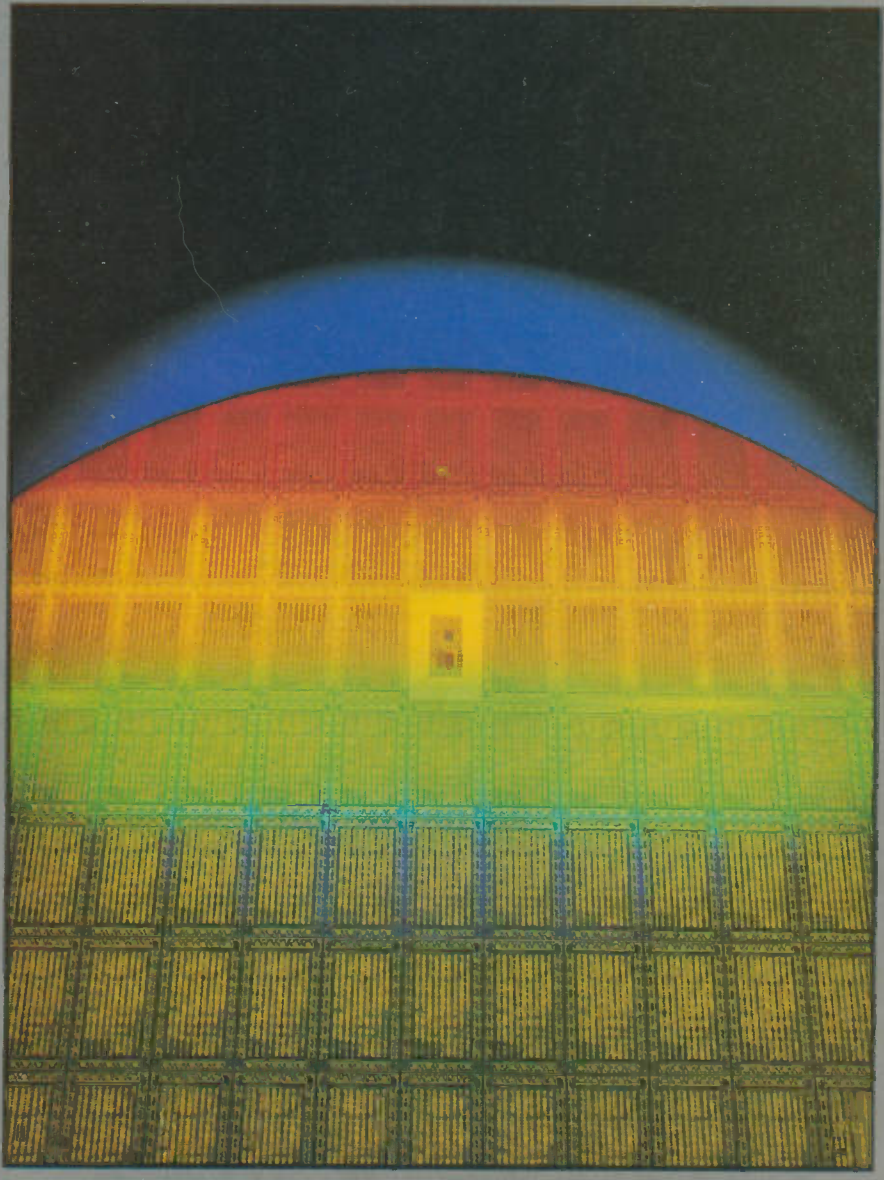
29 Windsor

PRACTICAL

ELECTRONICS

MAY 1986 · £1·25

SCIENCE AND TECHNOLOGY



SOLAR ENERGY
THE ULTIMATE POWER SOURCE

LOGIC CHECKER
A 16-CHANNEL TTL TESTER

ECHO REVERB
SPEECH-BAND EFFECTS UNIT

PE HOBBY BUS – A STANDARD
PERIPHERAL INTERFACE FOR ALL HOME COMPUTERS

COMPETITION
THE SOLAR CHALLENGE

P.E. PROJECT KITS

MAGENTA

Full kits include pcb's, hardware, cases (unless stated otherwise), IC sockets, wire, nuts & bolts. Article reprints extra 70p each.

THIS MONTH'S KITS – S.A.E. OR PHONE FOR PRICES

LOGIC PROBE Feb 86	£13.48
COMPUTER MOVEMENT DETECTOR Feb 86	£16.60
SPECTRUM SPEECH SYNTH & 8-BIT I/O PORT Jan 86	£28.19
HIGH PERFORMANCE STEPPING MOTOR DRIVER Dec 85	£20.98

EXTRAS: Transformer **£5.98**, Case **£2.95**, BBC lead & plug **£1.98**, Motor-1D35 **£14.50**

COMMODORE USER PORT EXPANDER Nov 85	£10.91
MODEL RAILWAY TRACK CONTROL Nov 85	£41.04
'SOUINT' ROBOT EYES Nov 85	£8.68
TOUCH CONTROL PSU Oct 85	£28.38
MODULATED SYNDRUM Oct 85	£26.58
GENERAL PURPOSE ROBOT INTERFACE, fully populated board Sept/Oct 85	£74.99
RS232 TO CENTRONICS CONVERTER Sept 85	£44.95
CAR BOOT ALARM Sept 85	£11.72
COMPUTER ENVELOPE SHAPER Aug 85	£22.19
VOLTMETER MEMORY ADAPTOR July 85	£10.98
STYLUS KEYBOARD FOR COM 64 Jun 85	£9.55
SYNTHESISER INTERFACE FOR COM 64 Jun 85	£15.69
AMSTRAD SYNTHESISER INTERFACE May 85	£25.38
CYLINDER THERMOSTAT May 85	£21.77
BBC POWER CONTROL INTERFACE Apr 85	£20.99
GUITAR ACTIVE TONE CONTROL less case Sept 83	£11.97
PROGRAM CONDITIONER June 83	£18.67
AUTO TEST SET May 83	£34.62
WIPER DELAY Apr 83 less relay	£8.24
BATTERY TESTER Apr 83	£13.25

DIGITAL CAPACITANCE METER

A superb instrument with a five digit 0.5 inch LED display giving direct readout of pF, nF and uF from 1pF to 1,000uF.
Exceptionally easy to use. A crystal timebase eliminates setting up procedures.
Ideal for schools, labs, and industry as well as electronics enthusiasts from beginners to experts.
Complete kit – including PCB, case, all components and hardware, **£35.98.** Reprints of article 70p.

EDUCATIONAL SETS

FUN WITH ELECTRONICS

Enjoyable introduction to electronics. Full of very clear full colour pictures and easy to follow text. Ideal for all beginners — children and adults. Only basic tools needed. 64 full colour pages cover all aspects — soldering — fault finding — components (identification and how they work).
Also full details of how to build 6 projects — burglar alarm, radio, games, etc. Requires soldering — 4 pages clearly show you how.
COMPONENTS SUPPLIED ALLOW ALL PROJECTS TO BE BUILT AND KEPT.
Supplied less batteries & cases.
FUN WITH ELECTRONICS, COMPONENT PACK £16.98
BOOK EXTRA £1.75.
Book available separately.

ADVENTURES WITH ELECTRONICS

An easy to follow book suitable for all ages. Ideal for beginners. No soldering, uses an S-Dec Breadboard. Gives clear instructions with lots of pictures. 16 projects — including three radios, siren, metronome, organ, intercom, timer, etc. Helps you learn about electronic components and how circuits work. Component pack includes an S-Dec breadboard and all the components for the projects.
Adventures with Electronics **£3.58.** Component pack **£20.98** less battery.

LOGIC TUTOR

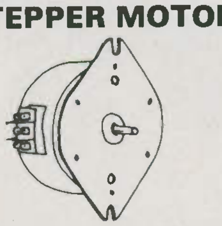
A specifically designed test bed for the practical side of the 8-part educational series 'Introduction to Digital Electronics' Practical Electronics Oct 83–May 84. Full kit includes screen printed pcb, power supply, connector strips and turned pin sockets (less case).

£34.98
REPRINTS EXTRA 70p EACH

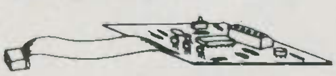
HIGH PERFORMANCE STEPPING MOTOR DRIVER

As featured in December issue
Kit including PCB, I.C. & All Parts £20.98
Transformer 30V 18VA **£5.98 extra**
Case (houses PCB only) **£2.95 extra**
Lead & Connector for BBC Computer **£1.98**
Motor – ID35 **£14.50**
TEA1012 also available separately **£6.88.** Data **£1.00**

STEPPER MOTOR



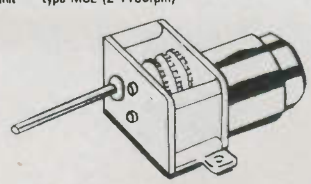
BBC TO ID35 STEPPER MOTOR INTERFACE KIT £13.99 PCB, driver IC, components, connectors and leads included. Demonstration software, listings, circuit diagram, pcb layout and construction details given. Requires unregulated 12Vdc power supply.
INTERFACE KIT (ref PE) **£13.99.**
OPTIONAL POWER SUPPLY PARTS **£4.67.**
ID35 STEPPER MOTOR 48 Steps. 12V **£14.50.**



DC MOTOR SETS

MOTOR — GEARBOX ASSEMBLIES 1.5V-4.5V.
Miniature precision made. Complete with quality electric motors. Variable reduction ratios. Long 3mm dia output shafts.

Small unit — type MGS (3-2200rpm)	£3.49
Large unit — type MGL (2-1150rpm)	£3.98



PULLEY WHEELS — metal 3mm bore	
10mm dia	£1.75
20mm dia	£1.84
30mm	£1.99
METAL COLLAR with screw — 3mm bore	24p
FLEXIBLE SPRING COUPLING 3mm L31mm	68p
FLEXIBLE METAL COUPLING 3mm	£2.98
FISCHERTECHNIK DC MOTOR SETS	
SMALL TYPE 187	£9.85
LARGE TYPE 185	£9.90
DC MOTOR 1.5V-4.5V RPM 4,400-8,700 Shaft dia 2mm L10mm. Body 29×38mm	
DC MOTOR TYPE — DC28	£1.98
FLEXIBLE STEEL SPRING DRIVING BELT	47p

12" long. Joins to itself or 2 or more can be joined where long lengths are needed.

BBC HEART RATE

BBC Heart Rate Monitor— Ready Built £35.99

Practise relaxation or monitor fitness with this plug-in heart rate monitor. Connects directly to the BBC computer. Programs give continuous heart rate displays, bar charts, graphs etc. Supplied with sensor, software & instructions — ready to plug in and use.

fischertechnik

We offer a range of the superb Fischertechnik sets. These cover robotics, electronics, electromechanics, motors and gears, and basic construction.
Robotics kit builds 11 different working models including a robot arm, graphics board, sorting system etc. Note that not all the models can be built at the same time. Simple to assemble. Easily combined with all other Fischertechnik kits. Top quality. Includes 2 motors, an electromagnet, lamps, potentiometers, switches etc.

ROBOTICS Kit (554) PE	£68.99
Construction/base kit (ut1)	£37.50
Motors and Gears (ut2)	£42.70
Use ut2 to motorise ut1	
Electromechanics (ut3)	£73.20
Electronics (ut4)	£93.90

BBC — ROBOTICS INTERFACE

A READY TO USE INTERFACE for the BBC computer and the Fischertechnik Computing and Robotics Kit (554).
Allows the BBC computer to operate all 11 of the standard models which can be built from the Fischertechnik Robotics kit.
The interface features forward, reverse and on/off control of four DC motors; on/off control output for driving an electromagnet or similar device; and eight switch inputs for reading microswitches or other binary inputs.
Two independent analogue input channels are provided for position sensing.
Supplied complete with connectors and leads the interface requires a power source of 9–12 volts at 1A.
Detailed programming information is supplied with the interface. A software disc with a comprehensive set of programs is also included.
FISCHERTECHNIK ROBOTICS — BBC COMPUTER INTERFACE (BUILT) (PE) **£69.95**

68000

MICROPROCESSOR TRAINER

AND SINGLE BOARD COMPUTER

A new single board training and evaluation system for the 16-bit 68000 Series Microprocessor. A standard working system in kit form costs just **£99.00 including VAT.** Programs are developed and written with the aid of an on-board monitor program. The system is programmed and run via an RS232 link from either a standard terminal or a BBC Computer programmed to act as a terminal (we can supply the necessary software). Optional extras include a line by line assembler, a peripheral I/O port and timer, and a G64 bus interface. Full sets of technical literature, programming information and manufacturers' data sheets are available to accompany the system.

AVAILABLE FROM STOCK NOW
PHONE OR WRITE FOR FULL DETAILS REF PE6

68705 MICROCONTROLLER TRAINER

A stand-alone unit with hexadecimal keyboard and 9-digit seven-segment display. Uses a control oriented 68705 microprocessor with a comprehensive monitor system. A bank of 8 LEDs and switches allows I/O control programs to be run before connecting to 'real' external circuits. An A/D–D/A board is also available along with full support literature. An excellent introduction to machine code programming right down to 'bit' level. Used in many educational establishments. A complete system costs under £50.
All in stock — Phone or write for details Ref PE6

68000 COMPONENTS

68000 P8	£21.20
68230 P8	£6.99
68681	£9.60
64 pin I.C. socket	98p
6116 (250n)	£1.99
6264 (250n)	£3.99
27128 EPROM	£3.88
MC1488	56p
MC1489	59p

CATALOGUE

Brief details of each kit, book contents, and illustrations and descriptions of our range of tools and components are all included.
Robotics and Computing section included.
Our advert shows just a selection of our products.
Up to date price list enclosed. Official orders welcome.
Catalogue & Price List — Send £1 in stamps etc or add £1 to your order.
Price list only 9×4 SAE.
Catalogue free to schools/colleges requested on official letterhead.

HOW TO ORDER

MAGENTA ELECTRONICS LTD.
PE6, 135 HUNTER ST.,
BURTON-ON-TRENT
STAFFS, DE14 2ST.
MAIL ORDER ONLY.
0283 65435, Mon-Fri 9-5.
ADD 60P P&P TO ALL ORDERS.
PRICES INCLUDE VAT.
SAE ALL ENQUIRIES.
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OUR PRICES INCLUDE VAT

Access/Barclaycard (Visa) by phone or post.
24 hr Answerphone for credit card orders.

OVERSEAS: Payment must be sterling.
IRISH REPUBLIC and BFPO: UK PRICES.
EUROPE: UK PRICES plus 10%.
ELSEWHERE: write for quote.

PE ROBOTICS MICROS ELECTRONICS INTERFACING

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CONSTRUCTIONAL PROJECTS

NEWS AND REVIEWS

REGULAR FEATURES

SPECIAL FEATURES

PE SERVICES

OUR JUNE 1986 ISSUE WILL BE ON SALE FRIDAY, MAY 4th, 1986 ***(see page 57)***

WHAT'S NEW . . .

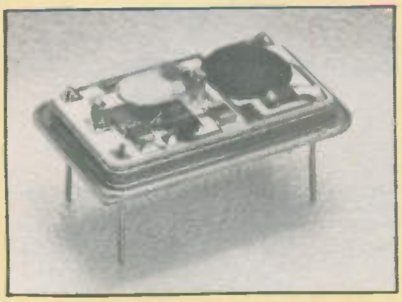
Quality crystal units in d.i.l. packages

IQD, a producer and supplier of quality crystal units and oscillators, now has available a 150 page catalogue which contains the UK's most comprehensive selection of frequency control devices.

Included in the catalogue is a range of metal packaged oscillators to fit a 14-pin d.i.l. layout. Maximum measurements are 13·08mm × 207mm × 7·62mm and the range provides the full spectrum of 16 asynchronous/synchronous data communications frequencies.

Compatibility and frequency range are available as follows: CMOS: High Speed, 800KHz–20MHz; ECL compatible: 4MHz–100MHz; Tri-state TTL compatible: 4MHz–5MHz; Complementary output (two phase) TTL compatible: 3·5MHz–20MHz; Crystal controlled dual baud generator (programmable divider).

Details from: IQD, North St., Crewkerne, Somerset TA18 7AR.



Filter socket complete with fuses and voltage selector

A new range of space saving combination filters for office machinery, technical instruments, computers and similar products have been introduced by Roxburgh Suppressors. Added to the company's existing range, the new space saving RFI suppression filters combine an IEC (DIN49457) plug socket with fuse cartridge and voltage selector.

The units act as power input sockets for suitable equipment and the voltage selectors are designed for two, three or four different voltages. The filters accommodate one or two fuse cartridges which can only be opened when the power line plug has been removed. Terminals for connection to an on/off switch are also provided. Two, 4A and 6A versions are available, and maximum leakage current at 250V, 50Hz is either 2 × 0·21mA or 2 × 2μA.

