pir to deter intruders. Good value at just £24.99 ref MAR25P4.

CARETAKER VOLUMETRIC Alarm, will cover the whole of the ground floor against forced entry. Includes mains power supply and integral battery backup. Powerful internal sounder, will take external bell if req'd. Retail £150+, ours? £49.99 ref MAR50P1.

TELEPHONE CABLE White 6 core 100m reel complete with a pack of 100 clips. Ideal 'phone extns etc. £7.99 ref MAR8P3.

MICRODRIVE STRIPPER Small cased tape drives ideal for stripping, lots of useful goodies including a smart case, and lots of components. £2 each ref JUN2P3.

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit just £5.99 REF: MAG6P8

SOLID STATE RELAYS Will switch 25A mains. Input 3.5-26v DC 57x43x21mm with terminal screws £3.99 REF MAG4P10

BUGGING TAPE RECORDER Small voice activated recorder, uses micro cassette complete with headphones. £28.99 ref MAR29P1.

ULTRAMINI BUG MIC 6mmx3.5mm made by AKG, .5-12v electret condenser. Cost £12 ea, Ours? just four for £9.99 REF MAG10P2.

RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. £79 each REF JUN79

ANSWER PHONES Returns with 2 faults, we give you the bits for 1 fault, you have to find the other yourself. BT Response 200's £18 ea REF MAG18P1. PSU £5 ref MAG5P12.

SWITCHED MODE PSU ex equip, 60w +5v @5A, -5v@.5A, +12v@2A,-12v@.5A 120/220v cased 245x88x55mm IEC input socket £6.99 REF MAG7P1

PLUG IN PSU 9V 200mA DC £2.99 each REF MAG3P9

PLUG IN ACORN PSU 19v AC 14w , £2.99 REF MAG3P10

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

ACORN ARCHIMEDES PSU +5v @ 4.4A. on/off sw uncased, selectable mains input, 145x100x45mm £7 REF MAG7P2

GEIGER COUNTER KIT Low cost professional twin tube, complete with PCB and components. Now only £19 REF AUG19.

9v DC POWER SUPPLY Standard plug in type 150ma 9v DC with lead and DC power plug, price for two is £2.99 ref AUG3P4.

AA NICAD PACK encapsulated pack of 8 AA nicad batteries (tagged) ex-equip, 55x32x32mm. £3 a pack. REF MAG3P11

13.8V 1.9A psu cased with leads. Just £9.99 REF MAG10P3

PPC MODEM CARDS. These are high spec plug in cards made for the Amstrad laptop computers. 2400 baud dial up unit complete with leads. Clearance price is £5 REF: MAG5P1

INFRA RED REMOTE CONTROLLERS Originally made for hi spec satellite equipment but perfect for all sorts of remote control projects. Our clearance price is just £2 REF: MAG2

200 WATT INVERTER Converts 10-15v DC into either 110v or 240v AC. Fully cased 115x36x156mm, complete with heavy duty power lead, cigar plug, AC outlet socket. Auto overload shutdown, auto short circuit shut down, auto input over voltage shutdown, auto input under voltage shut down (with audible alarm), auto temp control, unit shuts down if overheated and sounds audible alarm. Fused reversed polarity protected, output frequency within 2%, voltage within 10%. A extremely well built unit at an excellent price. Just £64.99 ref AUG65.

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17

MAINSCABLE Precut black 2 core 2 metre lengths ideal for repairs, projects etc. 50 metres for £1.99 ref AUG2P7.

COMPUTER COMMUNICATIONS PACK Kit contains 100m of 6 core cable, 100 cable clips, 2 line drivers with RS232 interfaces and all connectors etc. Ideal low cost method of communicating between PC's over a long distance. Complete kit £8.99.

MINI CYCLOPS PIR 52x62x40mm runs on PP3 battery complete with shrill sounder. Cheap protection at only £5.99 ref MAR6P4.

ELECTRIC MOTOR KIT Comprehensive educational kit includes all you need to build an electric motor. £9.99 ref MAR10P4.

VIEWDATA SYSTEMS made by Phillips, complete with internal 1200/75 modem, keyboard, psu etc RGB and composite outputs, menu driven, autodialler etc. £18 each Ref EF88.

BOOMERANG High tech, patented poly propylene, 34cm wing span. Get out and get some exercise for £4.99 ref EF83

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80

PEANUT TREE Complete kit to grow your own peanuts! full instructions supplied. £3 Ref EF45.

PLUG IN POWER SUPPLYS Plugs in to 13A socket with output lead, three types available, 9vdc 150mA £2 ref EF58, 9vdc 200mA £2.50 ref EF59, 6.5vdc 500mA £3 ref EF61.

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £15 REF: MAG15 12v psu is £5 extra REF: MAG5P2

***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15 REF: MAG15P1

LOW COST WALKIE TALKIES Pair of battery operated units with a range of about 200'. Ideal for garden use or as an educational toy. Price is £8 a pair REF: MAG 8P1 2 x PP3 req'd.

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range of up to 2km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £30.00 pr.REF: MAG30

COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £8.00 REF: MAG8P2.

LQ3500 PRINTER ASSEMBLIES Made by Amstrad they are entire mechanical printer assemblies including printhead, stepper motors etc etc In fact everything bar the case and electronics, a good stripper! £5 REF: MAG5P3 or 2 for £8 REF: MAG8P3

LED PACK of 100 standard red 5m leds £5 REF MAG5P4

UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc. Two types available 150w at £15 REF:MAG15P2 (23x23x23mm) and 200w at £20 REF: MAG20P3 (23x23x23mm)

GYROSCOPE About 3" high and an excellent educational toy for all ages! Price with instruction booklet £6 Ref EF15.

FUTURE PC POWER SUPPLIES These are 295x135x60mm, 4 drive connectors 1 mother board connector. 150watt, 12v fan, iec inlet and on/off switch. £12 Ref EF6.

VENUS FLYTRAP KIT Grow your own carnivorous plant with this simple kit £3 ref EF34.

PC POWER SUPPLIES (returns) These are 140x150x90mm. o/ ps are +12, 12,+5 and -5v. Built in 12v fan. These are returns so they may well need repairing! £3.50 each ref EF42.

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £15 REF: EF62 Transmits to any FM radio. (this is in kit form with full instructions.)

***FM BUG KIT** New design with PCB embedded coil for extra stability. Works to any FM radio. 9v battery req'd. £5 REF: MAG5P5

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

TALKING COIN BOX STRIPPER originally made to retail at £79 each, these units are designed to convert an ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? Price is just £3 REF: MAG3P1

TOP QUALITY SPEAKERS Made for HI FI televisions these are 10 watt 4R Jap made 4" round with large shielded magnets. Good quality. £2 each REF: MAG2P4 or 4 for £6 REF: MAG6P2

TWEETERS 2" diameter good quality tweeter 140R (ok with the above speaker) 2 for £2 REF: MAG2P5 or 4 for £3 REF: MAG3P4

AT KEYBOARDS Made by Apricot these quality keyboards need just a small mod to run on any AT, they work perfectly but you will have to put up with 1 or 2 foreign keycaps! Price £6 REF: MAG6P3

HEADPHONES Ex Virgin Atlantic. 8pairs for £2 REF: MAG2P8

DOS PACKS Microsoft version 3.3 or higher complete with all manuals or price just £5 REF: MAG5P8 Worth it just for the very comprehensive manual! 5.25" only.

GAS HOBS Brand new made by Optimus, basic three burner suitable for small flat etc bargain price just £29.95 ref EF73.

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £12.95 Ref EF82 extra pellets (500) £4.50 ref EF80.

CHRISTMAS TREE KIT Start growing it now! £3 ref EF53.

DOS PACK Microsoft version 5 Original software but no manuals hence only £5.99. 3.5" only.

PIR DETECTOR Made by famous UK alarm manufacturer these are hi spec, long range internal units. 12v operation. Slight marks on case and unboxed (although brand new) £8 REF: MAG8P5

MOBILE CAR PHONE £5.99 Well almost! complete in car phone excluding the box of electronics normally hidden under seat. Can be made to illuminate with 12v also has built in light sensor so display only illuminates when dark. Totally convincing! REF: MAG6P6

ALARM BEACONS Zenon strobe made to mount on an external bell box but could be used for caravans etc. 12v operation. Just connect up and it flashes regularly) £5 REF: MAG5P11

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

HEATSINKS (finned) TO220, designed to mount vertically on a pcb 50x40x25mm you can have a pack of 4 for £1 ref JUN1P11.

STROBE LIGHT KIT Adjustable from 1 hz right up to 60hz! (electronic asssembly kit with full instructions) £16 ref EF28.

ROCK LIGHTS Unusual things these, two pieces of rock that glow when rubbed together! belived to cause rain! £3 a pair Ref EF29.

NEW HIGH POWER LASERS

15mW, Helium neon, 3 switchable wavelengths .63um,1.15um,3.39um (2 of them are infrared) 500:1 polarizer built in so good for holography. Supplied complete with mains power supply. 790x65mm. Use with EXTREME CAUTION AND QUALIFIED GUIDANCE. £349+Vat.

WE BUY SURPLUS STOCK FOR CASH

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1995 100 PAGE CATALOGUE NOW AVAILABLE, 45P STAMP OR FREE WITH ORDER.

PORTABLE RADIATION DETECTOR WITH NEW COMPUTER INTERFACE.

£59.00

A Hand held personal Gamma and X Ray detector. This unit contains two Geiger Tubes, has a 4 digit LCD display with a Piezo speaker, giving an audio visual indication. The unit detects high energy electromagnetic quanta with an energy from 30K eV to over 1.2M eV and a measuring range of 5-9999 UR/h or 10-99990 Nr/h. Supplied complete with handbook.Ref. NOV 18.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL

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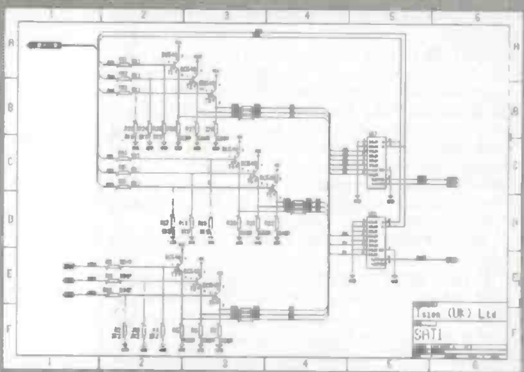
Is your PCB design package not quite as "professional" as you thought? Substantial trade-in discounts still available.

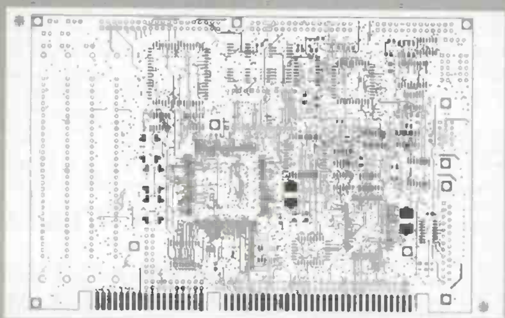
BoardCapture

Schematic Capture Design Tool

£395

- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full undo/redo facility (50 operations)
- Single-sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)
- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component-based power control
- Back annotation from BoardMaker2





BoardMaker

BoardMaker1 - Entry level

£95

- PCB and schematic drafting
- Easy and intuitive to use
- Surface mount and metric support
- 90, 45 and curved track corners
- Ground plane fill
- Copper highlight and clearance checking

BoardMaker2 - Advanced level

£395

- All the features of BoardMaker1
- Full netlist support- BoardCapture, OrCad, Schema, Tango, CadStar
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ETI ELECTRONICS TODAY INTERNATIONAL News...

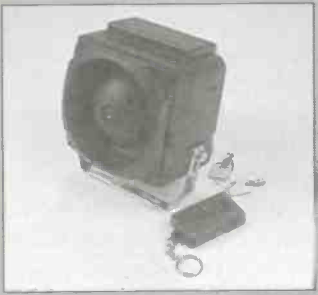
New Remote Vehicle Alarm

From the FOX range of low-cost, high quality, vehicle alarm systems from Maplin Electronics comes the expandable remote vehicle alarm with battery back-up. This top-of-the-range vehicle alarm system incorporates a host of features: such as LED status indicator, built-in parking light flasher, and an in-built engine ignition disable facility.

The lead from the ignition switch to the ignition coil is cut and the two leads are connected to two wires on the alarm. When the alarm is armed, the ignition coil is disabled, the engine will turn, but not start. An alkaline 9V PP3 back-up battery (not included) provides additional security. When armed, if the main power - or earth connection to the alarm is broken - then the alarm will be triggered. A key operated switch is provided on the back of the alarm that will bypass all the alarm functions when operated; this is useful when for instance, the vehicle is being serviced or valetted.

The range of optional extras that can be used with the alarm provides a very comprehensive and sophisticated vehicle alarm system. Complete with comprehensive fitting instructions, fixing kit, remote transmitter and warning stickers. A spare transmitter (£9.99) is also available.

For further information, please contact Maplin Electronics on 01702 552911.



Available from Maplin shops price £64.99 (Inc. VAT) or by mail order.

Multiple Processing with Alpha AXP

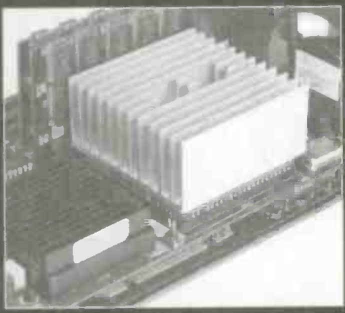
Myriad Solutions is launching the alpha drive CPU sub-system for use in high performance parallel and multiple processing computer systems.

Designed specifically to provide superior RISC performance for the parallel system developer, the Myriad alpha drive features the Digital Alpha DECchip 21064 running at 166, 233 and 275MHz and offers performance figures of up to SPECint 92 175.6 and SPECfp 92 272.8. Packaged in a durable steel case, alpha drive communicates with PC and workstation host computer systems using industry standard transputer and C40 comport links.

Its 64-bit RISC super scalar super pipelined architecture can provide a peak instruction execution of 550 million operations per second! In harnessing this performance, Myriad has devised the MaxCache memory manager to provide up to 800 MB per second burst read/write cache access of up to 32MB of memory. DRAM access of up to 128MB is available to support larger applications and data files.

Working closely with Digital engineers, Myriad have designed and built the smallest and fastest Alpha sub-system in the market. The Alpha Drive is a self-contained unit housed in a steel case with integral fan cooling and customer power management. A single unit is designed to fit compactly into a PC tower case with a simple cable attachment providing the hardware interface to the host PC through a transputer or C40 link adapter card. For use with workstations or small footprint PC machines, single or multiple alpha drives are supported in the external stand-alone Myriad Drive Box.

The alpha drive facilitates the development of multiprocessor applications with the use of the Parallel C / AXP software tools from 3L Ltd in Edinburgh. Incorporating the DEC Alpha C compiler, Parallel C supports an advanced microkernal to provide true multitasking, multiple threads and multiple priorities with pre-emptive scheduling. Run - time library support for initialisation, communication, load balancing and memory management allows the development of a distributed application running on one or more Myriad alpha drive units. Standardised 3L communication functions provide the tools to build heterogeneous networks of alpha drive, transputer (TRAM) and TI 320C40 (TIM) processor mode modules.

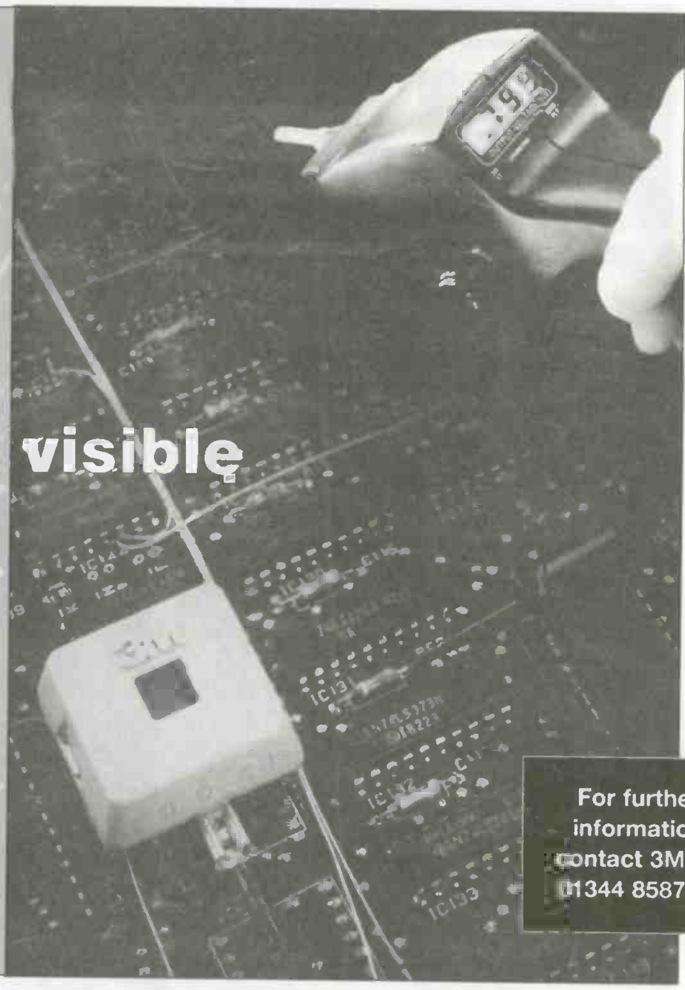


For further information, contact Myriad Solutions 01223 421181.

The problem with trying to control electrostatic damage (ESD) has always been identifying and measuring something which cannot be seen. Now, 3M Electrical Specialists has found a way of making visible the invisible with its new Static Event Detector.

The heart of the new kit is the 715M detector, a one-inch square electrostatic sensor module designed to monitor static events as they occur at all stages of production on ungrounded objects such as PCBs, parts trays or small assemblies. The detector can also be used to monitor parts-storage facilities, field service operations and to verify static control processes.

Make the invisible visible



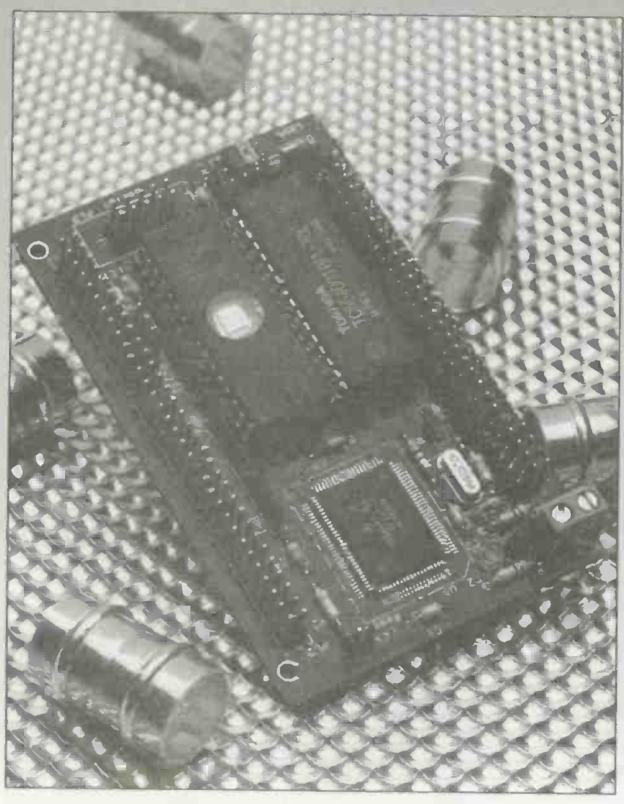
The sensor measures the difference between voltages transmitted to its backplate and its small conductive internal antenna. The antenna is then capacitively coupled to earth ground. During an ESD event, a brief difference in potential exists between the backplate and antenna, triggering the sensor, and activating an amplifying and latch circuit.

When triggered, the Static Event Detector indicates to operators where and when an ESD event has occurred, allowing them to collect measurement data with which to audit their process using statistical methods already in common use in many companies.

When it arrives on the market, the detector will be available alone (in packs of five) or as part of a turnkey audit kit, bundled with resetters, test boards, simulators, mounting clips and tapes.

For further information contact 3M on 01344 858739.

NEW MICRO MIDGET CPU ENGINE



The new Micro-Midget from CMS is a small (3.3" x 2" approx.) very powerful 16/32 bit controller. It is ideal as a component in intelligent control systems, with an advanced royalty free, real time operating system and full support for high level languages including C.

The controller has up to 22 digital I/O lines which can be configured for input or output as required, a single serial port operating at up to 38400 baud with RS-232 or RS-485 driver options and two 16-bit timer/counters. The peripheral expansion bus can be used with 6800C type devices, 8051 devices or 12C bus peripherals.

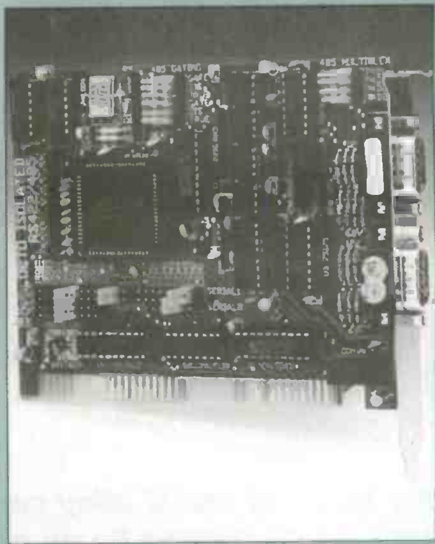
Applications are developed on a PC, downloaded to the Micro-Midget and tested in RAM. Up to 1 Mbyte of program space is available on board with up to 512 kbtye of Static RAM. The PC utilities are provided to allow the applications code to be EPROMed and run from power up.

The Micro-Midget can be considered as a component and can be plugged into the user's board as a CPU engine, with digital and serial I/O. All connectors are brought out on a 0.1" pitch to gold pin headers.

The board is priced at a remarkable £95 one-off and a PC starter pack containing all the software support, operating system, C compiler, PC utilities and a Micro-Midget from £295.

For further details contact Cambridge Microprocessor Systems Ltd on 01371 875644.

New Opto Dual RS422 Board



Brain Boxes have now added on-board diodes to their RS422/485 twin serial port card, thus offering transient spike protection for the line drivers. Protection from +ve spikes >12V and -ve spikes>-6.8V is now provided on the improved version of this half size card.

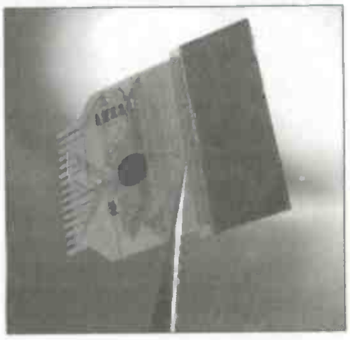
The card provides 2 RS422/485 serial ports independently configurable as RS422 with/without handshaking or RS485 full/half duplex, all optically isolated to 1500 Volts DC/1000 Volts AC. Each serial port may be jumper configured as COM1-COM8 with interrupt line jumper set to IRQ 2-7, 10-12, 14-15.

By adding the optional LPT adapter cable, a non-isolated parallel printer port set as LPT1-3 when interrupt 7 may be used. Thus allowing OS/2, Novell and UNIX full interrupt driven printer output. A buffered version of the card is available for Windows users. The top line card is under £200, including utility disk with sample programs, source code and terminal software, plus informative 55 page manual; the optional adapter cable under £10.

More information: contact Brain Boxes on: 0151 220 2500.

Super thin LCDs

For more information contact Anders Electronics Plc, on 0171 388 7171.



A range of Super-low profile Chip On Flex LCD dot matrix modules, ideal for any application where space is at a premium, is now available from Anders Displays.

With a thickness less than 2.0mm, they are suitable for a wide range of markets, such as mobile comms, telecommunications, hand-held instrumentation, metering, medical and automotive. As stand alone modules, the devices allow users to use in-house mounting and backlighting techniques, thus offering the possibility of a more cost-effective approach than using a standard dot matrix module. Tooling a mounting bracket, complete with integral backlight, is also possible if required.

Requiring an operating voltage of between 2.7V - 5.5V or 4.5V - 5.5V, the modules are easily customised, allowing icons to be modified to suit user requirements and pin-out connection to segments relocated to suit customer software listing. Extremely competitively priced - in line with existing dot matrix modules - the devices are expected to eclipse bezel type modules completely.

Event Diary

2 May	Starting in Contesting. Sunbury and District Radio Amateurs, Wells Hall Old School, Great Cornard. Tel: 01787 313212
8 May	Working wartime CW Shortwave station to celbrate VE day, Puckpool Park Wireless Museum, IOW. Tel: 01983 567665
16-18 May	Internet World, Wembley Centre, London. Tel: 0171 976 0405.
20 May	Ipswich Computer Show. Willis Corroon Sports and Social Club, The Street, Rushmere St Andrew, Ipswich. Tel 01473 272002.
6 June	Using Thermionic Valves, Sunbury and District Radio Amateurs, Wells Hall Old School, Great Cornard. Tel: 01787 313212
12 June	Open House, Stratford upon Avon and District Radio Society, Stratford upon Avon. Tel: 01789 740994.
26 June	Top Band Foxhunt, Stratford upon Avon and District Radio Society, Stratford upon Avon. Tel: 01789 740994.
4 July	Operating QRP, Sunbury and District Radio Amateurs, Wells Hall Old School, Great Cornard. Tel: 01787 313212
10 July	Summer School, Stratford upon Avon and District Radio Society, Stratford upon Avon. Tel: 01789 740994.
24 July	Construction Competition, Stratford upon Avon and District Radio Society, Stratford upon Avon. Tel: 01789 740994.

If you are organising an event which you would like to have included in this section please send full details to: ETI, Nexus House, Boundary Way, Hemel Hempstead, Herts HP2 7ST. Clearly marking your envelope Event Diary.

SHAPE MEMORY METAL

New types of metal alloy can change shape when heated by an electric current and are being used to replace traditional actuators. Nick Hampshire takes a look at this revolutionary technology and examines how they could be used to make muscles for future generations of robots

By In virtually every piece of electrical equipment there are devices which convert electrical energy into mechanical energy. The drive motor and head positioning actuator in a disk drive, the loudspeaker on a radio or TV, the fan in your PC, the compressor in the refrigerator. All these, and many more, use one of three different techniques for energy conversion - electric motors, solenoids, and piezoelectric materials.

To these three basic techniques we now need to add a fourth, potentially the most powerful, easy to use, cheapest and versatile technique of them all. A technique based upon a strange phenomenon known as Shape Memory Alloys (SMAs). A phenomena in which certain special metal alloys undergo changes in shape or hardness when heated or cooled and do so with great force.

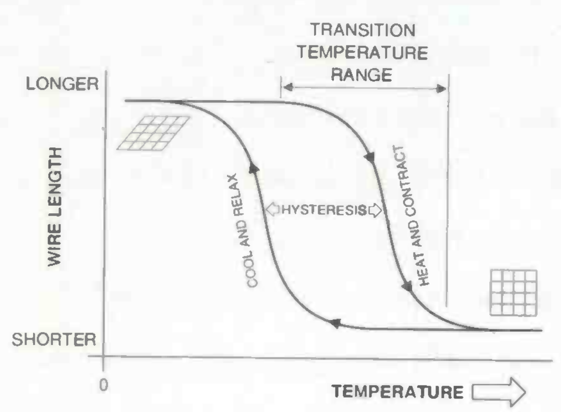


Fig.1. Temperature vs SMA wire length

What are Shape Memory Alloys?

Certain alloys of two or more metallic elements exhibit a property known as Shape Memory Effect. This effect means simply that they have a crystal structure which will completely change to another structure at a distinct temperature. In other words, one may completely deform a piece of such an alloy but when it is heated past a certain temperature, usually well under 100C and way below the melting point, it will return to the shape it had prior to being deformed.

Below the transition temperature a piece of SMA can be easily stretched and deformed. If it is then heated above the transition temepeerature it will return to its unstretched, undeformed shape. Hence the reason why they are called shape memory alloys.

A typical SMA wire can thus be stretched by up to about 8% and still contract to its original length when heated above the transition temperature (it will not properly recover from excessive stretching or deformation). In contracting it is capable of generating a considerable amount of usable force. Indeed, they are being widely talked about as the muscles for future generations of robot.

The usable force generated by a piece of SMA wire can be quite substantial, but is of course only generated by the contraction of a stretched wire. This means, of course, that in a practical SMA based actuator the wire must contract against an opposing force which will then stretch the wire as soon as the temperature of the wire drops below its transition point.

The transition temperature depends on the type of alloy, and can in fact be very precisely defined during manufacturing by careful control of the percentages of the different elements. Thus, the most common SMA is made from nearly equal proportions of nickel and titanium, and a 1% difference in the ratio of these two metals can lead to changes in the transition temperature in the range -100C to +100C.

The commonest SMA alloys are designed for use at room temperature and have transition temperatures of about +70C. However, higher transition temperatures are used where the cycle of contraction and stretching needs to be at a much higher rate than normal, the standard maximum cycling rate being about 50 cycles per minute.

The transition temperature is in fact spread over a small range, with the contraction temperature being slightly different from the relaxation temperature. A gap which is referred to as the temperature hysterisis, and which can be seen clearly in Fig.2.

The development of shape memory alloys.

We have said that SMAs are a new development, but this is not, strictly speaking, true since the shape memory effect of a gold cadmium alloy was first noted by the Swedish scientist Arne Olander in 1932, and he even went as far as predicting that it had potential use in converting heat into motion. Olander's discovery remained little more than a scientific curiosity until 1950 when L C Chang and T A Read of New York's Columbia University used X-rays to study this alloy and understand the changes in its crystal structure which account for the shape memory effect. Not only did their studies spark off a lot more research into SMAs but they actually demonstrated that the shape memory effect could be put to use and perform actual physical work.

The further research into SME was centred around the search for other alloys which exhibited this effect. This search which led to the discovery of another SMA, an alloy of indium and titanium. However, both these SMAs used very expensive metals and, in the case of the gold cadmium alloy, one which was very toxic. Factors which limited any further research into SME until 1963. It was then that the US Naval Ordnance Laboratory discovered that the shape memory effect was exhibited by an alloy of nickel and titanium that they were examining for use in non-corrosive marine applications.

This alloy was called Nitinol (Ni for nickel, Ti for titanium, and NOL for the Naval Ordnance Laboratory) and had none of the drawbacks of the two previous SMAs, it was relatively cheap

An electronic interface for SMA wire

The explosion in applications for SMA are primarily due to the development of electrically activated SMA wire. Electrical activation involves simply passing an electric current along an SMA wire so that it heats the wire above its transition temperature and thus causes it to return to its undeformed state.

Simply connecting a piece of SMA wire to a battery or other power source will work, but there is a serious risk of overheating the wire and thus potentially annealing it and in so doing destroying its existing 'memory'. A far better way is to use a driver circuit which controls the amount of current flowing through a wire and therefore the temperature of the wire.

The simplest form of SMA wire driver circuit is a passive current regulator which simply uses a resistor of suitable value in series with the wire as a means of limiting the current flow through the wire. The problem with this technique, though, is that different resistor values will need to be calculated for different wire lengths and different wire diameters. In other words the driver circuit will have to be taylored for each SMA actuator.

One way round this problem on computer controlled SMA actuators is to use pulse width modulation current limiting. This essentially means regulating the current flowing through the wire by rapidly turning it off and on, with the average current being determined be the percentage of time that the current is on. With this technique the average current delivered across the wire can be very precisely controlled by altering the on pulse width with respect to the off pulse width.

By far the best form of current driver, for all applications, is an active current driver. This is a simple circuit which will deliver a constant current for any length or diameter of SMA wire, with the only limit being that of the power supply. It essentially consists of a voltage regulator and a resistor. The resistor determines the current level and the voltage regulator adjusts its output to maintain a constant current. The circuit in this box shows a practical active current regulator for SMA wire actuators.

Of course there may be a requirement for other specialised actuators, which control acivation or relaxation speeds or even hold activation. Thus rapid actuation could be initiated by quickly sending a very large current through the wire and drop the current to a low level which would maintain activation without overheating the wire.

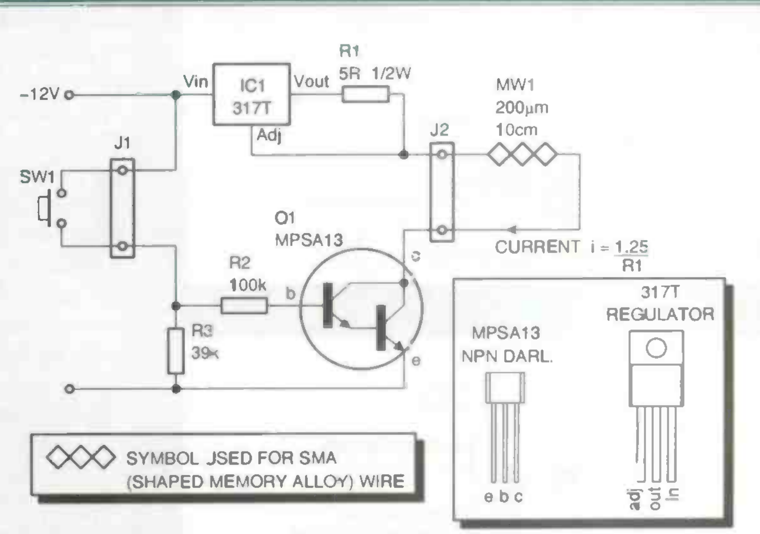


Fig.2. SMA wire driver circuit

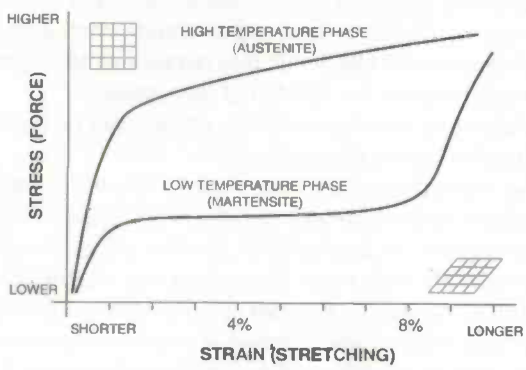


Fig.3. Typical stress vs strain curve for SMA

and non-toxic. On top of this, it possessed a much better deformation/recovery ratio than either of the other two SMAs. This discovery renewed interest in SMAs and their use and, by 1973, researchers in various centres around the world had discovered the shape memory effect in a range of other alloys. These included iron-platinum, copper-zinc, copper-tin, copper-aluminium-nickel, copper-zinc-aluminium, copper-gold-zinc, nickel-aluminium, and manganese-copper. Of all of these SMAs, the two most widely used because of their low cost, strength, and large deformation/recovery ratios are nickel-titanium and copper-zinc-aluminium.

During the late 60s and early 70s researchers started to develop applications for SMAs, and in the forefront of this work were NASA and the world's major defence companies. Indeed, the Soviet Union considered SMA technology so important that they developed the ability to produce nitinol in quantity. It was regarded as a strategic material and tons of it were stockpiled. A lot of work on SMAs was done by the military and much of it is only just starting to leak out into public domain. Amongst the non-military applications for SMAs that were developed in the 70's and 80's, NASA devised a system for unfolding satellite antennas when they were exposed to the heat of the sun. Other university and corporate researchers used SMAs to create small heat engines running on hot and cold water, electrically operated pipe valves, automobile fan clutches which engaged when the engine reached a certain temperature, and greenhouse window openers which were activated at specific greenhouse temperatures.

Many of these applications were initially not very successful because the quality of the available SMAs (they primarily used nitinol) was not good enough. But as metalurgical processes improved and the quality became more consistent and reliable, so the engineers became more successful in their attempts to put the shape memory effect to practical use.

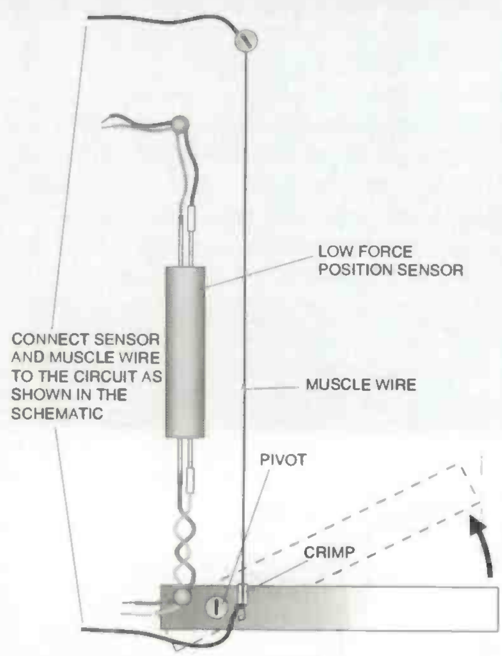


Fig.4. SMA wire based servo mechanism

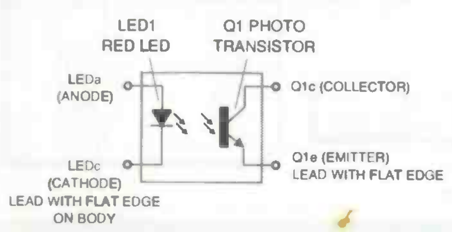


Fig.5. Low force position sense circuit

An SMA wire based servo system

Driver circuit may be called upon to hold the activation of an SMA wire based actuator at a certain level using some form of position sensing feedback loop. This is a similar application to those employed in servo control mechanisms, such as those used in radio controlled models.

This type of application needs two components, a low force position sensor and a driver circuit. If we are goint to use an SMA wire based actuator in place of a standard radio control servo then we can use the a standard servo R/C circuit can be used, with the wire connected in place of the conventional motor and a special position sensor in place of the potentiometer. (there are some very low cost R/C servo mechanisms on the market today and it is probably cheaper and easier to buy one of these and use the internal electronics tather than buying the components and building your own control circuitry.

A low force position sensor can be constructed from a photo transistor and an LED as shown in the accompanying diagrams. Note that the elastic band determines the force needed to extend the sensor and changing the force is simply a matter of changing the elastic, the paper tube acts as a guide and as a means of excluding any external light.

In the diagram for the R/C interface circuit note how the position sensor is connected to a typical R/C servo PCB, the variable resistors VR1 and 2 are used to adjust movemeny in the 'up stick' and 'down stick' positions respectively.

(The ideas here were drawn from Roger Gilbertson's Muscle Wires Project Book, available from Milford Instruments - Tel: 01977 683665. - this book is an excellent source of practical SMA based ideas and circuits)

Thus by 1971 two researchers in Brooklyn, New York, P.N.Sawyer, and M.Page, were able to build an artificial heart that was activated by 500um nitinol wire. But low cycle times meant that it could only run at about 12 beats per minute as opposed to 80 or 90 beats in a real heart. The SMA technology available today would mean that a version could now be built which would very nearly beat at the proper rate and thus could become a viable prospect in medical applications.
A lot of the early development work was related to the construction of pumps of various sorts since it was quickly realised that the ability of SMAs to perform useful work given very small temperature gradients made it the ideal techology for constructing heat engines. Such engines would be capable of turning very low grade thermal energy, in particular solar, geothermal, or waste industrial/domestic thermal energy, into useful high grade mechanical or electrical energy.
One of the earliest working SMA heat engines was developed in 1974 at the Lawrence Berkeley Laboratories in California and is based upon the differential pulley. A commercial version of this design which employs just a single coil of nitinol wire is capable of speeds of up to 1000PRM with a power output of 1watt using just hot and cold water as the power source.
In 1980 McDonald Douglas demonstrated a scaled up version which employed one hundred 50um mechanically connected nitinol wires. This also used hot and cold water as the power source and was capable of developing a power output in excess of 32watts. In building this engine, the designers discovered no fundamental reasons why it should not be possible to build very large and economically viable SMA based heat engines. Indeed it is rumoured that such engines are currently being designed in several parts of the world.

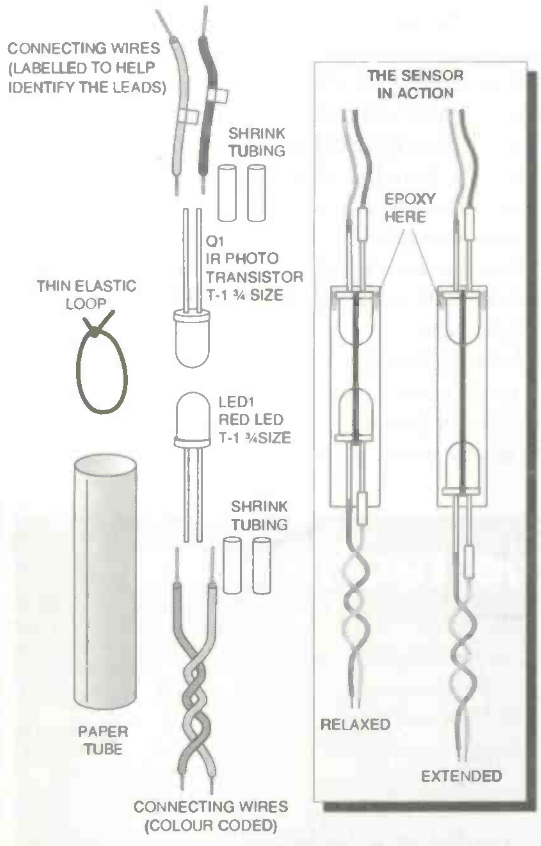


Fig.6. Construction of low force position sensor

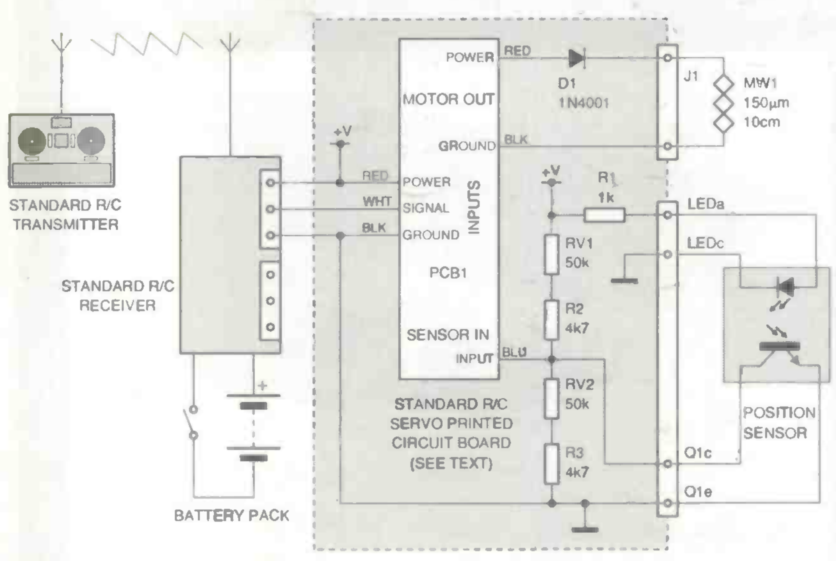


Fig.7. SMA servo circuit using R/C system

Commercial applications for SMAs

One company which began research into SMAs in the late 60s was the Californian based Raychem Corporation. They also joined the search for new SMAs and in the early 1970s launched two products, Betalloy, a copper-zinc SMA and Tinel a nickel-titanium SMA with an unique sub-zero transition temperature.

Raychem have used the sub-zero transition temperature of their Tinel SMA to produce a range of high performance couplings for aircraft hydraulic lines. These couplings are made of Tinel and both shipped and installed at about minus 200C (the temperature of liquid nitrogen). Once it is installed the coupling warms up and in so doing shrinks by about 8% in diamete,r thereby making a very tight leakproof seal (so far they have sold over one million units and not one has either leaked or failed, thus making it one of the most successful SMA products to date).

In the UK, one company which was an early researcher into SMAs and a developer of SMA based products was Delta Metals. Using nitinol they developed a range of automatic thermally operated vents for use in applications such as greenhouse windows. They also developed a range of fan clutches and hot water valves.
Not surprisingly the Japanese quickly realised the commercial potential for SMAs and in 1985 the Toki Corporation of Tokyo started manufacturing high quality nitinol wire under the trade name BioMetal. The technology for producing this wire had been discovered by Dr Homma whilst researching SMAs at Tokyo University and was important because it allowed the wire to be electrically activated, and in properly designed mechanisms operate predictably over millions of cycles without failure.
The BioMetal wires produced by Toki could not only be electrically activated (in other words heat was applied by sending an electric current along the wire) but could also be elongated by a very low deformation

force. These two factors led to an explosion in the range of application for the BioMetal nitinol wire, including acting as the muscles for robotic arms.

Throughout the late 1980s Toki and other Japanese companies, including Hitachi and Furukawa Electric, demonstrated a range of small to medium sized robot arms and hands which operated entirely using electrically actuated SMA wire. Hitachi even produced a four fingered robotic hand that was capable of lifting and manipulating objects in almost exactly the same way as the human hand. The hand unit was powered by twelve groups of 200um electrically actuated nitinol wire, four per finger. These wires were housed in the forearm.

When powered the wires contracted and closed the hand, gripping any object, when the power was removed from the wires a spring extended the wires and the hand opened. Under computer control any of the wires, in other words the finger joints, could be activated individualy to produce complex hand and finger movements

The production of BioMetal wire in Japan was very quickly followed by the production of similar products from US companies, including Dynalloy with its range of Flexinol pre trained nitinol SMA wires. These have also been extensively used in robotics. In 1989 Oaktree Automation Inc, of Alexandria Virginia, started development of an anthropomorphic robotic hand, the Fingerspelling Hand, which was designed as a tactile communications aid for deaf/blind people who are unable to read Braille

The Fingerspelling Hand was developed in conjunction with Gallaudet University, and partly funded by the US Department of Education. It is constructed from one hundred and eight 250um Flexinol wires that are housed in the forearm. The wires act in parallel with opposing wires providing flexion and extension as well as side to side motion where applicable, for each joint.

In use the hand functions as a kind of computer display. The user places his/her hand lightly on the Hand, reading a character at a time by feeling the hand shape, the device uses a common finger spelling alphabet. The data used to control the hand comes vie the controlling computer from a variety of sources, it could be a keyboard, a page scanner with OCR, a teletext decoder, a modem, etc.(SMA wires have also been used to create a computer controlled Braille character display).

Researcher's understanding of how SMAs behave and the techniques for making them has improved to a degree where SMA actuators are now being scaled down and used as components in micromecanical systems. In the US TiNi Alloy Company has now developed ways to use thin films of nitinol which have been formed on top of silicon wafers to create mocroscopic mechanisms.

In 1990 they demonstrated a microscopic electronic thin film SMA valve which used a chemically etched silicon base and a film of nitinol just 2um thick. It is capable of opening and closing in just 15milliseconds and allowed air at a pressure of

An SMA based programmable tactile array

A new application for SMA wires are the 'tactors' now being utilised in some advanced virtual reality and teleoperator systems to give the user a sense of virtual touch. This is very important in arease such as telesurgery where a remote surgeon often needs to feel texture and force feedback as well as see what he is doing. Other applications are in telerobotics, micro-robots, molecular modeling, control functions such as training and simulation cockpit, computer aided design, and sophisticated computer interfaces - super mice and joysticks.

Tactors fall into three categories, single tactors, and tactor arrays. Single tactors are used by and large used in vibratory mode and used to give simple warning messages. Tactor arrays on the other hand are used to give full tactile feedback and also for Braille communications systems. Such arrays will either have vibratory points under a stationary finger or raised points that are stroked by a finger tip

A tactor array has to be made small enough so that it will fit on a fingertip as perhaps part of a glove worn by the user, or some form of hand held device. The need to make them very small by and large precludes the use of conventional solenoids, although piezo electric resonators can be used for vibratory mode applications. However, SMA based miniature actuators are ideal for tactor arrays both in vibratory and raised point mode.

The design of an SMA tactor array is very simple - as can be seen from the accompanying diagram. It just consists of tiny spring levers made from a sheet of berellium copper that are bent at one end to protrude through holes in a top plate to provide the tactor sense points. A piece of SMA wire is attached to each lever and angled upwards to a connector block, so that when they contract the lever is angled upwards and the end protrudes through the hole, the springiness of the lever metal will then stretch the SMA wire as soon as power is removed.

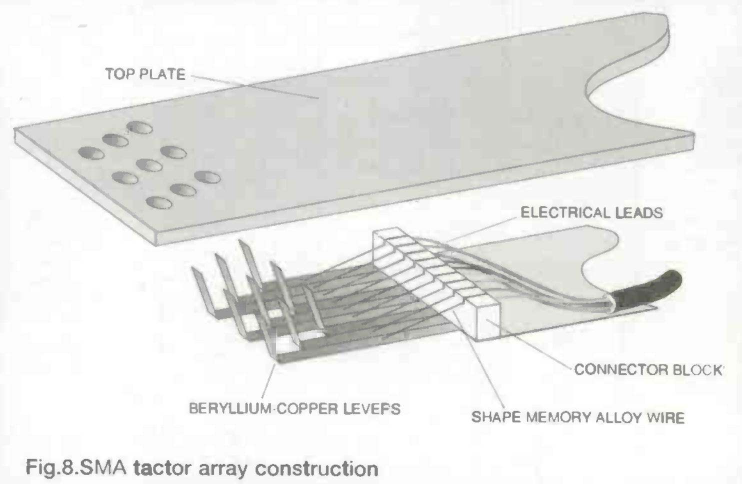


Fig.8.SMA tactor array construction

20psi to flow through it at a rate of 1litre per minute, and has a very high reliability, being capable of operating over millions of cycles. This is the first of many potential micromechanical applications for SMAs.

Another electronic application is the development by Betaphase Inc, of Menlo Park in California, of a range of very high density electrical connectors, with up to 190 signal lines per centimeter. They incorporate a special internal heating element which causes a SMA actuator to press back a spring and thus allow insertion of the circuit board.

Into the future.

The success of the Fingerspelling Hand has led to a lot of research, primarily in the US, into uses of electrically activated SMA wire in the field of robotics, teleoperator systems, muscle amplifiers, and medical prosthesis. By using multiple electrically activated SMA wires working in parallel it is possible to create actuators which can exert very considerable force in a small relatively light weight and low power package (see Table 1 for strengths of multiple wire systems)

Such totally integrated multiple SMA wire actuators are now being developed commercially and will allow enginers to create the robotic equivalent of biological muscles. Robots (and medical prosthesis units) which use these actuators will have a skeleton to which groups of actuators are connected to give quiet efficient linear motion without all the problems associated with hydraulic and pneumatic systems and the weight/ size problems assoiciated with electric motors. These SMA linear actuators will have their own in-built intelligence and will be controlled by a communications and power network from some form central motion control processor.

With light weight efficient, silent all electric linear actuators connected to a lightweight skelital framework it should be possible to design and build artificial limbs which will very closely resemble the biological equivalent in both form and function. The electronic limb would be controlled using signals derived from actual nerves which are then interpreted using advanced signal processing techniques (scientists are already working on such systems with considerable success).

It would also be possible to use such actuators to create muscle amplification systems which would give an ordinary human superhuman muuscle force or someone with reduced muscle function the ability to move without recourse to wheelchairs etc. Such muscle amplifier systems have been the subject of work in the past by the US military, but in a civilian version would take the form of an active externally worn brace with belt mounted power pack and control processor that would be able to sense the wearer's motion and be able to take corrective action to prevent a fall.

The ability to use SMA based linear actuators to build robot systems that very closely model human muscle based systems also means that they are an ideal candidate for use in teleoperator robots. These are robots which will exactly mumic the movements of a human operator, even though the operator may be thousands of miles away. In many ways the ultimate in virtual reality systems, but something which is being very closely examined for space and deep sea exploration as well as applications such as telesurgery (see ETI May 95 issue on virtual reality, and Feb 95 on electronics in medicine).

Finally we come to the application of SMA actuators in robots, this could be a minuature surgical robot no bigger than a pea, or an autonomous robot designed to construct and maintain some space based facility. Such actuators are ideal for use in subsumption based robot systems which currently look like the best bet for autonomous operation in distant locations (see ETI March 95 and November 94).

In short SMA based actuators in conjunction with advanced computer technology could give us the robot systems that have so far been pure science fiction.

Sources of SMA wire

Milford Instruments. Milford House, 120 High Street, South Milford, Leeds LS25 5AQ. UK Tel: 01977 683665

or

Mondo-tronics Inc. 524 San Anselmo Ave. #107 San Anselmo, CA 94960. USA. Tel: 415 455 9330.

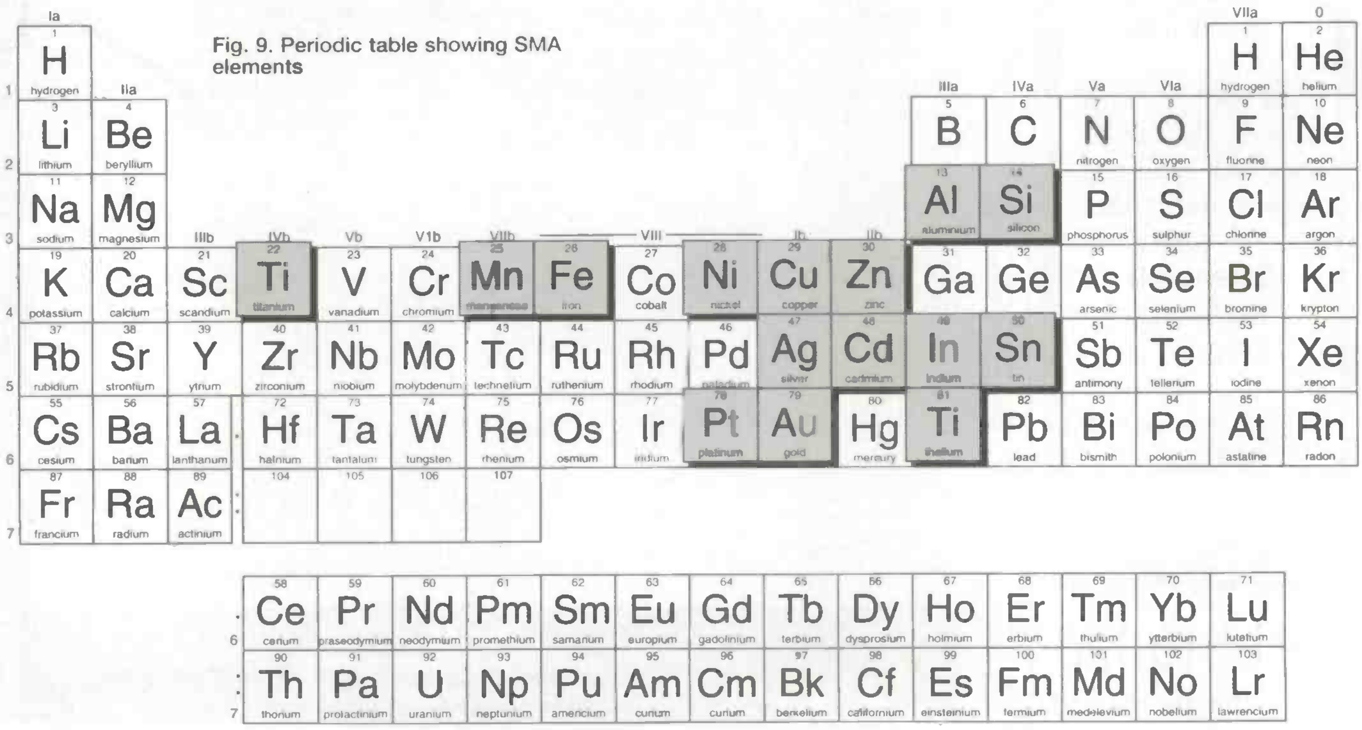


Fig. 9. Periodic table showing SMA elements

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SMA wire specifications

The following table gives some of the main specifications for Flexinol wire produced by Dynalloy. There are two main types of wire, the HT series and the LT series. The difference between the two lies in the transition temperature, the HT series has a higher transition temperature and because it cools 50% faster is therefore used in applications needing a faster cycle rate (note that the cycle rates quoted are for cooling in still air at 20C, moving the air or immersing in a liquid will increase cycle rates by up to ten times).

Wire diameter (μ meters)	Linear resistance (Ωs /meter)	Typical current (milliamp)	Deformation weight (gms)	Recovery weight) (gms)	LT cycle rate (cyc/ min)	HT cycle rate (cyc/ min)
37	860	30	4	20	52	68
50	510	50	8	35	46	67
100	150	180	28	150	33	50
150	50	400	62	330	20	30
250	20	1000	172	930	9	13

Notes:

- The contraction speed on all wires is about 1/1000sec
- The annealing temperature for nitinol is 540C and the melting point 1300C
- To convert recovery/deformation weight to Newtons multiply by 0.0098
- Maximum deformation ratio is 8%, recommended deformation ratio 3-5%

Table 1
Strength of multiple nintinol wires lifting in parallel

Wire size	number of wires	total force	total lift	total power
50um	10	3.43N	0.35kg	1watt
50um	50	17.2N	1.75kg	6watts
50um	100	34.3N	3.50kg	13watts
50um	250	85.8N	8.75kg	32watts
100um	10	14.7N	1.5kg	5watts
100um	50	73.5N	7.5kg	24watts
100um	100	147N	15kg	49watts
100um	250	367.5N	37.5kg	122watts
150um	10	32.3N	3.3kg	8watts
150um	50	161.7N	16.5kg	40watts
150um	100	323.4N	33kg	80watts
150um	250	808.5N	82.5kg	200watts
250um	10	91.1N	9.3kg	20watts
250um	50	455.7N	46.5kg	100watts
250um	100	911.4N	93kg	200watts
250um	250	2278.5N	232.5kg	500watts

Notes:
* individual wire length 10cms
* Total power is the power used in a typical contraction 0.5sec long.

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Fax: 01203 650773
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Gould 4050 – 35MHz Digital storage £650
Gould 5110 – 100MHz Intelligent oscilloscope £850
Gould OS4000, OS4200, OS4100, OS1000B .... from £125
Hewlett Packard 1740A, 1741A, 17744A, 100MHz dual ch .... from £350
Hewlett Packard 1707A, 1707B – 75MHz 2ch .... from £275
Hewlett Packard 54201A - 300MHz Digitizing £1750
Hewlett Packard 54504A - 400MHz Digitizing £3500
Hitachi V422 – 40MHz Dual channel £300
Hitachi V212 20MHz Dual Channel £175
Nicolet 3091 – LF D.S.O £1100
Philips PM 3315 - 60MHz - D.S.O. £750
Phillips 3206, 3211, 3212, 3217, 3226, 3240
3243, 3244, 3261, 3262 (2ch + 4ch) .... from £125 to £350
Philips PM 3295A - 400MHz Dual Channel £1950
Philips PM 3296 - 350MHz Dual Channel £1750
Tektronix 2213 – 60MHz Dual Channel £425
Tektronix 2215 60MHz dual trace £450
Tektronix 2235 Dual trace 100MHz (portable) £800
Tektronix 2335 Dual trace 100MHz (portable) £750
Tektronix 2225 – 50MHz dual ch £450
Tektronix 2465A – 350MHz , 4 channel £2950
Tektronix 2220 – 60MHz Digital storage £995
Tektronix 464/466 – 100MHz An storage .... from £350
Tektronix 465/465B – 100MHz dual ch .... from £350
Tektronix 7313, 7603, 7613, 7623, 7633, 100MHz 4 ch .... from £300
Tektronix 7704 – 250MHz 4 ch .... from £650
Tektronix 7844 – Fitted with 7A42, 7B80, 7B85 Plug-Ins £1500
Tektronix 7904 – 500MHz .... from £850
Tektronix 468 - 100MHz Digital Storage £800
Telequipment D68 - 50MHz Dual Channel £200
Other scopes available too

SPECTRUM ANALYSERS

Alltech 727 – Spec. Analyser 22.4 GHZ with
Alltech 70727 – Tracking Generator (10KHz – 12.4 GHz) } £2000
Hewlett Packard 3580A – -5Hz-50KHz £995
Hewlett Packard 182T with 8559A (10MHz – 21GHz) £3750
HP 3582A – 25KHz Analyser, dual channel £2500
Hewlett Packard 35601A - Spectrum Analyser Interface £1000
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Marconi 2371 – 30KHz - 200MHz £1250
Polrad 641-1 – 10MHz – 18GHz £1500
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Schlumberger 1250 - Frequency Response Analyser £2500
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Tektronix 7L14 with 7603 mainframe (1.8GHz) £2000
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Ballantine 323 True RMS Voltmeter £350
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Farnell RB 1030-35 Electronic load 1Kw £450
Farnell 2081 R/F Power meter .... POA
Farnell TSV 70 MkII Power Supply (70V-5A or 35V-10A) £200
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Fluke 5101B AC/DC Calibrator £6500
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Gould K100D – 100MHz Logic Analyser with Pods £350
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Hewlett Packard 334A – Distortion Analyser £250
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Hewlett Packard 3437A System voltmeter £350
Hewlett Packard 3456A Digital voltmeter £850
Hewlett Packard 3760/3761 Data gen + error detector .... each £300
Hewlett Packard 3762/3763 Data gen + error detector .... each £350
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Hewlett Packard 8684A 5.4GHz to 12.5GHz Sig-Gen £3000
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Hewlett Packard 6181C D.C. current source £150
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Hewlett Packard 5316A Universal Counter HP1B £550
Hewlett Packard 5316B Universal Counter HP1B £775
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Hewlett Packard 3779C Primary Multiplex Analyser £1000
Hewlett Packard 6623A Triple output system power supply £1950
Hewlett Packard 6453A Power supply 15v-200A £1250
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Hewlett Packard 3325A - 21MHz Synthesiser/Function Gen £1500
Hewlett Packard 8152A - Optical Average Power Meter £1250
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Bicycle LOOP alarm

Terry Balbyrnie shows how to construct a simple electronic device that will protect your precious bike from theft

Many people rely on a bicycle as their chief means of transport to and from work. Some use one to go shopping or simply to ride for exercise and pleasure. With bicycle theft now a growing concern, some means of protection is becoming essential.

The Bicycle Loop Alarm will provide good protection. However, it must be remembered that no alarm can provide complete security. If the bicycle is particularly valuable, it would be wise to consider buying a commercial unit which may offer a higher degree of protection but is possibly more expensive and difficult to use. Note that if the alarm is to be used in the rain, a waterproof enclosure would be needed and some care exercised to protect other components from the effects of the weather. With a little ingenuity, this circuit could be used to protect other items such as bicycle racks, boats, vehicle trailers, etc.

In some ways, this alarm resembles the mechanical combination lock which will be familiar to many readers. This has a barrel section attached to a chain. Four wheels on the barrel, bearing numbers 1 to 9, are lined up to show some secret code. The free end of the chain is then passed between the spokes of a wheel or round a post and inserted in the barrel. The wheels are then rotated to some random position thereby securing it. To remove the chain, the wheels must be set to the secret number again. As many will testify, this is a fiddly process - especially at night - and the combination can easily pass into the wrong hands. Since the secret number is determined when the lock is manufactured, it cannot be changed by the owner.

Permanently attached

Instead of the chain, this alarm uses a wire loop. If it is broken, an alarm will sound. The main unit, which is permanently attached to the bicycle frame, houses the circuit panel, battery pack, high-power sounder and key-operated switch. There are also two miniature line phono-type sockets on short pigtails (see photo). The loop itself consists of a length of insulated wire with a phono plug connected to each end. In use, a plug is inserted in one of the sockets and the loop passed between the spokes of a wheel. The other plug is inserted into the remaining socket. Alternatively, the loop may be passed around a post, railings, etc. Before leaving the bicycle, the alarm is armed using the key-operated switch. The whole operation is easy to perform even under dim lighting conditions and only takes a few seconds. If a plug is now removed from one of the sockets as will happen if the bicycle wheel rotates - or if it is snapped or cut - the circuit triggers and a 'yelping' type siren will sound. It will then operate for approximately 1 minute 40 seconds (100 seconds) or some alternative time chosen by the user. It can only be silenced before the end of its natural timing cycle by using the key-operated switch. When the alarm is disarmed, the wire loop may be removed and stowed away ready for further use. Spare loops are easily made to suit the purpose or when worn out and the key-operated switch may be changed quickly if a key is lost or gets into the wrong hands.

Carried away

If the lid is partially removed in an attempt to tamper with the circuit, this will trigger the alarm. Note also that the unit may only be removed from the bicycle frame by first removing the lid.

If the bicycle is moved slightly or if it falls over, this is unlikely to remove a plug or break the wire so false triggering should not occur. Note that this is the reason for using phono plugs in the loop rather than jack or other type of connector - the former need more force to disconnect them. This immunity from false triggering sets this alarm apart from those which rely on a movement or vibration sensor. Unfortunately, this type is sometimes activated by accidental movements as when the bicycle falls over.

The circuit draws no current while the alarm is off. While armed, it needs less than 100mA (85mA in the prototype unit) on standby rising to about 150mA when the alarm is actually sounding. In normal use, the 12V 'AAA' battery pack will provide many months of service even if the alarm sounds occasionally. The batteries should be tested every so often by triggering the unit for a few seconds. Poor battery condition is indicated by a weakening of sound, not by a reduction in the time period.

Circuit description

The complete circuit for the Bicycle Loop Alarm is shown in Fig. 1. Assume for the moment that key-operated switch, S2, is on (contacts closed) so that a supply is established from the 12V battery pack, B1. Assume also that a wire loop interconnects sockets, SK1 and SK2 via the loop and matching plugs PL1 and PL2 and that switch S1 contacts are closed. These contacts are held in the closed position while the lid of the case is in position and this provides the anti-tamper facility mentioned earlier.

The circuit is based on a monostable comprising integrated circuit timer IC1 and associated components. Once triggered, IC1 output - pin 3 - will become high (positive supply voltage) for a certain time. It then reverts to its original low state. Triggering is achieved by making pin 2 (trigger input) less than one-third supply voltage (nominally 4V) for an instant. In the absence of a trigger pulse, the low state of pin 3 will have no further effect. Normally, pin 2 is kept high (positive supply voltage) through fixed resistor R2 which prevents false triggering.

Quick pulse

The time period is set by the values of fixed resistor, R5 and capacitor C3. The higher the value of either or both, the longer will be the timing cycle. With the values used in the prototype, the time will be about 100 seconds. No adjustment is provided since the exact period is not thought to be particularly important. However, for a shorter timing, R5 could be reduced in proportion.

With the loop plugged in, each plate of capacitor C1 will be maintained in a high state - the left-hand one via the loop and switch S1 and the right-hand one via resistor, R2. With each plate of the capacitor at the same voltage, it is discharged. When the loop is broken, or when S1 contacts 'break' due to the lid being lifted, the left-hand plate of C1 will assume less than 4V due to the potential divider action of R1 and R2. This pulse will be transferred briefly to the right-hand plate and hence to pin 2. The specified value of R1 is sufficiently high to prevent an excessive current flowing continuously through the loop when the alarm is armed. This is a less than 2mA and may be regarded as negligible.

The reason for triggering IC1 via capacitor C1 (so called "a.c. coupling") rather than direct is that there is a high possibility of a potential thief or vandal setting off the alarm, running away and leaving the wire loop disconnected. Direct coupling would result in a continuous low state being applied to pin 2. This would cause the alarm to re-trigger when the timing cycle ended and the warning would sound continuously.

Short delay

While IC1 pin 3 is high - that is during the course of timing - current enters Darlington transistor TR1 base through resistor R6. The transistor turns on and collector current flows from the supply through electronic siren, WD1. It is essential to use a siren of the type specified in the components list. It must be loud enough and sufficiently small for the purpose, coupled with a low current requirement.

Capacitor C2 maintains IC1 reset input (pin 4) low for a short while after switch S2 is operated. It works in the following way. When the supply is established, the voltage across this capacitor will be zero since it is uncharged. It then charges through resistor R4. It will eventually develop a voltage of about 3.8V across it this being set by the potential divider R3 and R4. When the voltage rises to about 1V (which takes a fraction of a second), the i.c. is enabled. This provides a short delay during which time the i.c. is insensitive to triggering. If pin 4 were not held low during power-up, there is a strong possibility that the circuit would self-trigger when switched on which would be a nuisance. Resistor R3 allows C2 to discharge quickly when the circuit is switched off.

Using a car exhaust bracket, as described, is a convenient method by which the unit may be attached rigidly to the bicycle frame. These brackets may be purchased from any car accessory store such as Halfords. The diameter of the frame at the intended fixing position will need to be measured so that the correct bracket may be bought - they are available in a variety of sizes.

Construction

Most of the components for the Bicycle Loop Alarm are mounted on a single-sided printed circuit board (PCB). Fig. 2 shows full topside details (parts placement diagram).

Resistors R2 and R5 have a particularly high value - 33M

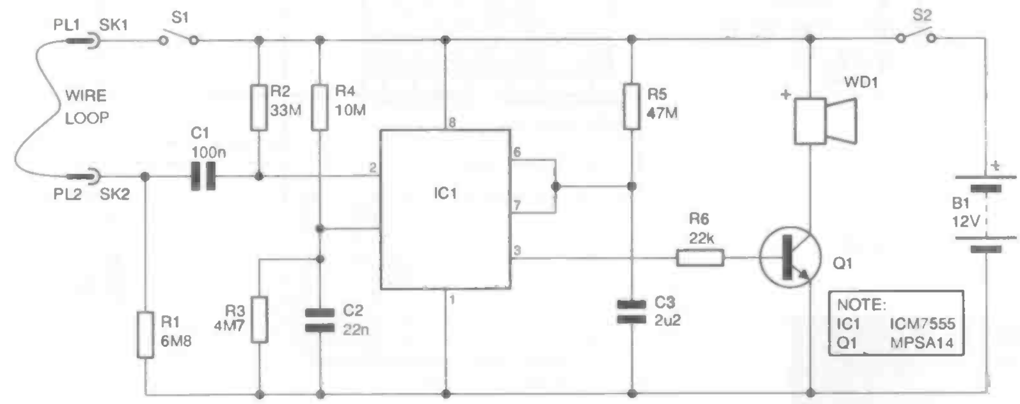


Fig.1. Bicycle loop alarm circuit diagram

and 47M respectively. They are available from certain mail order suppliers - see Buy Lines. Alternatively, they could be made up (or nearly so) by connecting 3 off and 5 off 10M units respectively in series zig-zag fashion (see Fig. 4).

Begin by drilling the single mounting hole in the position indicated. Follow with the soldered on-board components. The recommended assembly order is as follows. Firstly, solder the i.c. socket, then all resistors in position as indicated. Note that some resistors are mounted flat on the board while others are perpendicular to it. Add the three capacitors, noting that these should be of the specified type having 5mm pin spacing or they will not fit the layout without modification. Solder the Darlington transistor in position - this is the only on-board component where orientation is important (see Fig. 5).

Make up the output pigtails - one about 20 cm long and the other about 10 cm longer. The best wire to use is the extra-flexible type often used for test instrument probes. This will have 30 to 50 strands of 0.1mm diameter copper wire. Such wire will survive a lot of bending as will happen in the normal course of use. Do not use singe-strand wire which would break after a very short time.