Details from: Roxburgh Suppressors Ltd. Tel 0424 442160.

Temperature probe and snowmen

A low cost but very effective temperature probe is available which can be used for a wide variety of applications in schools and at home.

The probe has a range of –40 to 110 degrees celcius, plugs directly into the BBC analogue port and requires no external power. It is extremely robust and is supplied with a 1·5m, cable.

Two software packages are available for the probe. One is particularly appropriate to primary science as it displays a thermometer together with colourful pictures to give meaning to the concept of temperature. For example, if the probe is put into iced water a snowman will appear on the screen and a boiling kettle will appear at 100 deg.C

Details from: Capital Delta, 8 Dunlin Close, Poynton, Stockport SK12 1JS.

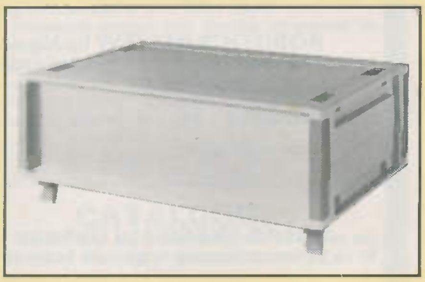
Lightweight case for 19 inch standard

Designed to meet the need for a strong, lighweight case to the 19 inch standard, the Internorm case is moulded in a new material developed specially for the product. The result is an attractive enclosure, styled to complement any modern office or laboratory, and strong enough to support a man's weight.

The simple yet versatile method of construction allows for wall-mounting or panel-mounting cases as well as free-standing versions. Cases may also be sealed to IP54 if desired.

Available in three widths, and heights of 3U upwards, features of the Internorm case include integral prop-up feet and a deep handle recess at each side to permit a balanced grip regardless of the centre of gravity position.

Details from: West Hyde Developments, 9–10 Park St., Ind. Est., Aylesbury, Bucks HP20 1ET.



Challenge to CRT technology

Epson (UK) has introduced an 80 character × 25 lines (640 × 200 Pixel) l.c.d. module known as the EG7001A-AR, which offers a viable alternative to CRT technology.

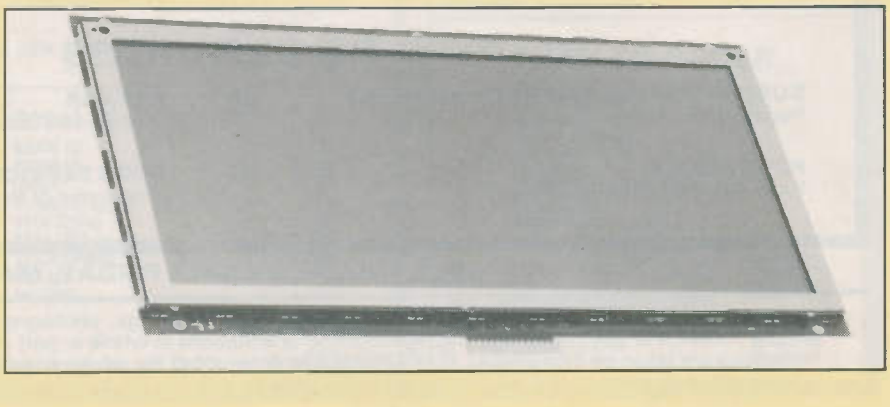
The display measures 280 × 116 × 16·5mm, yet for all practical purposes it matches a CRT for speed and has a life expectancy of 50,000 hours.

The module can be employed in conjunction with a touch sensitive keyboard to provide interactive user control and compares favourably in cost with any standard CRT. An optional backlight is available to improve readability in poor lighting conditions and it can be viewed from angles up to 30° from the plane.

Robust compared with a CRT unit, the l.c.d. generates no electrical interference and as such is ideal for applications close to, or in conjunction with magnetic tapes, sensitive instrumentation and navigation systems. Power requirements are low, at only about 20mA, making it ideal for portable battery powered equipment.

To back up the l.c.d., Epson has also introduced a single chip graphic l.c.d. controller i.c. which simplifies the interface between CPU, l.c.d. and video RAM. In character display mode it can control 80 characters × 25 lines and handle cursor control, scrolling of both whole or part page, 2-screen control and local character "flashing". Up to 160 characters can be accessed from the on-chip ROM with a further 256 available from an external ROM facility.

Details from: Epson (UK) Limited, Dorland House, 388 High Road, Wembley.



WHAT'S TO COME...

The Acorn Risc

Acorn are well known to most people as the manufacturers of the BBC computer. But, as yet, they are still unknown as the developers of a new and revolutionary microprocessor chip—the ARM or Acorn RISC Machine. RISC stands for reduced instruction set computer and is a new concept in processor design. Using the RISC design philosophy, Acorn have designed and produced in just 18 months, a 32-bit microprocessor more powerful than a 68020. Running Basic, the ARM processor has benchmarks which are almost 10 times faster than those of the IBM PC with its 16-bit 8086.

The ARM is a small (7mm square) chip with 25,000 transistors fabricated using conventional 3-micron CMOS technology and can perform 3 million instructions per second (MIPs) at a 5MHz clock rate. By comparison the 68020, a 16/32-bit processor, is on a 9mm square chip with 192,000 transistors fabricated using state of the art 2-micron technology and can perform 2·5MIPs at the same 5MHz clock rate.

Because the ARM chip is small and uses established technology, Acorn expect to be able to produce it for about one quarter of the price of other 32-bit microprocessors. Acorn expect to use the processor in a new generation of powerful low cost personal computers.

Currently Britain has a world lead in RISC processor design with three fully developed systems including the Acorn ARM and the INMOS Transputer (this is a RISC machine but with an architecture designed for parallel multiprocessing applications). The third 32-bit RISC processor is the Viper developed by the Royal Signals and Radar Establishment at Malvern for military applications. However, the UK's lead may be short lived. IBM has announced the development of a RISC processor to put in a new range of personal computers. The IBM development appears to have been prompted by companies like Acorn—ironic, since the RISC concept was first proposed by researchers at IBM in the early 1970s.

Colour Lcd Displays

Small portable colour TV sets using liquid crystal displays will be on the market very soon. So far, two Japanese companies, Epson and Matsushita, have announced working commerical standard colour l.c.d. displays. The Epson device is the larger of the two with a 5·13 inch diagonal screen with a resolution of 480 × 440 pixels (each pixel consisting of a red, blue and green segment). The backlit display is claimed to be almost as bright as a CRT and ten times brighter than a normal reflective l.c.d. The Matsushita display is slightly smaller (4.25 inch diagonal) with a 300 × 300 pixel resolution.

Of the two displays, the Matsushita one is already in production and is being incorporated into a small portable TV set. This TV set is scheduled to go on sale in Japan at the end of this month, and the company expects to be making 20,000 sets a month. The price in Japan will be about £230.

Optical Advances

Erricsson of Sweden have announced the development of an optical switch. This switch is capable of directing data from any one of eight incoming optical fibres to any one of eight output fibres. This is a very important advance and is one of the key elements in the development of an optical telephone exchange and eventually optical computers. The device is fabricated on a single 60mm × 40mm slice of lithium niobate and is the most complex such device yet developed.

Further advances in optical information transfer have come from British Telecom. BT have set a new world record for data transmission, over a 20 mile fibre optic cable link, of 2·4 billion bits per second. This data transmission rate would allow over 30,000 speech channels or 32 colour TV channels to be sent down a single optic fibre. BT have been able to achieve this by using a very pure, single wavelength light source. This has been derived from a 1·52-micron distributed feedback laser developed at BT's Martlesham Heath research labs.

COUNTDOWN

Events, diary dates and forthcoming attractions

Amstrad Computer Show May 31–June 1. Novotel, Hammersmith. K
ShowTech '86 May 13–15. Berlin.
British Laboratory Week Sept 23–25, Olympia. M
ITAME Sept 23–25. M
College. L.
CAD '86 Apr. 8–10. Metropole, Brighton. J
Internepcon Production Show Apr. 8–10. NEC, Birmingham. B
British Electronics Week Apr. 29–May 1, Olympia. M
East Suffolk Wireless Revival May 25. Civil Service Sportsground, Ipswich. C
SCOTELEX '86 June 3–5, Royal Highland Showground, Edinburgh. D
Software '86/Business Computer '86 June 3–5. Earls Court. E
Amateur Electronics Exhibition July 12–20. Esplanade, Penarth. A

A B.A.E.C. ☎ 0222 707813
B Cahners ☎ 01-891 5051
C Ipswich Radio Club ☎ 0473 44047
D Institution of Electronics ☎ 0706 43661
E Reed Exhibitions ☎ 01-643 8040
F ASCE Ltd. ☎ 06268 67633
G Electrex Ltd. ☎ 0483 222888
H Online ☎ 01-868 4466
I Trident Int. Ex. Ltd. ☎ 0822 4671
J Butterworth Scientific Ltd. ☎ 0483 31261
K Database ☎ 061-456 8383
L Imperial College ☎ 01-589 5111
M Evan Steadman ☎ 0799 26699

Printed Software

Typing in program listings from computer magazines and books is very time consuming and error prone; how much better it would be if a means could be developed for the computer to directly read such programs. This problem has now been solved by an American company, Cauzin Systems Inc. This company has developed a very ingenious method of storing programs, in printed form, which are directly machine readable.

The program is stored as a strip composed of dots, each dot representing a single bit. A 6-inch by 1-inch strip will contain about 5000 bytes of program. The software used to generate this strip will run on most home and personal microcomputers supporting a matrix printer. The printed strip incorporates error detection codes to keep read errors to a manufacturer-quoted 1 in 10 billion.

The really ingenious part of this product is the reader, which can be attached to any microcomputer. The user simply runs the scanner down the printed strip and the reader is capable of reading data from the printed strip even if that strip has been bent, creased, written over with felt tip pen or even had coffee spilt over it. This would be impossible for a normal optical reader, but the Cauzin reader does not use optics, it uses heat. The reader is designed to emit infra-red energy, which is then absorbed by the carbon granules in the ink. The reirradiated heat is then detected by a special infra-red detector and lense system. A microprocessor in the scanner inputs the data from the read sensor and converts it into machine readable data with full error correction.

01-208 1177 TECHNOMATIC LTD 01-208 1177

BBC Micro Computer System

BBC Master Series
AMB15 BBC MASTER Foundation computer 128K .... £435 (a)
AMB12 BBC MASTER Econet computer 128K (only ANFS) .... £348 (a)
AMC06 Turbo (65C102) Expansion Module .... £87 (b)
ADF13 Rom Cartridge .... £13 (d)
ADF10 Econet Module .... £49 (c)
ADJ22 Ref. Manual Part I .... £14.50 (c)
ADJ23 Ref. Manual Part II .... £14.50 (c)
ADJ24 Advanced Ref. Manual .... £19.50 (c)

ACORN COMPUTER SYSTEMS
BBC B PLUS with 128K .... £389 (a)
BBC B PLUS Econet & DFS .... £399 (a)
BBC Dust Cover .... £4.50 (d)

UPGRADE KITS
Econet Kit .... £55 (d)
1770 DFS Upgrade for Model B £43.50 (d)
1.2 OS ROM .... £7.50 (d)
DNFS ROM .... £17.50 (d)
ADFS Rom (for B with 1770 DFS & B Plus .... £26 (d)
64K Upgrade Kit for B Plus .... £35 (d)

ECONET ACCESSORIES
Econet Starter Kit .... £85 (d)
Econet Socket Set .... £34 (c)
File Server Level 1 .... £75 (d)
File Server Level II .... £210 (d)
Printer Server Rom .... £41 (d)
10 Station Lead set .... £26 (c)
Adv. Econet User Guide .... £10 (d)

ACORN ADD-ON PRODUCTS
Z80 2nd Processor .... £329 (a)
6502 2nd Processor .... £169 (a)
Teltext Adaptor .... £125 (b)
IEEE Interface .... £278 (b)

COMMUNICATIONS ROMS
Termulator .... £25 (d)
Communicator .... £49 (d)
Commstar .... £28 (d)
DATABEEB .... £24 (d)

BBC FIRMWARE & SOFTWARE
Database Management Systems
Word Processors — Languages
Spreadsheets — Utilities
For full details on the wide range of above packages please write to us.

TORCH UNICORN products including the IBM Compatible GRADUATE in stock
For detailed specification or information on our comprehensive BBC range please write to us.

PRINTERS

EPSON
LX-80NLQ .... £195 (a)
FX85 (80col) NLQ 8K RAM £315 (a)
Optional Tractor Feed .... £20 (c)
FX105 (136col) .... £449 (a)
JX80 4 colour printer .... £435 (a)
LQ800 (80col) .... £595 (a)
LQ1500 (136col) 2K buffer .... £875 (a)
LQ1500 (136col) 32K buffer .... £950 (a)

PLOTTERS
Epson H180: A4 4 colour Plotter .... £345 (a)
Hitachi 872: A3 4 colour Plotter .... £465 (a)

TAXAN KAGA:
KP810 80 Col NLQ .... £195 (a)
KP910 156 Vol NLQ .... £339 (a)
JUKI 6100 Daisy Wheel .... £289 (a)
HR15LX (Serial) .... £295 (a)
HR15LX (Serial) £385 (a)

Paper:
2000 Sheets Fanfold:
9.5" x 11" .... £13 (b)
14.5" x 11" .... £18.50 (b)
Labels: (per 1000)
3.5" x 17/16" Single row .... £5.25 (d)
27/16" x 17/16" Triple row .... £5.00 (d)

ACCESSORIES

EPSON
FX plus sheet feeder .... £129.00 (b)
LX80 Sheet feeder .... £49.00 (b)
Paper Roll Holder .... £17.00 (d)
FX80 Tractor attachment .... £37.00 (c)
Interfaces: 8143 RS232 .... £28.00 (c)
8148 RS232 + 2K .... £57.00 (c)
8132 Apple II .... £60.00 (c)
8165 IEEE + cable .... £65.00 (c)
Serial & Parallel Interfaces with larger buffers available.
Ribbons: RX/FX/MX80 .... £5.00 (d)
RX/FX/MX100 .... £10.00 (d)
LX80 .... £6.00 (d)
Spare pens for H180 .... £7.50/set (d)
FX80 Tractor Attachment £37 (c)

KAGA TAXAN
RS232 Interface + 2K Buffer .... £85 (c)
Ribbon KP810/910 .... £6.00 (d)

JUKI:
RS232 Interface .... £65 (c)
Spare Daisy Wheel .... £14.00 (d)
Ribbon .... £2.50 (d)
Sheet Feeder .... £182 (a)
Tractor Feed Attachment .... £129 (a)

BROTHER HR15:
Sheet Feeder .... £189 (a)
Tractor Feeder .... £99 (a)
Ribbons Carbon or Nylon .... £4.50 (d)
Red Correction Ribbon .... £2.00 (d)

BBC Printer Lead:
Parallel (42") .... £7.00 (d)
Serial .... £7.00 (d)
Printer Leads can be supplied to any length.

MODEMS
— All modems listed below are BT approved

MIRACLE 3000:
A new range of microprocessor based modems offering of upto 2400 baud, full duplex. Features include 'HAYES' protocol compatibility, auto answer, auto dial, speed buffering, printer port, data security option etc. Mains powered.
WS3000 V2123 (V21 & V23) .... £295 (b)
WS3000 V22 (as above plus 1200 baud full duplex) .... £495 (b)
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KAGA KX1203A Hi Res 12" Etched Amber Screen .... £105 (a)
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No of ways	Header Plug	Receptacle	Edge Conn.
10	90p	85p	120p
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34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways	9	15	25	37
MALE:				
Ang. Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	-
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St Pin	100	140	210	380
Ang. pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	-
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2 × 36-way	250p	—
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2 × 32 way St Pin	230p	275p
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3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B		400p
IDC Skt A + C		400p

For 2 × 32 way please specify spacing (A + B, A + C).

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21 pin Scart Connector 200p
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	Solder	ZDC
36 way plug	500p	475p
36 way skt	550p	500p
24 way plug IEEE	475p	475p
24 way skt IEEE	500p	500p

PCB Mtg Skt Ang Pin
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24" Single end Male £5.00
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20-way	85p	50-way	200p
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	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	-
20 pin	75p	-
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

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Using 'Prestel' type protocols for information and orders phone 01-450 9764. 24 hour service, 7 days a week.

DF BEACON TIMER

BY R. A. PENFOLD

Accurate offshore aid for small craft navigation

As both nautical and non-nautical readers are probably aware, there are a number of radio direction finding beacons situated around the shores of the UK to aid offshore navigation, and intended mainly to assist with small craft navigation. What is probably less well known is that there are considerably more radio beacons than available operating frequencies, and a system of time-sharing has been adopted. This has beacons in groups of six which transmit in sequence for one minute each, starting on the hour. Thus the first beacon transmits for one minute starting on the hour, 6 minutes past, 12 minutes past, and so on. The second beacon transmits at 1, 7, 13, etc., minutes past each hour, the third operates at 2, 8, 14, etc., minutes past each hour, and so on.

The purpose of this timer project is to indicate which direction finding beacon in each group is transmitting at any moment. The timer is a sort of single digit clock which simply counts in minutes from 1 to 6 over and over again, and by resetting it to 1 on the hour, thereafter it gives the required indication of which beacon in the sequence is operating. This avoids the possibility of miscalculating which beacon is transmitting, and the potentially disastrous consequences of such an error. Good accuracy is of course essential, and the circuit has therefore been made crystal controlled. The unit is primarily intended for use with a 12V boat supply, but the use of low power CMOS circuitry makes it feasible to use a built-in 9 volt battery if preferred.

SYSTEM OPERATION

Although the unit is basically just a crystal oscillator, divider chain, and single digit counter, there are a couple of complications that must be overcome. These both involve the count from 1 to 6; a standard counter circuit does, of course, count from 0 to 9. The counter consequently requires some additional circuitry to provide a reset as the count advances to '7', and to then introduce an additional clock pulse to immediately take the counter from 0 to 1. Fig. 1 shows the make-up of the unit in block diagram form.

The crystal oscillator operates at a frequency of 4194304Hz, which when divided by a twenty-two stage binary counter gives a 1Hz output. In this case a 14-stage counter followed by an 8-stage type is used to provide the twenty-two divider stages. The signal is then further divided by ten and by six to give the one pulse per minute required to drive the counter circuit. The final clock signal is fed to the counter by way of a form of gate circuit, but this always enables the clock signal to pass through to the counter. The purpose of the gate is to enable extra clock pulses to be mixed in with the main clock signal.

The clock signal is also fed to a form of divide-by-six circuit, and this is used to provide a reset pulse to the counter as it advances to '7'. This resets the counter to '0', but the reset pulse is also

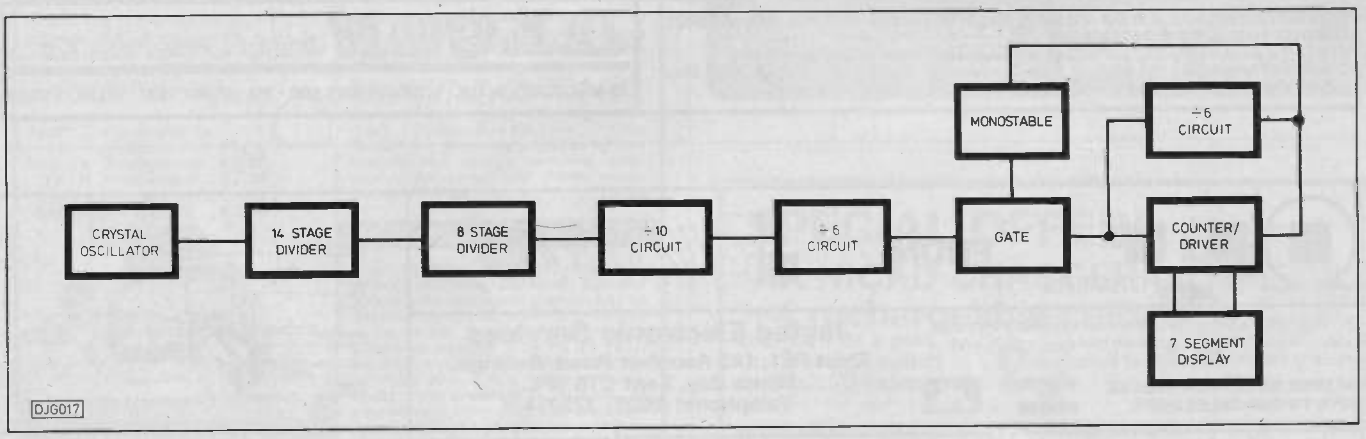
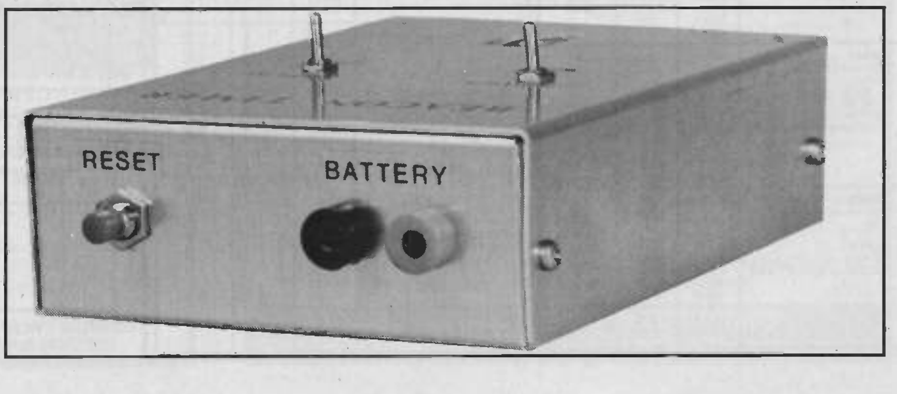


Fig. 1. *Block diagram*



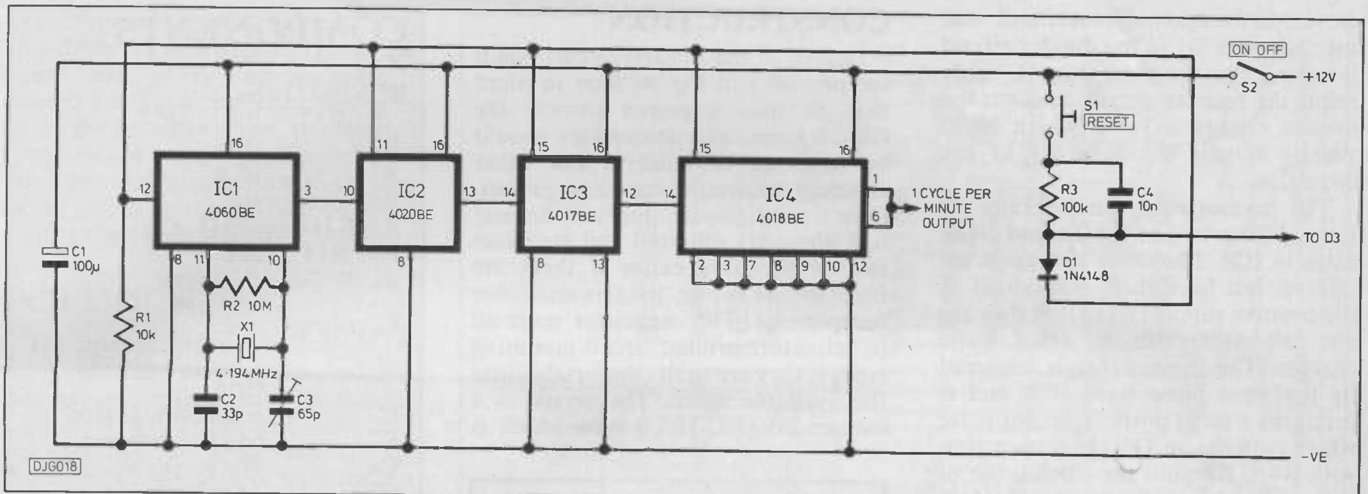


Fig. 2. *Clock generator circuit diagram*

used to activate a monostable multivibrator. The latter provides a short output pulse, and this is coupled into the gate circuit where it provides the additional clock pulse which moves the counter on to '1'.

For an application of this type a red l.e.d. display is probably the most practical, and it is a display of this type which is utilized here.

CIRCUIT OPERATION

Fig. 2 shows the circuit diagram for the clock generator stages while Fig. 3 shows the counter circuit.

IC1 is a 4060BE oscillator and fourteen stage binary divider. The oscillator can operate as a C-R or crystal type, but in a critical application of this type the accuracy of a C-R type is totally inadequate and a crystal oscillator has to be used. C3 enables the operating frequency to be trimmed to precisely the required frequency. IC2 is a 4020BE fourteen stage divider, but in this case only eight stages are utilized and the other six are just ignored. The divide by ten action is provided by IC3 which is a 4017BE decade counter/one-of-ten decoder. Here it is used as a straightforward decade counter and no use is made of the one-of-ten capability. The final divider stage is IC4. This is a 4018BE 'divide by n' counter which is connected here to operate in the divide by six mode.

When the counter is reset to '1' it is essential that the divider stages are also reset, so that the full one minute is allowed to elapse before the counter is advanced to '2'. R1 normally holds the reset inputs of all four dividers in the low state, but when S1 is operated these inputs are briefly taken high as C4 charges. R3 ensures that C4 discharges when S1 is released, so that another reset pulse is obtained when S1 is next operated.

COUNTER CIRCUIT

Turning now to the counter circuit of Fig. 3, IC5 is the counter/driver device, and this is a 4026BE driving a seven-segment common cathode l.e.d. display via current limiting resistors R5 to R11. S3 enables the display to be switched off when the unit is not being used, in order to conserve the battery. IC5 does actually have an input which can be used to switch the display on and off, but in this case it is easier just to have S3 in series with the display's cathode terminal.

IC7 is another 4017BE decade counter/one-of-ten decoder, but this time it is used in the role of a one-of-ten decoder. It is wired so that as its '7' output goes high it resets both itself and IC5. D2 is wired between the '7' output and the reset input so that the reset button S1 is not blocked from resetting IC5 and IC7. D3 couples both

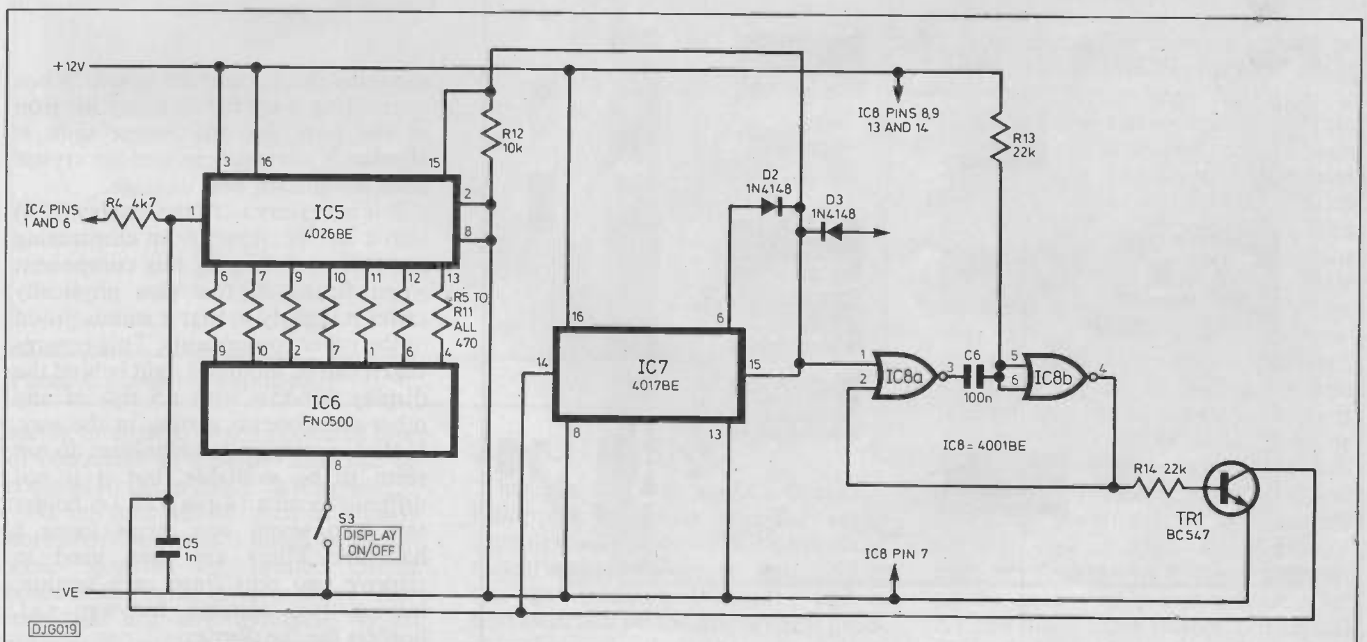


Fig. 3. *Counter stages circuit diagram*

devices to the manual reset circuit, and together with D1 in the divider circuit it ensures that the pulse from IC7 only resets the counter circuit, and not the divider circuits as well (which could slightly impair the accuracy of the circuit).

The monostable multivibrator is formed from two of the 2 input NOR gates in IC8. The other two gates are unused, but have their inputs tied to the positive supply rail so that they are not left vulnerable to stray static charges. The monostable is triggered by the reset pulse from IC7, and it produces a short positive output pulse which switches on TR1. In conjunction with R4, TR1 pulls the clock input of the counter low. Of more significance, at the end of the pulse the clock input of the counter goes high again, and it is this low-to-high transition which clocks the counter from '0' to '1'. The output pulse from IC8 is only about 2ms in duration, and this results in the counter being so rapidly advanced that '0' does not appear to be displayed at all, and is apparently totally suppressed.

The current consumption of the unit depends largely on how many display segments are active, but is generally in the region of 40 milliamps. The stand-by consumption when the display is switched off is only about 3·5 milliamps with a 12V supply, or 2 milliamps with a 9V supply. This is low enough to permit economical operation from a fairly high capacity 9V battery such as six HP7 size cells in a plastic holder, which should provide several weeks of continuous operation.

CONSTRUCTION

Details of the printed circuit board are provided in Fig. 4. Bear in mind that all the integrated circuits are CMOS types, and accordingly should be mounted in holders. The other standard antistatic handling precautions should also be observed. Several link wires are required and construction is probably easier if these are fitted before the i.c. holders and other components. The capacitors must all be miniature printed circuit mounting types if they are to fit comfortably into the available space. The crystal is a wire-ended (HC-18/U) type which is mounted direct onto the board. When connecting it try not to apply the iron to the joint for any longer than is absolutely necessary so that the crystal does not sustain heat damage.

It is necessary to fit the display (IC6) into a holder. Apart from eliminating the risk of damaging this component when fitting it, this also physically raises it slightly so that it stands proud of the other components. This ensures that it can be mounted right behind the display window with no risk of any other components getting in the way. Unfortunately, suitable holders do not seem to be available, but it is not difficult to cut a 14-pin d.i.l. i.c. holder into two seven way strips using a hacksaw. Pliers are then used to remove two pins from each section, leaving two suitable five-way s.i.l. holders for the display.

Assuming that the unit will not be powered from an internal battery pack

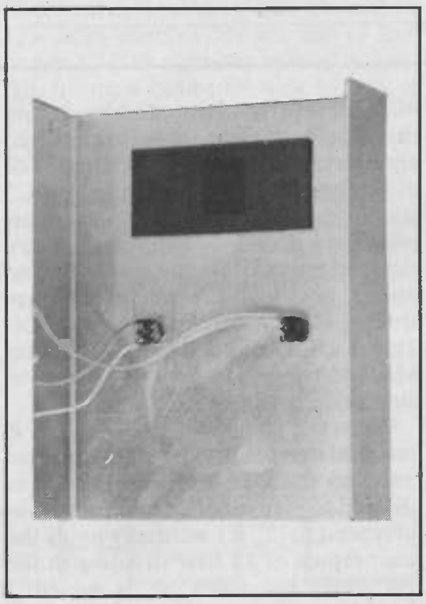


Photo 2. *Top panel details*

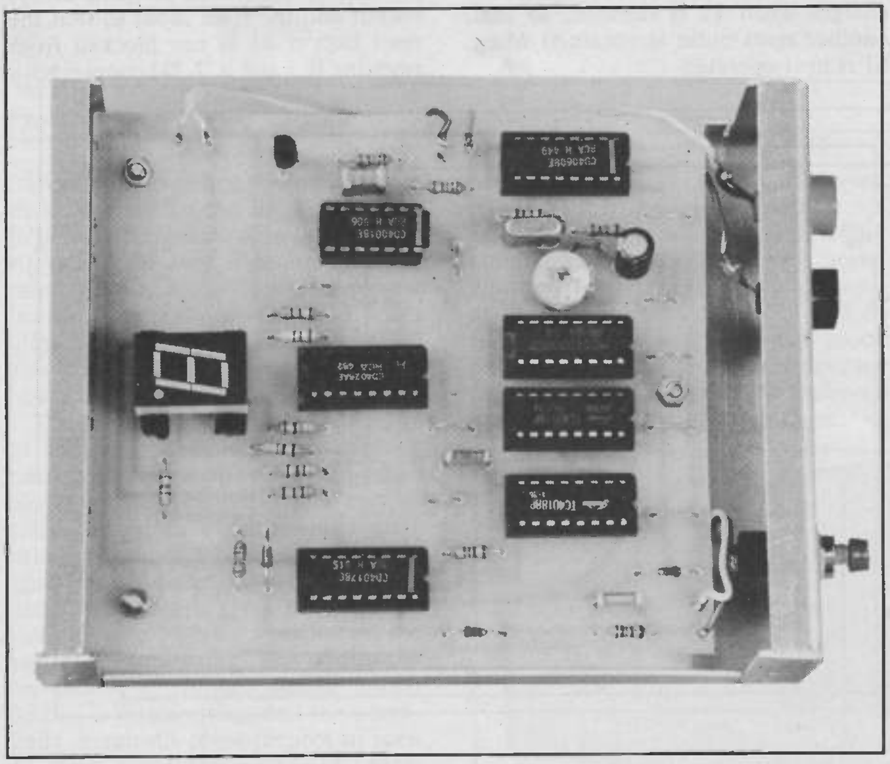


Photo 3. *P.c.b. and construction details*

COMPONENTS . . .