Complete construction of the PCB by soldering the negative (black) connection of one of the battery snap connectors to the pad labelled "B1-" (this will need to be extended). Solder a 10 cm piece of light-duty stranded connecting wire to the pad labelled "S2". Solder one end of the shorter pigtail to the pad labelled "SK2". Solder the sounder wires to WD1 + and WD1 - pads, taking care over the polarity or it will not work.

Getting ready

Prepare the box to receive the internal components. Begin by drilling the two holes in the base for the exhaust bracket which will be used to secure it to the bicycle frame later. After that, hold the sounder in place and mark out the holes for the mounting bracket. Note that when the unit is in position, the sounder points downwards. In the prototype, the bracket supplied with the sounder was raised on 5mm long spacers so that it took up a more suitable position in the end panel. Mark the position of the hole through which the sound will pass. For maximum sound output a matrix of small holes will not be satisfactory and the whole of the front face should be exposed. To do this, drill a circle of small holes around the circumference as marked out then join them together using a small hacksaw blade. The edge may then be smoothed using a half-round file. Drill the holes for the bracket, for PCB mounting and for the pigtails. Fit this latter one with a rubber grommet.

Drill holes for key switch S2 and for microswitch S1 mounting (see photograph). Attach the microswitch and adjust the lever so that the contacts are held in the closed position (that is, the switch is heard to click) when the lid is in place. This will ensure that the alarm will trigger when the lid is lifted a little.

A bit of support

Attach all remaining components apart from the circuit panel itself and, referring to Fig. 3, complete the internal wiring. Holders for 8 off 'AAA' cells do not appear to be readily available. In the prototype, the 12V supply was therefore obtained by connecting two sets of four cells in series as shown (hence the need for two snap connectors). The common connection should be sleeved or taped over to insulate it. The two cell holders were joined together using adhesive fixing pads. It is important to note that there are exposed connections on the ends of the battery holders and these must be insulated from the metal box. This may be done with a thick layer of PVC tape. If the specified enclosure is used, its height is such that the lid section will press on the top of the battery snap

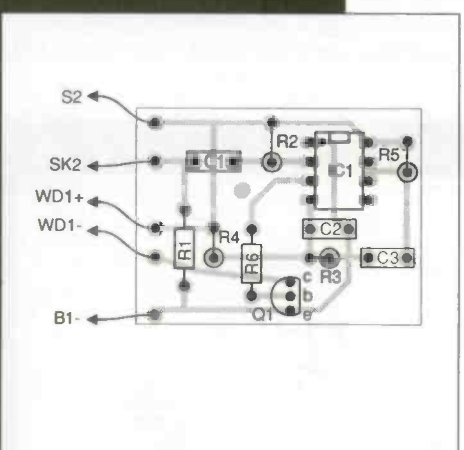


Fig.2. Bicycle loop alarm PCB component overlay

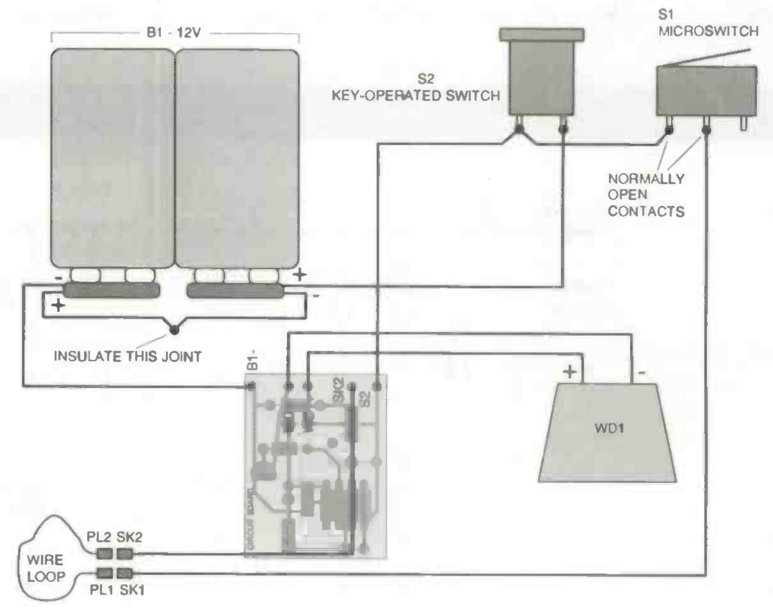


Fig.3. Bicycle loop alarm wiring diagram

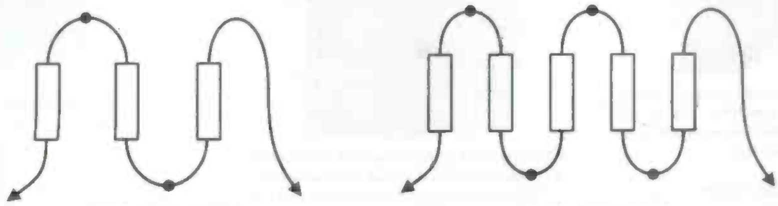


Fig.4. Resistor connections

Pin connections for darlington transistor - looking at flat face

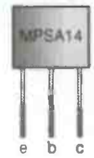


Fig.5.Darlington transistor pin connections.

connectors and give firm vertical support. Lateral support may be given using a small bracket. Make sure that the batteries are secure because they will be subject to considerable vibration and jolting in use. The wiring may be tidied up by using small cable ties.

Connect the longer pigtail to one of the microswitch normally-open contacts as shown. Knot the two pigtails together and pass them through the grommet. Adjust them so that there is some slack left on the inside. Cut them to the same length outside and fit the line sockets making sure these are secure. Note that, for this purpose, it does not matter if the tip and sleeve terminals are connected together. Insert the i.c. into its socket observing the orientation and mount the circuit panel using a single fixing in the hole drilled for the purpose. The panel will need to be raised about 10 mm using a plastic stand-off insulator to provide clearance for the knot in the pigtails.

Note that all components are mounted in the lower section of the box since this method imposes least strain on the wiring. With switch S2 off, place the batteries in the holders and secure them.

Prepare the loop itself by cutting off a suitable length of wire of the same type as already used for the pigtails. Solder the inner (tip) connection of a phono plug to each end of the wire. As with the sockets, it does not matter if the sleeve connection is used too. Secure the wire and make sure that pulling on it will not dislodge the soldered connections. Attach the unit to the bicycle frame. Some PVC tape wrapped around it at the point of attachment will protect the paintwork.

Warning: operating this device in an enclosed space and close to the ears can cause temporary discomfort or even permanent damage to the hearing. Testing should therefore be carried out with the sounder hole taped over to reduce the noise.

Attach the lid and plug the loop into both sockets. Arm the alarm by switching S2 on. The sounder should remain silent. Unplug one end of the loop. The alarm should sound and continue doing so even when the plug is replaced. Check that it times out after about 1 min. 40 sec. Arm the alarm again and check that it is triggered by partially lifting the lid.

If all is well, the Bicycle Loop Alarm may be put into permanent service. Remember to operate the alarm for a short while every few weeks to check the condition of the batteries. Happy cycling!

Buy Lines

Most of the components for the Bicycle Loop Alarm are readily available. The only ones which may cause sourcing difficulties are resistors R2 and R5. These are available from Maplin as "high voltage" resistors order code V33M and V47M respectively. They are also available from Electromail as "High Ohmic" resistors order code 158-187 and 158-193. They could also be made up using 10M resistors in series as explained in the text.

PARTS LIST

Resistors

- R1 5M6
- R2 33M
- R4 10M
- R5 47M
- R6 22k

All resistor 0.25W 5% except R2 and R5 which will be as available - see text.

Capacitors

- C1 100n polyester film
- C2 22n polyester film
- C3 2m2 polyester film

All capacitors 5mm lead spacing

Semiconductors

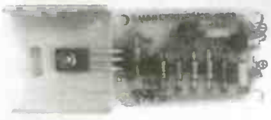
- IC1 ICM7555 CMOS timer
- TR1 MPSA14 Darlington transistor

Miscellaneous

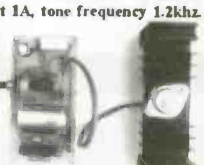
- S1 Sub-miniature lever arm microswitch
- S2 SPST key-operated switch
- WD1 Audible warning device 12V d.c. 150mA 110dB at 1m minimum.

- Aluminium box size 125 x 85 x 60 mm
- Car exhaust bracket (see text).
- Phono plugs - 2 off
- line phono sockets - 2 off.
- Extra-flexible wire, holder for 8 'AAA' cells (or two holders for 4 cells - see text)
- PP3 - type battery snap connectors - 2 off
  8 'AAA' alkaline cells
- Rubber grommet
- Stand-off insulators

A mini FM transmitter, very high gain preamp, supplied complete with FET electret microphone. Designed to cover 88-108 Mhz but it is easy to change it to cover 63-130Mhz. Works with a common 9v (PP3) battery. 0.2W RF. £8.22 Kit no 1001.



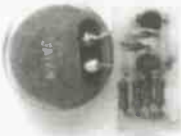
Electronic siren kit with an impressive 5 watt power output. Ideal for car/bike alarms etc. 6-12vdc, max current 1A, tone frequency 1.2khz. £7.05 Kit no 1003.



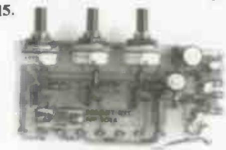
3-30v Power supply, variable, stabilized power supply for laboratory use. Shortcircuit protected, suitable for professional or amateur applications. 24v 3A transformer is also needed to complete the kit. £16.45 Kit no 1007.

Powerful 1 watt FM transmitter supplied complete with piezoelectric microphone. 8-30vdc. At 25-30v you will get nearly 2 watts!. £14.10 Kit no 1009.

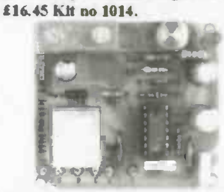
FM/AM Scanner, well not quite you have to turn the knob yourself but you will hear things on this radio (even TV) that you would not hear on an ordinary radio!. Receiver covers 50-160Mhz both AM and FM. Built in 5 watt amplifier. £17.62 Kit no 1013.



Mosquito repeller, modern way to keep midges at bay! Runs for about a month on a 1.5v battery. £8.22 Kit no 1015.



3 channel wireless sound to light system, mains operated, separate sensitivity adjustment for each channel, 1,200 watt power handling. Microphone included. £16.45 Kit no 1014.



Motorbike/cycle trembler alarm, adjustable sensitivity, preset alarm time, auto reset. Could be connected to bikes horn etc. £14.10 Kit no 1011

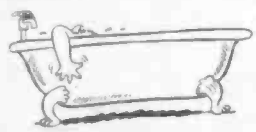
0-5 minute timer, adjustable from 0 to 5 mins, will switch up to 2A mains. Perfect for alarms, photographic laboratories etc. 12vdc. £8.22 Kit no 1020.

4 watt FM transmitter, small but powerful transmitter, 3 RF stages, microphone and an audio preamp include in kit. £23.50 Kit no 1028.

25 watt FM transmitter 4 RF stages, preamp required (our kit 1068 is suitable). Due to the complexity of the transmitter it is supplied in built up form only. £92.82 Kit no 1031.

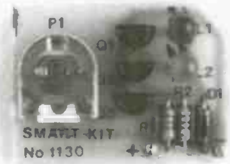
Strobe light, adjustable frequency from 1- to 60 Hz (a lot faster than conventional strobes) mains operated. £18.80 Kit no 1037.

Ultrasonic radar ideal as a movement detector with a range of about 10 metres, automate your cat flap! 12v operation so ideal for cars, caravans etc. £16.45 Kit 1049.

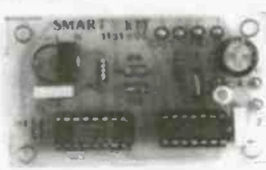


Liquid level detector useful for detecting fluid levels in tanks, fishponds, baths or as a rain or leak alarm. Will switch 2A mains. £5.87 Kit no 1081.

Combination lock 9 key, easily programmable, will switch 2A mains. Complete with keypad. 9v operation. £11.75 Kit 1114.



Phone bug detector, this device will warn you if somebody is eavesdropping on your phone line. £7.05 Kit no 1130.



Robot voice, interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £10.57 Kit no 1131.

Telephone bug, small bug powered by the telephone line, starts transmitting as soon as the handset is picked up! £9.40 Kit no 1135.

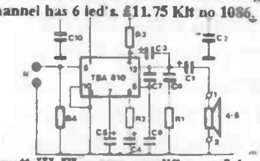
function generator, produces sinusoidal, saw tooth and square waves adjustable from 20hz-20khz, separate level controls for each shape. Will produce all 3 together. 24vac £17.62 Kit no 1008.

3 Channel light chaser, 800 watts per channel, speed and direction controls supplied with 12 leds and mains triacs, so you can use mains light bulbs if you want. 9-15vdc £19.57 Kit no 1026.

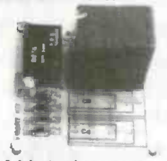
12v flourescent. A useful kit that will enable you to light 4' flourescent tubes from your car battery! (you will also need a 9v 2A transformer, not supplied) £9.40 Kit no 1069.

VOX switch, sound activated switch ideal for turning tape recorders on and off when sounds are heard. Makes the tape last a lot longer! adjustable sensitivity, built in delay. £9.40 Kit 1073.

Incar sound to light, Put some atmosphere in your car with this mini 3 channel sound to light. Each channel has 6 led's. £11.75 Kit no 1086.

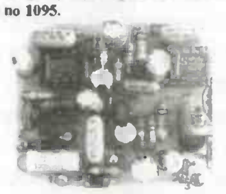


7 watt HI FI power amplifier useful, powerful, ideal for intercomms, audio systems, car use etc. 12-18vdc 500mA. £8.22 Kit No 1025.



Phone call relay, useful device that operates a relay when ever the 'phone rings, could be used to operate more bells or signalling lights etc. Will switch mains at 2A. £11.75 Kit no 1122.

Lead acid charger, two automatic charging rates, visual indication of battery state, ideal for alarm systems, emergency lighting etc. 100mA 12vdc. £14.10 Kit no 1095.



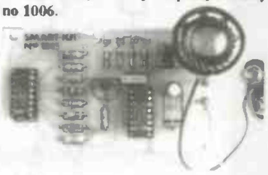
Car alarm system, works on voltage drop and/or vibration, entry and exit delays plus adjustable alarm duration. Good for cars, caravans etc. £14.10 Kit no 1019.

Portable alarm system, based on a mercury switch. The alarm continues to sound until the unit is disabled by the owner. Buzzer included. £12.92 Kit no 1150.

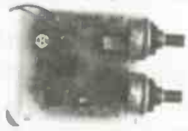
Preamp mixer, 3 input mono mixer, separate bass and treble controls plus independent level controls. 18vdc, input sens 150mv. 100mA. £17.62 Kit no 1052.

Mini metal detector, suitable for locating pipes in walls etc, range 15-20 cm, complete with case. 9v operation. £9.40 Kit no 1022.

800 watt single channel sound to light kit, mains operated, add rhythm to your party for only £9.40 Kit no 1006.



Sound effects generator, produce sounds ranging from bird chips to sirens, complete with speaker, add sound effects to your projects for just £10.57 Kit no 1045.



Guitar preamp with tone controls, small enough to fit inside any guitar, based on TL082 IC, 9-12vdc, 50mA. £9.40 Kit no 1091.

15 watt FM transmitter, 4 stage high power, preamp required. 12-18vdc. Can use either ground plane, open dipole, or Yagi. Supplied in built form only at £81.07 Kit 1021.

Telephone amplifier, Very sensitive amplifier which uses a 'phone pickup coil (supplied) will let you follow a conversation without holding the phone. £12.92 Kit no 1059.

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3. Geiger counter kit, contains everything you need to build a working counter £22.32.
4. Solar energy kit, contains a solar panel, motor, buzzer and cable for experiments £5.87.
5. Electronic accupuncture kit, may help with migrane, poor circulation, backache etc. £8.22.
6. Electrifying apparatus kit, produces a weak adjustable high tension of 80-300v from a 9v battery, ideal for catching worms etc! £9.40.
7. Adapter bug kit, contains everything you need to build a professional bug built inside a standard 13A mains adapter! the bug is mains powered so it operates all the time the adapter is plugged in. Price is £16.45 for the complete kit including adapter. H and tools and glue required.
8. Nicad charger kit automatic charger for cells from 1.2v to 15v, 7 settings 50600mA, transformer required 18-20v 600mA. £9.40.

9&10. Inverter kits, produce 240vac from a 12vdc supply, two versions are available a 15w one at £14.10, and an 80w version at £23.50.

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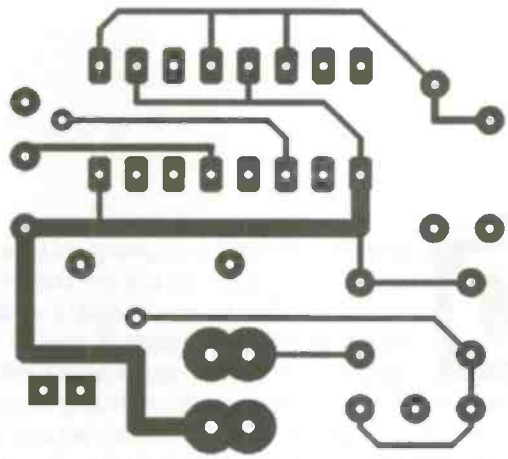

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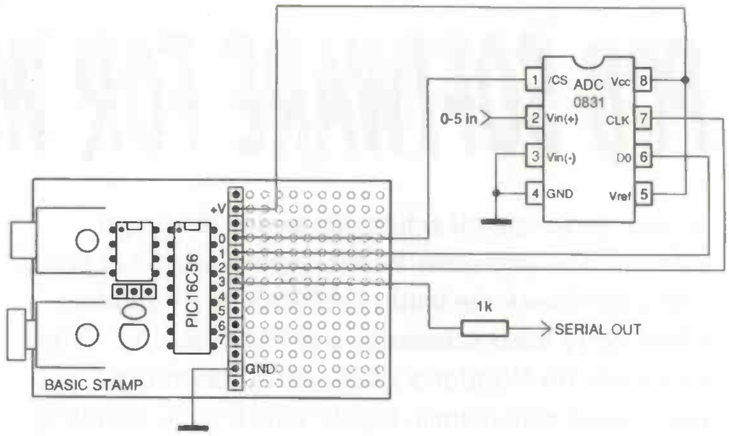
STAMP PROJECT

Using the STAMP computer to input analog signals



One of the commonest requirements in any microcontroller application is to input and process analog data. This could be simply a variable voltage signal from some other piece of equipment, or it could be the output from some sort of measurement circuit, perhaps measuring temperature, pressure, strain, pH, etc. In this short article, we look at the hardware and software required to interface an 8-bit serial analog-to-digital converter to the Parallax BASIC Stamp.

The BASIC Stamp's instruction pot performs a limited sort of analog-to-digital conversion. It lets you interface nearly any kind of resistive sensor to the Stamp with a minimum of difficulty. However, many applications call for a true voltage-mode analog-to-digital converter (ADC). One that's particularly suited to interfacing with the Stamp is the National Semiconductor ADC0831.

:Interfacing the ADC0831 requires only three input/output lines, and of these, two can be multiplexed with other functions (or additional 0831's). Only the chip-select (cs) pin requires a dedicated line. The ADC's range of input voltages is controlled by the Vref and Vin(-) pins. Vref sets the voltage at which the ADC will return a full-scale output of 255, while Vin(-) sets the voltage that will return 0.
In the example application, Vin(-) is at ground and Vref is at +5; however, these values can be as close together as 1 volt without harming the device's accuracy or linearity. You may use diode voltage references or trim pots to set these values.

How it works

he sample program reads the voltage at the 0831's input pin every 2 seconds and reports it via a 2400-baud serial connection. The subroutine conv handles the details of getting data out of the ADC. It enables the ADC by pulling the cs line low, then pulses the clock (clk) line to signal the beginning of a conversion. The program then enters a loop in which it pulses clk, gets the bit on pin ad, adds it to the received byte, and shifts the bits of the received byte to the left. Since BASIC traditionally doesn't include bit-shift operations, the program multiplies the byte by 2 to perform the shift. When all bits have been shifted into the byte, the program turns off the ADC by returning cs high. The subroutine returns with the conversion result in the variable data. The whole process takes about 20 milliseconds.

Modifications

You can add more 0831s to the circuit as follows: Connect each additional ADC to the same clock and data lines, but assign it a separate cs pin. Modify the conv subroutine to take the appropriate cs pin low when it needs to acquire data from a particular ADC. That's it.

```
' PROGRAM: AD_CONV.BAS
' BASIC Stamp program that uses the National
ADC0831 to acquire
' analog data and output it via RS-232.

Symbol       CS        =       0
Symbol       AD        =       pin1
Symbol       CLK       =       2
Symbol       S_out     =       3
Symbol       data      =       b0
Symbol       i         =       b2

setup:       let pins = 255            ' Pins high
(deselect ADC).
     let dirs = %11111101     ' S_out, CLK, CS
outputs; AD input.

loop:gosub conv                ' Get the data.
     serout S_out,N2400,(#b0,13,10) ' Send
data, CR, LF.
     pause 2000                ' Wait 2 seconds
     goto loop                 ' Do it forever.

conv:low CLK                   ' Put clock line in
starting state.
     low CS                    ' Select ADC.
     pulsout CLK, 1            ' 10 us clock
pulse.
     let data = 0              ' Clear data.
     for i = 1 to 8            ' Eight data bits.
     let data = data * 2       ' Perform shift
left.
     pulsout CLK, 1            ' 10 us clock
pulse.
     let data = data + AD      ' Put bit in LSB of
data.
     next                      ' Do it again.
     high CS                   ' Deselect ADC when
done.
     return
```

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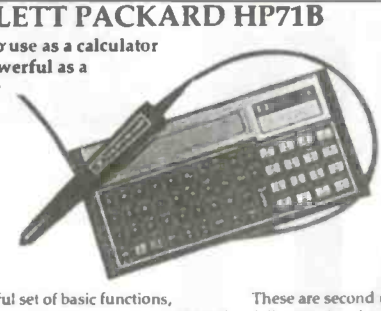

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- Advanced statistics functions enabling computations on up to 15 independent variables.
- Recursive subprograms and user defined functions.
- An advanced internal file system for storing programs and data – the HP71 has continuous memory – when you turn the computer off it retains programs and data.
- A keyboard that can be easily customised for your specific application.
- HP-1L Interface pre-installed to create a system that can print, plot, store, retrieve and display information. Control or read instruments or speak to other computers, 5000 bytes/sec. Built in ROM includes 46 separate commands. Interface to HP-1L, HP-1B, RS232C, GPIO or series 80. Includes connection cables

These are second user systems ex NHS are fully tested and working but have no programming (THAT IS UP TO YOU)

HP71B £29.95
Bar-code Reader £12.95
AC Power Supply £4.95
(Works from batteries normally)
Keyboard Overlay £1.00
(Limited quantities)
Unknown Program – Memory Modules (2 different types) £3.00
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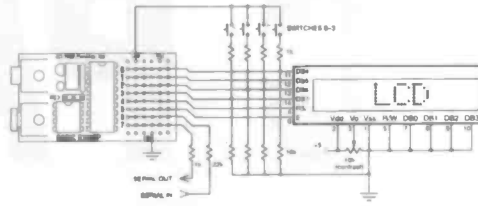
BASIC Stamp -Stamp sized Computer runs BASIC

The Basic Stamp by PARALLAX measures only 40x60mm yet is a true microcomputer that runs BASIC programmes written on your PC. Its size, ease of use and extensive I/O features make it an ideal tool for both educational and industrial applications as well as for the serious hobbyist.

Writing programmes for the Stamp is easy. A 3-pin cable connects the Stamp to your PC printer port. One piece of software is used to enter, debug and download your programme. Features include 8 I/O lines, non-volatile memory, serial comms, pulse measurement and PWM; all achieved with a minimum of external components.

Typical Application



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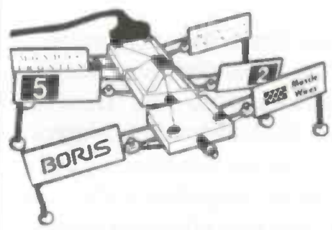

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1uf 250vdc 30p each, 20p 100+, 10p 1000+
3.3uf 100vdc 30p each, 20p 100+, 15p 1000+
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32x29x17mm case 75p each 60p 100+
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Making use of the PC PARALLEL

In this tutorial project, Stephen Smith looks at different ways in which the PC parallel port can be used to control external circuitry

When people think of interfacing to computers, visions of expensive expansion cards fitted within their PC are brought to mind. This idea of fitting cards into a machine is scary for some and impossible for others. The interface that all PCs have, as do many other types of computers, is the parallel (or centronics) printer port. You may have wondered exactly what this parallel port is capable of. This port is normally used to transfer data to a printer, a byte at a time (8 bits in parallel). The parallel printer port on PCs have 8 data bits and 9 control lines (that is 5 inputs and 4 outputs). These input and output lines are completely user definable and, as such, can have uses other than printing. The low cost of multi-I/O cards (one parallel and two serial ports for £8 or £12 with hard and floppy disk controllers) compared to dedicated digital I/O cards (up to £80 for a professional card giving 24bits of I/O) makes the parallel port very attractive to the cost conscious hobbyist.

Many copy protection dongles use the parallel port as do data transfer packages to communicate between PCs or a PC and a peripheral (e.g. tape backup or scanner). The universal nature of the parallel port has led to numerous uses as an expansion port. Analogue to digital converters, for instance, are manufactured to talk to the parallel port of a PC (e.g. the devices made by Pico Technology), and many EPROM and universal programmers use this port for data transfer and control.

The Printer Port.

The pin out of a standard 25 way D type parallel port is given in table 1. The eight data bits D0(LSB) to D7(MSB), are used to transfer the data byte to the printer. The active low Strobe is generated by the PC to indicate that the data is valid. The inputs Busy and Ack (active low) are used to tell the PC that a data transfer is welcome and data has been successfully received. PaperEnd and Error warn the PC of any errors that the printer has detected. Select selects the connected printer and SelectIn, indicates that the printer recognises that it has been selected. AutoFd advances the paper by one line while Init, when activated for more than 50ms, initialises the printer to a known state.

- When the printer is initialised and selected, data transfer is achieved by the following steps.
- Wait for Busy to go Low.
  This is the printer saying OK send me data.
- Put data onto the data lines (D0-7).
- Delay at least _ms.
- Pulse Strobe for at least _ms. PC's saying data is valid now.
- Upon receipt of Strobe the printer pulls Busy high.
- Hold the data for at least another _ms.
- Sometime after this the printer will pull Ack low for 5ms minimum.
  This is the printer saying that was OK.
- Then, when ready, the printer lowers Busy to continue the cycle.

Printer Port Handling In BIOS and DOS

IBM has defined three input/output address ranges at which parallel printer ports are recognised. This allows up to three printer ports labelled LPT1, LPT2 and LPT3. The correspondence between LPT number and the base address is defined by the PC's BIOS. Upon power up, the BIOS attempts to identify printer ports at three address ranges (3BCHex on mono display cards, 378Hex and 278Hex on input/output adapters). The BIOS tries these three in order and if a printer port is identified the base address at which it occurs is placed in a table, starting at memory address 408Hex. This table has four possible entries of 16bits each. Some software ignores this table but DOS printing uses it, so it is a good idea to use it to keep compatible. A parallel port at one of these addresses is identified by writing AAHex to the base address (therefore the data register) and reading back from the same address. If AAHex is read back the BIOS considers this to be a parallel port and puts its base address in the table. If anything connected to the parallel port (e.g. a printer that is turned off) interferes with this identification procedure the printer port may be ignored, or if another device that allows register feedback, is at a reserved address it will get incorrectly identified as a printer port.

The number of parallel ports identified is stored in the two most significant bits of the byte at memory address 411Hex. (It is confusing to note that the table has four locations but the count of ports can only go up to three.) The first parallel port is assigned to device LPT1. The second, LPT2 and the third, LPT3, if they are all present. Any ports not present are not assigned and, as such, cannot be accessed. When printing from DOS the PRN device is an alias for LPT1, although this can be changed with the use of DOS's mode command.

By swapping base addresses in the table you can swap between printer devices, as a number of printer swapping

PORT

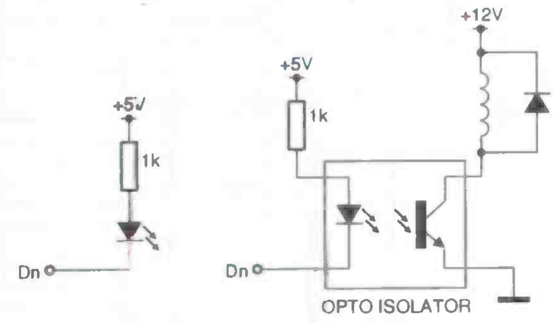


Fig.2. Optoisolator circuit for computer interface designs.

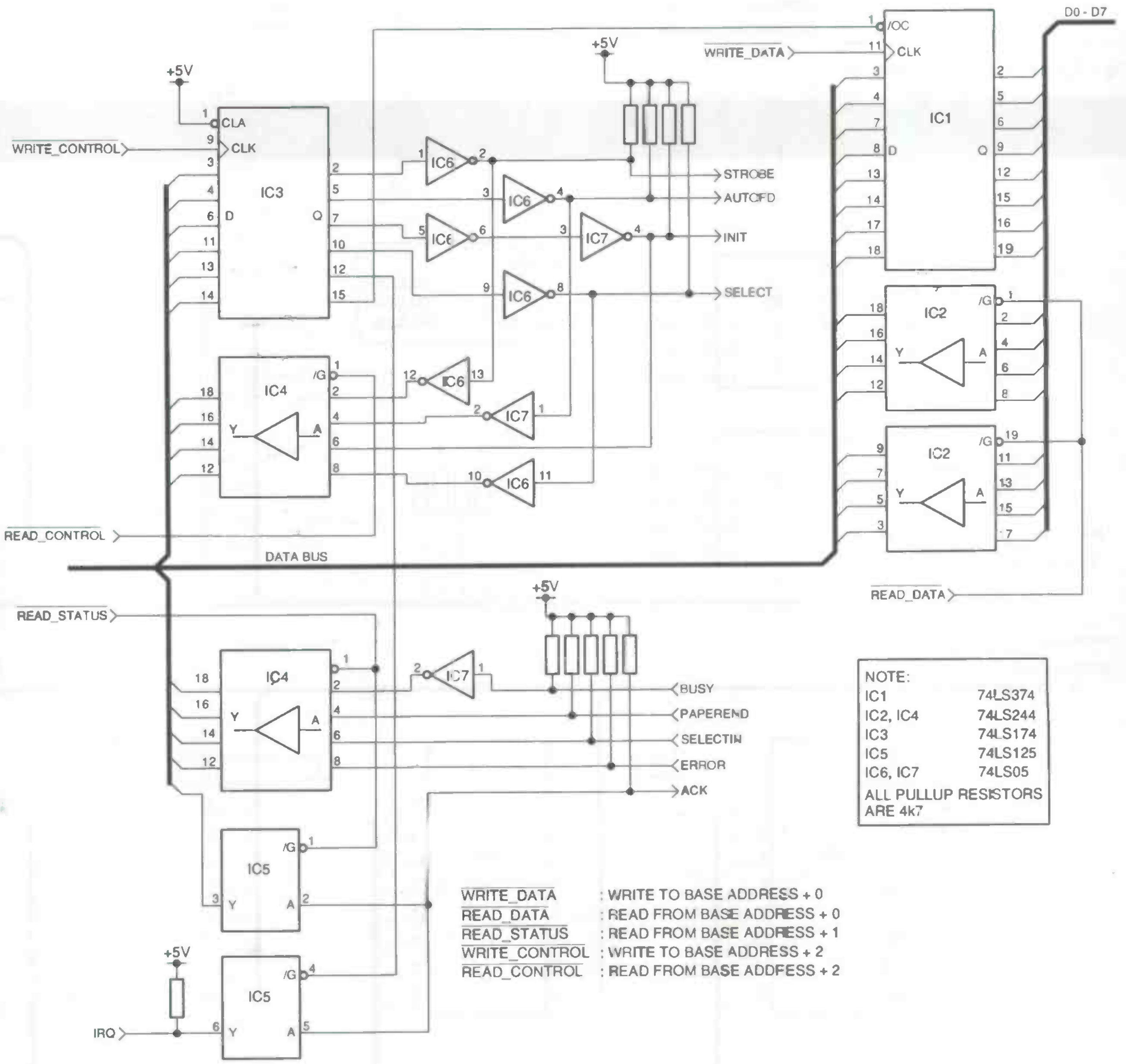


Fig.1. Generic printer port

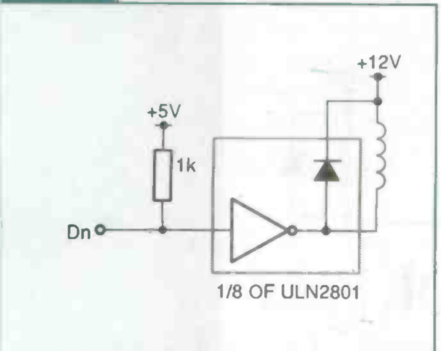


Fig.3.Driving higher voltages from a standard output port

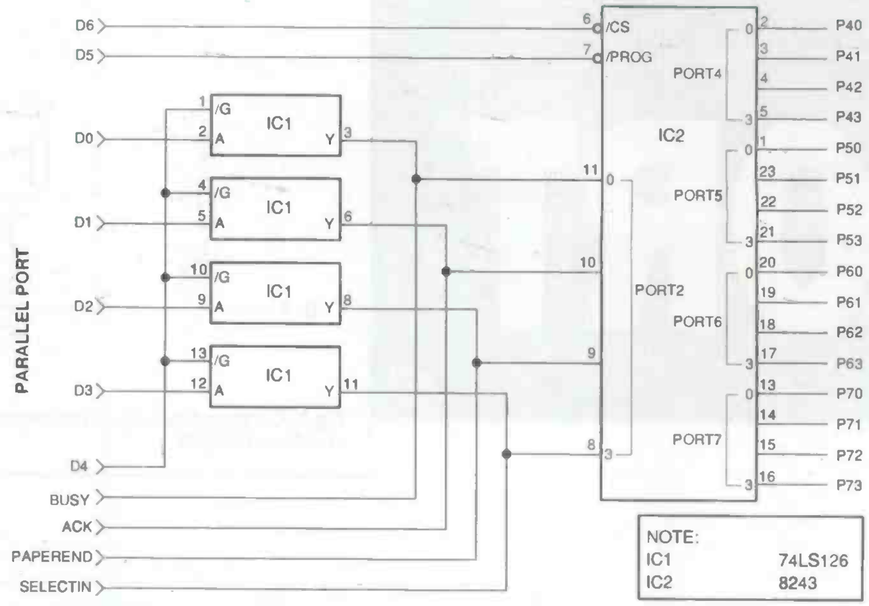


Fig.4.A 74LS based port extender

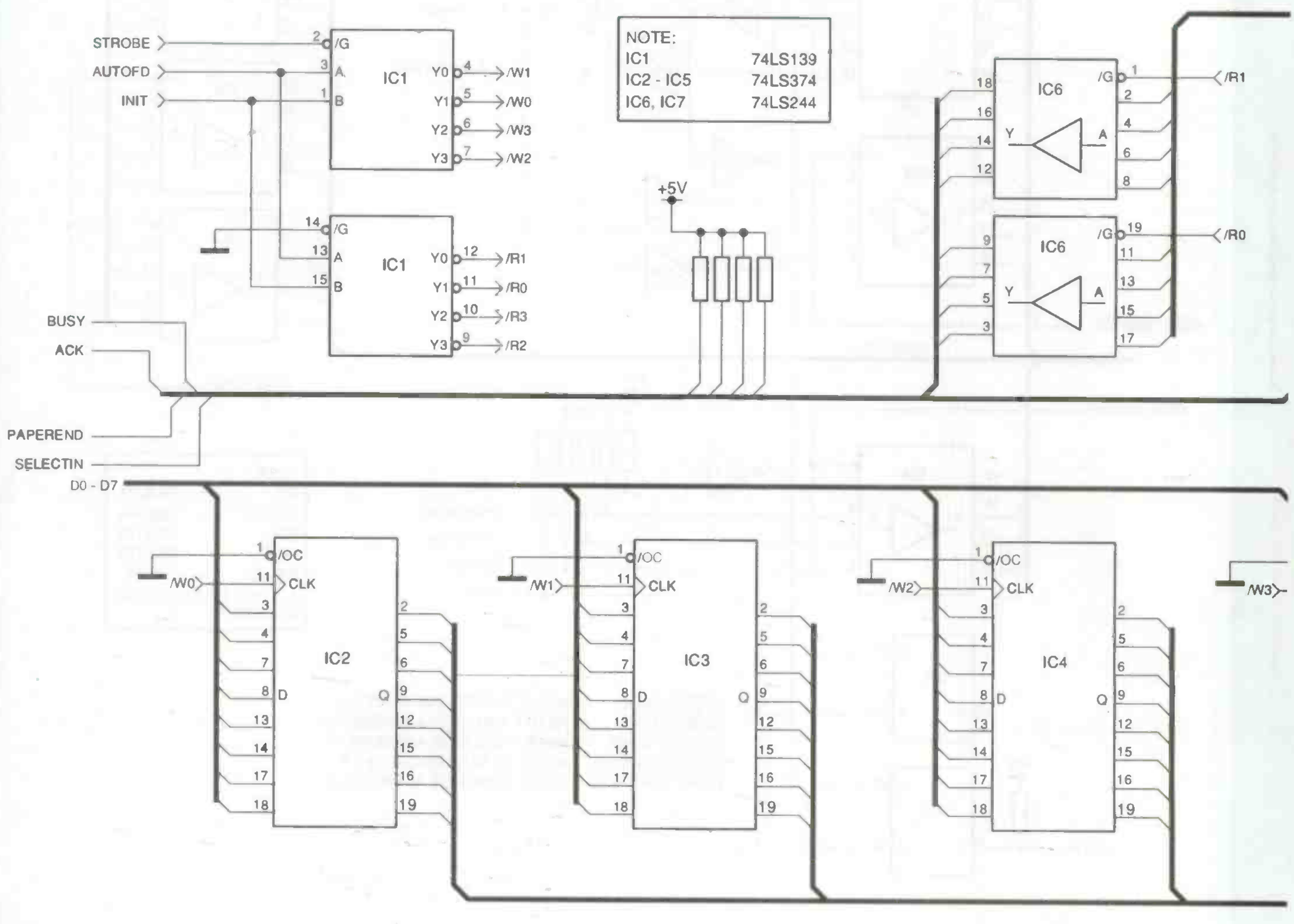


Fig.5. 8243 based port extender.

programs do. Beware, 400Hex to 407Hex is used to store the base addresses of the PC's COM ports (the serial ports), some serial port software supports more than four COM ports and can overwrite the parallel port base addresses. This is rare, but beware. Just to recap, table 2 shows the allocation of LPT's. Note that MDA is Monochrome Display Adapter.