RESISTORS

R1,R12	10k (2 off)
R2	10M
R3	100k
R4	4k7
R5–R11	470 (7 off)
R13,R14	22k

all $\frac{1}{4}$W 5% carbon film

CAPACITORS

C1	100µ 10V radial elect.
C2	33p ceramic plate
C3	65p foil trimmer
C4	10n polyester layer
C5	1n polyester layer
C6	100n polyester layer

SEMICONDUCTORS

TR1	BC547
D1–D3	1N4148 (3 off)
IC1	4060BE
IC2	4020BE
IC3,IC7	4017BE (2 off)
IC4	4018BE
IC5	4026BE
IC6	FND500 or similar CC l.e.d. display
IC8	4001BE

MISCELLANEOUS

X1	4·194MHz wire-ended crystal
S1	Push to make
S2,S3	s.p.s.t. sub-min. toggle (2 off)

P.c.b. PE109; case about 133 × 105 × 38mm; 16-pin d.i.l. i.c. holder (6 off); 14-pin d.i.l. i.c. holder (2 off); 4mm sockets (2 off); red display filter material; wire; solder, etc.

a case measuring about 133 by 105 by 38 millimetres is adequate to house the board and other components. If desired it might actually be possible to fit in the batteries under the printed circuit board using a case of this size, but if internal batteries are to be used as the power source it would be much easier to use a slightly larger case.

PCB MOUNTING

The printed circuit board is mounted on the base panel of the case, but long spacers are fitted over the mounting screws in order to raise the board and bring the display just beneath the display window (which is cut in the top panel at the appropriate position). Probably the easiest way of making the display window is to first drill or punch a hole about 10 to 12 millimetres in diameter, and then file this out to the required rectangular shape using a small, flat, tapered file. The finished unit will look neater if some red display window material is glued in place behind the cutout, but this is not essential.

S2 and S3 are mounted on the top panel of the case, but they must be carefully positioned where they will not foul components on the printed circuit board and prevent the lid of the case from being fitted into place. S1 is mounted on one of the end panels, as are a couple of 4 millimetre sockets, spring terminals, or any preferred type of connector so that the unit can be coupled to the external 12V supply.

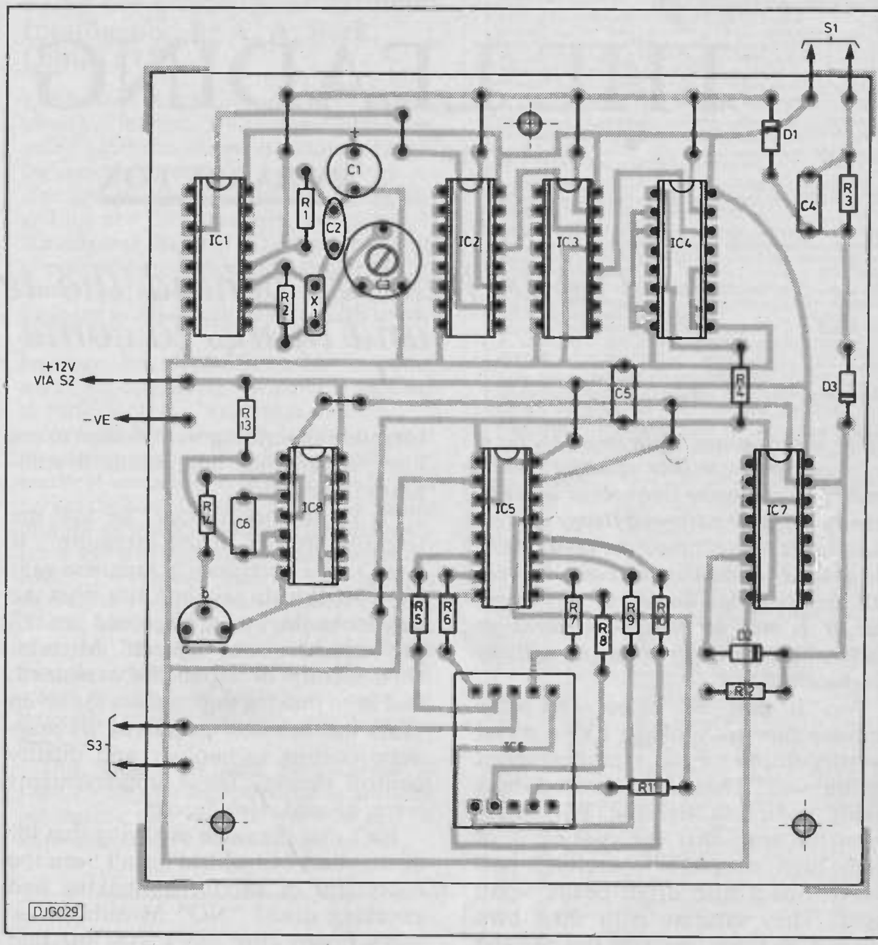


Fig. 4. *P.c.b. and component details*

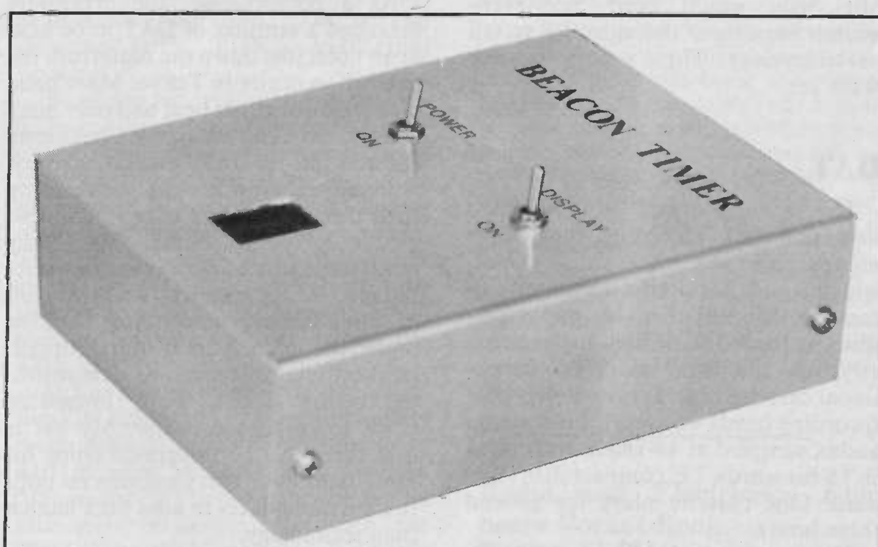


Photo 4. *Complete unit details*

As the unit will be used in a fairly hostile environment is might be worthwhile spraying the printed circuit board with one of the protective coatings that are now available. If an aluminium case is used it would also be a good idea to protect this with several coats of paint or a clear lacquer.

ADJUSTMENT

Initially set C3 at about half capacitance (i.e. with the moving vanes roughly half enmeshed with the fixed vanes) and switch display switch S3 to the "on" position. When the unit is first switched on the display will probably show a random character (which might not even be a legal character), but when reset button S1 is operated the display should immediately switch to '1'. If it does not, switch off at once and recheck the unit thoroughly. Assuming that the reset functions properly, check that the display goes through the correct '1' to '6' sequence, and then resets to '1' again, with each count taking one minute.

The accuracy of the unit should be quite good with C3 merely set at about half value. You may prefer simply to leave it at this setting and recalibrate the unit more frequently rather than spend a lot of time trying to optimise the unit's accuracy. If you do wish to find the optimum setting for C3, then S1 should be reset exactly on the hour with the aid of the Greenwich time pips or some other accurate time source. Note that S1 should be operated at the instant the unit is to be reset, and it should not be held down and then released at the instant the hour is reached. The unit should then be checked against the time standard each day. Reduce the capacitance of C3 to speed up the timer, or increase its value to slow it down. The degree of accuracy that can be attained depends on the quality of the crystal used for X1 and many other factors, but crystal controlled timers can usually achieve an accuracy of better than one second per day.

THE LEADING EDGE

BY BARRY FOX

The technology behind the technology and things to come

Off to Birmingham, train fare £25, for a press conference. "One of the World's leaders in computer technology is set to launch the most advanced floppy disc on the market today", read the invite. "On the grounds of security we cannot reveal full details of the launch at this stage. But it is not an under-statement to declare categorically that it will be spectacular".

Was it daft PR hype? Or some genuine new technology, like a metal powder floppy of the type developed by Maxwell? These metal-coated discs treble recording density, but suffer from the snag that the coating is of such high magnetic coercivity that conventional disc drive heads won't work. They saturate with their own flux before recording onto the disc and overload with signal on replay, causing errors in the bit stream.

So could it be the launch of a vertical recording medium? In conventional floppies the magnetic particles lie end-to-end, parallel with the surface. In a vertical medium the particles are all alligned perpendicular to the surface.

Recording density is increased by a factor of at least ten, just as you can get the whole world on the Isle of Wight if everyone stands up. The snag again is that conventional heads won't work. A double head is needed, which makes a sandwich with the recording medium to channel the flux vertically.

The invite carried the name Mitsubishi so obviously it couldn't just be PR hype. Japanese companies with the technical clout of Mitsubishi don't do that sort of thing. Or do they?

SAMURAI WARRIOR

Yes they do. I arrived at the Birmingham Exhibition Centre to see "the most advanced floppy disc on the market today . . . amidst one of the tightest security operations ever mounted for an exhibition in the UK". What I saw was two imitation Samurai warriors posing for pictures. So was an imitation Marilyn Monroe, complete with Seven Year Itch skirt. There was no technical presentation. The PR man who had arranged the "spectacular launch" gave me a pack of trade literature describing what looked to me like just another bog standard computer floppy disc.

"It IS new technology" he told me tetchily, "It's all in the literature". It wasn't, so I persisted. A Japanese gent from Mitsubishi said he knew what the new technology was, but could not tell me because it was "secret". Mitsubishi's factory in Japan, he explained, had been making floppy discs for seven years but has now improved its magnetic coating technology and quality control checks. These improvements were, he said, also "secret".

Isn't that the same as saying that for seven years Mitsubishi hasn't been too successful or careful in making and checking discs? "NO" Mitsubishi assures floppy disc users. It's just that they are now even better.

I never thought that a company like Mitsubishi would need 'now-even-whiter-than-white' detergent PR to sell its technology. There's hope for the West yet.

DAT

The Japanese are all set to launch a new domestic recording tape technology this year. It's called DAT, which stands for digital audio tape. A cassette, smaller than an audio cassette, is loaded with very high coercivity tape the same width as conventional cassette tape. It runs slowly past recording heads which lay down stereo audio, sampled at 44·1KHz and coded in 16-bit words, i.e. compact disc standard. One cassette plays for around three hours.

There are two DAT standards, S-DAT and R-DAT.

S-DAT works on the *stationary* head principle. The tape head is sub-divided into a large number of small sections which each lay down a narrow parallel track along the tape. So the digital words bits are spread across the tape as well as along it.

For R-DAT, the tape runs round a *rotating* head drum, as in a video recorder. Although at first sight R-DAT looks technically more complicated, all the engineering development work has already been done for portable video. S-DAT is not as simple as it looks. The head has to be divided into 22 separate sections to cover half the 3·81mm tape width. The only way to construct the head is by thin film etching technology. That is expensive, and practical problems, like tape weave, have not yet been reliably solved. So it is far more likely that R-DAT will become the true standard.

The Japanese planned to launch DAT last year at the Tokyo hi fi show. At the last minute the Japanese retail trade brought enough pressure to bear on the exhibition organisers to cancel the launch. "We are trying to sell compact discs and 8mm video" they said, "we don't need anything new. What's more the launch of DAT will make existing audio cassette recorders obsolete overnight".

As a compromise, the organisers arranged a seminar of DAT to be held at an hotel just down the road from the exhibition centre in Tokyo. More pressure was brought to bear and only Sony showed up. The company's engineers showed an R-DAT machine which worked well until it went wrong. They then threw a blanket over it and told everyone to go home. The Sony machine is small, like a portable radio, but is so far supported by a suitcase full of breadboard electronics hidden under the table. This is quite normal. It's how compact disc was demonstrated before launch. Fully integrated chips followed soon after. My bet is that there will be integrated chips for DAT later this year. Commercial politics are more likely to hold back launch than technology.

STANDARD

DAT is not just a domestic standard. Last year in Britain Sony showed its DAT prototype to broadcaters, including the BBC. The broadcasters were impressed by Sony's philosophy on DAT. It can be used for anything from digital tape domestic Walkman up to studio mastering. There is plenty of room in the bit stream for digital codes which stop and start a player, with cueing as accurate as compact disc.

LEADING EDGE

The BBC like this because existing low cost digital recorders, like the Sony F-1, are very difficult to cue. The best available is the Sony C9, with F1 PCM adaptor. But it's still nowhere as accurate as a DAT machine will be.

One thing is certain. Now that DAT has been developed, it will hit the market sooner or later. The Japanese manufacturers like the idea because it will replace the compact audio cassette. This was developed by Philips and the Japanese have never liked to be dependent on Western technology.

This dislike was neatly summed up by a fascinating document given to me recently by TDK in Japan. It is a 30-page "history of the Japanese magnetic tape industry". Inevitably the first half refers to early development in the West. The text accurately credits Danish engineer Valdemar Poulsen for making the first wire recorder in 1898. It credits Pedersen in 1907 for DC-bias, Carlson in 1927 for AC bias and Fritz Pfleumer in 1928 for the first magnetic tape. There are references to BASF, AEG, Ampex, 3M and Philips. The research work, I understand, came from a Japanese audio society which has prepared the text for TDK. The interesting part is what happens when the story switches to Japan. Suddenly company names disappear. Only NHK, the state radio and TV station, is mentioned. Every other Japanese innovation and invention is credited to "a Japanese company" or "another Japanese company". The names Sony, Matsushita, and even TDK are all missing from TDK's historical briefing.

There are two explanations for this. Take your pick from either or both.

I know from visiting Japanese firms many times over the last ten years, that they cannot bear to mention the names of their rivals even in conversation. They just behave as if the rivals don't exist. TDK was smart enough to know that it would discredit the whole historical document to mention only the TDK name.

At top management level, the situation is different. Although business rivals, the top people work together as part of what has become known as "Japan Inc.". They see themselves as ultimately in competition with the West, rather than each other. It doesn't matter to them who invented what, as long as it was Japanese.

The TDK historical document fits both requirements. It contributes to Japan Inc. and gives no unnecessary credit to one firm at the expense of others. When I was first given the document in Japan, I handed it straight back saying it was no use without Japanese names. Three months later I was sent a revised copy through the post. It still contained no Japanese names. PE

BOOK REVIEWS

LISP the Language of Artificial Intelligence, by A. A. Berk. Collins £9.95.

Why should someone interested in electronics be interested in a computer language called LISP, the answer is robotics. Lisp is the principle language employed by researchers in robotics, artificial intelligence and the new fifth generation computers. It is a language designed to be flexible enough to express some of the most complex mathematical and logical structures. Lisp is in fact designed as a language to be 'human intelligence orientated' and is thus the ideal language for applications like robotics where the controlling computer is required to perform simple 'intelligent' tasks.

Dr A. A. Berk is well known as an author on microcomputers and this book forms an excellent introduction to LISP. In the first part of the book the author takes the reader through an introduction to artificial intelligence and the fundamental concepts behind LISP. The second part of the book is devoted to a practical introduction to LISP, clearly laid out with the aid of frequent examples many of which are orientated towards artificial intelligence. The book covers all aspects of LISP from simple list processing to advanced data structures and recursion.

This book is an ideal introduction to LISP for all who are interested in artificial intelligence and ways in which it can be implemented on a normal home micro.

68000 Machine Code Programming, by David Barrow. Collins £12.95.

The Motorola 68000 series microprocessors are rapidly becoming a standard for many 16- and 32-bit home and personal computers. It is the 68000 which is the power behind the new Commodore Amiga and the Apple Macintosh. It may still be a little bit ambitious for the hobbyist to build a project around the 68000, but I am sure it will not be long before such projects are included in magazines like PE.

This book sets out the principles of programming the 68000 in machine code and every programmer of 68000 based systems will find this book a very useful source of all the essential information required.

Radio and Electronics Engineers Pocket Book. Newnes £5.50.

This is a very handy little pocket book which will prove an invaluable aid to everyone interested in electronics. This book is now in its 16th edition and this new edition is revised so as to be totally up to date. Crammed into its 170 pages is a wealth of information, tables of data, formulae and conversion factors; in fact virtually everything which is relevant to the designer, student, or service engineer.

This pocket book is an absolute must for everyone interested in electronics and will doubtless prove to be a constant companion.

SCIENCE FEATURE

PHOTOVOLTAIC TECHNOLOGY

BY PROFESSORS R. HILL AND N. M. PEARSALL

SOLAR cells convert sunlight directly into electrical power. The cells produce both electric current and voltage by the 'photovoltaic effect' and the technology is often given the name 'photovoltaics'. Modern cells are a product of the modern electronics industry, but solar cells are amongst the very earliest electronic devices. The first crude device was made by Edmund Bequerel in 1839, whilst the first solid state device was made in Cambridge in 1876. Both of these early solar cell devices were discovered by accident but, in the 1880's, Christian Fritz in the USA and Sir George Minchin in London designed and built solar cells and tried to improve their efficiency. In 1891, Rollo Appleyard, in an enthusiastic report of Minchin's work, invited his readers to 'behold the blessed vision of the sun, no longer pouring his energies unrequited into space, but, by means of photoelectric cells and thermopiles, these powers gathered into electric storehouses to the total extinction of steam engines and the utter repression of smoke'.

The modern solar cell was discovered, also by accident, in 1954 at Bell Laboratories in the USA. The US Army used solar cells in 1958 on their first space satellite, *Vanguard I*, and the space race of the 1960's led to a great improvement in the solar cells used to power the satellites. The oil crisis in 1973 led the governments of the USA, Europe and Japan to research for alternative energy supplies and research and development effort on solar cells increased dramatically. Although government support is now much weaker, due to a temporary easing of the energy supply problem, these efforts have produced cells which are efficient and cost effective in many applications and an industry which is confident in its ability to meet the challenges ahead.

HOW SOLAR CELLS WORK

There are many cell structures based on different semiconductor materials, but by far the most common is the p-n homojunction single crystal silicon cell. This cell will be used as an example for the discussion of cell operation. Different types of cell will be considered later in the article.

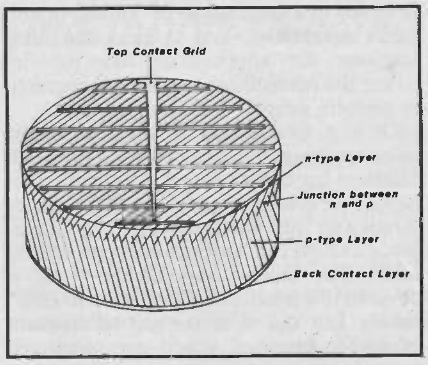


Fig. 1. *A typical solar cell*

A typical single crystal silicon solar cell (Fig. 1) consists of a wafer of silicon about $\frac{1}{4}$mm thick, and about 10cm diameter, with electrical contacts on each face. The bottom contact is a layer of aluminium, but the top contact is in the form of a grid, since it must allow as much light as posible to reach the silicon whilst also collecting the electric current as efficiently as possible.

When the sunlight enters the silicon, all the visible and near infra-red light is absorbed. The absorbed light gives its energy to electrons in the silicon, which then becomes electrically conducting. In a semiconductor such as silicon, electrical conduction is due to electrons (with a negative electrical charge) and to holes (which act like positive charges). The junction between the top n-type silicon layer and the p-type base layer contains a strong electric field. This field causes the negative electrons to move towards the front contact and the positive holes to move towards the back contact. Thus, the top contact becomes negative whilst the bottom contact becomes positive and a voltage is set up between the two contacts. The movement of electrons and holes constitutes an electric current and so the absorption of light in a solar cell produces both current and voltage and, hence, electrical power (power = current × voltage). The process is represented by the flow chart. A spectral response curve is shown in Fig. 2.

In bright sunlight, a 10cm diameter cell will give an output of about $\frac{1}{2}$ volt and 2 amps, i.e. about 1 watt of power. Manufacturers quote the output of their cells for a sunlight intensity of 1 kilowatt per square metre (similar to that of the Sahara Desert at noon). This standard output is labelled 'peak watts' or 'Wp' and is measured at a standard temperature of 25°C. The power output of a solar cell varies with the light intensity falling on it. The current output will halve if the light intensity is halved, but the voltage output will drop by only a few percent. The voltage output also depends on the temperature of the cell and decreases by about $\frac{1}{2}$% for every degree Celsius rise in temperature above 25°C.

SILICON SOLAR CELLS PRODUCTION

The raw material for silicon solar cells, as for silicon chips, is silicon dioxide, found as quartz or quartz sand. This must be reduced, to remove oxygen, and then purified to a few parts in a thousand million. Single crystals of silicon are grown, usually 10cm diameter and up to 1·5m long, and these crystals are then cut into wafers about $\frac{1}{4}$mm thick. These wafers are the starting material for all silicon electronic devices, including transistors, integrated circuits and solar cells.

To make solar cells, p-type silicon wafers must have a thin layer of dopants, such as phosphors, diffused

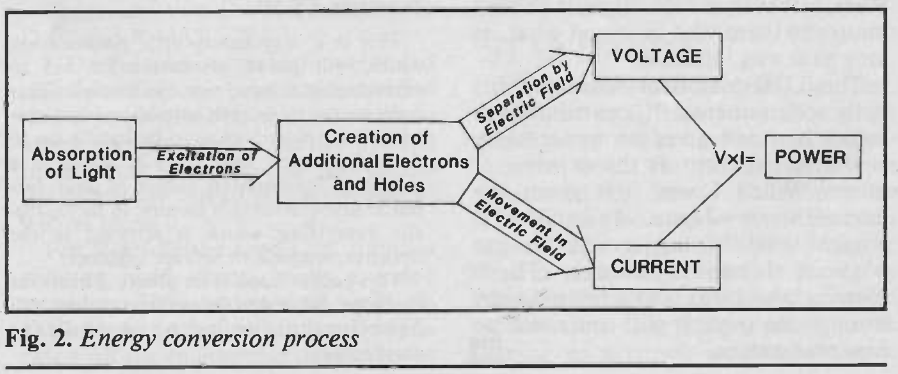


Fig. 2. *Energy conversion process*

into one face to form the top n-type layer and the junction. The top and back contacts must be formed and the top silicon surface is coated with an optically transparent layer to reduce the reflection of light (similar to the blooming of lenses for a camera).

Each cell is tested to ensure that it performs to specification and the cells are then connected together, with the top contact of each cell connected to the back contact of the preceding cell in the series. To ensure that the output from a module will charge a 12 volt battery even in moderately bright sunlight, 30–36 cells are connected together in this way and then encapsulated in modules.

Solar cells are fragile objects so the module must provide mechanical strength to withstand wind loads, hailstorms, etc. Solar cells and their electrical connections have to be protected from environmental attack by moisture and atmospheric corrosives. Cell temperatures can vary from −20°C on a cold night to +60°C on a hot sunny day, so the thermal expansion of the cells must be allowed for. The string of series connected cells is usually encapsulated in a layer of soft plastic, with an upper face of glass and a backing layer of plastic, metal or glass. A metal framework around the edges provides additional mechanical strength and a means of fastening the modules on to a structure.

Typically, a module will give a power output of 30–40Wp. When more power is required, modules can be connected together in series (positive to negative) to increase the voltage or in parallel (negative to negative, positive to positive) to increase the current. The modules are fastened to a secure structure, which holds them in the correct position to receive the maximum energy from the sun and which can withstand wind loads, etc. These 'arrays' of modules can be fixed or they can be driven to constantly face the sun. Arrays vary in size from a few modules, for telecommunications, say, to hundreds of thousands of modules, for large grid connected utility supplies. The largest array in the world to date has a peak power output of 10MW, whilst the largest in the EEC is rated at 0·3MWp.

NEW TYPES OF SOLAR CELL

The single crystal silicon cell has dominated the photovoltaics market for many years, due, in part, to the strong background in the processing of silicon built up by the electronics industry. It provides a reproducible, stable device, which can be economically competitive for several applications. However, new cell types are constantly under development, in an effort to improve efficiency and/or reduce costs.

The possible applications for solar cells can be split into two categories, these being space and terrestrial use. Since the device requirements differ for these two environments, the type of cell being developed differs also. Solar array for powering satellites require highly efficient cells, which have a high tolerance to the rigours of the space environment and have a high power/weight ratio. Candidate cells to replace silicon include those based on gallium arsenide, now entering production, and, in the future, those based on indium phosphide. The requirements for a space cell are discussed in more detail in the next section.

For terrestrial applications, the efforts have been directed towards the development of cells which are less costly than single crystal silicon. Some progress has been made by the use of polycrystalline silicon, but the greatest potential for cost reduction lies in the use of thin film cells. These offer the possibility of a reduction in the amount of material used and the fabrication techniques are generally more applicable to low cost mass production. They also have the advantage of flexibility in device size. The front runner in this field is undoubtedly the amorphous silicon cell, which is best known for its use in calculators, watches, etc., but is now entering the power market. Other thin film cells of note are those based on copper indium diselenide and cadmium telluride, both in conjunction with cadmium sulphide.

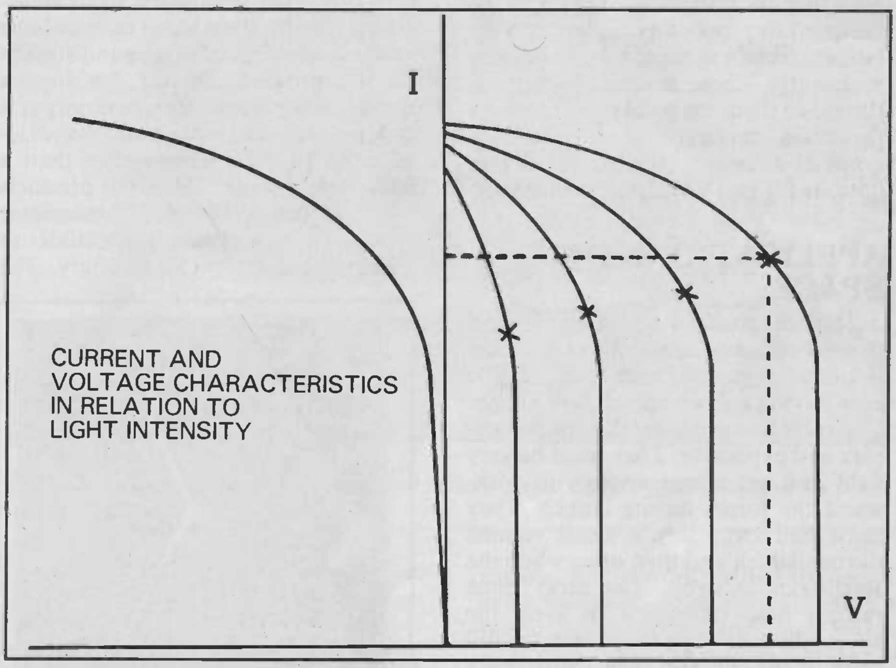


Fig. 3. *Current-Voltage characteristics*

Further in the future, the conversion efficiently of photovoltaic devices may be increased to 30% or even 40% by the use of several types of cell in a cascade. A semiconductor junction is an efficient converter of light to electricity only for a narrow range of wavelengths, whilst the output from the sun is spread over the range from 400–1200nm, i.e. ultra-violet to infra-red. We can design devices where the light passes through several different junctions, each of which converts a separate wavelength range into electrical power efficiently. Although the physical processes needed to do this are fairly well understood, the technology is extremely difficult, particularly as the production must be relatively low cost, and it will be some years before these very high efficiency cells become commercially available.

USING SOLAR CELLS

Solar cells are semiconductor diodes, so their characteristics are similar to those of any diode but with the addition of a large reverse current whose magnitude is proportional to the intensity of light absorbed in the cell (see Fig. 3). Solar cells are power generators because their output is composed of a reverse current and a forward voltage, as shown in the diagram. The voltage across the cell is equal, by Ohm's law, to the product of the current and the load resistance. The forward voltage across the cell induces a forward current which opposes the reverse current generated by the light. At open circuit voltage, these forward and reverse currents are equal, so the nett current is zero. The maximum power output of the cell occurs when the products of the cell voltage and current is a maximum and the load should be designed so that its resistance (R_L) is given by $V_m = I_mR_L$. If the power of the light falling on the solar cell is P_{in}, the efficiency of the cell is $P_{out}/P_{in} = V_mI_m/P_{in} = V_{oc}I_{sc}FF/P_{in}$, where FF is the 'Fill Factor' of the cell and is a measure of the 'squareness' of the I/V characteristic.

APPLICATIONS OF PHOTOVOLTAICS

Photovoltaic power supplies have no moving parts and no fuel costs. In addition, they are silent and non-polluting in operation. They can be designed to supply any range of power output, from less than 1 watt to many megawatts. These unique characteristics make them the ideal power sources for many applications and the new types of solar cell increase the design options for cost effective products.

APPLICATIONS IN SPACE

This was the first major application of solar cells and is still one of the most important markets, with each satellite now having an average of 3kW arrays. The solar arrays for satellites are complex and expensive. They must be very light and yet strong enough to withstand the forces during launch. They must fold away into a small volume during launch and then open when the satellite is in orbit. The array must radiate heat efficiently to keep the solar cells cool when they are in the full glare of the sun and then withstand a drop in temperature to about that of liquid air (−200°C) when the satellite is shadowed by the Earth. Not surprisingly, solar arrays for space satellites cost about £1000 per watt.

Silicon solar cells are sensitive to the radiation in space, made up mainly of protons and electrons from the solar wind. At the end of life of a satellite the efficiency of the silicon cells will often have dropped from the initial 12–14% to only about 8–9%. The solar array must be designed to power the satellite at the end of life, so the array is considerably oversized at the beginning of life. It is possible to reduce the cost of the array if cells with a higher radiation resistance are used, even if the cells are more expensive than silicon. Gallium arsenide solar cells have efficiencies of about 15% at the beginning of life and 11–12% at the end of life, so the array can be about 20% smaller in area than an array of silicon cells with the same end of life power output. Gallium arsenide cells are starting to be produced for the new generation of satellites and may replace silicon cells for many applications. Further into the future, gallium arsenide cells could be challenged by indium phosphide cells with efficiencies of 15–20% and even less degradation over their lifetime.

CONSUMER PRODUCTS

This category covers all products in which the photovoltaic power supply is built in, such as calculators, watches, clocks, etc. The range of products is always expanding and these applications account for over $\frac{1}{4}$ of the total annual photovoltaic output worldwide at present.

Most consumer products now use thin film solar cells made from amorphous silicon, since these can easily be made in a variety of shapes and sizes to fit the product. By far the biggest market is for calculators. Not only is it cheaper for the calculator manufacturer to fit solar cells rather than a battery in the calculator, but products such as the 'credit card' calculator would be just about impossible to make with a replaceable battery. The Japanese dominate the market because, in 1978, their calculator manufacturers made the decision to make their own thin film cells in-house and this has reduced their costs considerably. The major calculator manufacturers now produce about one million solar powered calculators per month.

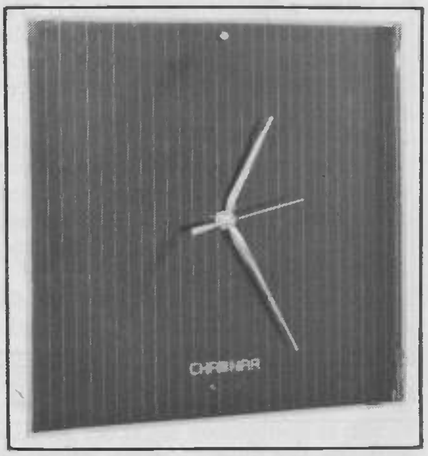


Photo 1. *Solar powered clock from Chronar Ltd.*

Other products such as watches, clocks, toys and kitchen equipment are coming onto the market. The range of such products is limited only by the ingenuity of the inventors.