Programming

When printing, DOS handles the allocation of printing devices to address (see above), but when using the parallel port as input or output, the programmer needs to know which address the LPT device is assigned to. Listing 1 gives a piece of code to find the Base Address of a port from its device number (1-3). This, like the other programming examples given here, is written in QBasic as supplied with MS-DOS 5.0 and subsequent versions. This listing turns the LPT number into an address in the look up table, then reads the Base Address of the port from the memory location calculated. From this Base Address, the addresses of the Data Register, Status register and Control Register are derived.

INT17

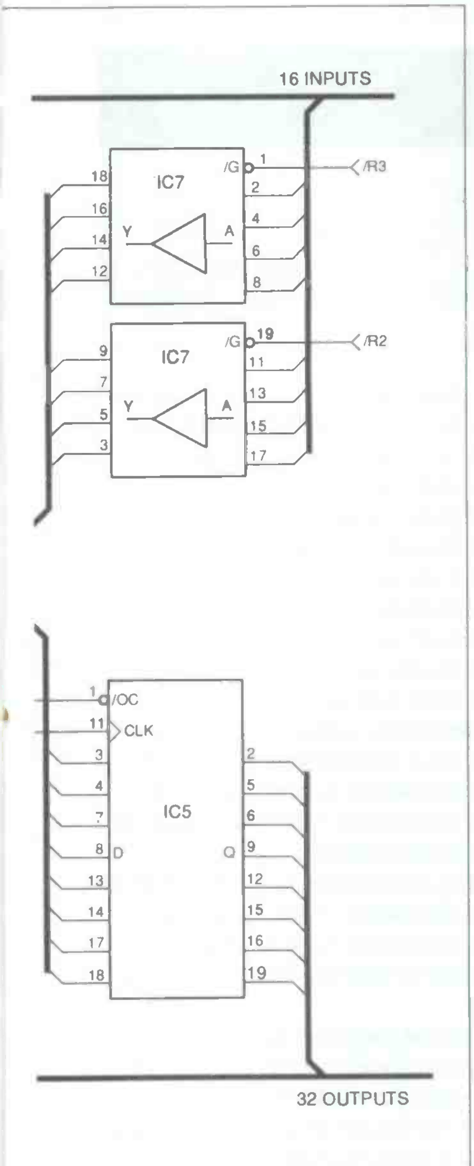
The PC's BIOS initialises both the hardware and the base address look up table as described above, The BIOS supports printing with INT17 (which is used by INT5, the print screen function). This is called with the required set up in specific registers of the micro-processor. The index of the parallel port in the base address look up table is put in DX. This is 0-3 representing LPT1-4. (Yes, you can access the fourth in the list here, but exactly what happens is BIOS dependent.) The byte to be sent to the printer is put in AL if necessary. AH is given a value of 0, 1 or 2.

AH=0 Printer character in AL.

AH=1 Initialises the port, returns the status in AH.

AH=2 Return the status in AH.

The status returned is the state of the five inputs (the highest five bits of the byte, see table 4 for the bit allocations) and the LSB is set if a time-out has occurred.



Interrupts

The MDA parallel port and that at 378Hex are allocated IRQ7, and the port at 278Hex is allocated IRQ5. The idea behind this was to generate an interrupt upon the Ack signal from the printer. This then can tell a printer driver to send its next byte. Unfortunately, this is rarely possible and is very infrequently used. IRQ5 and 7 are consequently considered free, and so are used by various other cards, e.g. network or sound cards. IRQs are used by some other operating systems and some parallel port data transfer systems.

A Typical Printer Port

Figure 1, shows a generic parallel port. The data bits are latched together by a write to base address + 0 (see tables 3 and 4 for register addresses and bit assignments) and can be read back at the same address. These and the other output may have capacitors to ground to remove fast transients. The control outputs are latched and inverted by open collector inverters, except Init which is inverted twice to maintain the same polarity. Each of these outputs are pulled up with 4K7 resistors. These bits can be read back (with the same polarity as they were written) as they too are buffered at the same address. The status of the printer can be read from the port by the five inputs, of which only Busy is inverted. Two of the other bits of the control register are also used. The first (bit 4 of the control register) enables the interrupt, passing the Ack signal to the buses appropriate IRQ line. The other (bit 5 of the control register) is only used in bi-directional parallel ports to enable or disable the eight data lines.

Bi-directional Parallel Ports

The output latch used to handle the eight data bits has an output enable control which is, in the original IBM PC, tied to ground to permanently enable the outputs. As mentioned above this output enable can be controlled by bit 5 of the control register, allowing software to control this output enable. Tri-stating the output, creates an input only port. This was first introduced on IBM's PS2 systems, but the original IBM PC could be converted to this as all the required hardware is present; only the output enable connection needs to be made. This suggests that IBM considered the bi-directional port initially and abandoned it. This control over the direction of data transfer allows a greater degree of communication with the printer and a wide variety of other uses. The ability to send or receive a byte of data creates a range of data transfer applications between two PCs or a PC and a peripheral. (See communications below.)

Dongles

One of the non-printer uses of parallel ports are to talk to copy protection dongles. These devices sit between the PC's parallel port and the printer, monitoring the data being sent out. They usually only process data when the Strobe is high, therefore ignoring printed data allowing the printer to work in conjunction with the dongle. Dongles tend to be powered from the parallel port's data and control lines through a couple of diodes to sum the current from several outputs. When more than a milliamp or so is pulled from an output, its voltage can drop significantly. These outputs are guaranteed to source current up to 2.6mA, but also the voltage is within the range of 5-2.4V. This is officially a definite no-no, but it does work if you are careful.

Communications

The idea of transferring data to/from your PC in a high speed parallel form is very attractive, because it can provide an efficient means of data transfer at a very low cost. Many commercial packages, such as LapLink or MS-DOS's interlnk,

Table 1
Parallel port pin out and signal details

Pin No.	Name	Active High/Low	Input/Output
1	Strobe	Low	Output
2	D0 (LSB)	High	Output
3	D1	High	Output
4	D2	High	Output
5	D3	High	Output
6	D4	High	Output
7	D5	High	Output
8	D6	High	Output
9	D7 (MSB)	High	Output
10	Ack	Low	Input
11	Busy	High	Input
12	PaperEnd	High	Input
13	SelectIn	High	Input
14	AutoFd	Low	Output
15	Error	Low	Input
16	Init	Low	Output
17	Select	Low	Output
18-25	Ground	-	-

Table 4
Bit definitions within the registers

Bit No.	7	6	5	4	3	2	1	0
Data Register	D7	D6	D5	D4	D3	D2	D1	D0
Status Register	Busy	Ack	Paper End	Select In	Error	-	-	-
Control Register	-	-	Output Enable	IRQ Enable	Select	Init	AutoFd	Strobe

can use the parallel port for file transfer between PCs. A number of storage systems, such as hard disks, floppy disks, CD-ROMs and tape back-up systems use the parallel port for data transfer as an alternative to dedicated interfaces. These systems tend to be more expensive than their dedicated counterparts and have significantly lower data transfer rates. Nevertheless, these systems are easy to connect and transport (i.e. to use on different machines) and can be invaluable to portable computer users.

Table 5 gives the connections for a nibble mode data transfer cable. The use of bi-directional ports or the misuse of the open collector outputs can give the user byte transfers, but these methods are not universally compatible or safe. The use of the lower half of the data bits and status lines to transfer data a nibble at a time is slower, but works reliably. Data bit 3 and Error are used to perform handshaking between systems. Just a warning; the D7 bit is inverted in transfer into the Busy line.

User Input/Output

When not in use for printing, the parallel port is ideal for the hobbyist to perform simple input or output tasks. Any of the status inputs could be used to read the status of a switch or other digital signal. As all the inputs are pulled up internally, a switch only needs to pull the input to ground when activated. Relying upon the internal pull ups may prove to be temperamental in some cases so, if this is the case, use external pull ups to 5V. The control outputs are implemented with open collector outputs. These, when outputting a logic low pull the output to a low level. But when outputting a logic high the output goes high impedance, being pulled up by 4K7 resistors to 5V, and can be pulled low by external events. So if the outputs are forced to a logical 1, they can be mis-used as inputs, with internal pull ups, through the register feedback buffers. This does work, but is not recommended as it abuses the outputs and some multi-I/O cards do not correctly implement the control outputs with open collector outputs.

B:Using the digital outputs of the parallel port to drive digital systems, such as an ADC or DAC, is simply done but it is a good idea to pull up the inputs to your system to guarantee the logic levels provided by the output. Examples of this form of control include a PC based controller for a model railway and access to devices over the I2C serial bus. The data outputs, as stated earlier, can only source 2.6mA (Max.) and this is only guaranteed for one output. You cannot hope to pull that from all the outputs without damaging the device. Powering projects from the parallel port is, as stated earlier, not advisable so an external power supply is needed for example take 5V from the Games Port (Pin 8).

Figure 2a shows how a LEDcan be controlled by a data output. These outputs can sink up to 24mA each and as such can be more useful than sourcing current. So you think, "Ok I can create a pretty light show with my PC. So what?" Opto isolators are just a LED driven to cause a photo-transistor to conduct.

Figure 2b shows how an opto isolator can be used to drive a relay. Once you can get a LED to flash, any other I/O is only a small step further on. Non-isolated relay control is easy to achieve, as in figure 3, by using a Darlington driver, such as the ULN2801.

Port Extenders

The main reason people buy or build a digital Input/output card for their PC, is because they require more inputs or outputs than the parallel port can offer. This is where port extenders come in. They multiplex the inputs and outputs available on the parallel port to provide a more useful number of inputs and outputs (see ETI November '94 for such a project based upon shift registers). Figure 4 gives an example of how to provide up to 16 inputs and 32 outputs with a relatively low chip count (7 chips in fact). Replacing the 74LS139 with two 74LS138's can double the number of I/O bits available (use Select as the next input of the 74LS138). This circuit latches the data into one of the external latches by putting the data into the data register and setting the control register to select the appropriate external register. The Strobe signal is then pulsed low to latch the data. The inputs are multiplexed, in banks, onto the status lines controlled by the same control lines as the outputs.

Listing 2 shows how the discrete port extender is programmed. This code sends a Byte to the specified expanded port and then reads in a nibble from the separately defined expanded input. This nibble is processed to present it in the lower half of a byte, with the correct logic levels.

Figure 5 shows an I/O expander based upon the 8243. This chip is an I/O expander designed for use with the 8048 family of micro-controllers. It communicates via a four bit data bus and a few control signals. Data bits D0-3 are used to send data to the 8243 through the 74LS126. This data buffer allows these bits to be disabled and data from the 8243 to be read in to the PC on the status lines. The 8243 provides four, four bit I/O ports (16 bits altogether).

To talk to the 8243 an instruction is given to the data bus (D0-3) and the Prog line is taken from high to low (all this while CS is low of course). If the instruction is a write, the appropriate data nibble is placed on the bus and the Prog line taken high again. If a read instruction is used, the 74LS126 is disabled to allow data to be output by the 8243 without conflict and then the data is read into the PC. A port on the 8243 is considered to be an input port if it has had a read instruction directed towards it. This means that a dummy read of any input port is required to set up the port before use. Also you cannot read back the status of an output, as it will be converted to an input by the read.

If 16 I/O lines are not enough for you, it is possible to use a number of 8243's with a different chip select (e.g. use D7 or D6 and D7 via a 74LS139). This is not shown diagramatically or in the example program, but should not prove difficult for the experienced hobbyist. Listing 3 shows an example programming for this form of port extender.

One note on compatibility with printing; it is a good idea to store the contents of the control register on start up, before it is corrupted by your program, and then restore this value to the control register when the program ends. This ensures that the correct configuration is present to allow printing to take place after your program has run.

WARNING

Do not connect any externally powered circuit to your parallel port unless you have checked and double checked your work. Use current limiting resistors (10K) in series with the signals if possible.

It is important to note that modern PCs have their parallel ports on the same small piece of silicon as the serial ports and floppy, hard disk controllers. So, electrically, the parallel port is very close to expensive parts of your system, like the motherboard and hard disk. Damage to the parallel port puts these expensive parts in danger. Please do not let this deter

Table 5
Nibble mode transfer cable as used for MS-DOS interlnk

Machine 1	Machine 2
D4 (6)	Busy (11)*
D3 (5)	Ack (10)
D2 (4)	Paper End (12)
D1 (3)	Select In (13)
D0 (2)	Error (15)
Busy (11)*	D4 (6)
Ack (10)	D3 (5)
Paper End (12)	D2 (4)
Select In (13)	D1 (3)
Error (15)	D0 (2)
GND (25)	GND (25)

*** Note that Busy is inverted**

Table 2
Base addresses for each LPT device

	MDA Present	No MDA Present
LPT1	3BCHex	378Hex
LPT2	378Hex	278Hex
LPT3	278Hex	N/A

Table 3
Register definitions

Name	Read and/or Write	Location
Data Register	Read and Write	Base Address
Control Register	Read and Write	Base Address + 2
Status Register	Read Only	Base Address + 1

you, just be careful. The electrical parameters given in this article are correct for the original IBM parallel port, implemented using discrete 74LS technology. Modern ASIC implementations of the parallel port may not conform to these specifications, but can sink reasonable current to drive LEDs, etc.

The circuits and systems presented here are not intended to be full projects and, as such, no PCB or other support is available. These have been devised only as examples and ideas to inform you and invoke your imagination. The parallel port is an easy and universal way to interface to your PC, so have fun experimenting.

Listing 1

```
REM This code shows how to read the base address
        of a LPT port
REM from the installed devices table.
REM Set PORT equal to the LPT port number 1,2 or 3
REM TableStart is the start of the base address
        lookup table.
REM The SEG is defined to access the bottom
        segment.
REM Then MemoryAddress is calculated from the
        port number and start of table.
REM This location is read and the word is put
        together from two bytes.
REM Using the BaseAddress from the table the
        registers addresses are found.
REM Data Register is at the Base Address itself.
REM Status Register is the second location (
        BaseAddress + 1 ).
REM Control Register is next ( BaseAddress + 2 ).
PORT = 1
TableStart = &H408
DEF SEG = 0
MemoryAddress = TableStart + 2 * (PORT - 1)
BaseAddress = PEEK(MemoryAddress) +
        (PEEK(MemoryAddress + 1) * 256)
DataRegister = BaseAddress + 0
StatusRegister = BaseAddress + 1
ControlRegister = BaseAddress + 2
PRINT "The base address for LPT"; PORT; "is ";
HEX$(BaseAddress); "Hex"
```

Listing 2

```
REM Example of how to write to the Discrete Port
        Expander.
REM Set number of expansion port in ExpPort.
REM Set Byte to the data to be sent.
REM Put this data on to the data bits D0-7 (
        DataRegister ).
REM Define the port number onto the appropriate
        bits of the Control Register
REM Pull Strobe low to latch the data on to the
        defined expansion port.
REM Strobe goes High again and the data is
        latched.
ExpPort = 0
Byte = &H55
OUT DataRegister, Byte
OUT ControlRegister, ExpPort * 2
OUT ControlRegister, 1 + (ExpPort * 2)
OUT ControlRegister, ExpPort * 2
REM To Read from the Discrete Port Expander.
REM Set ExpInput to the number of the expansion
        input port
REM Put this Input port's address on the Control
        Register
REM Read the data in
REM Then invert Busy bit and shift data down by
        four bits.
ExpInput = 1
OUT ControlRegister, ExpInput * 2
DataIn = INP(StatusRegister)
DataIn = (DataIn XOR 128) / 16
```

Listing 3

```
REM To Talk to the 8243 Based Port Expander.
REM Some consts required to drive 8243, common to
        Write and Read.
CONST CS = &H40
CONST PROG = &H20
CONST OE = &H10
REM Write to 8243 Port Expander.
REM PORT = number of the port to write to; 4,5,6
        or 7.
REM Nibble = four bits to send.
REM Give instruction which is the same as PORT
        number for Writes.
REM Take Prog low.
REM Put the Nibble of data on Port 2
REM Take Prog High again to end write cycle.
REM Put the Chip Select for the 8243 High at the
        end.
PORT = 4
Nibble = 14
OUT DataRegister, PORT + PROG + OE
OUT DataRegister, PORT + OE
OUT DataRegister, Nibble + OE
OUT DataRegister, Nibble + PROG + OE
OUT DataRegister, Nibble + PROG + OE + CS
REM To Read from the 8243 first send instruction.
REM That instruction is the PORT number with bit
        2 reset.
REM Take Prog Low to indicate instruction on bus.
REM Put OE Low, so data can be read in.
REM Read in the data.
REM Manipulate Nibble so it contains the data
        with correct polarity.
REM Take CS High at the end.
PORT = 5
OUT DataRegister, (PORT AND 3) + PROG + OE
OUT DataRegister, (PORT AND 3) + OE
OUT DataRegister, 0: REM i.e. disable OE with PROG
LOW
Nibble = (INP(StatusRegister) XOR &H80) / 16
OUT DataRegister, PROG + CS + OE
```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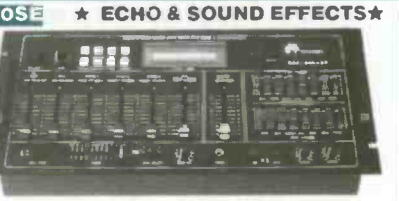

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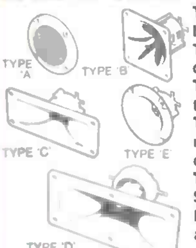

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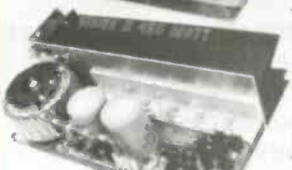

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Uncovering SECRETS

Douglas Clarkson looks at the forthcoming NASA European Space Agency probe to Saturn - the Cassini Mission

The exploration of the Solar System beyond Mars by unmanned craft could well be described as now being in its 'third' phase. During phase one the Pioneer craft such as Pioneer 11 in 1979 in its flight towards the outer reaches of the solar system, valuable information was obtained which was used to design and direct the Voyager satellites I and II some ten years later.

The extensive data of the Voyager craft in turn allowed specific missions to be designed such as the Galileo mission for Jupiter and the Cassini Mission for Saturn. While the Galileo craft is due to encounter Jupiter this year, the Cassini mission has still some way to go before launch.

While Saturn is even farther away from us than Jupiter and may be expected to present a cold and utterly barren environment, scientists have long been curious about Titan, Saturn's largest moon. Titan is large enough to support and retain an atmosphere, although the gases present are quite unlike those at present in our own atmosphere. A key part of the Cassini mission to Saturn will involve the launching of aprobe through Titan's atmosphere in order to sample its composition. This Huygens probe is also designed to send back any images it may capture during its descent or from its surface if a landing is successfully achieved.

Figure 1 shows the large planet as imaged by Voyager 2 from a distance of 13 million miles. The three small white dots at the base of the picture are the moons Tethys, Dione and Rhea. Saturn is widely accepted as the most beautiful planet in the Solar System.

Saturn's secrets: Early observations

After first having observed the rings of Saturn in 1610, though without appreciating what they were, Galileo Galilei was even more astonished in 1612 when the feature apparently vanished. It was however, the Dutch scientist Christian Huygens, who, with the benefit of better optics around 1655, was able to identify the feature as a set of rings around the planet. As Saturn orbits round the sun every 29.5 years and the axis of rotation of the planet (rings included) is inclined at 20 degrees, so on occasion when viewed from earth the rings can appear to vanish. Huygens also discovered the largest moon, Titan.

During subsequent observations, the French-Italian astronomer Jean-Dominique Cassini was able to identify the additional moons of Iapetus, Rhea, Tethys and Dione. In addition, in 1675, Cassini discovered that the rings of Saturn are divided by a narrow gap - termed the Cassini division. Thus, while Galileo and Huygens were involved in important stages in discovering the first of Saturn's secrets, it was Cassini who through much patient observation added considerably to the knowledge of Saturn and her attendant moons and rings.

Saturn: Facts and figures

The four giant gaseous planets of the Solar System, Jupiter, Saturn, Uranus and Neptune form a family with shared characteristics. Saturn is nearly ten times the diameter of the Earth and its volume would enclose 815 Earths. Its density, however, is less than that of water. The orbit of Saturn is perturbed somewhat by the attraction of Jupiter and as a result the distance of Saturn from the sun varies between 9.0 Astronomical Units (AU) and 10.1 AU. The surface gravity of Saturn is 1.16 of that of the earth.

The relatively great distance of Saturn from the sun results in the planet receiving about 1/100th of the amount of incident sunlight as does the earth. In contrast to most earth orbit satellites which can utilise solar energy from silicon cells, Saturn-bound probes need to carry their own on board power sources.

The axis of Saturn is inclined at 26 degrees to the horizontal

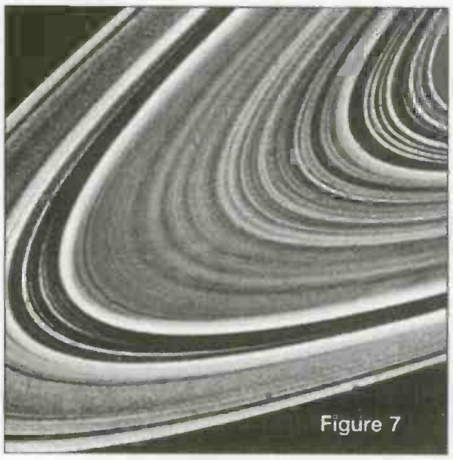


Figure 7

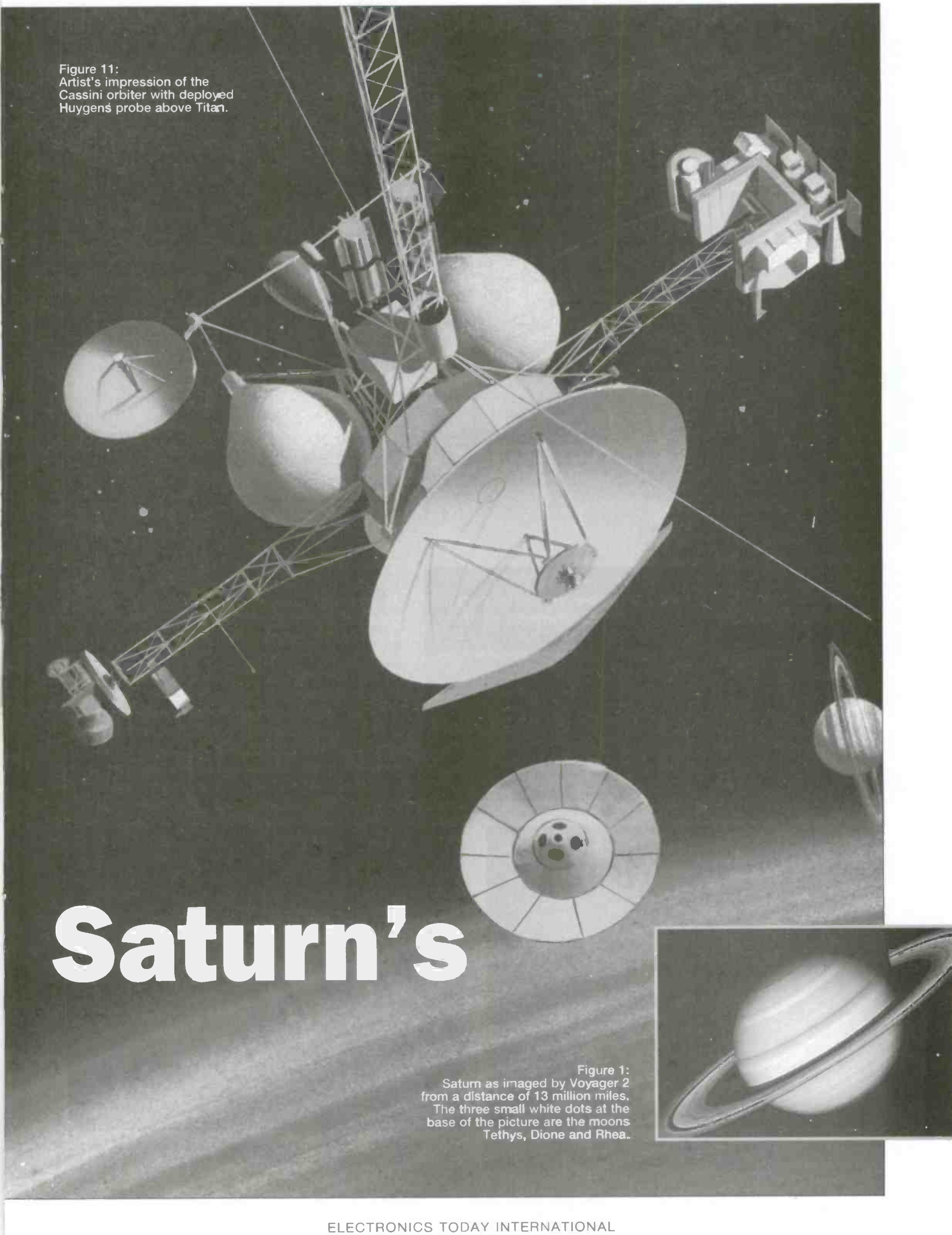


Figure 11:
Artist's impression of the Cassini orbiter with deployed Huygens probe above Titan.

Saturn's

Figure 1:
Saturn as imaged by Voyager 2 from a distance of 13 million miles. The three small white dots at the base of the picture are the moons Tethys, Dione and Rhea.

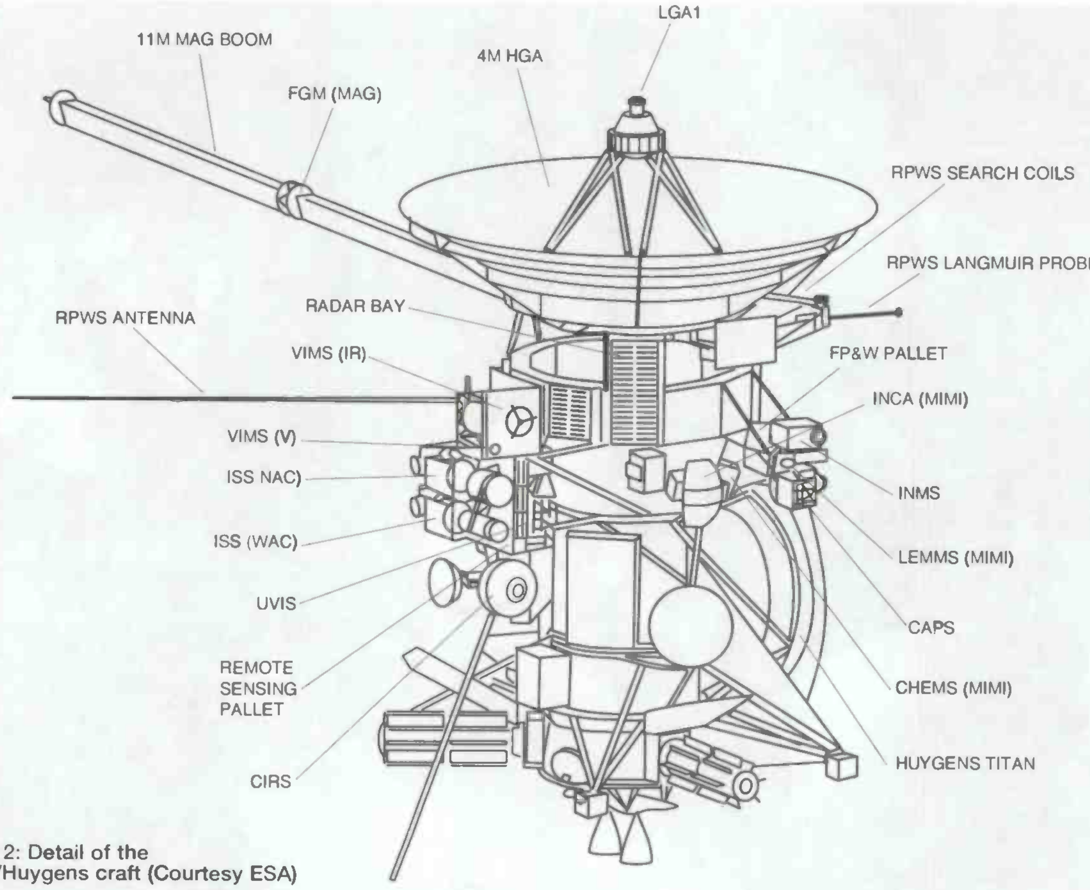


Figure 12: Detail of the Cassini/Huygens craft (Courtesy ESA)

Table 1: Relationship between escape velocity and atmospheric status of various planets of the solar system.

Planet	Escape velocity (km/sec)	Atmospheric Status
Mercury	4.25	NONE
Earth	11.2	YES
Mars	5.02	NONE
Jupiter	59.5	YES
Saturn	32.26	YES

- even greater than Earth's inclination of 23.5 degrees. The Saturn day is 10 hours and 40 minutes and the Saturn year 29.5 'Earth' years.

Saturn is a large planet - its equatorial radius is 60,330 miles. In many ways, the structure of Saturn and its associated planets has been determined by the sheer mass of material which has generated a gravitational field strong enough to retain the lightest elements, Hydrogen and Helium, in its atmosphere and also in liquid and solid forms at depth within the fabric of the planet. If the total mass of Saturn had been below a critical value then it would gradually have lost first its mass of Hydrogen and then its mass

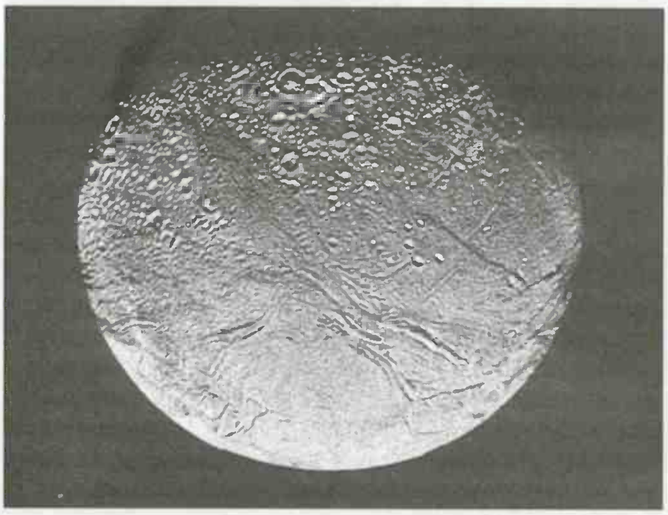


Figure 3: Image of Enceladus taken from a distance of 74,000 miles by Voyager II. There appears to be areas of recent ice melting.

Figure 4: Image of Iapetus taken by Voyager II, revealing sharply contrasting colour details of the surface.

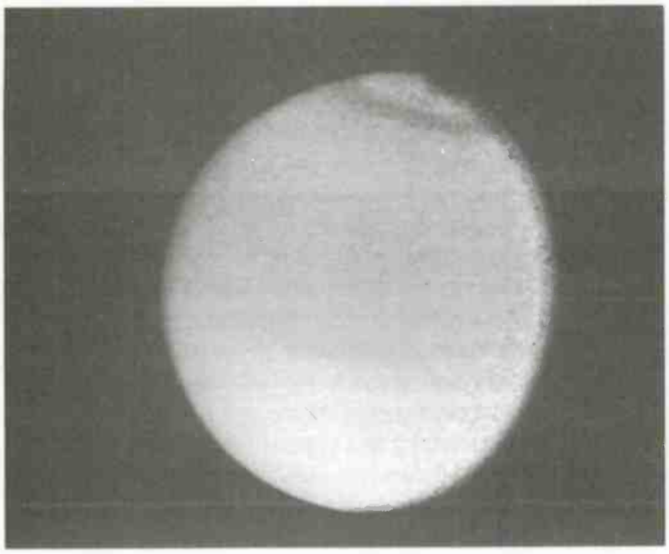


Figure 5: Details of Titan taken by Voyager 2 in 1981.