STAND ALONE TERRESTRIAL APPLICATIONS

This category covers a wide range of stand alone applications, with power levels ranging from 30–40W to several kW. Photovoltaic modules can be used to charge batteries for many applications in the leisure and military markets and to supply electricity for remote homes away from the grid. For some applications, such as telecommunications and cathodic protection, photovoltaic power systems are already the first choice, due to their reliability and low maintenance requirements. Photovoltaics is already economically competitive in some situations in developing countries for irrigation, lighting, medical refrigeration, village electrification, etc. As system costs fall over the next few years, these applications will develop into a major market.

The challenge in these applications is not so much in the photovoltaic array as in the overall system. The electricity produced by the photovoltaic array is used to provide a service such as water for drinking or irrigation. The water pumps for these systems must use the electricity as efficiently as possible, with very high reliability, very simple servicing and a long working lifetime, in order to take advantage of the reliability of the modules themselves. The same considerations apply to the refrigerators for vaccine storage, batteries for lighting, etc., and the whole system must be designed for maximum efficiency and reliability.

Photovoltaics offers a technical solution to the problem of reducing the enormous disparity in wealth between the poor and rich countries. Almost all of the very poor countries are in the low latitudes where sunlight is abundant. The technology to provide these poor countries with the water, communications, lighting and basic medical services which they need to begin the long process of economic development, is now available. The technology, however, is just the first step. It can bring enormous benefits to the developing countries only if these countries and the aid agencies apply their organisation, economic priorities and political willpower to the application of photovoltaics as an aid to rural development.

THE FUTURE OF PHOTOVOLTAICS

The directions in which the technology of photovoltaics will develop are reasonably clear to see. The efficiency of the cells and modules will increase as existing cells are improved and new types of cell are brought into production, and module efficiencies of over 20% might be expected by the end of the century. The cost of cells and modules reduces as production processes improve and the volume of production rises. Costs as low as 1–2 per peak watt should be possible in the 1990's, although the retail cost could be higher.

Photo 2. *Courtesy of Energy Conversion Devices Inc.*

The applications of photovoltaics will grow for the rest of this century and beyond. Space satellites get bigger and require more power, and more and more are launched each year. Photovoltaics will appear in a wider range of consumer products as designers learn to use their unique characteristics. The use of photovoltaics in the leisure markets, for battery chargers and battery replacement is also likely to grow, but the major stand-alone use in developing countries depends as much on international economics and political will as it does on technical advances.

At the time of the oil crisis in 1973, photovoltaics was seen as a possible replacement for fossil fuelled power stations. There are examples of large systems (up to 10MWp) connected to a utility grid, but, at present, the use of photovoltaic arrays for large-scale power generation is economic only under very special circumstances. The climate must be suitable, the peak load in the utility grid must coincide with the peak sunlight intensity (e.g. air conditioning) and the investment credit and tax system must be favourable. At present, these conditions occur together only in the southern USA and the tax system there may change adversely. In Europe, some utilities are considering the use of photovoltaics, particularly for island communities with a large influx of summer visitors. As the cost of photovoltaics falls, such large systems will become more widespread, although they are likely to be confined mainly to latitudes below 40–45°.

Photovoltaics is a very young technology. As a truly commercial industry, it is less than 10 years old and it is in a period of rapid technical change and rapid growth. The unique characteristics of solar cells allow them to be used for power cources ranging in size from milliwatts to megawatts, in applications from rural Africa to space satellites. This versatility will ensure a bright future for photovoltaics, which will grow into a major worldwide industry. PE

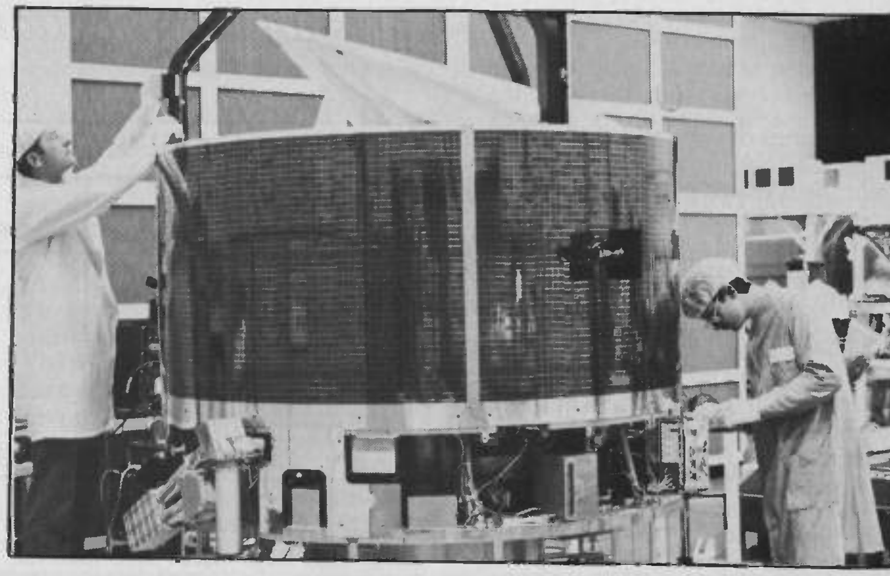


Photo 4. *Giotto Spacecraft under construction—solar cells wrapped around the body*

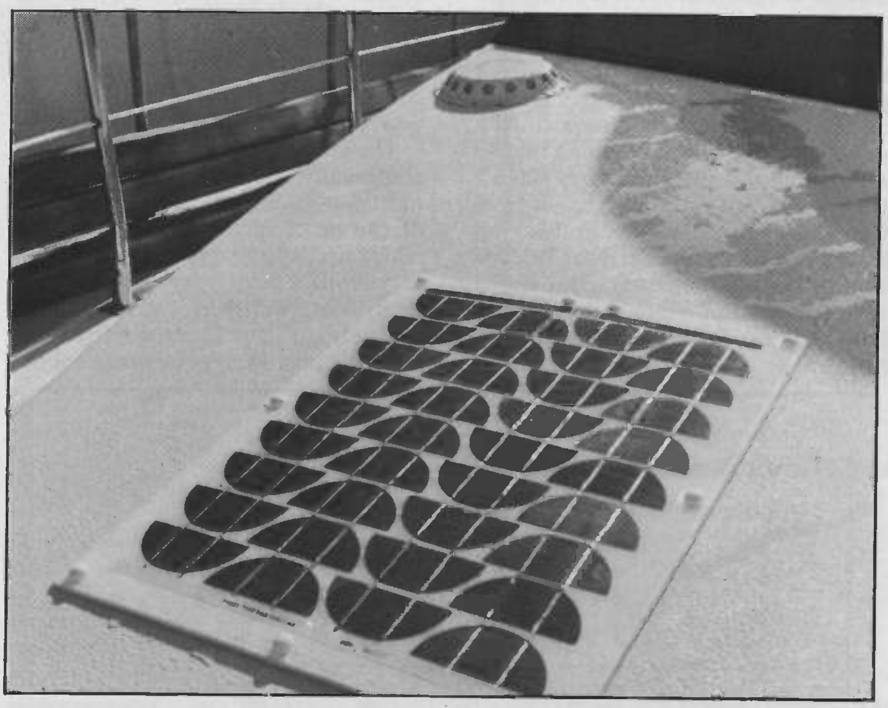


Photo 3. *Solar module on leisure craft for powering navigation equipment (courtesy of PAG Solar Technology Ltd.)*

1). Solar Trust for Education and Research—an organisation to develop awareness of solar energy in schools.

2). International Solar Energy Society (ISES)—an organisation to further the general development of solar energy. ISES also publishes a range of documents on solar energy, mostly conference abstracts.

Both the above organisations are located at 19 Albermarle Street, London W1.

If you are interested in the subject of solar energy ISES is organising a conference in London on the 15th May 1986 entitled 'Solar Energy for Developing Countries'. If you wish to attend please contact the Administrator of ISES at the above address, registration fees are £44 for members of the public and £20 for students.

USING SOLAR CELLS

By NICK HAMPSHIRE

Light power available to the hobbyist —ideas and applications

Two forms of solar cell are available to the hobbyist, silicon wafers and amorphous silicon plates. Of these two types amorphous silicon plates are both cheaper and easier to use offering both high voltage and high power output, typically 20 volts at 50mA from a 12″ by 4″ plate at a cost which is often as low as £6.00 per watt for a large panel. This compares with silicon wafers which can offer high power output but at low voltages, typically, 4 volts at 1 amp from a 4″ square wafer at a cost of about £12.00 per watt. Silicon wafers have an advantage over amorphous plates in that they are very light and are thus ideal for solar power applications, where low weight is essential, such as satellites or the Solar Challenger aircraft.

PRECAUTIONS

Using silicon wafer solar cells requires certain precautions. The wafers are very thin, less than 0·5mm, and consequently very fragile. A broken or cracked wafer, if it works at all, will probably have very reduced efficiency. Wafers must therefore be securely supported and if used outside then the front surface must be protected from the weather and abrasion impact, etc. When soldering wires to silicon wafer solar cells, one to the solder connector on the bottom surface and one to the solder fingers on the top surface, great care must be taken to apply only the minimum amount of heat. Overheating by leaving the soldering iron on too long or using too large an iron will destroy the silicon wafer in the solder area and probably render the cell useless.

The problems associated with mounting and connecting amorphous silicon solar cells is considerably less. Since amorphous cells are manufactured by depositing a film of silicon on to a sheet of glass they are both much more robust and also have less need for protection from accidental impact and the elements. Another virtue of amorphous cells is that they can come in quite large panels, up to 12″ × 36″ with a power output of up to 10 watts at 14 volts. This large panel size and the additional fact that small cells can be made simply by cutting up large cells with a glass cutter makes the fabrication of a desired solar panel much easier.

Table 1. *Electrical characteristics of Chronar solar cells*

	PANEL SIZE			
ELECTRICAL (NOMINAL)	102×305mm	204×305mm	305×305mm	305×915mm
OPEN CIRCUIT VOLTAGE (VOLTS)	20	20	20	20
SHORT CIRCUIT CURRENT (AMPS)	0·1	0·2	0·3–0·45	1–1·2
NOMINAL POWER UNDER FULL SUN (WP) (WATTS)	1	2	2,3,4,5	10,12,14
WEIGHT POUNDS	0·5	1	1·5	4·5
KILOGRAMS	0·23	0·46	0·7	2·1

Solar cells of either form are usually used in conjunction with a battery or other power storage device in order to even out the high power output during sunny periods with the low or zero power output during cloudy weather or at night. Some applications such as a solar powered ventilation fan would not require the use of a battery since it would only be required to operate when the sun was shining, in this kind of application the solar cell can be used as not just a power source but also a sensor. NiCad or similar rechargeable batteries can be kept constantly recharged by simply connecting across the two solar panel outputs. Because solar cells have a variable voltage output it is important that diode protection is placed between the battery and the solar cell in order to prevent the battery discharging itself across the cell during periods of low light and thereby damaging the cell. Diode protection does pose one problem on low voltage systems in that the voltage drop across the diode may be unacceptably large, this must be taken into consideration when designing solar power systems.

The inability of solar cell systems to continually and reliably produce a required voltage and power output is one of the problems of solar engineering which needs to be overcome especially in countries with very variable light intensities. Batteries can be a part solution but they do not contribute to ensuring that the system works at peak

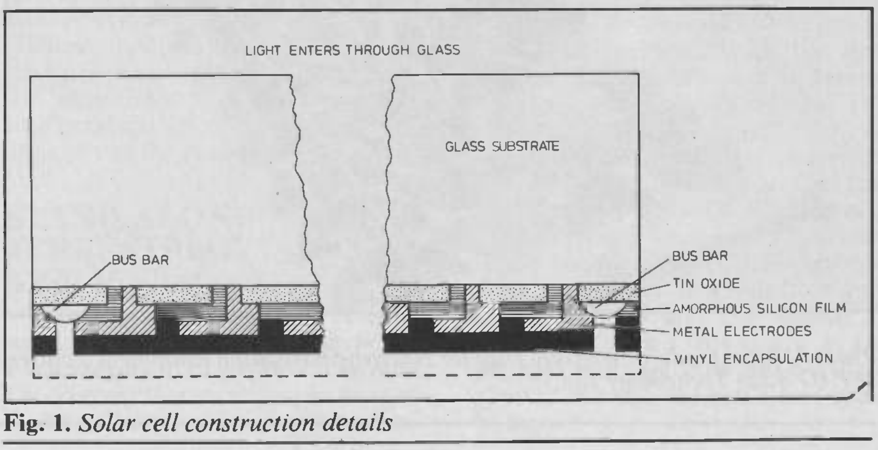


Fig. 1. *Solar cell construction details*

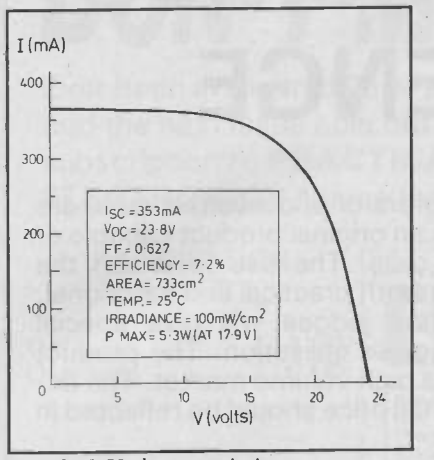


Fig. 2. *I/V characteristics*

efficiency. Peak efficiency requires that the light reaching the solar cell has an energy equivalent of at least 1kwatt/sq metre. Light concentrator mirror systems and solar tracking panels are two answers to this problem, though in either of these cases the power used to track or focus the solar energy must be only a fraction of the power produced by the solar cells. Another part of the solution is to use high efficiency power conversion systems to ensure constant voltage and current output with the minimum energy loss thereby enabling batteries to be charged at peak efficiency.

Solar cells are very easy to use, the challenge lies in using them in imaginative applications and ensuring that they are producing energy at maximum efficiency. There are a host of applications where it is difficult to use mains power and where the use of batteries is often inconvenient and unreliable. Till now solar cells have often been too expensive to even be considered, with the advent of amorphous solar cells this is no longer a serious constraint.

AMORPHOUS SILICON SOLAR CELLS

An amorphous silicon photovoltaic panel is a series of monolithic interconnected cells on a single glass substrate. The technology used to create these panels uses a thin film of amorphous silicon sandwiched between two conductive layers deposited onto glass. The cells are interconnected during the manufacturing process to provide appropriate voltage and current, the electric output is from electrodes on either side of the panel.

The manufacturing process starts with the deposition onto a sheet of glass of a transparent coating of tin oxide. This coating is patterned by a laser into conductive and non-conductive areas. A thin layer of semiconducting amorphous silicon is deposited next using RF vacuum vapour deposition and is similarly patterned. The amorphous silicon layer in fact consists of three layers to form a p-i-n structure, the p layer is silicon carbide to ensure a wide spectral activity range, the i layer is hydrogenated amorphous silicon and a further layer of amorphous silicon creates the n layer. Finally a layer of aluminium is deposited to create the rear contact and similarly patterned. Fig. 1 is a diagram showing a cross section across these layers. Light coming through the glass substrate is now converted to electricity. Copper busbars are deposited onto the edge of each panel to act as electrical conductors; these and the rear of the panel are then coated in an encapsulation of vinyl plastic.

These cells show an energy conversion efficiency of between 5% and 7·2%. The Spectral response curve shows that the panels are most efficient with light at a wavelength of about 550mm. Fig. 2 shows the I/V curve for a foot square panel; the curve has the same shape for panels of different sizes. PE

PRACTICAL ELECTRONICS SOLAR CHALLENGE

The Challenge

Practical Electronics in association with Chronar Ltd. (manufacturers of photovoltaic cells) are sponsoring a challenge in which readers of *PE* are invited to design an original product capable of commercially exploiting cheap amorphous silicon photovoltaic cells. The use to which the product is put is left to the imagination of the reader but should be both practical and functional. As befits *PE* the idea should make use of electronics and the judges will give special consideration to entries which promote maximum efficency in power utilisation. The product should have wide appeal in the UK and overseas, therby justifying a high volume market. The design should also be cost effective, i.e. the anticipated achievable retail price should be reflected in the estimated approximate manufacturing costs.

Entry to the Challenge

Readers are invited to submit a written proposal for an application. The proposal should give details of all circuits, mechanical construction, etc. However, it is not required that the reader has actually built a full working prototype before submitting an entry. The judges must simply be satisfied that the entrant has adequately considered and solved all the technical problems associated with the design. All proposals must be submitted before September 7th 1986, and be accompanied by the entry form at the bottom of this page.