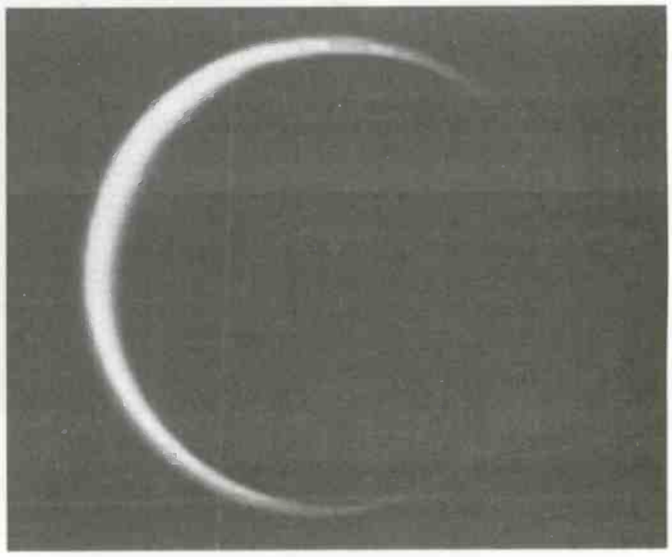


Figure 6: Picture of Titan taken by Voyager II which reveals details of the moon's thick atmosphere.

of Helium as the associated gas molecules attained sufficient velocity to escape from Saturn's gravity and venture out into space

Table 1 indicates the escape velocity of a range of planets in the solar system with details of atmospheric status.

Saturn is considered to have a rocky core of probably the same size of the Earth but contains material around three times as dense. With increasing depth beneath the top of the cloud layers, both the temperature and the pressure within the atmosphere increases. Hydrogen in a metallic state is considered to start to exist at a depth of 32000km beneath the clouds at a level where the temperature is 9000K.The temperature at the cloud tops of Saturn is estimated to be -180C.

Saturn's magnetic field was discovered by Pioneer 11 in 1979. This field, which is around 1000 times greater than that of the Earth, has a significant influence in the interaction of Saturn with the Solar Wind - the stream of charged particles streaming out from the sun. The area within this field - the magnetosphere is a key factor in atmospheric chemistry for Saturn's and also Titan. The interaction of Saturn's magnetic field with high energy cosmic rays of charged Hydrogen nuclei (protons) renders part of Saturn's surface relatively free of cosmic ray radiation.

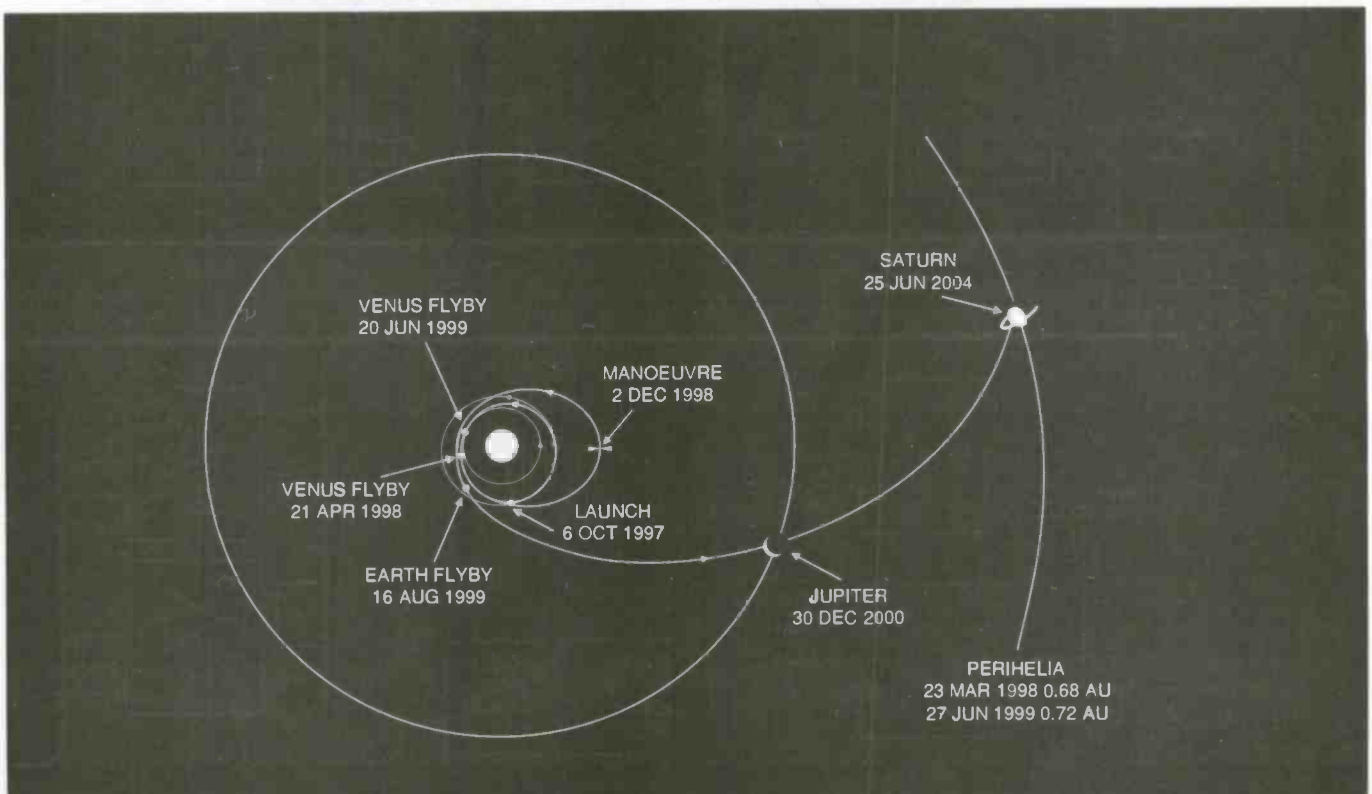


Figure 9. details of the interplanetary trajectory of the Cassini/Huygens spacecraft (Courtesy ESA)

Figure 8: Details in Saturn's northern hemisphere cloud structures. (Slide P-23922) (Courtesy NASA)

Saturn's moons

One of the major attractions of Saturn is that it has the most extensive set of moons of any planet in the solar system. Over 20 have been identified. Table 2 summarises the principal moons of Saturn.

The Voyager missions in their transit past Saturn and its moons made various surprising discoveries. Figure 2 shows a montage of the Saturnian system taken from images from Voyager 1 during November 1980. In the upper left is Rhea with Enceladus below, just above Dione. Ringed Saturn is above Dione; Tethys and Mimas with its large impact crater are to the lower right. Titan is in the upper right.

The moon Enceladus, shown in figure 3, while covered with ice, displays abnormally smooth areas with the absence of craters as if there have been episodes of melting over parts of its surface. Stranger still is the object Iapetus as shown in figure 4. One of its faces is exceedingly bright while its leading side is exceedingly dark - consisting possibly of areas of organic, carbon-based material.

Titan, however, remains Saturn's biggest secret. Figure 5 shows details of the shrouded moon taken by Voyager 2 in 1981 from a distance of 1.4 million miles. Titan lies hidden beneath an opaque atmosphere more than 50% denser than that of the Earth. Nitrogen is probably the principal component of Titan's atmosphere. Methane (a few percent) and Hydrogen (0.2%) are likely present. There may also be a high percentage of Argon - as high as 20% - though this will need to be confirmed by direct atmospheric sampling. Figure 6 indicates a picture of Titan taken by Voyager II which reveals details of the moon's thick atmosphere. Scientists have observed a brownish orange haze in Titan's atmosphere which is considered to originate from complex organic molecules. This is considered to result from photolysis of methane caused by solar ultraviolet radiation, cosmic rays and particles travelling within the magnetosphere of Saturn.

Titan is of very high scientific interest since it may hold vital clues to the initial development of the earth's atmosphere from 4.5 billion years ago to its present condition and also to the development of the early building blocks necessary for the evolution of organic carbon-based life forms. Scientists have made a range of speculations about conditions on Titan. These range from an interesting but lifeless terrain to the possibility of lifeforms existing in covered lakes of liquid hydrocarbons warmed by the planet's internal heat. It will be quite some time, however, before such scientific curiosity is satisfied.

Seen in context, however, Titan could easily have existed in the Solar System as an individual planet such as Mars or Mercury. Therefore, rather than having to voyage to distant star systems in the hope of finding 'interesting' planets or moons, Titan is one in our own backyard.

The Rings

The Voyager mission provided a wealth of information about Saturn's rings and, while some old problems were solved, new ones were created. Figure 7 shows details of the ring structure taken by Voyager II. The earth observation based convention of banding the rings as A, B, C and D from the outside towards the centre considerably oversimplifies the fine detail observed by the Voyagers. Fine structured rings are observed also to be present in the Cassini division. The material within the rings of Saturn range from sub microscopic dust to lumps of ice the size of houses. The rings are dense

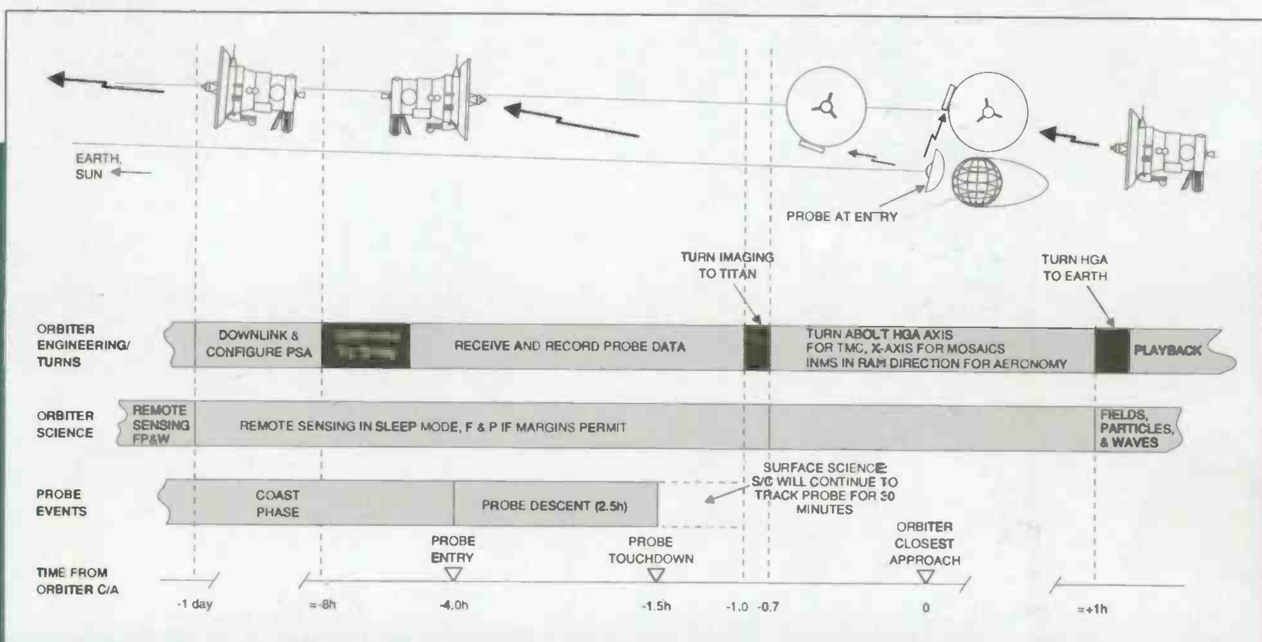
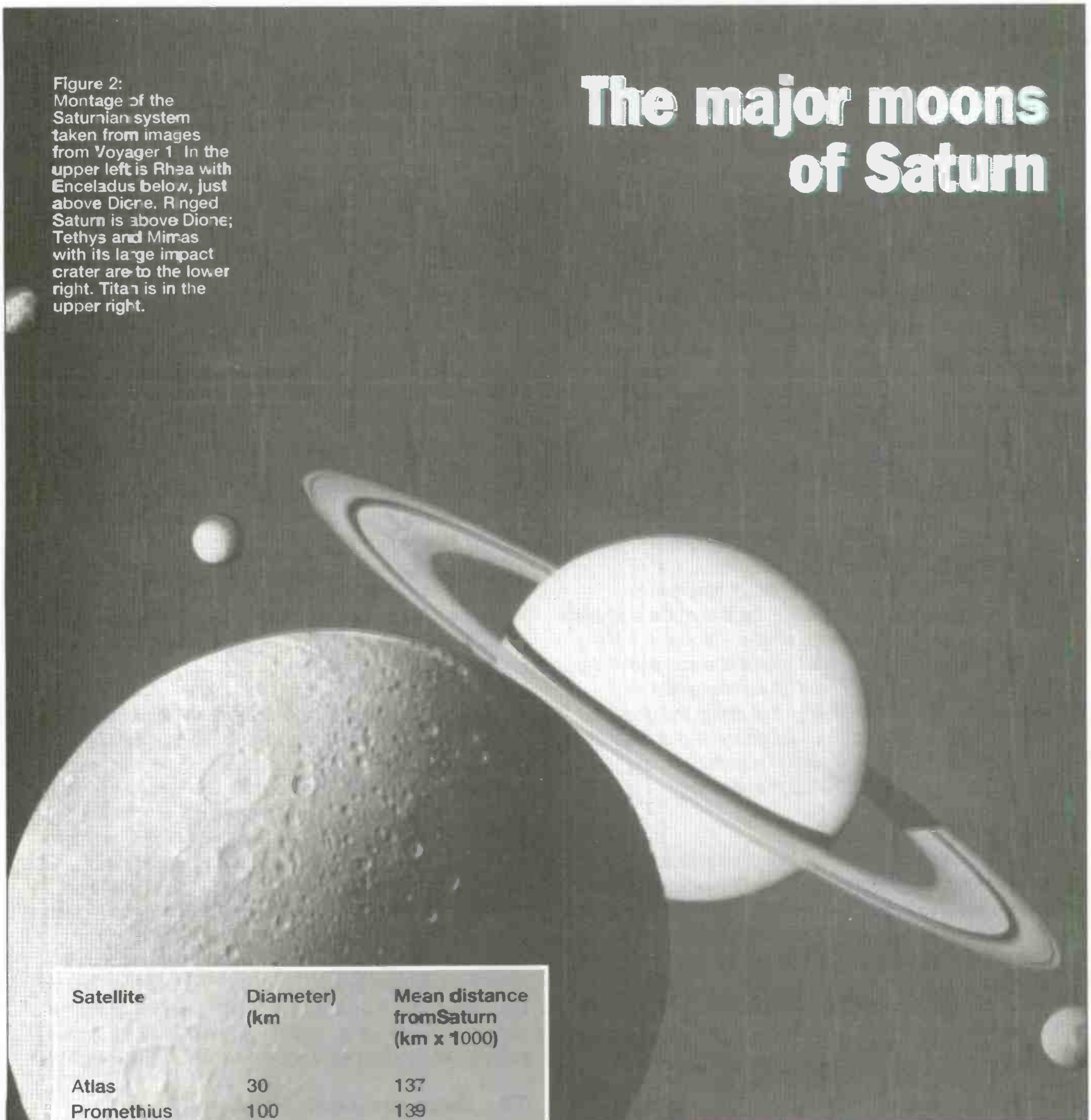


Figure 14: Data capture and relay of Huygens probe data by the Cassini orbiter. (Courtesy ESA)



The major moons of Saturn

Figure 2: Montage of the Saturnian system taken from images from Voyager 1. In the upper left is Rhea with Enceladus below, just above Dione. Ringed Saturn is above Dione; Tethys and Mimas with its large impact crater are to the lower right. Titan is in the upper right.

Satellite	Diameter) (km	Mean distance fromSaturn (km x 1000)
Atlas	30	137
Promethius	100	139
Pandora	90	142
Janus	190	151
Epimethius	120	151
Mimas	390	187
Enceladus	500	238
Tethys	1080	295
Telesto	25	295
Calypso	25	295
Dione	1120	378
Electra	30	378
Rhea	1530	526
Titan	5800	1221
Hyperion	300	1481
Iapetus	1480	3561
Pheobe	220	12960

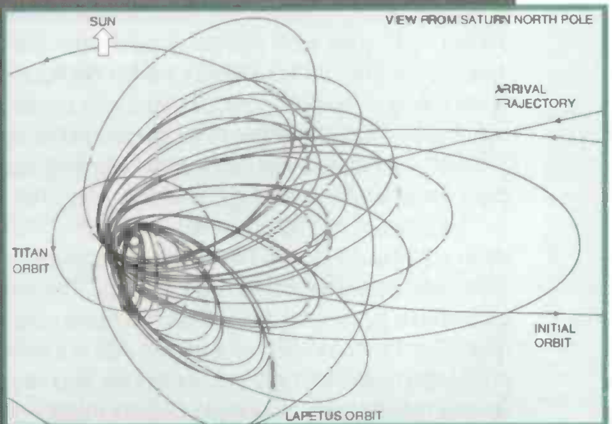


Figure 10. Sequence of orbits planned for the Cassini orbiter craft (Courtesy ESA).

enough to cast deep shadows on the surface of Saturn.

The rings are considered to interact with the retinue of orbiting moons and moonlets although most of these lie beyond the outer extent of the ring system. Scientists are particularly interested in the ring structure since that may provide clues relating to the condensation of dust and gas at the birth of the solar system.

The Voyager mission captured flickering lights in sections of Saturn's ring structure. These are thought to be caused by charged particles in the planet's magnetosphere.

Saturn: Atmosphere and cloud systems

The Cassini orbiter will be able to monitor the atmospheric features of Saturn both in greater detail and for a longer time scale than the Voyager probes. This will give a better appreciation of the natural cycles of development of weather systems as observed in the swaths of circling clouds. Figure 8 shows details in Saturn's northern hemisphere cloud structures.

While Saturn's atmosphere is approximately 94% Hydrogen and 6% Helium, traces of a range of other atmospheric components have been identified. These include Ammonia, Phosphine, Propane, Methylacetylene and ethane. It is likely that many more compounds await detection.

While on the Earth there are significant temperature differences between poles to equator, on Saturn the equivalent temperature differences are much smaller - around 5 K. Like Jupiter, Saturn radiates more heat than it absorbs from Solar Radiation though it is unclear what gives rise to Saturn's internal heating. Most of the energy that drives the cloud systems on Saturn originates as heat convecting up from deep within the planet. The Cassini mission will afford ample opportunity to monitor Saturn's cloud systems.

All about the mission

The Cassini probe is due to be launched in October 1997 by a Titan IV-Centaur rocket from Cape Canaveral in Florida. Since Saturn is farther from the sun than Jupiter, and payloads require more energy to reach Saturn than Jupiter, because of overcoming the gravitational attraction of the sun. Due also primarily to limitations in payload capacity, the flight path to Saturn will take place via gravity assist encounters with several planets of the solar system. Two are planned for Venus and one each for the Earth and Jupiter.

Figure 9 shows the interplanetary trajectory of the Cassini/Huygens spacecraft. Hopefully, Cassini will survive unscathed as it traverses the asteroid belt between Mars and Jupiter. If all goes well, Cassini should enter Saturn orbit during June 2004. The orbit of Cassini will be configured to allow observation of polar as well as equatorial zones. Figure 10 indicates the complex series of orbits planned for the Cassini craft. The craft will initially enter into a wide orbit and the Huygens probe released towards the end of this initial orbit around Saturn.

The present mission plan dates from mid 1992 when a more ambitious NASA CRAF/Cassini programme approved in 1990 was scaled down to reduce costs. The mission is a partnership between NASA, ESA (European Space Agency) and ASI - the Italian Space Agency. ASI is involved in producing Cassini's high gain antennae and key parts of several experiments. The main Cassini mission will be commanded from the Cassini Mission Support Area (MSA) at the Jet Propulsion Laboratory (JPL) in Pasadena, California. The Huygens Probe Operations Centre (HPOC) will be at ESOC Headquarters in Europe. Links to the Cassini craft will be undertaken by means of NASA's extensive Deep Space Network. Aerospatiale/Cannes was selected by ESA as the main Huygens contractor in November 1990. The initial orbits of Cassini are planned to be at an altitude above Saturn equivalent of one sixth of its diameter. During its planned four year mission, the craft will undertake around sixty orbits of the large planet. On account of the principal interest in observing Titan, Cassini's orbit has been planned to allow over thirty encounters with the large mysterious moon. Changes in orbit are undertaken either by propulsive manoeuvres or Titan gravity assist encounters.

The Cassini Spacecraft

An artist's impression of the Cassini craft is shown in figure 11. The weight of the Cassini orbiter at launch including propellants will be almost six tonnes. The actual Huygens probe itself weighs around 350 kg. Cassini will be powered using radioisotope thermoelectric generators which utilise Plutonium. Such power generators have already been used for the Galileo and Ulysses missions. The details of the Cassini/Huygens craft design are shown in figure 12.

The Cassini orbiter carries a total of twelve scientific experiments with the Huygens Titan probe carrying another six. The Cassini mission makes extensive use of developments in electronics. While previous planetary spacecraft such as the Voyagers used on-board tape recorders, the Cassini mission utilises new solid-state recorder technology with no moving parts. Extensive use is being made of very high speed integrated circuit (VHSIC) chip technology for the on-board computer. Application-specific integrated circuit (ASIC) are also being utilised. The power systems of the Cassini orbiter have been upgraded to include innovative solid-state power switches which will eliminate current and voltage transients and provide significantly improved component lifetime.

The Cassini orbiter carries a broad range of instruments which include high resolution infra-red spectrometers, CCD detectors for photometric images (200 nm to 1100 nm), synthetic aperture RADAR, Ultraviolet spectroscopy, electron spectrometers, dust particle detectors, magnetic field detectors, mass spectrometer, ion imager and radio and plasma wave detectors. Thus, the surfaces of Titan can be imaged in much the same way that Magellan mapped the surface of Venus using synthetic radar techniques. Table 3 indicates the components of the Cassini Craft at launch.

The Huygens Titan Probe

The Huygens probe is being supplied by the European Space Agency. The Huygens probe will be launched from the Cassini orbiter in late 2004 and drop into Titan's atmosphere

Table 3
Launch components of the Cassini craft

Item Orbiter (dry mass including payload)	**Mass (kg) 2150**
Probe (+ 50kg payload)	343
Probe Support equipment	30
Launch adaptor	165
Bipropellant	3000
Monopropellant	132
Launch mass	5820

some three weeks later. Up to this time the Cassini craft can monitor the condition of the instruments aboard Huygens and where necessary undertake calibration checks and monitor battery condition. The last operation undertaken before separation is the activation of the battery circuits and the resetting of the probe's timer in order that it should be activated before it enters Titan's atmosphere.

The probe will initially enter the top of the atmosphere and begin making measurements in the layer of haze above the cloud tops. This study will be undertaken by an aerosol collector pyrolyzer, a gas chromatograph and a mass spectrometer. During the descent, various instruments will record temperature, pressure, atmospheric density and energy balance in the atmosphere. The Huygens probe carries a camera to capture pictures of the Titan landscape.

Scientists can only speculate what features may exist on Titan's surface. There is the possibility that the surface of Titan is covered by lakes or oceans of methane or ethane. The Huygens probe is designed to function even if it lands in liquid. A surface science package has been designed by the University of Kent at Canterbury to determine characteristics of any landing site. The Huygens probe is anticipated to land at a velocity of between 5 to 7 metres/sec. This is equivalent to dropping the probe from a height of two metres above a surface in earth's gravity.

Information captured by the Huygens probe will be stored on board and relayed to the Cassini orbiter while it is still within range. This data will in turn be relayed onto earth.

The Landing Programme

The deployment and landing of the Huygens probe is certainly one of the most complex manoeuvres undertaken during space exploration. Initially, the Huygens probe will be released some 22 days before the Titan encounter. It will be released with a relative velocity of 30 cm/sec and with a rotation rate of seven revolutions per minute. This gives a degree of stability of the craft during its coast phase to Titan and during its descent stage through Titan's atmosphere.

During the initial descent through Titan's atmosphere, the probe is protected by a heat shield some 2.7 metres in diameter using heat resisting components Proial and AQ 60. At initial impact into Titan's atmosphere the craft's velocity will be 6000 m/s. This will rapidly be reduced to 400 m/s (Mach 1.5) in less than two minutes at which stage the parachute deployment stage will be initiated by the firing of a mortar. Some thirty seconds after the main eight metre diameter parachute has been deployed the front heat shield will be released so that it falls clear of any probe landing site and avoids instrument contamination.

At this stage, various of the sampling ports on the probe are opened and scientific investigation begins. In order, however, to speed the descent, after 15 minutes a smaller 2.5 metre parachute is deployed. The landing sequence is indicated in figure 13.

One of the main limitations of the Huygens probe is the power requirements of the on board laboratory systems. A total energy capacity of 1800 Wh will be supplied which should provide sufficient power for a 153 minute mission - 2.5 hours of descent and three minutes on the surface. Data captured by the various instruments will be buffered internally prior to transmission to the Cassini orbiter.

The Cassini/Huygens Probe Interaction

As the flexibility of space craft increases, so also does the associated complexity of mission control and co-ordination. Figure 14 indicates the main stages of the mission to capture data from the Huygens probe. Initially, the Cassini craft is turned so that the high gain antennae is pointing towards Titan in order to capture the probe descent phase and up to 30 minutes of data after touchdown. The on-board Cassini imaging systems are then directed to Titan and other Cassini specific modules are activated for analysis of Titan data. Around one hour after closest approach, the Cassini orbiter turns its high gain antenna towards earth for the playback of data.

The Huygens probe is therefore launched ahead of the orbiter so that it touches down some 1.5 hours ahead of the closest approach of the orbiter. Due to the limited battery life of the Huygens probe, there is no opportunity for a repeat run. It is a once only event. As a comparison, the Mars landers could use solar cells to maintain on-board systems.

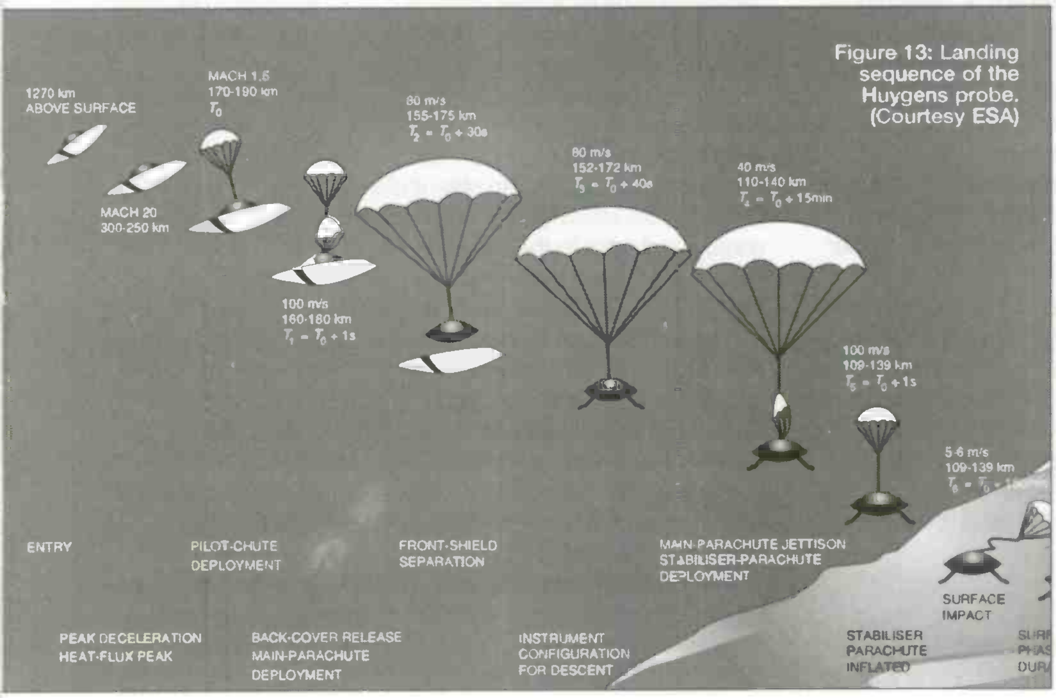


Figure 13: Landing sequence of the Huygens probe. (Courtesy ESA)

Summary

The Cassini mission is a highly ambitious undertaking. The design of the craft far exceeds in complexity that of the highly successful Voyager vehicles. This added complexity, however, introduces complication at the human level in co-ordinating and controlling the mission. As well as scientific skills being tested at the limits of knowledge, it will also be most demanding on human capabilities and resourcefulness.

Images courtesy of NASA and European Space Agency

Switch regulators

Dave Bradshaw takes a look at the design and construction of some simple switch regulators power supplies which offer the user more current and higher efficiency

Imagine a regulator that will produce a regulated output with more current than the input. Let's take a it a stage further: imagine being able to get several different voltages from one input unregulated supply, at high efficiency. Take a look at Figure 1, which shows a 40V 1A unregulated supply feeding three switching regulators giving a total of 3.5A of current at different voltages. Yes, 3.5A is perfectly possible form a 1A unregulated supply. The power is fine: the total input power is 40W and the output power is 29.5W, and the efficiency is just under 75%.

Using linear regulators, the total current from all three regulators would be limited to 1A and the efficiency would be around 20%. This is because linear regulators act as clever attenuators, regulating the output voltage by adjusting the voltage drop across the input and output terminals of the regulator. Unlike switching regulators, they cannot increase the current available.

DIY switchers

Switched mode supplies are now widely used to power computers and they are getting increasingly common in audio and video equipment. However, they are still a no-go area for one-off and amateur designs. This is despite ETI, trailblazing as ever, publishing a practical design in June 1983, when a certain long-forgotten D. Bradshaw was editor. The ETI design was a full-blown PSU delivering 12V at 4A, but it required three transformers, a couple of high-voltage MOSFETs and a heap of transistors, diodes and passive components.

In contrast, Nat Semi's Simple Switchers make it a cinch to knock up a fixed or variable switching regulator. They cost a little more, but they offer a broader input voltage range, higher efficiency and lower heat dissipation.

Like a linear regulator, this particular switching regulator takes an unregulated input and produces a regulated lower voltage. But because the switcher transforms power, the output current is normally larger than the input current. Switchers can work efficiently from higher input voltages, so several switchers can be used to supply different output voltages from a single input voltage with no efficiency penalty. Other switchers, like the LM2577, produce a higher voltage than the input, but I'm saving that for a future article.

How they do it

Switching regulators use the fundamental property of an inductor, which is the ability to store energy and, using the stored energy, oppose any change in the current flowing through itself. The inductor's energy is stored in its magnetic field, built up while current is being passed through it. Turn off the current, and the inductor will do its best to keep the current flowing, making sparks jump across switch contacts (or across spark plugs in a car's ignition systems). The property of resisting change gives inductors their frequency-dependent impedance (the quicker the change, the more the inductor resists, so the higher its impedance).

The switching regulator exploits the inductor's property by turning the current supply on and off in a controlled way; this is shown in Figure 2. Inside the regulator IC is a 52kHz oscillator with a variable duty-cycle: the relative lengths of the 'on' and 'off' periods can be changed while the total period is kept the same. The oscillator output drives a transistor that acts as a power switch; one 'terminal' of the switch is attached to the unregulated input, and the other terminal to one end of the inductor.

The duty cycle of the oscillator is set by a circuit which measures the output voltage (at the junction of inductor L1 and capacitor C4) via the feedback connection to the IC. If the output voltage is too low, the duty cycle is lengthened, i.e. the switch stays on for longer so more current flows through L1 into C4; if the voltage is too high, the duty cycle is shortened, so that less current flows into the capacitor.

If the unregulated input were the only source of current, the switcher would not be able to supply an output current that is higher than the input current. Here's where the inductor's energy storage comes into play. It stores energy in its magnetic field while the switch is 'on' and current is flowing from the unregulated input to the output. When the switch is turned 'off', the inductor keeps current flowing by drawing positive current from the ground via the 'catch' diode, D5, as shown in Figure 3.

The best analogy I can think of is of a water wheel (Figure 4a) that feeds water from a higher level to a lower one. The flow of the water turns the wheel quickly, building up momentum. If the higher level water is shut off via a tap, the wheel carries on spinning because of its momentum. If we supply it with water from a level that is below the output level (Figure 4b), the wheel will scoop up this water to the higher output level, losing momentum as it does so.

The inductor is acting like the water wheel, except that rather than mechanical energy (momentum), its energy is stored as a magnetic field. The energy makes the inductor 'scoop up' current from ground and supply it to the output.

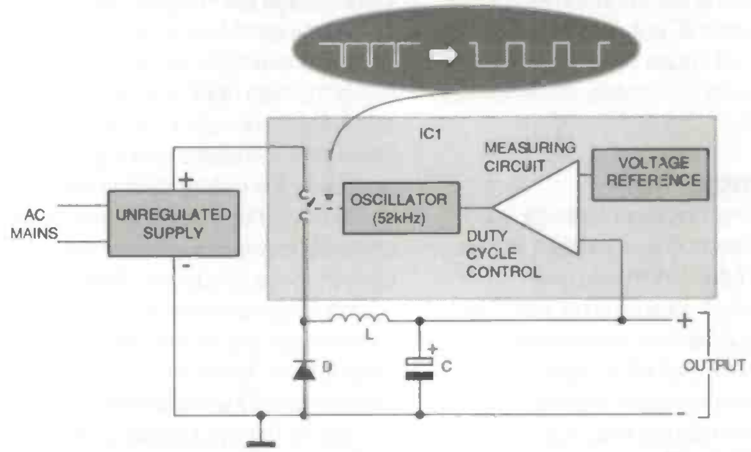


Fig 1. 3.5A output from 1A input - it is possible!

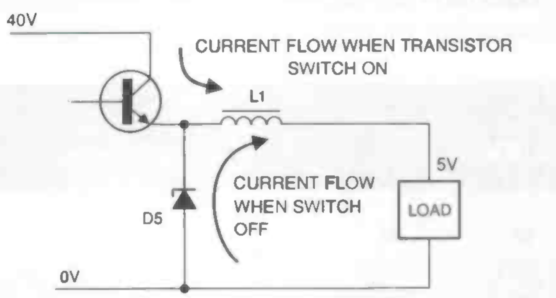


Fig.2. The essential elements of the switcher are the switch itself, an inductor, a capacitor and a controlled oscillator.

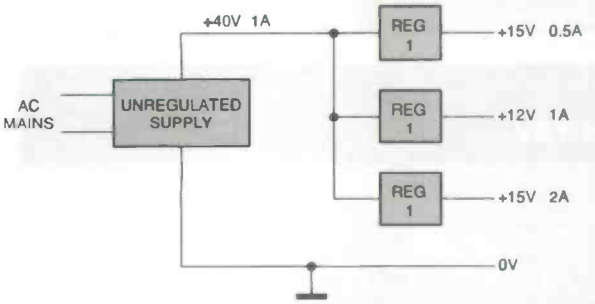


Fig 4. The water-wheel analogy: while the top tap is open (Fig 3a), the water wheel is pushed round faster and faster, building up momentum; when the top tap is shut (Fig3b), the water wheel scoops up water from the lower tap, losing momentum.

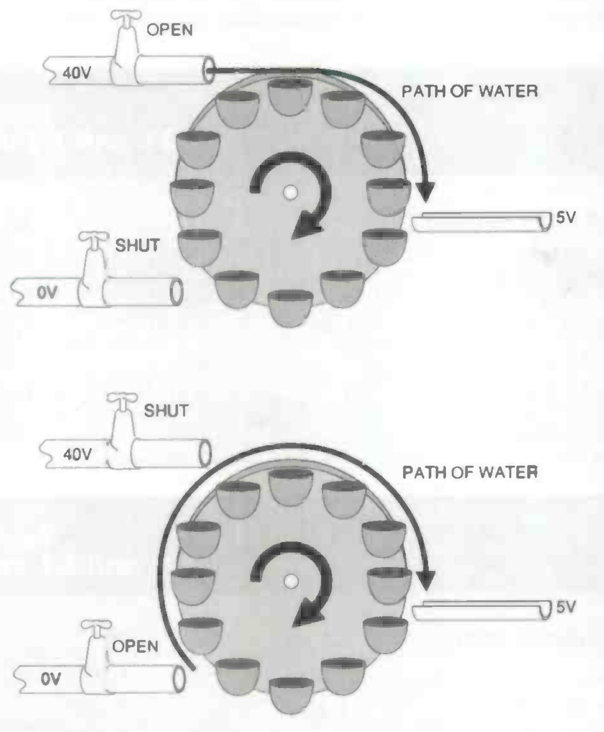


Fig 3. Essential switcher action: while the transistor conducts, current flows through the inductor, building up the magnetic field; when the transistor is off, current flows from the diode, but from ground to positive due to the action of the Inductor.