The Awards

The judges will make the awards on the basis of the entries' originality, commercial application, efficiency in using solar power. The entry which in the opinion of the judges best fills these criteria will be awarded a first prize of £100 plus a 12″ panel Chronar photovoltaic battery charger. There will be three runner-up awards of a Chronar 330 4″ solar battery charger and one year's free subscription to *PE*. If in the opinion of the judges any of the ideas are commercially exploitable then the sponsors of this challenge will undertake to assist the inventor in either patenting or registering the idea and will then assist the inventor to organise manufacture of the product under license. This follow-up assistance by the sponsors could lead to substantial rewards for the inventor of any original idea.

The Judges

Each entry to the challenge will be judged by a team of four judges; they are: Professor R. Hill of Newcastle; Mr. Wood-Tate, Managing Director of Chronar Ltd.; Mike Kenward, editor of New Scientist; Nick Hampshire, editor of Practical Electronics.

Rules

1 — all entries must be original ideas conceived by the entrant and not copied from any source.
2 — the judges' decisions will be final.
3 — the organisers do not accept responsibility for the safe keeping or return of any submitted material.
4 — It is the entrants' responsibility to ensure that entries are received at our offices before the closing date.
5 — the competition is not open to any employees or their families of either Chronar Ltd. or Practical Electronics.

ENTRY FORM

I wish to enter for the Practical Electronics/Chronar Ltd. 'Solar Challenge' competition. Enclosed with this entry form is my entry for the competition. I undertake that my entry abides by the rules of the competition and that this entry is entirely my own work.

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....

Signed ....

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NOTCHER EFFECTS UNIT

BY JOHN SIMON

An unusual musical effects unit producing harmonic waveforms

IT WOULD be a rash person who claimed to have devised a new form of musical effects unit, but this unit is certainly of a type which I have not previously encountered. It is a form of tracking filter, and in its main operating mode it acts as a notch filter which removes (or at least seriously attenuates) the fundamental frequency of the input signal, leaving only the harmonic content. With most sources this gives a rather weird "hollow" sound. One might expect that it would give a sort of frequency doubling or tripling effect, depending on the relative strengths of the harmonics on the input signal. In fact there is a frequency multiplication effect if the input and output waveform are examined on an oscilloscope, but due to the way in which human hearing operates the frequency multiplication is not apparent when listening to the processed signal. This is presumably caused by the same effect that results in bass notes reproduced through a small loudspeaker sounding quite acceptable to the listener, even though the fundamental frequency and possibly even some of the lower harmonics are not reproduced. The brain tends to compensate for the absent frequency components to some extent.

This removal of the fundamental frequency is something that can be achieved with a synthesiser that has notch filtering, provided the filter can be set up to accurately track the keyboard. In practice few synthesisers have this facility, but a tracking filter has the advantage of being usable with practically any electric or electronic instrument, such as an electric guitar, and it is not limited to use with synthesisers.

This unit has a second mode of operation, and when switched to this it provides bandpass filtering. The effect of the unit is then to greatly attenuate the harmonic content on the input signal, giving an output that is virtually a sinewave. This gives a flute-like sound even with a fairly harsh sounding input signal such as a sawtooth or the output from an electric guitar. Again, this is something that can be achieved with some synthesisers, but it can be applied to practically any instrument with the aid of this unit.

Although tracking filters can be quite complex, this one is reasonably simple and inexpensive to construct, but it has a respectable level of performance with quite low noise and distortion levels. It tracks over a pitch range of at least four octaves.

OPERATING PRINCIPLE

The circuit is built around a switched capacitor filter, which is a type that uses an electronic switch and a low value capacitor to replace the resistor in a conventional R–C lowpass filter, as shown in Fig. 1. The capacitor is first connected across the input, then across the filter capacitor at the output, then across the input again, and so on. In this way it provides a signal transfer from the input to the output, as does the resistor in a conventional R–C filter. Also like the resistor in an R–C filter, it provides only a limited signal transfer, and the output will only be a faithful reproduction of the input signal if the input frequency is low in relation to the switching frequency. Remember that the switched capacitor is much lower in value than the filter capacitor at the output of the circuit, and that any sudden change in the input voltage will therefore require a number of charge transfers before the output voltage fully adjusts to the new potential.

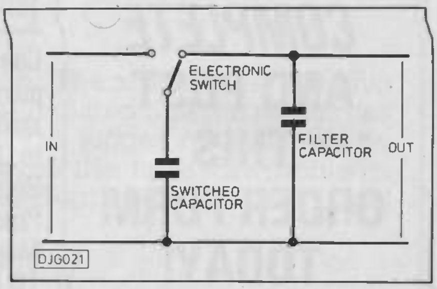
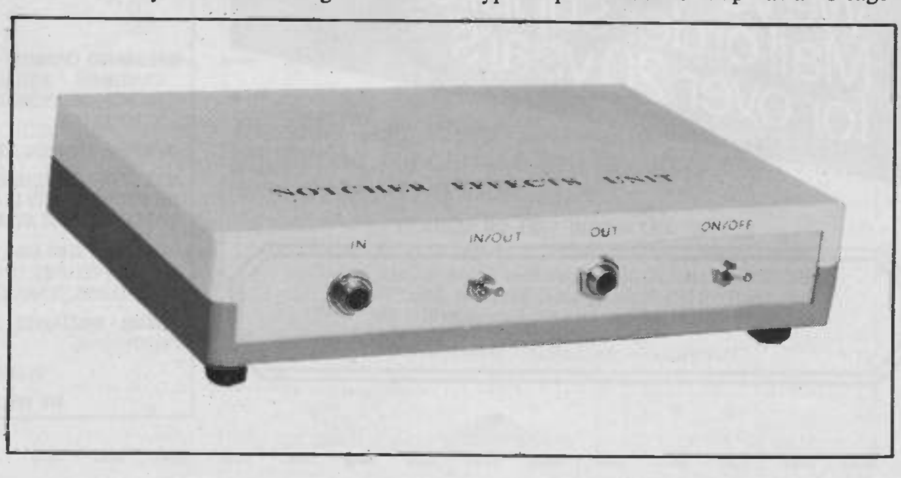


Fig. 1. *Switched capacitor filter*

What is of primary importance here is the ability to vary the cutoff frequency of the filter by changing the switching frequency. The higher the switching frequency the greater the rate at which current can be transferred from the input to the output, and the higher the filter's cutoff frequency. In fact the cutoff frequency varies in proportion to changes in the switching frequency. This design is based on one of the two switched capacitor filters in the MF10CN integrated circuit, and with this device the cutoff frequency can be either 1/50th or 1/100th of the switching frequency.

The block diagram of Fig. 2 shows the system used in this tracking filter, which is a standard phase locked loop type. A phase locked loop has a voltage



controlled oscillator which is locked onto the same frequency as the input signal. In this case the MF10CN is used in the mode where the clock frequency is one hundred times the cutoff frequency, and we require a clock frequency at one hundred times the fundamental input frequency. All that is needed to make a phase locked loop provide a suitable frequency is a divide by one hundred circuit connected between its VCO output and the input of the phase comparator. The phase locked loop then locks the divided signal onto the same frequency as the input signal, giving a VCO frequency some one hundred times higher.

In this unit two divide by ten circuits connected in series are used to provide the divide by one hundred action. An amplifier is used ahead of the phase locked loop, and this ensures that the circuit has good sensitivity and that lock is not lost until the input signal has decayed by a substantial amount. A trigger circuit is used to provide the phase locked loop with a pulse input signal, and this is essential as the particularly phase locked device used here is a CMOS type which requires normal CMOS input levels and switching speeds.

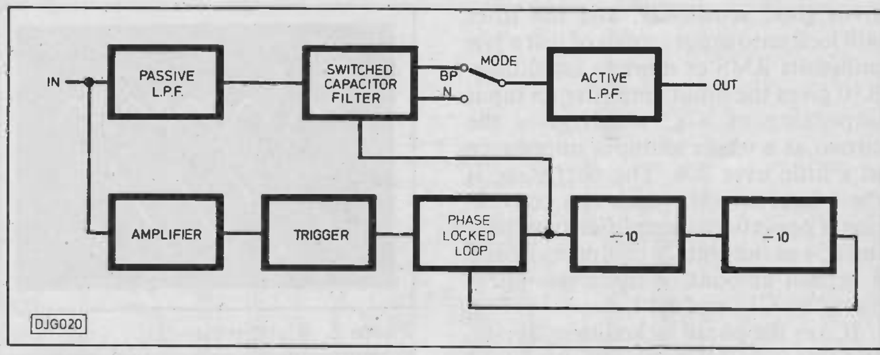


Fig. 2. *Block diagram*

the filter, but only at a fairly low level of about 10 millivolts RMS. An active lowpass filter at the output of the unit reduces the clock breakthrough to a totally insignificant level of under 1 millivolt RMS. This stage also provides buffering at the output.

CIRCUIT OPERATION

The circuit diagram of the filter stages appears in Fig. 3, while the circuit diagram of the clock generator stages is given in Fig. 4.

Taking Fig. 3 first, the input lowpass filter is a simple single stage type which is formed by R3 and C3. There is an mid-supply voltage, in order to set the desired operating mode. In this circuit R1, R2, and C2 provide the mid-supply bias voltage, and the filter is connected in the mode where the clock frequency is one hundred times the cutoff frequency. Notch, bandpass, and lowpass outputs are available, and S1 is used to select either notch or bandpass filtering. There is no point in including a lowpass filter mode as this would give an effect that would be virtually indistinguishable from the bandpass type. Note that some pins of IC1 are left unconnected, as one of the two identical filters in the MF10CN device is unused in this circuit.

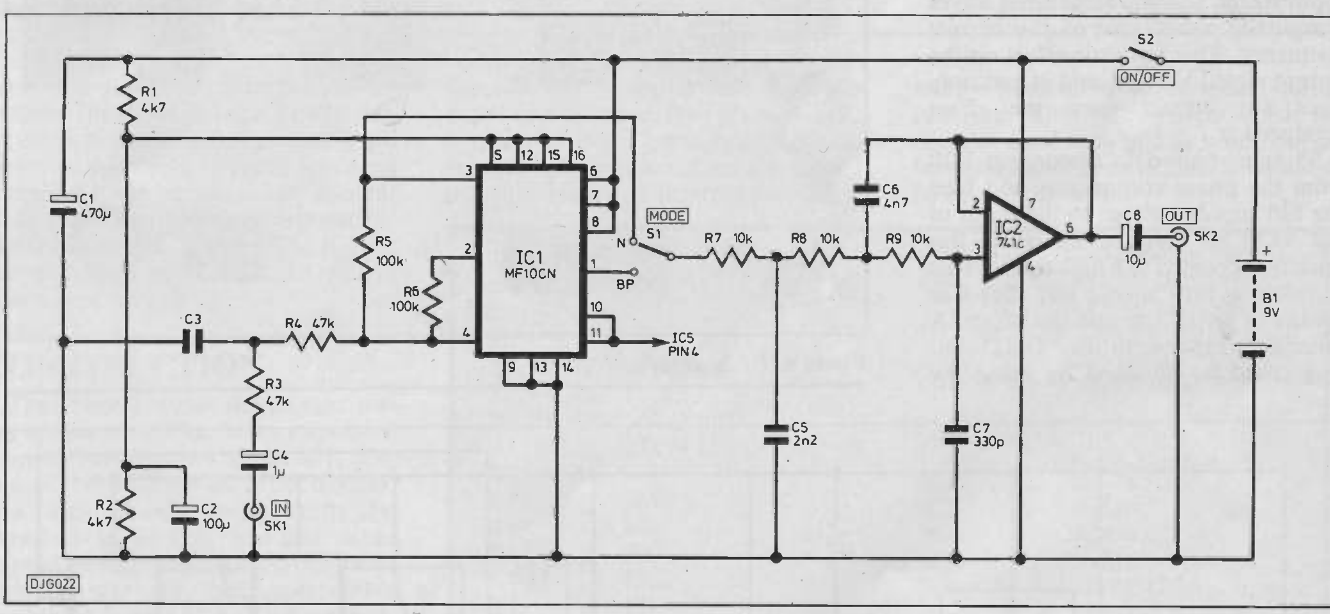


Fig. 3. *Filter chain circuit diagram*

The output of the VCO directly drives the clock input of the switched capacitor filter. A simple passive lowpass filter ahead of the switched capacitor filter prevents problems with heterodyne whistles caused by high frequency input signals reacting with the clock signal. A switch selects either the notch or bandpass output from the filter, which is actually a two stage (12dB per octave) type which also incorporates some additional stages to give state variable filtering. The clock signal breaks through to the output of operational amplifier at the input of the switched capacitor filter device (IC1), and this operates in the inverting mode with R3 plus R4, and R5 acting as the negative feedback network. These give a voltage gain of approximately unity and an input impedance of 94k, although the latter is reduced by the clock generator circuit which is also fed from SK1. R6 sets the Q value of the filter, but in this case the Q is not of great importance, and R6 sets a Q value of 1. IC1 has various inputs that must be tied high, low, or to

The selected output signal is connected to the input of a third order (18dB per octave) active lowpass filter which is based on buffer amplifier IC2. The cutoff frequency is at about 10kHz or so which obviously gives less than the full audio bandwidth, but it also gives sufficient bandwidth to give excellent results.

Turning to the clock generator stages, IC3 is used in the input amplifier, and this is a standard operational amplifier inverting mode circuit with a voltage gain of about 47 times. This gives good sensitivity, and the filter will lock onto input signals of just a few millivolts RMS or more in amplitude. R10 gives the input amplifier an input impedance of 47k, which gives the circuit as a whole an input impedance of a little over 30k. The next stage is the trigger circuit, which is a conventional operational amplifier type having IC4 as the voltage comparator, and a certain amount of hysteresis introduced by C12 and R17.

IC5 is the phase locked loop device, and this is a CMOS 4046BE type. C13 and R19 are the timing components in the VCO, while R20 and C14 are the lowpass filter connected between the output of the phase comparator and the input of the VCO. The values in the filter have to be something of a compromise as a large time constant is needed in order to give a reasonably wide tracking range, but a short time constant is needed in order to make the filter track rapidly from one note to the next. The specified values give a useful tracking range of four octaves or more, and although the filter tracks less than instantly from one note to the next the performance is more than adequate in this respect. The fairly long time constant used does mean that the VCO will not always lock perfectly onto the input signal, and will sometimes waver marginally either side of the correct frequency. This has little effect on the output signal though, and it certainly does not detract from the effect produced.

S3 can be used to disconnect R20 from the phase comparator and feed the full supply voltage to the input of the VCO so that the operating frequency is boosted to a high figure. This provides a very simple but click-free means of switching out the effect. A more flat response in the "OUT" setting could be obtained by using the lowpass output of IC1 rather than the bandpass output, but the bandpass output was chosen as it still gives a fairly flat response with S3 set to the "OUT" position, and it gives slightly more attenuation of harmonics on the input signal when the effect is switched in.

VR1 is an offset control, and this sets the minimum frequency that the VCO can achieve. In practice this is set for a minimum frequency of about 18kHz so that the VCO can never come into the audio range and produce audible breakthrough at the output. This limits the minimum operating frequency of the filter to about 180Hz, but this is low enough to permit good results to be obtained with most instruments. However, the unit would clearly not be usable with something like a bass guitar.