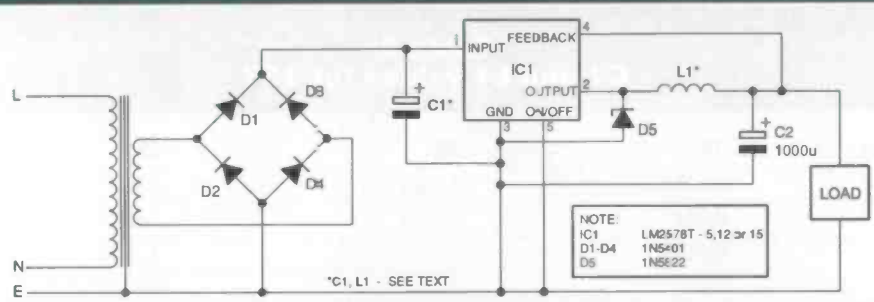


Fig 6. The switcher circuit for fixed 5, 12 and 15 V supplies.

The inductor used cannot be any old inductor. It has to be a type that is specified for switched mode use, and it must be capable of carrying the full current. The 'catch' diode also is special, a conventional rectifier diode is not up to the job. It has to be a fast-recovery high-current device, but not all fast recovery types are suitable, some will cause instability and/or electromagnetic interference. Normally a Schottky diode is used for its 'soft' turn-off characteristics.

Input ripple and efficiency

In most cases, the switchers are direct replacements for linear regulators, but they have some different characteristics. As we have already seen, the switching regulator transforms power, so a large difference between input and output voltages is not a problem. With a linear regulator, high voltage difference means high power dissipation, and the regulator will shut itself off to avoid frying.

As with linear regulators, you have to watch that the instantaneous voltage on unregulated supply lines does not drop below the minimum input voltage, otherwise some very nasty 100Hz ripple will feed through to the output. A step-down switcher has a minimum overhead of around 2V, depending quite a lot on current drawn and other operating conditions.

Unlike linear regulators, extra margin does not mean extra dissipation; rather, we can use a wider margin to increase transformer efficiency. In linear supplies, we normally use a high-value smoothing capacitor to achieve a low ripple on the input voltage (as in Figure 5a). This enables us to keep regulator heat dissipation low by keeping the input voltage just above the minimum overhead required by the regulator. The penalty for this is the high ripple current flowing in the transformer, rectifiers and capacitors - up to 50 times the average output current. Small internal resistances lower the overall efficiency markedly and lower the output current capability.

The switcher's ability to take a higher input voltage enables us to increasing the transformer voltage. Lowering the reservoir capacitor size produces a longer conduction period (Figure 5b), so reducing losses in internal resistances. The ripple voltage is much larger, but so long as there is a good safety margin between the minimum voltage the regulator needs and the lowest part of the wave form, the switching regulator works fine. The higher the input voltage, the higher the ripple voltage can be.

There is a absolute restriction on input voltage, which is that it must not exceed 45V, the absolute maximum rating of the LM2575/6 series. Nat Semi does produce high voltage versions, LM2575HV and LM2576HV, with absolute maximum input voltages of 63V. However, I was unable to find suppliers.

Table 1
C1 and L1 values for 5V

Transformer voltage	9	12	15	18	22	25, 28, 30
C1 for 1A (uF)	4,700	1,000	470	330	220	220
C1 for 2A (uF)	10,000	2,200	680	680	470	220
C1 for 3A (uF)	12,000	3,300	1,500	1,000	470	330
L1 for 1A (uH)	220	220	330	330	330	330
L1 for 2A (uH)	100	100	150	150	150	150
L1 for 3A (uH)	68	100	100	100	100	100

Table 2
C1 and L1 values for 12V

Transformer voltage	15	18	22	25	28,30
C1 for 1A (uF)	3,300	1,000	470	330	220
C1 for 2A (uF)	6,800	2,200	1,000	680	470
C1 for 3A (uF)	10,000	3,300	1,500	1,000	680
L1 for 1A (uH)	330	330	470	680	680
L1 for 2A (uH)	150	220	220	330	470
L1 for 3A (uH)	100	150	150	220	220

Table 3
C1 and L1 values for 15V

Transformer voltage	18	22	25	28,30
C1 for 1A (uF)	2,200	1,000	470	330
C1 for 2A (uF)	4,700	2,200	1,000	680
C1 for 3A (uF)	6,800	2,200	1,500	1,000
L1 for 1A (uH)	330	470	680	680
L1 for 2A (uH)	220	330	330	330
L1 for 3A (uH)	150	150	220	220

One final word before we get stuck into the nitty-gritty is that the LM2575/6 have an on/off control on pin 5. None of the circuits here make use of this control, so they all take it to earth.

Fixed voltage regulators

There are five different fixed-voltage switching regulators circuits here, with outputs of 5, 6.3 12 and 15, and 25V, and a variable voltage options. There is fixed 3.3V version of the Simple Switcher that I haven't made use of, but which could use the same circuit values as the 5V regulator.

Including a 6.3V version may seem quirky, but it is the reason why I got involved with the Simple Switchers. I was looking for an efficient way of supplying valve heaters with 6.3V DC, so as to reduce mains hum in a valve preamplifier. The solution was the first supply I built using these devices, but I quickly realised how many other uses there were.

The circuits are shown in 1A, 2A and 3A versions, with a wide range of input and output voltages. Although the circuits hardly change, the component values do vary a lot, so be sure to use the right values. The 1A version uses the LM2575 series regulators, while the 2 and 3A versions use the LM2576T versions (there's no particular reason for using the LM2575 series for 1A, except that it is a little cheaper).

Figure 6 shows the basic circuit for the fixed 5V, 12V and 15V regulators (the 6.3 volts and 25 volts versions are described below). Figure 7 shows the corresponding PCB layout. Figure 6 is drawn to emphasise the importance of short PCB track paths between IC1, C1 and 2 and D5, in particular short earth paths; if you do not use the PCB, you must keep these paths as short as possible.

For each output voltage, the inductor value and minimum size of capacitor in the unregulated supply depend on the input voltage and output current. I have given the appropriate values for C1 and L1 in Tables 1-3.

For the capacitor values, I have chosen commonly-available values where possible; however, if you cannot find the value specified, use the next available value above; the circuit is not critical in this respect. If you use a capacitor with tolerance greater than 20%, you should use the next value up anyway.

At first sight, some of the C1 values may seem remarkably low - for example, 330uF for a 5V 3A output from 25V - but this is because I have allowed for quite a lot of ripple. Raise the values if they worry you, or if you find any ripple breakthrough in the output.

The optimum value of L1 varies according to the maximum current output. Some values of L1 may be hard to get; use the next lowest value that you can find.

If you have a free choice of transformer secondary voltages, I suggest choosing a value that is mid-way or above in the table. If you ever want to use the same transformer to supply other switchers with different voltage outputs, choosing a higher voltage adds flexibility.

The maximum input voltage to the IC is 45V, and this dictates a maximum transformer secondary voltage of 28V RMS. This gives a rectified peak voltage of 39.6V with no load, i.e. a safety margin of just over 10%. This margin is needed because under no or light load, transformers usually give a few extra volts. However, I have included 30V in the tables as it is a commonly available secondary voltage and should be acceptable provided the supply output will always be under heavy load. 30V RMS gives a rectified peak voltage of 42.4V, leaving only a 2.6V safety margin, but with a heavy load there is an additional voltage drop of around 2V across the rectifier diodes, leaving a 10% (4.6V) safety margin.

Because of the improved efficiency, transformer current requirements are lower than you would normally expect, particularly for the higher voltages. As a rough guide, the transformer current rating (It amps) is given by:

$$It = 2 \times Vo \times Io/Vt$$

Where Vo is the maximum output voltage of the regulator, Io is the maximum required current in amps, and Vt is the nominal voltage of the transformer secondary. This assumes an overall efficiency of 50%, including losses in other parts of the power supply.

This relationship applies to all the different versions of the circuit.

Next Month...

We will look at 6.3V, 25V, and variable voltage regulators.

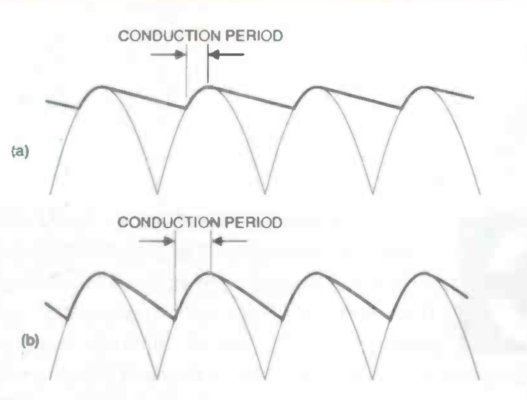


Fig 5. In Fig 5a, a high reservoir capacitance value leads to the very short conduction time; In Fig 5b, the conduction time is increased but so is ripple. So long as the unregulated voltage is above the operating margin needed by the regulator, high ripple can lead to higher efficiency.

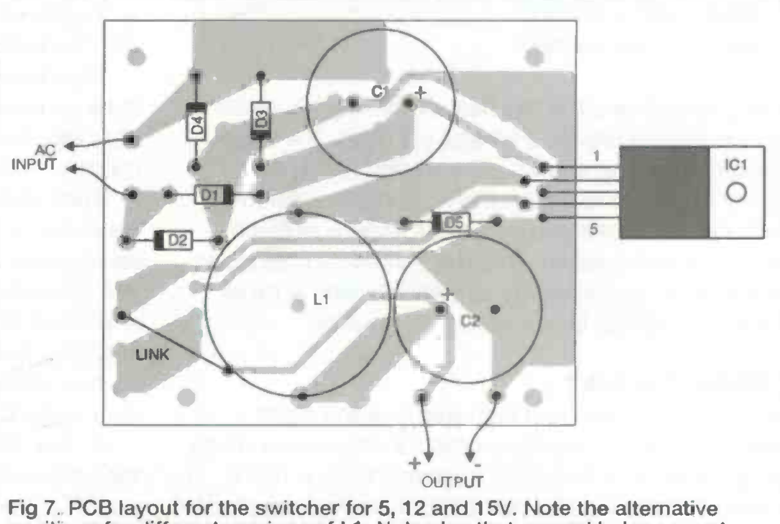


Fig 7. PCB layout for the switcher for 5, 12 and 15V. Note the alternative positions for different versions of L1. Note also that several holes are not used in this version. Be careful with the orientation of C1. The PCB tracking connecting C2, L1, the output and the feedback may look odd, but it is correct (the shape is to minimise the effect of ripple current).

4 Channel Touch Switch Interface

Another useful add-on module for Richard Grodzik's 80188 single board computer

Continuing a series of modules for the 80188 embedded controller, this circuit features a touch sensitive keypad and tri-colour LED indicator. This interface is interrupt driven; switch 'presses' are checked at a rate of 100 times a second. When a switch is touched, the LED colour will indicate which switch channel has been activated; a background program can then determine what action to take dependent on the contents of the AL register:

AL register contains 00H; no switch has been pressed

01H; switch 1 pressed
02H; switch 2 pressed
04H; switch 3 pressed
08H; switch 4 pressed

If more than one switch is touched accidentally, no switch press is registered to provide a fail-safe condition. The touch pads may be larger than shown, effectively increasing the sensitivity of the switch to a point that no contact needs to be made with the switch; the proximity of the finger is all that is needed to activate the switch. This switch interface then would be ideally suitable in a intrinsically safe environment, since all conductive surfaces can be insulated from the user.

How does it work?

The hybrid circuit (consisting of both analogue and digital components), relies on capacitance effect to introduce a phase shift in a digital signal. In the block diagram shown, a 100Hz square wave signal generated by the 80188's timer is applied to an octal latch, so that the logic level at its inputs are changing at a steady rate. A phase shifting circuit - the 10K variable resistor, and a 100 pF capacitor form a simple integrator which integrates the square wave input: the slope of the output signal depends on the value of the variable resistor. Increasing the CR value reduces the slope of the waveform and therefore modifies the time at which the Schmidt trigger will change its logic level. Note that these changes are barely perceptible and a good 50Mhz storage scope is required to observe this effect.

The 10K potentiometer is adjusted to the point where the latching signal (active high) applied to pin 11 of the 74373 latch causes the clock inputs of the switches (1D - 4D) to be latched through to the outputs (1Q - 4Q) when the 100Hz signal is at logic low. This can easily be checked by means of a logic probe. As the clock signal continues to toggle, the octal latch outputs will remain low. A further CR network formed by a 10K resistor and a 1000pF capacitor introduces a further phase shift so that an active high interrupt signal is generated just after the 74373 is latched.

The interrupt signal causes an interrupt service routine (ISR) to be executed which reads in the output logic levels of the latch into Port B of the 8155, and hence to the 80188, where a check is made of the logic levels which should be all low.

If one of the touch pads is touched, the extra capacitance generated by the finger produces a phase shift of the input square wave to that channel, effectively 'widening' the pulse so that, when the latch signal goes high, the logic level at this input is at a logic high level - the remaining input channels being at logic low. The activated channel causes a logic high signal to be latched to the output pin of the 74373, which is subsequently read by the CPU when an interrupt is issued.

An indication of which switch channel has been activated is the function of the tri-colour LED, whose inputs are connected via FET buffers to Port C.

Construction

A double-sided board was used for the touch interface circuit. Making a double-sided board is not beyond the realities of the

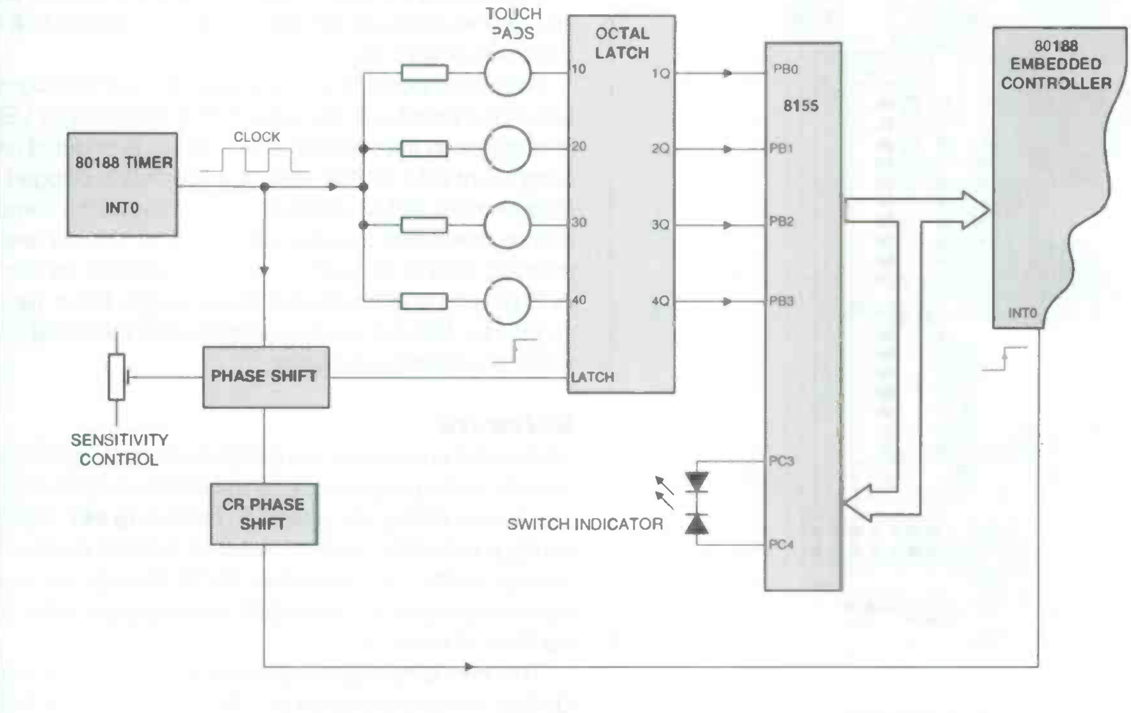


Fig. 1. Touch switch interface block diagram

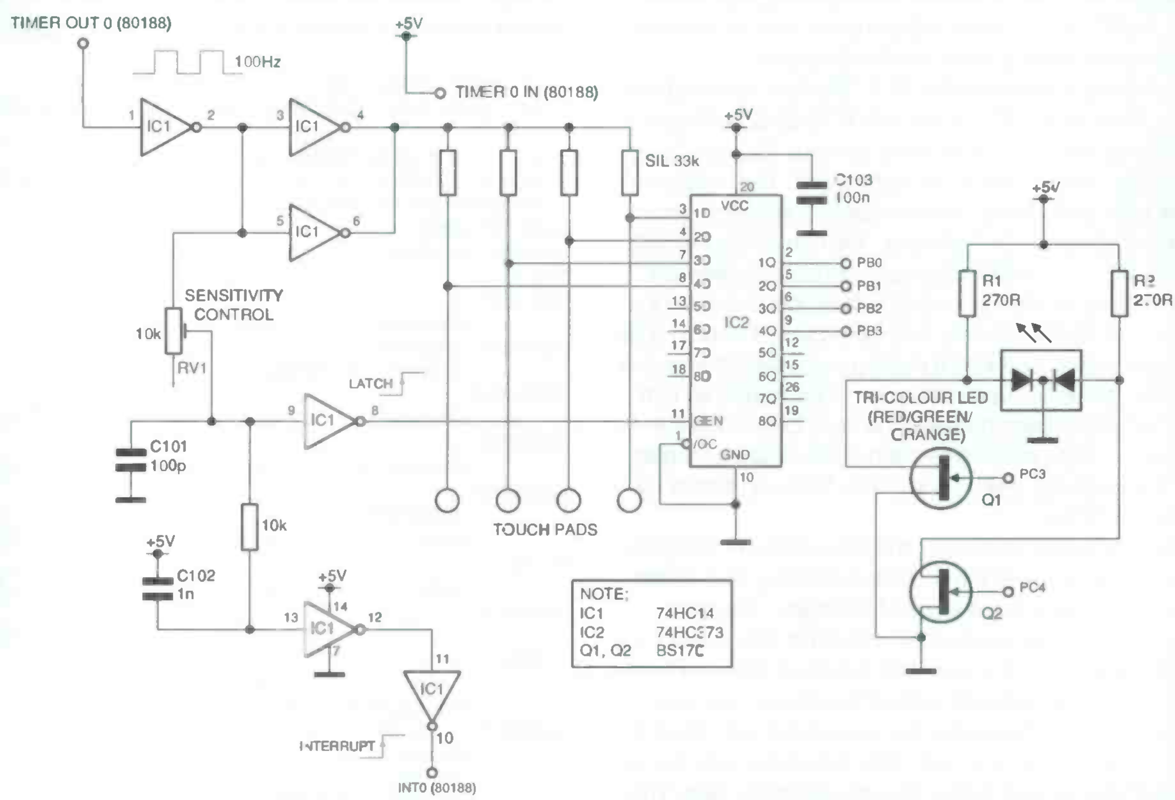


Fig. 2. Touch switch circuit diagram

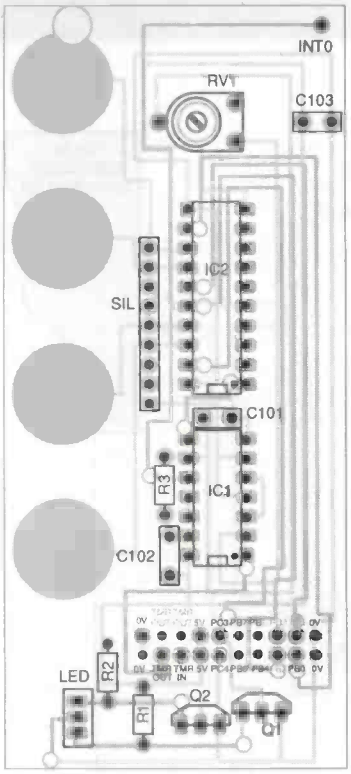


Fig. 3. Touch switch PCB component overlay

home constructor. Who would have thought it possible 20 years ago, that the design and programming of a small microcomputer would be possible on a kitchen table?. I, for one, did not, I must admit. My initial response to the PC was that it was an over-priced word processor, little realising that several years later, the PC would be an indispensable tool on which all my microcomputer development would take place.

Back to making a double-sided PCB. We have all found that designing a single-sided PCB, even with PCB CAD facilities is a time-consuming task if size constraints or many ICs have to be accommodated. How to avoid too many links?. The answer is making a double-sided board where copper connecting tracks are placed on both sides of the board - the normal copper side and also the component side. Electrical connections between bottom and top layers are then made with simple 0. 8 mm pins which are inserted into the 'pin-thru' holes and soldered on both sides.

The most common problem is making a double-sided board is how to align the artwork on both sides of the board, so that there is correct registration between the component sides and the copper side. A few millimetres out and the board becomes unusable. The following method has been tried and tested by the author many times.

Offer the copperside artwork to one side of the UV sensitive board, having first removed the protective backing. Secure the artwork with a couple of small strips of Sellotape - having a slightly larger board than required will make this task easier - the board is then later cut to final size. Drill two small diameter holes (0. 6mm) at diagonally opposite ends of the board, including both pieces of artwork. Now offer the component side artwork to the other side of the board - print side outwards - and line up with the aid of the two pilot holes. Secure with sticky tape. The board can now be exposed to UV light and chemically processed as usual i. e developed in a solution of caustic soda and then etched in ferric chloride. Since both sides of the board need to be etched, turn the board periodically , making sure that the necessary safety precautions are observed. Use vinyl surgical gloves to protect the hand - the common kitchen 'rubber' gloves tend to disintegrate in contact with ferric chloride and should not be used. Finally, the board is washed and dried and the thru holes are pinned through with special 0. 8 mm track pins or with wire.

All the components are now assembled on the 'component' side of the board with the exception of the tri-colour LED which is mounted on the opposite side - the leads soldered on the component side, so that when this interface is plugged into the module of the 80188 embedded controller, all the components sit face down, with the LED pointing up. A 'wander' lead is soldered to INT0 pad on the interface card with connects to the INT0 pin on the embedded controller board. Drill a 10mm hole so that the 10K pot can be adjusted when the circuit is mated with the embedded controller.

Software

Most of the procedures to initialise the 80188 have been used in describing the programming of the 80188 controller board so they should not be too unfamiliar. Procedure INIT_PORTS configures the 8155 ports, Procedure Initialise enables the INT0 interrupt system and procedure VECTOR loads the address of the interrupt service routine (ISR) into the vector table located in the RAM of the 8155.

The timer is configured at the start of the program and is identical to the listing given in 'TIMER0. ASM' in the first part of the programming course. Once the timer, ports and interrupt system has been initialised, the interrupt flag is enabled and the processor just 'sits' doing nothing. This is the background program which is left for the user to program for their own requirements.

Every 20 Ms, an interrupt is issued and the ISR routine reads the logic states of the switch outputs, switches on the LED the correct colour and returns to the background program.

```
;4 CHANNEL TOUCH SWITCH INTERFACE.
;TRI-COLOR LED INDICATES WHICH SWITCH HAS BEEN
TOUCHED
;INDICATING RED,GREEN,ORANGE OR OFF
;SWITCH IDENTIFICATION (1,2,4,8) RETURNS IN AL
;REGISTER IN BACKGROUND PROGRAM.
CODE SEGMENT
ASSUME CS:CODE
ORG 0
ORG 0400H
        TIMERMODE       EQU 0FF56H      ;TIMER 0
CONTROL REGISTER
        COUNTER EQU 0FF50H      ;16 BIT COUNT
REGISTER
        MAXCOUNTA       EQU 0FF52H      ;MAX COUNT
REGISTER A
        MAXCOUNTB       EQU 0FF54H      ;MAX COUNT
REGISTER B
        SQUAREWAVE      =       0C003H
        MAXA    =       01B03H          ;MAX COUNT
VALUE A
        MAXB    =       01B03H          ;MAX COUNT
VALUE B
                        ;SQUARE WAVE OUTPUT ON
TIMER 0 OUT
                        ;AT 100 HZ
        MOV DX,MAXCOUNTA        ;NOTE TIMER 0 IN
CONNECTED TO 5V
        MOV AX,MAXA
        OUT DX,AX
        MOV DX,MAXCOUNTB
        MOV AX,MAXB
        OUT DX,AX
        MOV DX,TIMERMODE
        MOV AX,SQUAREWAVE
```

```
        OUT DX,AX
        MOV SP,0FFH            ;INITIALISE STACK
POINTER
        MOV DX,0FFA2H  ;LOWER CHIP SELECT
        MOV AX,038H
        OUT DX,AX
        CLI            ;DISABLE INTERRUPTS
        CALL INIT_PORTS
        CALL STOP
        CALL VECTOR
        CALL INITIALISE
                       ;BACKGROUND PROGRAM
RUNS,INTERRUPTED 100
                       ;TIMES/SECOND TO READ
SWITCHES
BACKGROUND:
        STI            ;ENABLE INTERRUPT
                       ;WAIT FOR INTERRUPT  AT
INT0 PIN 45
                       ;WHEN INTERRUPT
ISSUED,READ SWITCHES
                       ;USERS PROGRAM GOES HERE,
                       ;REGISTER AL (LOWER
NIBBLE) CONTAINS
                       ;SWITCH STATUS
        JMP BACKGROUND
ISR:            ;INTERRUPT SERVICE ROUTINE
        CLI     ;DISABLE INTERRUPT
        MOV SI,0102H   ;READ PORTB
        MOV AL,[SI]
        AND AL,0FH     ;MASK OUT BITS 4 - 7
        PUSH AX ;SAVE STATUS OF SWITCHES
        CMP AL,1
        JNE SWITCH_2
        MOV DI,0103H   ;PORT C
        MOV AL,010H    ;GREEN LED ON
        MOV [DI],AL
SWITCH_2:
        CMP AL,2
        JNE SWITCH_3
        MOV DI,0103H   ;PORT C
        MOV AL,8       ;READ LED ON
        MOV [DI],AL
        JMP NO_SWITCH
SWITCH_3:
        CMP AL,4
        JNE SWITCH_4
        MOV DI,0103H   ;PORT C
        MOV AL,0        ;ORANGE LED ON
        MOV [DI],AL
SWITCH_4:
        CMP AL,8
        JNE NO_SWITCH
        MOV DI,0103H   ;PORT C
        MOV AL,01FH    ;LED OFF
        MOV [DI],AL
NO_SWITCH:
        MOV DX,0FF22H  ;EOI REGISTER NON SPECIFIC
        MOV AX,0800FH  ;END OF INTERRUPT,RESET
INTERRUPT FLAG
        OUT DX,AX

POP AX          ;RETREIVE SWITCH STATUS
        IRET    ;RETURN FROM INTERRUPT
STOP PROC NEAR
        MOV DI,0103H   ;INITIAL LED STATUS = RED
        MOV AL,8
        MOV [DI],AL
        RET
STOP ENDP

INIT_PORTS PROC NEAR
        MOV DI,0100H   ;PORT COMMAND REGISTER
        MOV AL,0DH     ;PORT C OUTPUT:
                       ;PC3 RED LED
                       ;PC4 GREEN LED
                       ;PORT B INPUT   (SWITCH
OUTPUTS)
                       ;PORT A OUTPUT  (UNUSED)
        MOV [DI],AL
        RET
INIT_PORTS ENDP
                       ;LOAD CS:IP VALUES OF
INTERRUPT
                       ;ROUTINE INTO VECTOR TABLE
VECTOR PROC NEAR
        C_S EQU 0FF80H ;BASE ADDRESS OF EPROM
        INT_TYPE   EQU 12
        INT0 = INT_TYPE *4      ;ADDRESS 30H
        MOV AX,OFFSET ISR       ;LOAD ADRESS OF
INTERRUPT ROUTINE
        MOV DI,INT0     ;INTO INTERRUPT VECTOR
TABLE
        MOV [DI],AX     ;ADDRESS 030H = IP OFFSET
        MOV AX,C_S
         MOV DI,INT0+2 ;ADDRESS 032H = CODE
SEGMENT
        MOV [DI],AX
        RET
VECTOR ENDP

                       ;CONFIGURE INT0 INTERRUPT
SYSTEM
INITIALISE PROC NEAR
        MOV DX,0FF28H  ;MASK REGISTER ,ENABLE
INT0
        MOV AX,000EDH
        OUT DX,AL
        MOV DX,0FF38H  ;INT0 CONTROL REGISTER
        MOV AL,050h    ;LEVEL (LOGIC HIGH)
INTERRUPT
        OUT DX,AL
        RET
INITIALISE ENDP
DELAY PROC NEAR
        MOV CX,01FFFH
LEDS:LOOP LEDS
        RET
DELAY ENDP
ORG 07F0H       ;RESET VECTOR FFFF0
        JMP 0FFC0:0000
ORG 0800H
CODE ENDS
END
```

PARTS LIST

Capacitors

- C1 100nF
- C2 100pF
- C3 1000pF

Resistors

- R1 10K
- R2,3 270R
- SIL1 33K x 8
- VR1 10K

Semiconductors

- Q1,2 BS170
- IC1 74HC373
- IC2 74HC14
- LED1 Tri-colour (red/green/orange) LED

Miscellaneous

- Skt1 0. 1in connector pins

A floppy disk (3-1/2") containing all the source code and object code files of the course, including printable artwork files is available (price £12. 50 P & P inc) from the author:
Mr. R. Grodzik (Micros), 53 Chelmsford Road, Bradford BD3 8QN, England.

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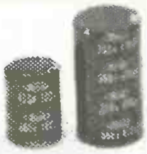

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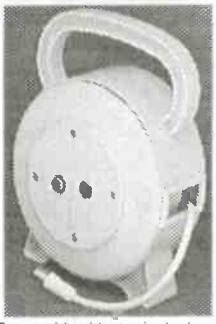

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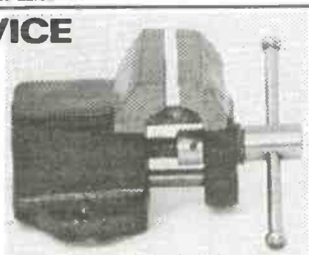

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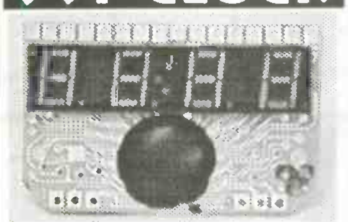

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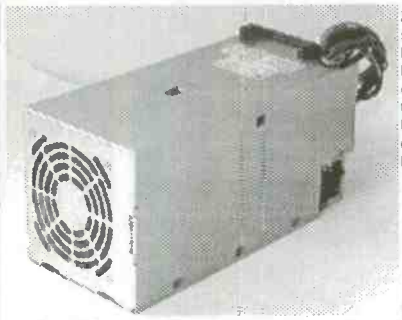

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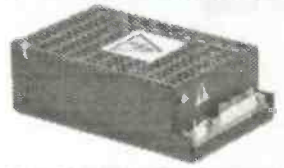

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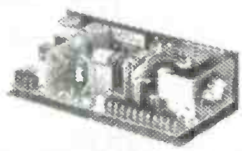

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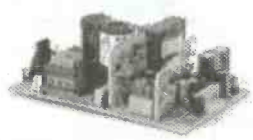

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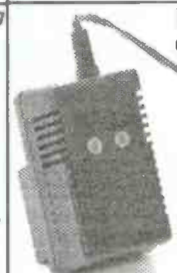

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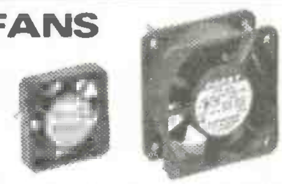

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PIC Programmer

Robin Abbott explains how an inexpensive PIC programmer can be constructed for home use

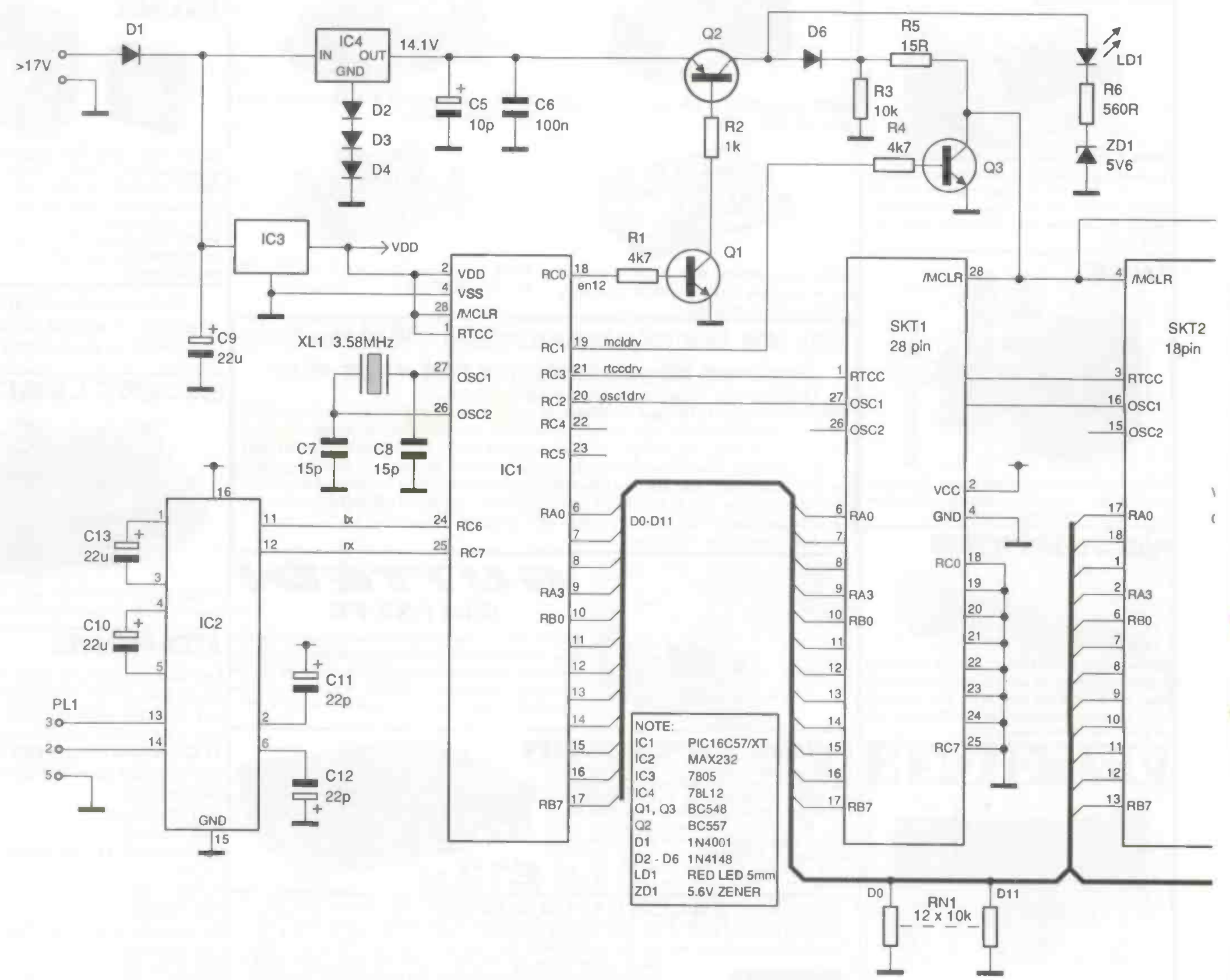


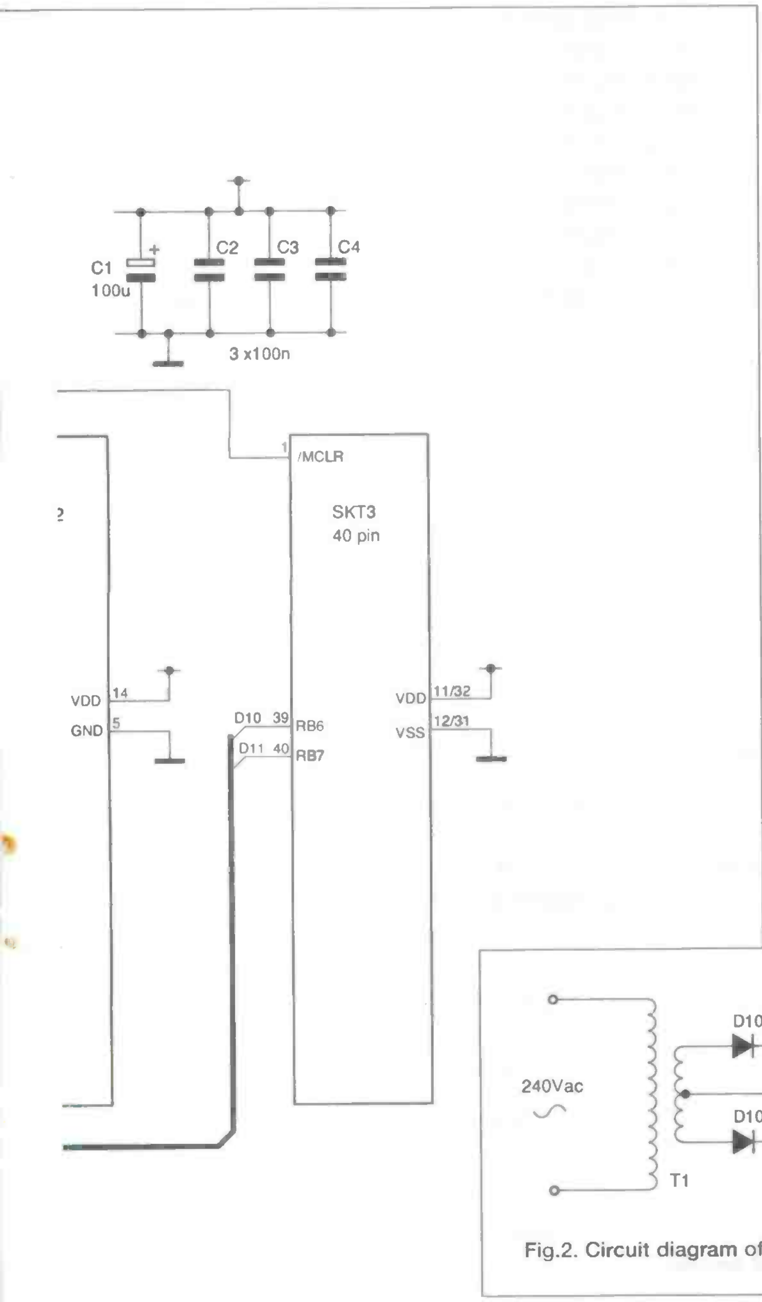
Fig.1. PIC programmer circuit

As readers of any of the electronics magazines over the last couple of years will have noticed, the microchip PIC devices have become increasingly popular with home constructors. They offer a fast RISC architecture, on board RAM, PROM and peripherals offering use in a wide range of applications which previously may have taken considerable amounts of logic.

The development tools for PICs are available free of charge from Microchip, however the commercially available PIC programmers are, unfortunately, quite expensive and often will only program a small subset of the available PIC devices. This project describes a PIC programmer for home or other small scale use which can be constructed for a total cost (including software) of around £35.00. It has the following features:

- **Reads, programs, and verifies PIC 16C54, 55, 56, 57, 58, 64, 71, 74 84 and any other upcoming 18, 28, or 40 pin PIC devices which conform to the current PIC serial programming specification.**
- **Reads and programs EEPROM device data areas.**
- **Will program serial devices in circuit with a 4 wire interface.**
- **Fully supports user data area and configuration fuses.**
- **Serial interface to host PC.**
- **Windows host software available.**
- **Loads and saves Intel hex, hex text and binary file formats produced by Microchip Assembler (MPASM).**
- **Host software supports automatic device serialisation.**

The programmer is constructed on a fibreglass PCB which is not cased to save costs. A standard 3 wire RS232 serial interface running a simple command interface is provided to the host PC. The programmer operates from an 18v supply, a suitable mains driven supply is described in this article.



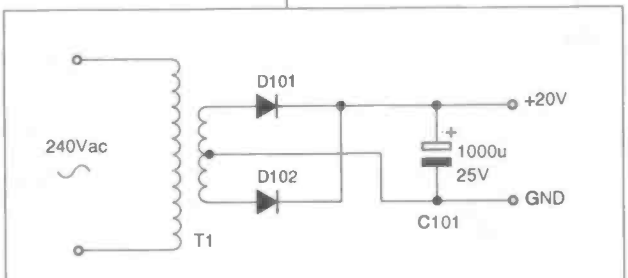


Fig.2. Circuit diagram of PIC programmer power supply

Circuit Description

Figure 1 shows the circuit diagram of the programmer. Programming a PIC requires two power supplies, a 5v supply for the main circuitry of the device, and a supply between 12.5V and 13.5V for the programming algorithm. IC3 provides a 5V supply and IC4 provides a 14.1V programming supply (voltage drops in other parts of the circuit reduce this to 13.3V at the PIC).

The main functionality of the programmer is provided by IC1, another PIC device, the PIC16C57. This device is used because it has 80 bytes of RAM which are needed to buffer information from the host PC, and it also has 20 I/O pins - programming the parallel devices requires a 12 bit interface to the PIC being programmed. The design uses a cheap 3.58MHz colour crystal as a main oscillator. The control signals needed for programming are the RTCC and OSC1 pins of the device being programmed, these are driven directly from IC1.

The programming supply is switched from IC1 by TR2 and TR3. TR2 enables the programming supply which is connected to the MCLR pin of the device through D5 and R5 (these are needed when devices are programmed in-circuit). TR3 provides a fast switch open collector to ground so that the programming supply is turned off quickly enough when programming in-circuit. LD1, R6 and ZD1 provide a visible indication that the PIC device in use has the programming supply connected and should not be inserted or removed. ZD1 ensures that LD1 will not illuminate unless the programming supply is well above 5v.

The interface to the device being programmed is provided through a 12 bit bus, D0 to D11. IC1 port pins RA0 to RA3 are the lower 4 bits of the bus, and port pins RB0 to RB7 are the upper 12 bits of the bus. RN1 provides a pull down to the bus.

IC2 is a MAX232 device which provides an RS232 interface from a 5v supply, It connects to port C of IC1. The serial interface is 3 wire, and operates on a request/acknowledge protocol. When the programming supply is disconnected the MCLR, RTCC and OSC1 pins of the device being programmed are all held low by IC1. The programming bus is held low by RN1, and so the only pin on the programmed device which is above ground is the power supply pin. Normally it is not considered good practice to

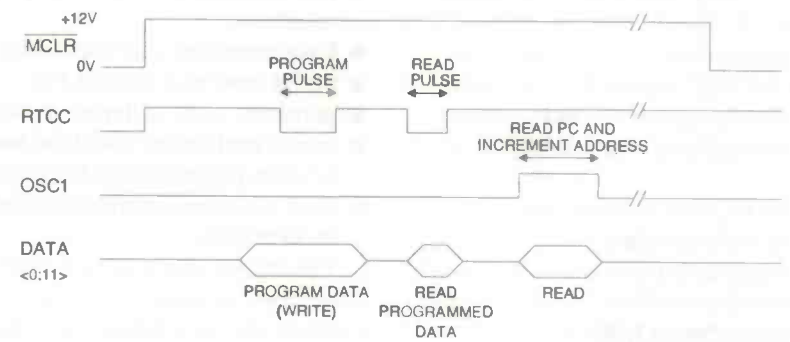


Fig.3. Parallel programming interface

insert a device into a circuit with the power supply connected. However, in this case, as we can guarantee that all other pins are held at ground or are open circuit then there is no possibility of latch up.

To simplify the circuit separate sockets are provided for 18, 28 and 40 pin devices. The host software allows full configuration of device parameters allowing new devices to be programmed as they become available.

Figure 2 shows the circuit diagram of the power supply. A 15-0-15V transformer may be used as current consumption is so low that the input voltage remains above 19V at all times. The power supply is constructed in a small case with an integral mains plug.

Programming interface to Parallel devices

The older PIC devices - those in the 16C5XX series can only be programmed in parallel mode. These devices require a 12 bit data interface together with a programming control interface, because of this heavy I/O requirement they cannot be programmed in-circuit by this programmer.

To enter programming mode the MCLR pin of the device must be taken to at least +12.5V in less than 1uS whilst the RTCC pin is held high. Once in this mode the device can be read or programmed. To program the device, the word to be programmed must be placed on the data bus. The RTCC pin is then driven low to program the word. To verify the word which has been written the RTCC pin is driven low again,

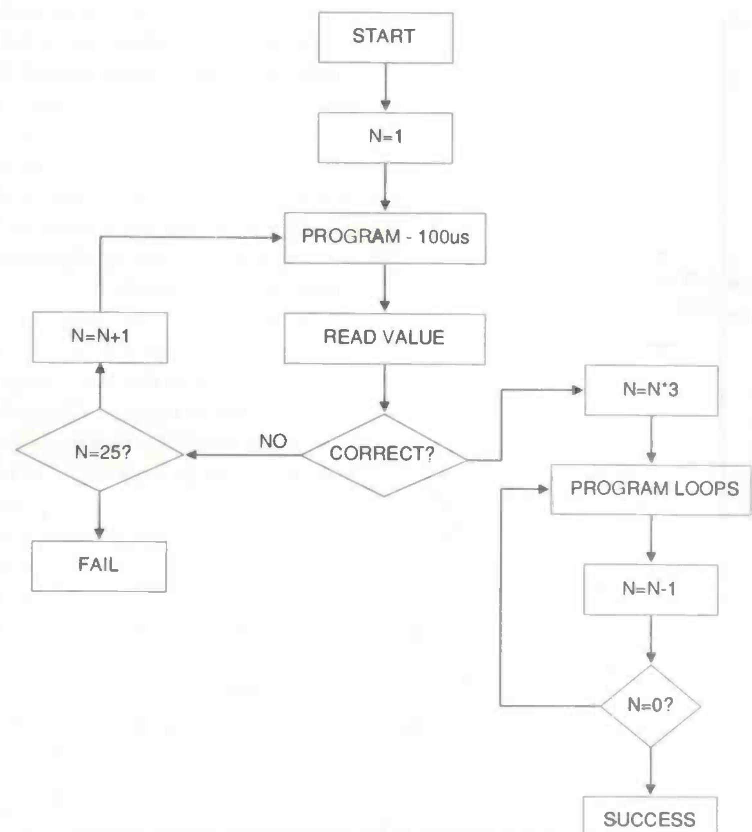
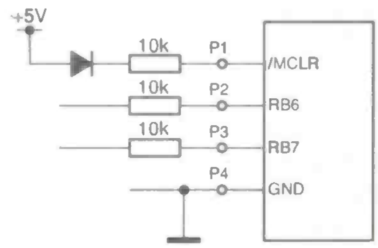


Fig.4. Programming cycle for each word in UV EPROM devices



PIC TO BE PROGRAMMED

Header cable - connect 16 pin
DIL header as follows:

Header pin	Circuit pin
4	P1
10	P2
11	P3
5	P4

Fig.5. In-circuit programming

during this second period the data word is output on the data bus. The programming/verify cycle is described below. To increment the program counter and look at the next word the OSC1 pin is used as a clock. Whilst it is high the current contents of the program counter are output on the data bus. The OSC1 pin may be used to step through the PIC reading its program without changing it.
Figure 3 illustrates the programming interface for parallel devices.

Programming interface to Serial devices

The more recent PIC devices can be programmed in a parallel or serial mode. For this programmer serial mode is used for these devices, except for the bulk erasure of EEPROM devices which is only possible using parallel mode. As for parallel devices the PIC enters programming mode when the MCLR pin is taken to +12.5V. However, for these devices, the RB7 pin is used as data, passing information into or out of the device. Pin RB6 is used as a data clock. These devices have a 6 bit command which is entered into the serial input, and is then followed either by 16 bits of data which is either clocked in to the device for programming, or is clocked out of the device for reading.
B:The commands available include reading and writing program, user and configuration data areas, as well as EEPROM data memory in those devices which include EEPROM memory. The EEPROM devices have a bulk erase facility which must be used if the code protect fuse has been programmed. However the bulk erase procedure must use the parallel programming mode, and so is only available on 18 and 28 pin devices.
To adjust the device programming pulse width in these devices there is a start programming and an end programming command which are given to time the pulse width accurately.

Programming

Programming of the EEPROM devices is straightforward, the programming is self timed, and there is no need to explicitly erase the device (unless the code protect fuse has been set).

Programming of the UV EPROM and OTP devices is more complex. These devices have a speed programming algorithm where repeated programming pulses of 100uS are used. After each pulse the device is read to check if it has been programmed successfully. Once the device has successfully returned the correct word then three times as many pulses as those initially required are applied to overprogram the device. This procedure is illustrated in figure 4.

The host software reports the average number of initial programming pulses required. In the prototype only one initial pulse was ever required unless the power supply was reduced well below specification. However, this may increase with devices which have been programmed multiple times.

Please note that the only part of the programming algorithm not implemented by this programmer is the verification of programmed information at different values of Vdd. This has little practical impact but consequently Microchip would class the programmer as "development" only.

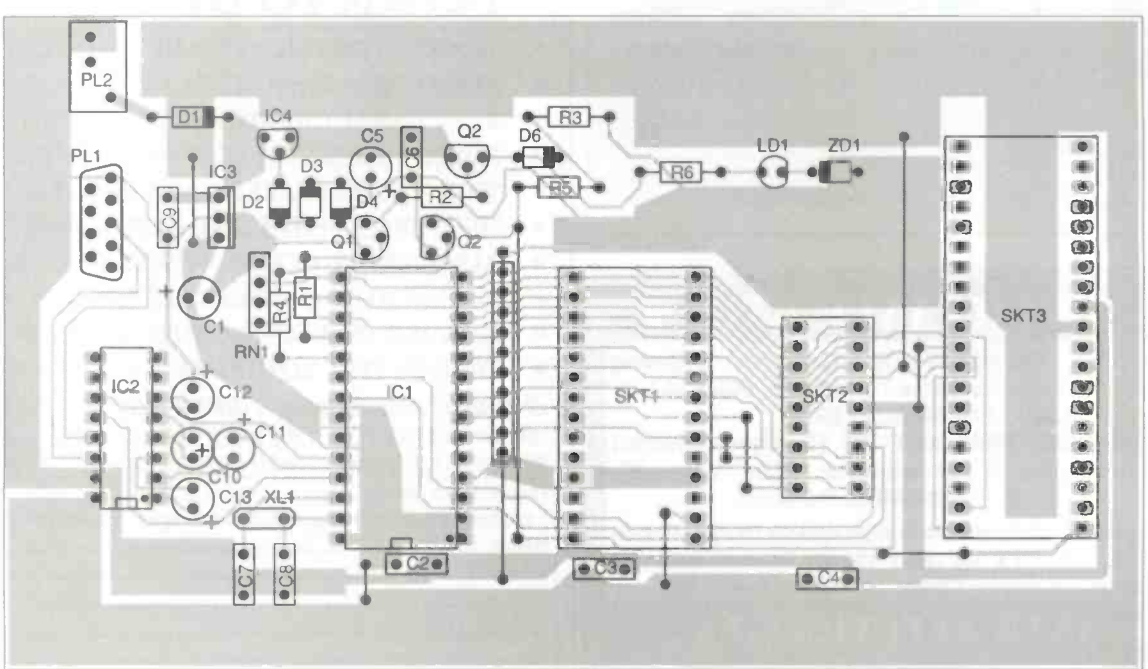


Fig.7. PCB component overlay

In circuit programming

In-Circuit programming is only available with serially programmed devices, and will not operate with EEPROM devices which have been code protected, or with UV EEPROM devices which have been programmed. The currently available devices which can be programmed in-circuit are the 16C64 16C71,16C74, and 16C84. The 16C84 can be reprogrammed in-circuit allowing updating of software in the field.

Figure 5 shows the circuit diagram of the application circuit. A 4 way header cable must be made up with a 16 pin DIL header connecting to RB6, RB7, MCLR and ground in the application circuit as shown in figure 5. The 16 pin header is inserted in SKT 2 so that pin 1 of the header is inserted into pin 1 of SKT 2. This will leave 2 pins of SKT 2 unconnected. The header cable must be as short as possible.

Note that in the application circuit the RB6 and RB7 pins must be capable of being driven by the programmer overdriving any signals present in the circuit. Resistors Rs shown in figure 5 are used to allow the programmer to drive the PIC regardless of any other signals driving the device. Note also that during programming the I/O pins of the PIC will all be floating.

Construction

The programmer is constructed on a fibreglass PCB with four rubber feet which prevent the PCB from scratching any surface on which it is used.

The PCB overlay is shown in figure 7. Construction is not complicated, insert all the jumpers and horizontally mounted components first, IC1 and IC2 should be socketed. Insert the capacitors, crystal, IC3 and PL1 last. Note the resistor network RN1. RN1 can be made up from one 9 way SIL resistor network and one 3 way SIL network. However as these appear to be unobtainable then RN1 can be made up from 12 individual vertically mounted resistors.

SKT1, SKT2, and SKT3 are the device programming sockets. Zero Insertion Force (ZIF) sockets can be used here. Howeve,r they are expensive and can be replaced with stacked DIL sockets. If this is to be the case, then ensure that the device programmed is inserted into a DIL socket, and that the board has at least two stacked sockets. This will ensure that sockets with bent pins can be replaced without unsoldering from the PCB. 18 pin ZIF sockets are hard to find, and the prototype used a 20 pin socket for SKT2. If ZIF sockets are used then they should be either long pin devices, or should be mounted on two stacked DIL sockets to raise them above the board and components.

A serial cable needs to be constructed, or a standard serial cable can be used. As there are a variety of serial ports connectors available then it is likely that different host PCs will need different connectors. If you choose to make up a cable for the host PC then follow the connections shown in figure 9.

The power supply is constructed in a small case with an integral mains plug. There are only three components in the power supply apart from the transformer. These are mounted on a small piece of veroboard. Ensure that the transformer and power supply board are bolted firmly into the case. In the prototype, the exposed mains pins were liberally smeared with silicone rubber sealant to insulate them.

FIGURE 9
Serial Cable from programmer to host PC

Programmer	PC connector type:			
PL1	9way female	9way Male	25 way Female	25way Male
2	3	2	2	3
3	2	3	3	2
5	5	5	7	7

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We will look at the PIC programmer software, as well as testing and using the programmer.

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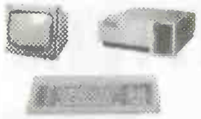

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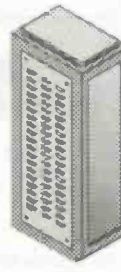

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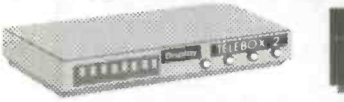

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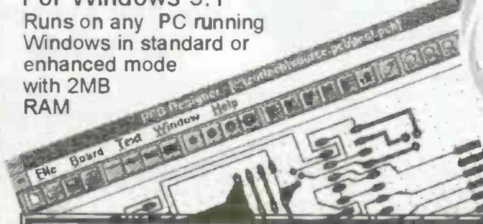

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Light Gun Central

Robin Abbot continues his project to build the light gun central unit for the ETI Laser Tag game system, he looks at building the unit and writing the software for it.

This fourth part of the light gun project covers the central renewal station. The station provides the capability to organise different game types, to adjust the length of the games and to automatically provide scores for individual players and for the teams. It also allows light guns to be programmed with their Identities which are stored in EEPROM in the light gun micro-controller

The central renewal station consists of two pieces of equipment: the central and the external display. The central provides the processing capability for the game and has a keyboard and LCD display for game control and reporting. It also has a serial port which drives either the external display or a printer.

Last month we looked at a general description of the central unit and how it works, and how it communicates with the player units. We continue with a look at constructing and programming the central.

Processor board

It was decided to use a Z80 for the main processor of the central. This is a very cheap device which has plentiful development tools, and which is powerful enough for the relatively low processor load required in the central. Unfortunately, the relatively large amount of ROM and RAM required (14K of EPROM, 1K of RAM) prevents the use of any of the readily available microcontrollers. The software for the central is written in a mix of assembler for the interrupt routines and compiled C for the main functions of the central.

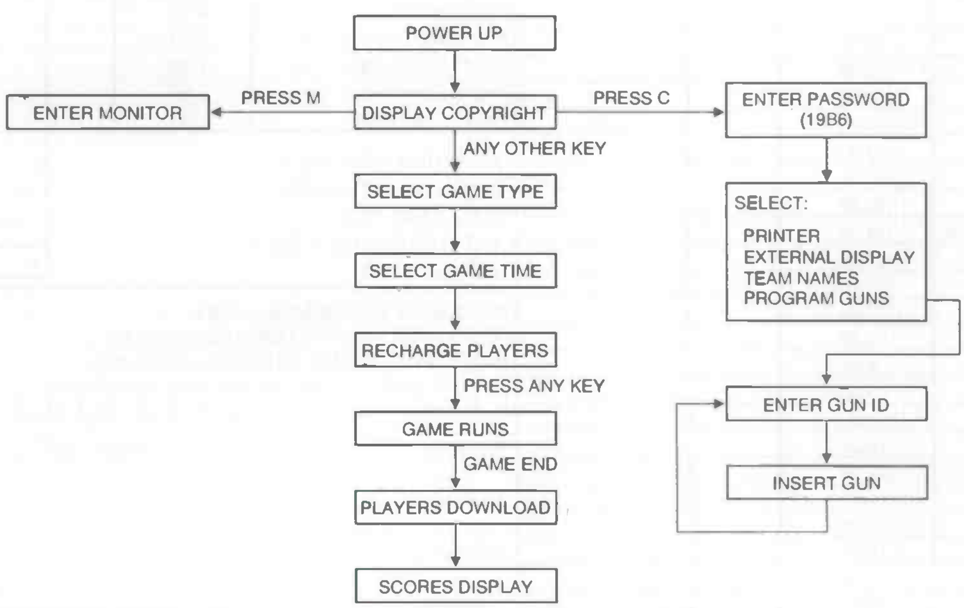

Fig.1. Operation of the central

Byte	Name	Value (Hex)	Notes
1	Start flag	AA	Always has the value AA, shows start of packet
2	Type	00-01	00 for a renewal packet 01 to program the gun ID For ID packets bytes 4 to 9 are set to 00
3	Shots	00-FF	Number of shots per life For an ID packet this the ID of the gun to program For ID packets bytes 4 to 9 are set to 00
4	Timelo	00-FF	Lower byte of game time left in seconds
5	Timehi	00-FF	Upper byte of game time left in seconds
6	Game type	00-07	Type 0 is normal Type 1 is warriors All other types are spare
7	Lives	00-7F	Number of lives for user Note numbers greater than 1F(Hex) are used only for special purposes, as the number of lives transmitted from the gun to the central is limited to 5 bits
8	MRC	00-9F	ID of the most recently renewed user used to acknowledge the gun Bit 7 if set shows that this user is a warrior
9	MRCBUT1	00-9F	As MRC for the most recently renewed user but one
10	Checksum	00-FF	8 bit checksum - lower 8 bits of the additive sum of bytes 2 to 9 (does not include start flag)

Fig.6. Renewal packet from central to guns

The processor board is based on the Forth single board computer presented in ETI in the April 1994 issue. To recap, this board offers the following functions:

- **Z80 running at 3.7MHz**
- **32K of EPROM**
- **32K of battery backed RAM**
- **Two 10 bit output ports**
- **Two 10 bit input ports**
- **Bi-directional serial port**

For the central only one input and one output port are used. The serial port is used to communicate to the external display and the printer; it was also used to connect the monitor used for development. Regrettably, it is not possible to omit the serial port driver IC if no external devices are in use because the underlying monitor used in the central checks the serial port during initialisation and will not proceed if it is absent.

The circuit has been modified from that shown in the original article, and the modified circuit diagram is shown in figure 7. Please refer to the original article for details of the main operation of this board.

The modifications are concerned with the use of interrupts. The driver for the serial port used in the central requires interrupt operation to provide a bi-directional buffer and XON/XOFF signalling. The transmit and receive ready signals from IC10 are combined by a spare OR gate in IC3 with an open collector output which drives the interrupt pin of the Z80 directly. There is also an additional interrupt input provided for the interrupt signal from the auxiliary board. This interrupt occurs every 1/16th of a second and is used in normal operation for timing purposes and to trigger communication with the guns and bases.

There is one other important modification to the board - IC7. This is because the original board used a simple decoding scheme for I/O devices. IC7 enables the peripheral devices whenever the IORQ line from the Z80 is low, there is no decoding of the read and write signals from the Z80. This is normally acceptable - a read from one of the output ports will write a spurious value to the port, but as the input and output ports are at different addresses then they never need to be read in practice.

However, when interrupts are used in the Z80, the processor provides a special interrupt acknowledge cycle when IORQ is driven low without WR or RD going low; this will write spurious values to the output ports. To correct this, a new decoding device (IC100) is included for the output ports.

The serial chip (IC10) is provided with its own decoding for read and write signals and is not affected by the interrupt acknowledge cycles.

The other modifications to the card are that the serial connector is now a 9-pin device mounted off the board, there is a diode connected in series with the power supply (one reverse connection to the power supply - and an open circuit regulator was enough!), and the reset button is mounted on the case.

Software

The operation of the complete software is too complex for review here. However, a brief consideration of the mechanisms used whilst the game is running may be of interest.

The Z80 is interrupted 16 times a second. This is used to keep time during the game. On even interrupts the renewal packet is transmitted to the guns, and on odd interrupts the Z80 will accept messages from any guns requesting transmission. Any messages from the bases are built up over several seconds, the interrupts count the length of the data bits to decode the message. Interrupts also read keypresses from the PIC and buffer them for use in the main program.

The main program runs in a loop which waits for the passing of a second to update the main display. In addition, when an interrupt routine detects an incoming message from a gun or a base, it sets a flag which enables processing of the message in the main program. On receiving a message from a gun the renewal packet is updated with the ID of the gun, and the checksum is recalculated. The refreshed renewal packet is sent to the gun on the next interrupt.

The central keeps a record of all the players in the game which is used to generate the secret agents and warriors, and to ensure that all the players have downloaded at the end of the game. The player record maintains a list of all renewals and a count of the total lives used by a player. The team scores are updated and displayed during the game, the player scores are calculated at the end of the game. The scores are shown at the end of the game and updated once per second.

Auxiliary board

The auxiliary board provides the following functions:

- **Writing to the LCD display. The drive to the LCD module is fairly complex and requires a delay between commands which is as much as 4mS. The processor on the board implements a buffer for commands written to the module.**
- **Scanning the keyboard and translating keypresses and shift keys to ASCII codes. It also debounces the keyboard, and provides auto repeat if keys are held down.**
- **Driving and flashing the LEDs.**
- **providing a 1/16th of a second interrupt to the main board.**

The auxiliary board is mounted in the top of the case and all of the peripheral devices are connected through it. This allows the main board to be mounted in the base of the case, and there is only one cable connection to the main board for all the functions of the central.

The auxiliary board is based on the PIC16C57 micro controller (well we had to get one in somewhere!); its circuit diagram is shown in figure 8. This processor has 80 bytes of RAM which is sufficient to buffer commands to the LCD module.

The LCD module is driven by port C, bits 1 to 7. The LCD module is set into 4 bit mode to reduce the I/O requirement on the PIC.

The keyboard consists of four rows and five columns. Resistors R16 to R19 prevent dual keypresses from causing excess current drain if a high and low output are connected together. The red and green LEDs are driven by two of the keyboard outputs (they are not driven during keyboard scanning, but this occurs only briefly every 16th of a second and is not perceptible).

The interrupt output on RB5 drives the main board through TR4. This is to provide an open collector drive, allowing interrupts from the auxiliary board and the serial port to be "wire-oar's" on the main processor card.

The two wire communication to the Z80 card is provided on port bits RC0 and RB7 of the PIC and provides bi-directional communication and transmit/receive request and acknowledgement. This is used to send commands and text for the display module, to read the keyboard, to control the operation of the LEDs, and to release the interrupt signal from the Z80 when the interrupt routine is executed. The scope of the operation of the protocol between the Z80 card and the auxiliary board is too extensive for this article, but full details are available from the author.

The other components on this card are concerned with the communication with the guns and the bases. Note that all connections to the guns and the bases run through the auxiliary board.

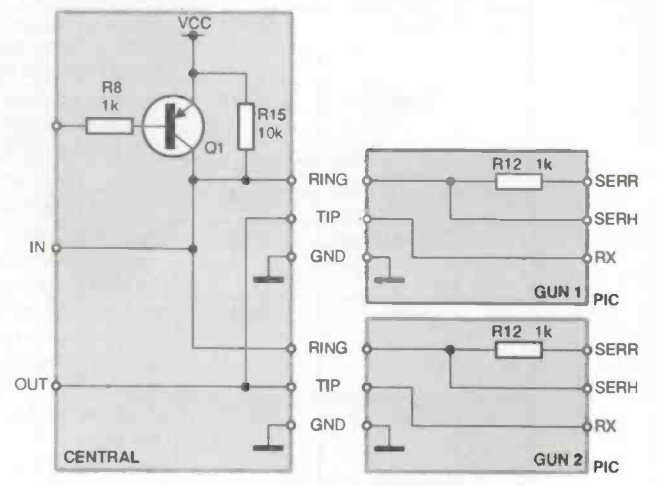

Fig.3. Simplified renewal circuit

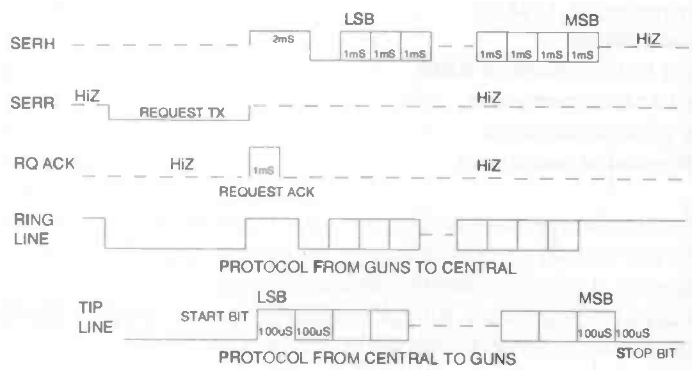

Fig.4. Serial protocols

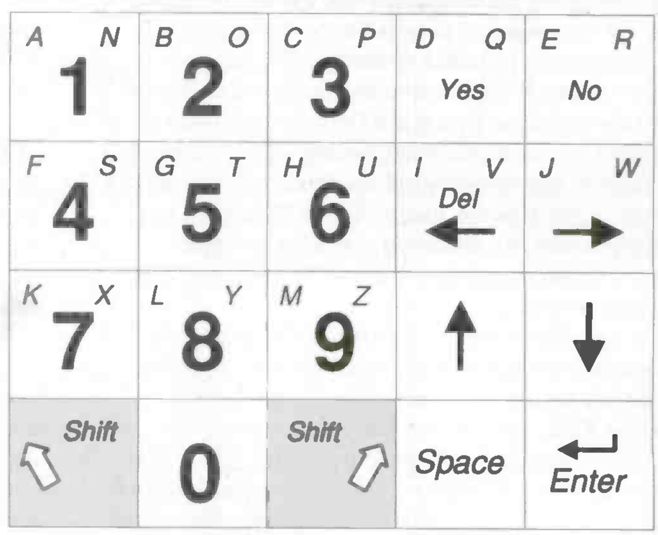

Fig.11. Keyboard overlay

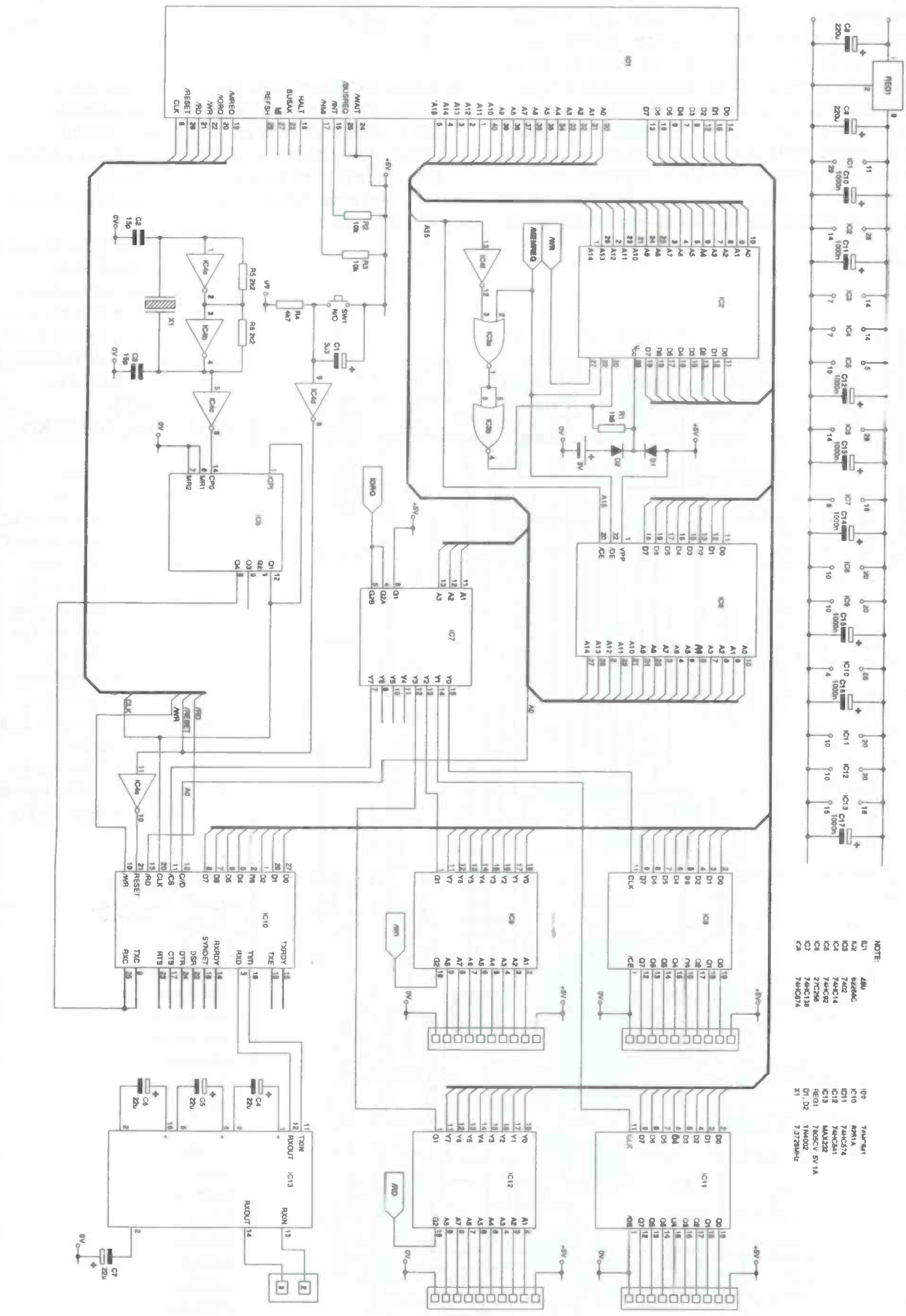

Fig.7. Circuit diagram for main processor

Construction

There are two boards to construct in the central. The first is the main processor board, and the second is the auxiliary board.

The main processor board should be constructed with care as there are many narrow tracks. Our problem with the main board was very small track breaks which are extremely difficult to see. The overlay for the processor board is shown in Figure 9. This is built in the same way as in the original article except for the modifications. Cut the circuit board tracks from IC7 pins 14 and 15 as close to the IC as possible. Drill holes in the board about 0.2" from IC7 to allow connection to the tracks which have just been cut. Drill small holes by IC10 pins 14 and 15, IC2 pin 27, IC1 pin 16 (by R2). and IC3 pins 8,9 and 10. Be careful not to cut any existing tracks.

Fit all the wire links. Do not fit the RS232 socket, but fit veropins into pins 1, 2 and 3 of the position for the socket. Now consult the circuit diagram whilst making the following modifications.

- **Solder IC7 directly into the board. Now take a 74HCT138, or a 74LS138 (IC100) and carefully cut off pins 9,10,11,12 and 13 at the IC. Bend pins 4,14 and 15 horizontally. and cut these pins so that about 0.1" of the pin is left on the IC.**
- **Fit IC100 over IC7 and solder the remaining pins of IC100 to IC7.**
- **Wire IC100 pins 14 and 15 to the tracks which originally connected to IC7 pins 14 and 15. Wire IC100 pin 4 to IC2 pin 27.**
- **Wire IC3 pin 8 to IC10 pin 15 and IC3 pin 9 to IC10 pin 15.**
- **Wire IC3 pin 10 to IC1 pin 16.**
- **Fit a veropin and connect to IC1 pin 16 for the interrupt input. (We cut the copper land under X1 in two, and drilled two holes in the now spare land, one for the pin, and one for the connection to IC1.)**
- **Cut the track from the power supply positive input, drill two holes and fit D100 in series with the positive input.**
- **Fit veropins in the hole for the reset switch (SW1).**

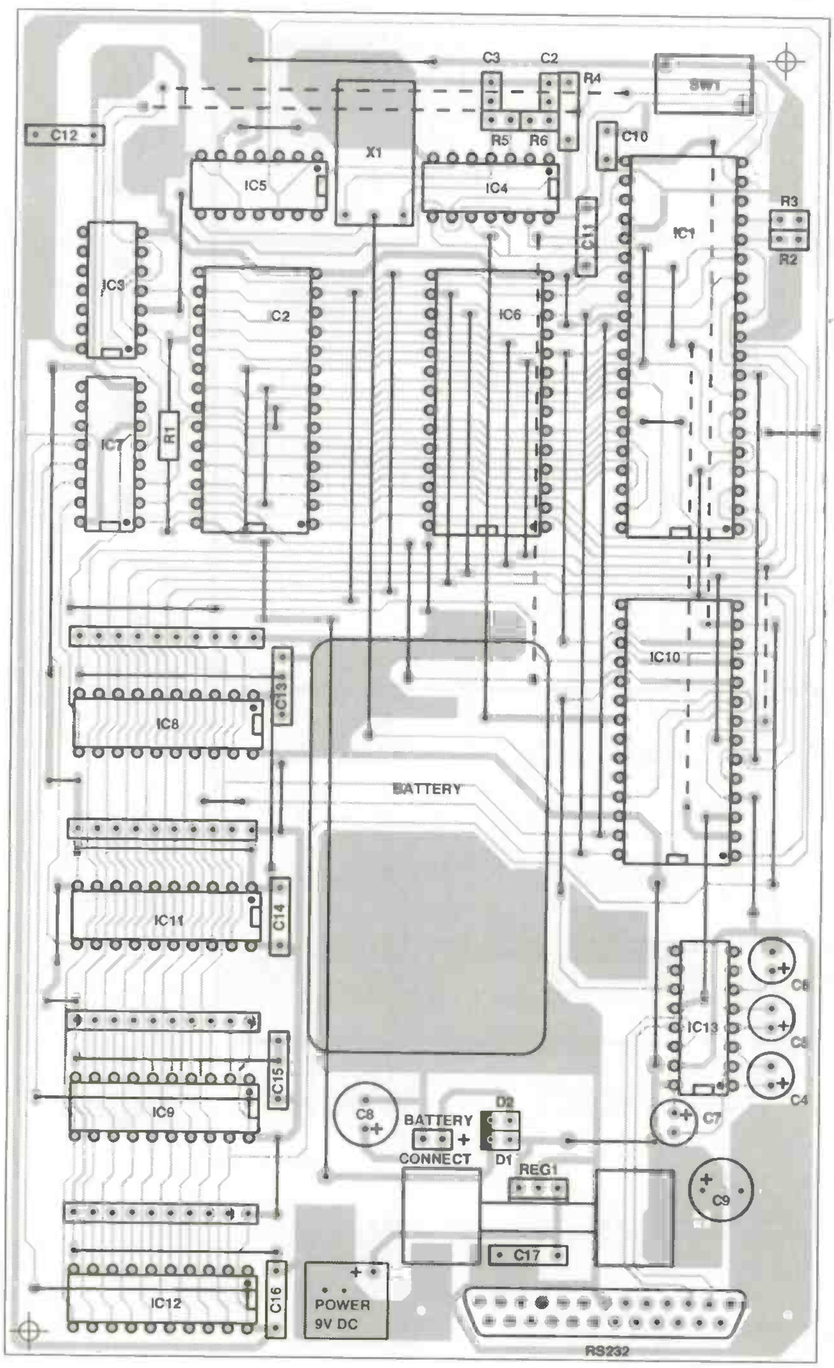

Fig.9. Component overlay for main processor

Superglue the longer wire links to the board. Fit all remaining components, socket all remaining ICs, noting that IC11 and IC12 are not fitted. Glue XL1 and the heatsink for the regulator to the board using silicone rubber. Do not connect the batteries or fit the ICs yet. To increase confidence in the construction it is worth checking all of the narrow tracks for continuity.

The auxiliary board has wider tracks and is slightly easier to build; its overlay is shown in figure 10. Please ignore the components shown in the bottom right of the layout and the prototype card which are intended for later expansion.

There are three wire links, fit these first. Fit a socket for IC1. Resistor networks RN1 and RN2

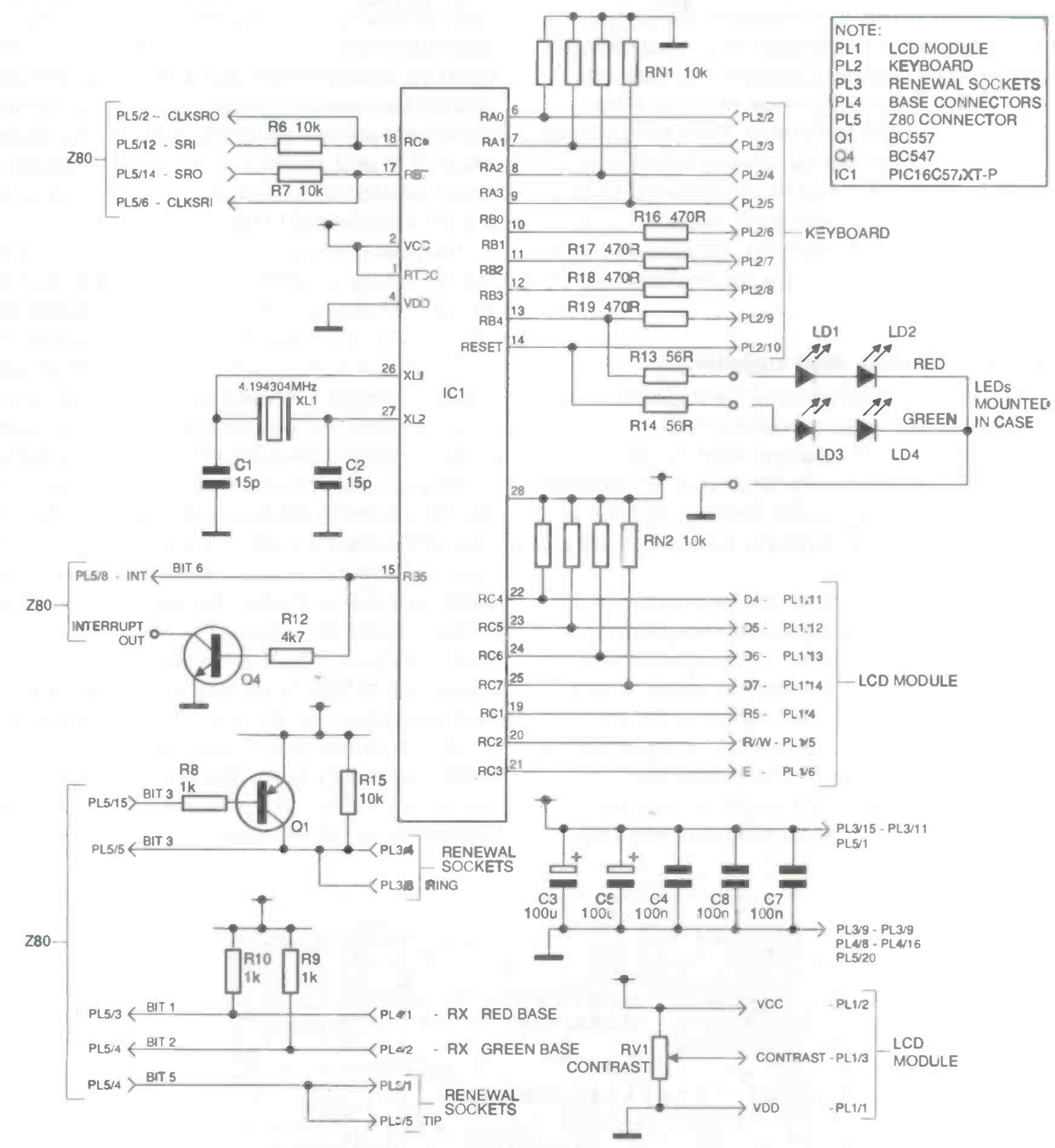

Fig.8. Circuit diagram for auxiliary board

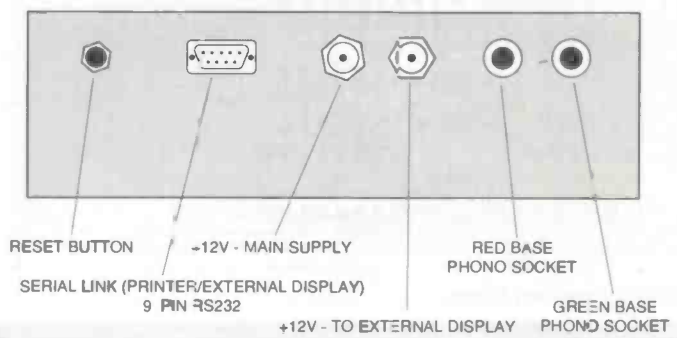

Fig.12. Connectors on rear of case

are made up by mounting resis-tors vertically and soldering to a tinned wire connected across the other pins of the resistors and down to the common connection.

The keyboard is supplied with its own connector PL2 which can be mounted directly to the PCB,. However, the keyboard tail is very short and we had to fit an extension on a small piece of veroboard. PL2 is fitted so that the connectors are closest to IC1, Pin 1 of PL2 is the pin which connects to the keyboard track with no connection to any of the keys. The IDC connectors PL1 and PL5 are fitted with the slot facing away from IC1. PL1 is a 16-way connector; remove two end pins to make it a 14 way connector. When fitting the IC sockets for PL3 and PL4, note that pin 1 is the opposite direction from IC1. Fit veropins for the LEDs and the interrupt output. Also fit the two veropins for the power supply for testing.

Physical construction and cabling

Consult the circuit diagrams throughout all the stages of wiring up the case. Photograph 1 shows the inside of the top of the case. We used a plastic case 22x15x6cm. All of the connectors, the auxiliary board, the keyboard and LCD module are fitted into the top. The serial connector, two power sockets, the base connector and reset switch are mounted at the back of the case as shown in figure 12.

The keyboard is glued to the top of the case and the tail fits through a slot cut in the top of the case. The keyboard is assembled by copying the overlay (figure 11) and gluing it between the membrane and the mask which fits on top. As for all other parts of the project silicone rubber is extensively used here.

Use an IDC connector for the LCD module; again remove the same 2 pins as from the connector PL1 to convert the connector to 14 pins and solder to the module so that the connector protrudes behind the display; the slot points away from the ICs on the back of the module. The LCD module is fitted into the front of the case and a hole is cut to view the module from outside the case.

The two renewal sockets are fitted into opposite sides of the case, flanked by one of the green and one of the red LEDs on each side of the case. The renewal sockets are wired to PL3, common, tip and ring are wired directly to each other. To connect the renewal sockets, we used an IC socket and wired the renewal sockets directly to it; the IC socket plugs directly into PL3. In similar fashion, the phono sockets for the base communication links are wired to PL4. The LEDs and interrupt line are wired directly to the veropins.

The main board is mounted on the bottom panel of the case. The two power sockets are wired directly to each other to allow the external display to be powered. The sockets are then connected to the supply pins on the main board. The serial port connector is a 9 pin socket; pin 2 of the socket goes to pin 3 of the connector on the board, pin 3 of the socket to pin 2 of the board, and pin 5 of the socket to pin 1 on the board. The reset button is wired to the veropins which replace SW1.

Now use IDC connector cable to make up two data cables. The 16-way lead from the auxiliary board to the LCD module uses IDC connectors which are pressed onto the cable with a vice, or a large pair of pliers. Make sure that the red stripe on the cable goes to the left when the slot is held pointing downwards on the connectors. The lead from the Z80 card to the auxiliary card is made up with 20-way cable. Connect to the IDC connectors so that the red stripe is to the left when the slot is held downwards. On the other end of the cable, split the cable in half and wire the two 10-way connectors so that the half with the red stripe connects to the plug by IC9 with the red stripe nearest pin 1 of IC9. The 11th wire of the cable (the first wire of the second half of the cable) is wired to the second connector

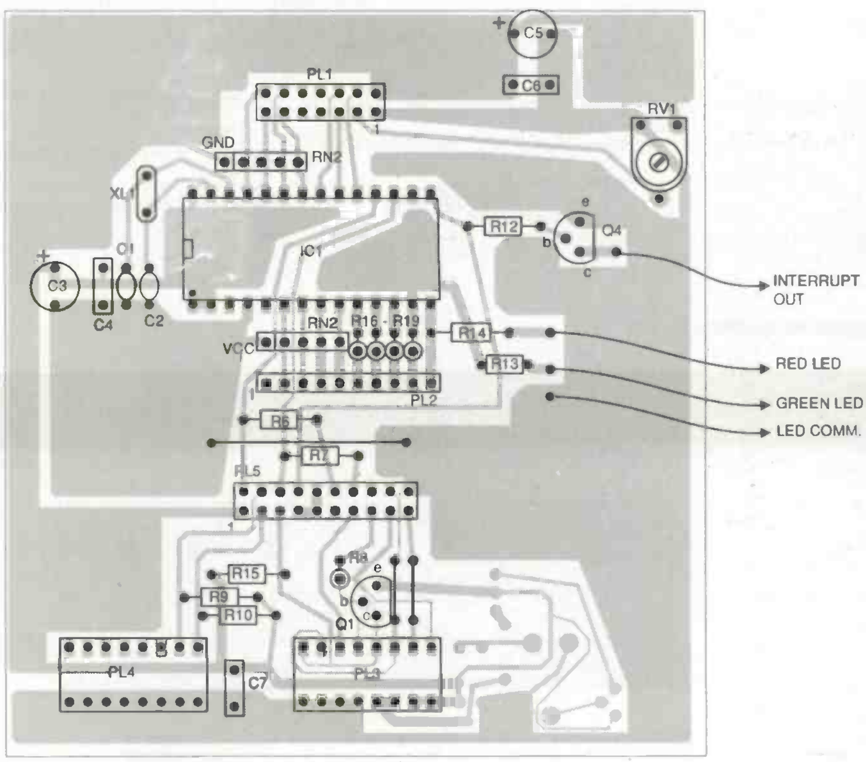

Fig.10. Component overly for auxiliary board.

nearest pin 1 of IC8.

The renewal leads are two back to back 3.5mm jack plugs. They are connected using 1m 3-way coiled cable. Use the best possible construction technique for this cable as it will be subjected to considerable strain. The power supply lead connects to spade terminals for a 12v sealed lead acid battery.

Testing and Set-up

Do not insert any ICs yet. Connect only the cable from the auxiliary board to the LCD module. Do not make the connection from the main board to the auxiliary board. The auxiliary board has a diagnostic mode to assist set-up independently of the main processor. Connect a 10K resistor from the end of both R6 and R7 (it doesn't matter which end) to +5v so that pins 17 and 18 of IC1 are pulled up.

Use a multimeter to check that the frame of the LCD module is connected to pin 4 of IC1 confirming that the power supply to the LCD is correct. Do not connect IC1 yet and wire the auxiliary board to +5V using the two veropins. The LCD module should have one of its rows slightly darker than the other, this can be varied with VR1. Check the power supply to IC1. Power down, insert IC1 and power up again. The display will show "OK!" Now check that if keys are pressed then the letter or number of the key is shown for 1 second in the bottom right of the display. The letters are accessed by pressing the shift keys. Finally, check that the interrupt output on pin 15 of IC1 is producing an 8Hz square wave (use an oscilloscope or analogue multimeter); this is the diagnostic mode which indicates that the main processor is not communicating with the auxillary card.

Now disconnect the power supply from the auxiliary board and the two resistors connected to R6 and R7. Connect the main 12V power supply and check that the main card has +5v at the correct pins on the ICs. Disconnect power. Now insert all the main card ICs and the cable from the main board to the

PARTS LIST

Main Processor Board, Parts List

Resistors

R1	1K5
R2,3	10K
R4	4K7
R5,6	2K2

Capacitors

C1	10uF
C2,3	15pF
C4-7	22uF
C8,9	220uF
C10-16	0.1uF
XL1	7.3728MHz

Semiconductors

IC1	Z80
IC2	62256
IC3	7402
IC4	74HC14
IC5	74HC92
IC6	27C256
IC7,100	74HC138
IC8	74HC574
IC9	74HC541
IC10	8251A
IC13	MAX232
D1,2,100	1N4001
Reg 1	7405

Miscellaneous

- Battery holder
- Heatsink
- IC sockets
- 2 x 10way SIL plugs & sockets
- Veropins
- 2 x AAA batteries

Auxiliary Board, Parts List

Resistors

R6,7,15	10K
R8,9,10	1K
R12	4K7
R13,14	56R
R16,17,18,19	470R
RN1	4x10K
RN2	4x10K
VR1	10K

Capacitors

C1,2	51pF
C3,5	100uF
C4,6,7	100nF
XL1	4.194304MHz

Semiconductors

IC1	PIC16C57/XT-P
TR1	BC557
TR4	BC547
LD1,2	Red LEDs
LD3,4	Green LEDs

Miscellaneous

PL1,5	16 way IDC socket
PL2	Keyboard connector
PL3,4	16 pin IC sockets
Veropins	

Case & Connectors

20 way IDC	50cm
16 way IDC	50cm
Coiled cable	2m

Connectors

Phono sockets	2
2.1mm power sockets	2
9-way D-connector	1
3.5m jack sockets	2
3.5mm jack plugs	4
16 way IDC plugs	4

Miscellaneous

Case	1
M3 nuts and bolts	
Reset switch (push to make)	1
LED holders	4

- Keyboard (20 way), Maplin code: JY05F
- LCD module - 20 chars x 2 lines, Hitachi LM032XMBL, Maplin code: DK66W

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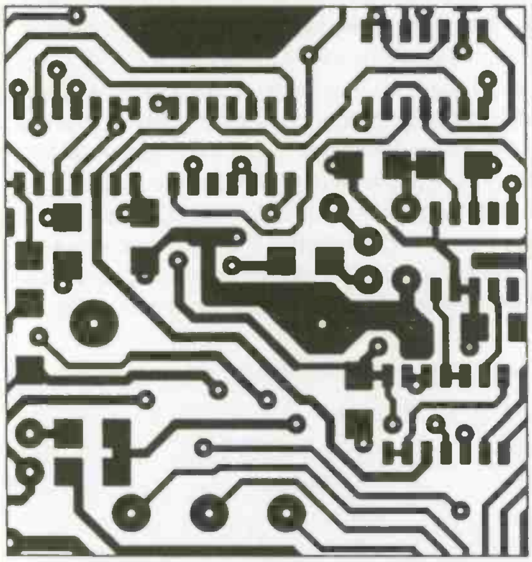

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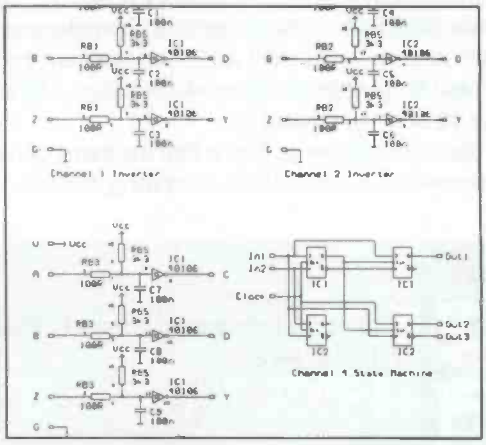

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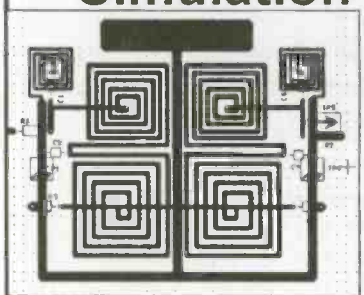

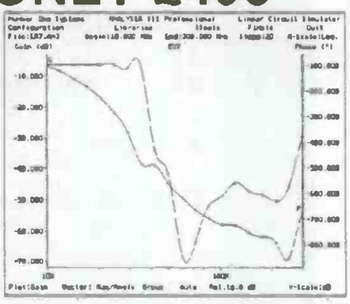

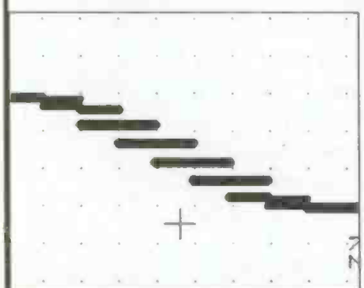

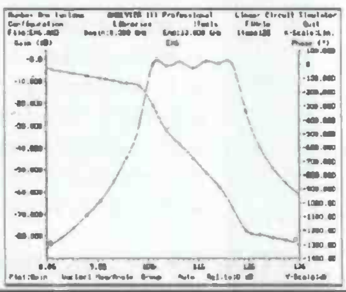

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auxiliary board. Check that the power supply pins on the ICs on the main card are connected to the correct power pins on IC1 of the auxiliary card. This will confirm that the cable has been wired correctly.

Connect the main power supply, wait for about 1 second and the base should spring into life! Use light guns and bases to confirm operation in accordance with the instructions shown at the start of this article. Check operation of the LEDs and both renewal sockets. Note that to use the central the guns should be powered up in normal renewal mode. This is achieved by removing the power recharging plug from the gun whilst NOT holding the gun trigger down. Remember that, until programmed, the guns will all have an ID of Red 8.

To use a printer or an external display then enable them in the configuration menu.

Finally fit the AAA batteries for RAM backup and confirm that the selected configuration is held through power down. Adjust the contrast of the LCD with VR1.

If at any point in testing the base cannot be made to operate as expected then check power supplies to ICs, and check for continuity and ensure that there are no short circuits.

Other Information

Some of the HC and HCT devices specified in the components list for the main board can be very hard to obtain (in fact I'm not sure that the 'HC92 has ever been manufactured). With the exception of IC3 and IC4 they can all be replaced by LS devices with no penalty except for power consumption and noise immunity - use HC/HCT devices wherever possible. Viewcom electronics are happy to sell to the hobbyist, and stock nearly all of the devices and the crystal on the main card - 0181-471-9338. The PIC, LCD module and keyboard are available from Maplin - 01702-554161.

If a printer is used then it must be set to 9600 bps, 8 bit, No parity. Select XON/XOFF signalling. If it cannot be made to operate then try swapping pins 2 and 3 over in the cable. Remember the printer must be selected from the configuration menu, and will only operate to display scores at the end of the game.

If the base is used at night then a backlit LCD module may be used. This requires a 5v supply connected at the rear of the module at the opposite end to the data connector. This should be connected to the main card power supply near the regulator. However backlit LCDs are considerably more expensive than the normal modules.

The game type control is table driven and the author would be pleased to accept suggestions for modifications, enhancements, or new game types within the limitations imposed by the operation of the guns.

Software

The author is prepared to program the EPROMs and PICs for this project. Send erased 27C256 and PIC16C57/XTP devices together with a return SAE (at least A5) and a cheque for £20.00 to Robin Abbott, 37 Plantation Drive, Christchurch, Dorset, BH23 5SG. This includes fuller details on the operation and player scoring of the central and an explanation of the areas of protocols not covered in this article. This will enable further development and experimentation.

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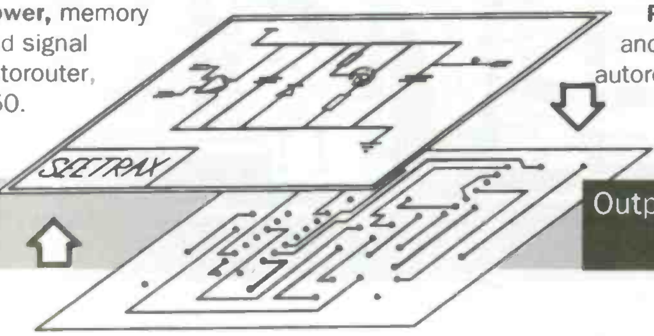

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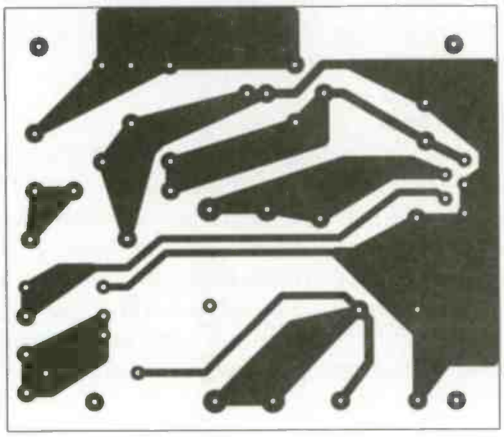

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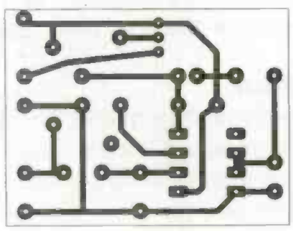

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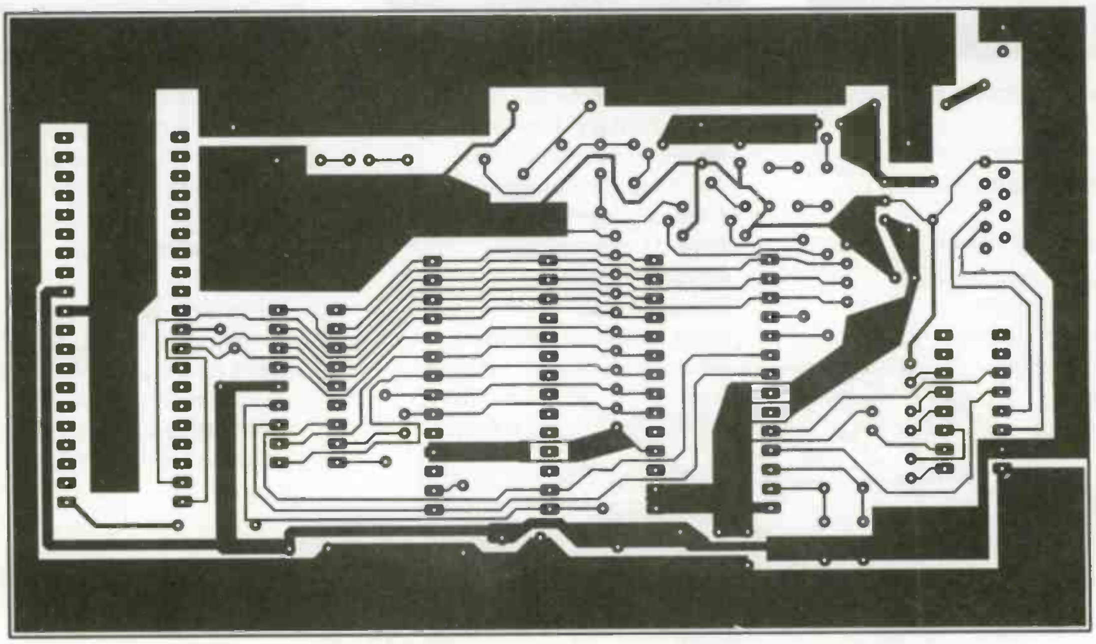

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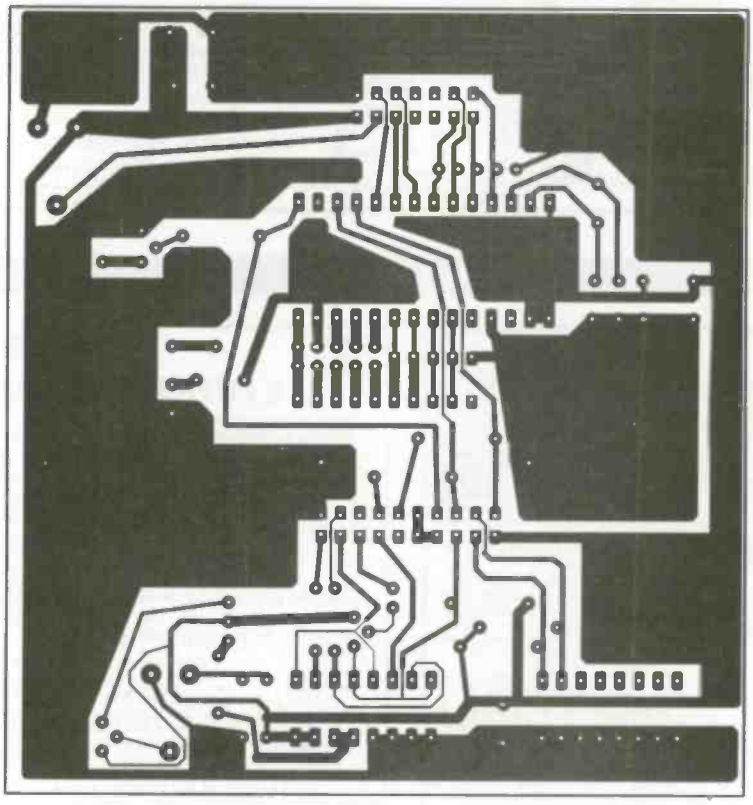
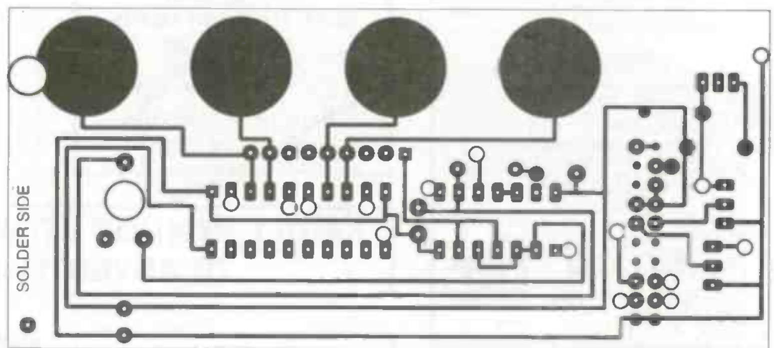


Light gun central



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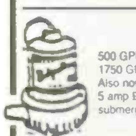

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Open Forum

The British government, in the form of Science Minister David Hunt, has published the first of a series of reports which forms one of the central components of what has been grandiosely entitled the Technology Foresight Programme. The report contains a collection of futuristic ideas: the first five cover health, transport, financial services, chemicals, and construction. Another ten reports covering other areas are due to be published shortly.

The reports have been produced by a team of academics and industrialists under the auspices of Hunt's Office of Science and Technology, and are designed to enable industrialists to identify markets and technologies which are likely to be most lucrative over the next twenty years.

Crystal ball gazing is always fun, and I am sure that the authors of these reports enjoyed themselves greatly, but do we really want to return to the days of government-directed research and industrial development. I am sure that the readers of ETI, who are actively involved in science and technology, can see the enormous flaws in this development, however well intentioned.

The areas of greatest commercial potential in the future are all too often those areas which defy identification. Only a few years before Yuri Gagarin's first flight, eminent scientists were still saying that manned space flight was impossible. When Intel developed the first microprocessor chip for use in calculators and process control equipment, very few people even remotely foresaw the rise of the personal computer industry. With all respect to the individuals involved, academics are notoriously poor judges of what will be a commercial success, as for industrialists, I am sure that if they see a good commercial idea they will keep it to themselves rather than tell the competition about it. Then of course we come to politicians and civil servants. Here I am afraid that the level of ignorance about science and technology is, in my own experience, horrendous. We cannot take these reports seriously. They are an interesting read, but they cannot be considered as a science and technology road map to the future. When it comes to the commercial application of science and technology the future is far too complex, full of far too many unforeseen events and interactions to be put under the direction of a government committee.

The only way to develop the science and technology that will be the basis of tomorrow's industries is to give scientists, engineers, and industrialists a free rein. Mistakes will be made, money wasted, but in the long term the success rate for this approach will be infinitely better. Let scientists and engineers follow their instincts, to discover whatever there is to discover, and let industrialists use their judgement about what makes a commercial success.

Instead of attempting to direct science, technology, and industry, the government should be trying to make it easier for people to exploit new ideas and developments, and turn them into commercial products. This includes better access to funding, better tax allowances for R&D, better education of scientists and engineers in the workings of business and finance, and of businessmen and accountants in some of the more general aspects of science and engineering. Let us try and create a culture in this country of the successful scientist/ engineer/ businessman, where the man at the top can talk to financiers and research scientists with equal ease.

Instead of pointing at certain ideas as being the boom industries of the future, the government should be improving the flow of information between scientist and industrialist, and vice versa. The government should, for example, be funding the translation of foreign language research papers. Why are we all too often so ignorant of research work, and industrial development, that is going on in Russia, Japan, China, India, and even our close EU neighbours such as France and Germany.

Take the case of shape memory alloys featured in this issue, we have been able to find out plenty of information about what has been done in America, since we share the same language. But the enormous amount of published work from Japan and Russia, is closed to most of us, and yet may well contain information which could be the basis of an enormously successful product. If such information was easily available in translation, then who knows what potential commercial successes might be uncovered?

Next Month...

In the July 1995 issue of ETI we conclude the laser tag system with construction of a large character score display board. We feature another of Richard Grodzik's add-on boards for his 80188 single board computer project, an analogue input. We will also complete Robin Abbott's PIC programmer project, and Dave Bradshaw's practical introduction to switch regulators

We continue our series of projects built around the Parallax Stamp computer with a look at building a range of versatile pulse measurement system that will connect to your PC. We will also be continuing the series of projects by Bart Trepak which use the PIC microcontroller.

From Terry Balbirnie there is a practical look at a novel technique for making printed circuit boards. The main feature article will look at one of the most successful microprocessor designs of the last couple of years, the British designed ARM chip, and at some truly revolutionary future developments from this world leading Cambridge high technology company.

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