IC6 and IC7 are the dividers, and these are CMOS 4018BE divide by N counters which are connected as straightforward divide by ten circuits here. Two high value supply decoupling capacitors are used to prevent the second divider stage from placing noise spikes onto the supply lines and

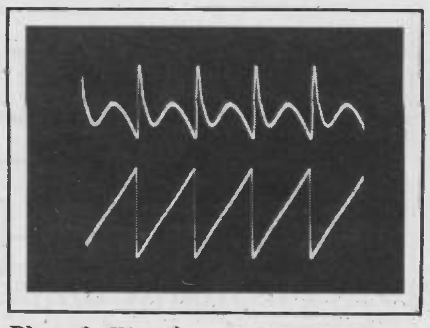


Photo 2. *Waveforms—1*

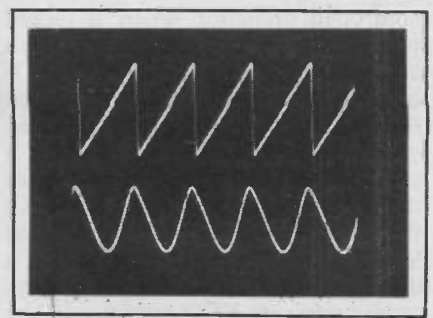


Photo 3. *Waveforms—2*

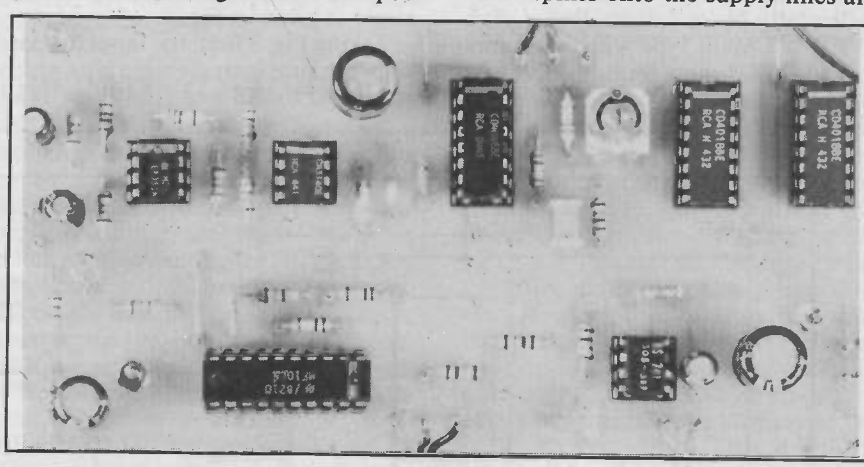


Photo 4. *P.c.b. details*

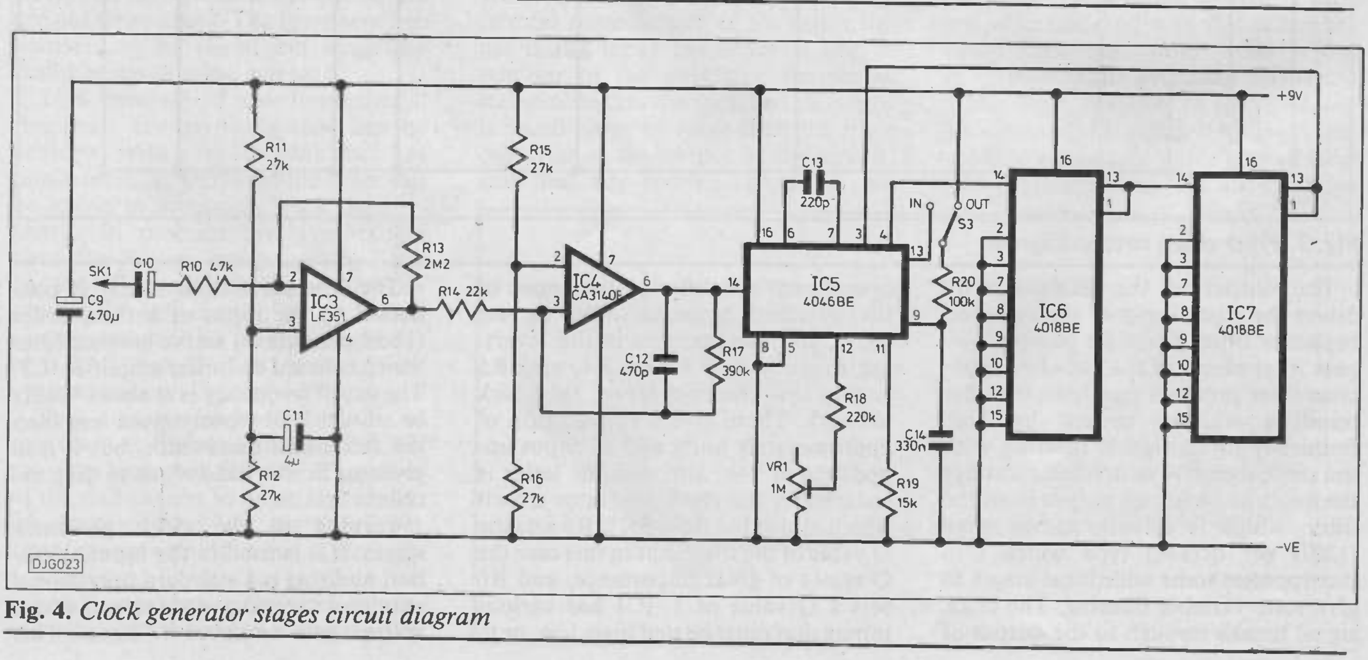


Fig. 4. *Clock generator stages circuit diagram*

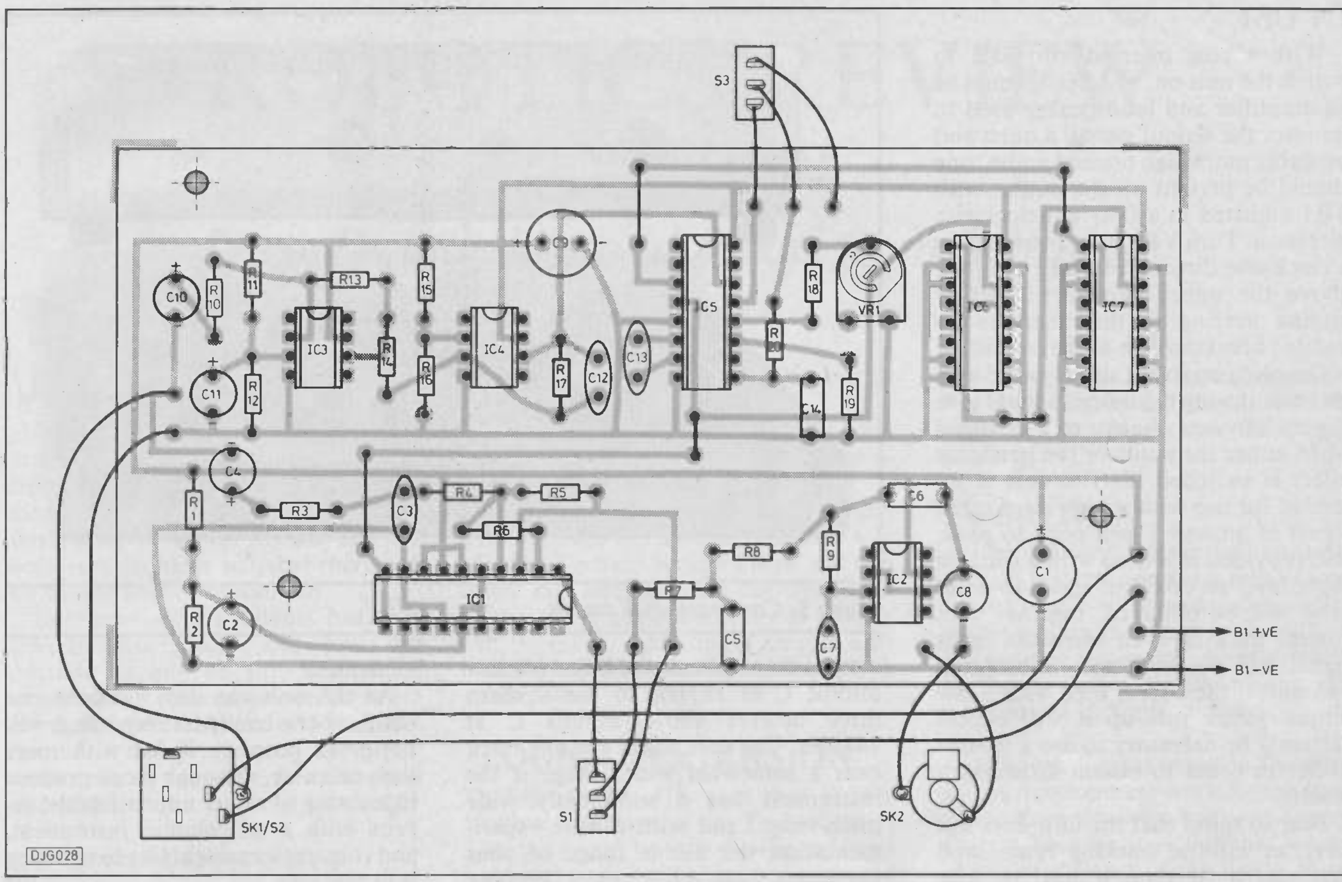


Fig. 5. *P.c.b. and component details*

producing audible breakthrough at the output. The breakthrough on the prototype was measured at almost 80dB down on the output clipping level, but if desired it can be reduced by another 12dB or so by wiring a 47μ capacitor direct across pins 8 and 16 of IC7 on the underside of the printed circuit board.

CONSTRUCTION

The printed circuit design and wiring are shown in Fig. 5. An important point to bear in mind is that IC1, IC4, and IC5 to IC7 are all MOS devices, and they should consequently be mounted in sockets and the other normal antistatic handling precautions should be taken. In other respects there is nothing much of note about construction of the board, but do not overlook the five link wires and fit pins at the points where connections to off-board components will be made.

A plastic and metal case was used for the prototype filter, with the controls and sockets mounted on the front panel. Probably most constructors would prefer to build this project as a standard pedal type effects unit, and a strong case such as a diecast aluminium type must then be used. S3 would need to be a heavy duty push button type mounted on the top panel of the case so that it could be operated by foot. In fact S1 could also be a top panel foot operated type if desired. S2 is a pair of make contacts on SK1, so that the unit is automatically switched on when a plug is inserted into SK1, and switched off again when the plug is removed. This is a system which is often utilized with effects units, but a separate on/off switch could obviously be used if preferred.

COMPONENTS . . .

RESISTORS

R1,R2	4k7 (2 off)
R3,R4,R10	47k (3 off)
R5,R6,R20	100k (3 off)
R7,R8,R9	10k (3 off)
R11,R12, R15,R16	27k (4 off)
R13	2M2
R14	22k
R17	390k
R18	220k
R19	15k

POTENTIOMETER

VR1	1M hor. sub-min preset

CAPACITORS

C1,C9	470μ 10V radial elect (2 off)
C2	100μ 10V radial elect
C3	390p ceramic plate
C4,C10	1μ 63V radial elect (2 off)
C5	2n2 carbonate
C6	4n7 carbonate
C7	330p ceramic plate
C8	10u 25V radial elect
C11	4μ7 63V radial elect
C12	470p ceramic plate
C13	220p ceramic plate
C14	330n carbonate

SEMICONDUCTORS

IC1	MF10CN
IC2	741C
IC3	LF351
IC4	CA3140E
IC5	4046BE
IC6,IC7	4018BE (2 off)

MISCELLANEOUS

SK1	Standard jack with d.p.d.t. contacts (S2)
SK2	Standard jack
S1,S3	s.p.d.t. min toggle or heavy duty push button (2 off)
S2	(part of SK1)
B1	9 volt (PP3 size)

Case about 205 × 140 × 40mm; printed circuit board, PE107; battery connector; 20-pin d.i.l. i.c. holder; 16-pin d.i.l. i.c. holder (3 off); 8-pin d.i.l. i.c. holder (3 off); wire; solder, etc.

IN USE

With a plug inserted into SK1 to switch the unit on, and headphones or an amplifier and loudspeaker used to monitor the output signal, a quiet and probably quite high pitched audio tone should be present on the output with VR1 adjusted in a fully anticlockwise direction. Turn VR1 just far enough in a clockwise direction to take the tone above the upper frequency limit of human hearing so that there is no audible breakthrough at the output.

Coupling an input signal to the unit and monitoring the output should give a very obvious change to the signal when either the notch or the bandpass effect is switched in. The unit is intended for use with a high level input signal of around 1 volt peak to peak, and provided it is used with a suitable input level an excellent signal-to-noise ratio will be obtained, together with correct tracking even when the input signal has decayed by a substantial amount. If the unit is used with a low output guitar pick-up it will almost certainly be necessary to use a preamplifier in order to obtain satisfactory results.

Photo 5. *Constructional details*

Bear in mind that the unit does not have an infinite tracking range, and that you must keep within the four octaves from (about) the F sharp below middle C at 185Hz, to the F sharp three octaves above middle C at 1480Hz. The unit might actually track over a somewhat wider range if the instrument has a sufficiently wide pitch range, and with a little experimentation the usable range of your particular unit will soon become evident.

As the unit can only produce one notch or one bandpass response it will not work properly if fed with more than one note, although it can produce interesting (if rather unpredictable) results with a polyphonic instrument, and constructors might like to try using it in this way. PE

ROBOTICS REVIEW

BY NIGEL CLARKE

Lego-Technic kits and robots from Selfridges

WHEN Gordon Ashbee opened his Robotics Workshop in London in 1984 he found that he was spending much of his time answering queries from robot enthusiasts. One of the most common questions was about the interfacing of home micros and robots—the problem was that there was no simple answer or solution.

Interfaces were available but they were machine specific and it was not possible to buy an interface which would work a wide range of micros. He contacted Peter Mellor of Micro-Robotics of Cambridge and he began work on developing a universal interface.

RESULT AVAILABLE

After almost a year's work the result is now available, but linking micros and robots is only one of the functions of what the company calls a revolutionary new micro-controller. Reacting to information from a variety of sensors and keyboards it can control motors, servos, relays and other devices.

The controller uses a 6303 CMOS processor with up to 24K of RAM with battery back-up, 16K of system ROM and a socket for 16K applications ROM. It can accept up to eight analogue inputs as well as information from two shaft encoders and Micro-Robotics' Snap vision system. Data will also be accepted from a 20-key matrix.

Up to four digital outputs can be controlled as well as 16 servos, an eight stepper motor driver card and 32 characters l.c.d. The programming is done by plugging into the host computer using a serial interface with the computer running a terminal emulator program, preferably one conforming to the VT 100 specification. The program is developed on the computer using the controllers' own high-level language, which the makers say is similar in structure to Basic or Logo and anyone familiar with those languages should have no problems.

The system is multi-tasking and applications can be programmed into onboard EPROM.

Once the program is downloaded the host computer can be disconnected and the controller with its battery back-up can then be easily moved to wherever it is needed.

Priced at £195 plus VAT for the 8K version it is available from Commotion of Middlesex.

After two years of development and testing Lego has unveiled its latest kits in the Technic series. There are two new kits and they are the first from Lego which allow a number of models to be made, including a simple arm and X-Y plotter, and be controlled by a computer.

LOGICAL EXTENSION

Lego in the UK says that it is a logical extension of the Technic series having begun by introducing the basic concepts of mechanics then moved onto motors and transmission adding manual control later and now computer control.

Although the kits have been developed specifically for schools it will be possible for people to buy them privately.

IN BRITAIN

The back-up material contains enough information for a full 20-week school course with teachers' guide and student projects. It has been built on the basis of the examination curricula in Britain and intensive testing at a number of schools throughout the country.

Although Lego is based in Denmark all the development work for the latest in the Technic series has been done in Britain because it is felt that we are ahead of the rest of the world in the teaching of technology. The new kits are to be adapted for other countries with interfaces for their particular popular micros.

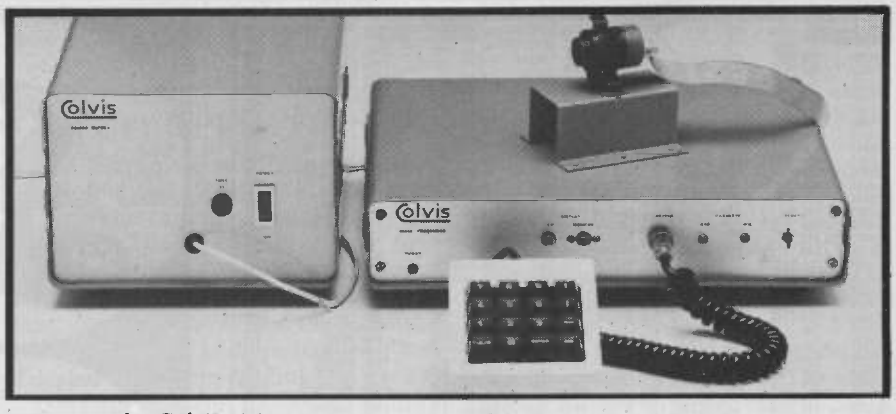


Photo 1. *The Colvis vision system*

The basic set contains two d.c. motors, two opto-sensors and counting discs, steering elements and wheels with a total of 404 elements. Apart from the robot arm it is possible to control a ferris wheel, washing machine, conveyor belts and automatic door.

The other kit contains 458 elements including an extra motor allowing quite complex models to be built including the °X-Y plotter.

As the kits will not be launched until August, exact prices have not been worked out but it is expected that one kit plus an interface for the BBC B and a complete set of programs and back-up material will cost about £200.

Other than from a computer the models can also be controlled by the manual control board which Lego introduced towards the end of last year. For a little under £30 the controller has three switch panels and is powered by batteries. It can also control the Lego Buggy which was launched at about the same time.

One of the pioneer companies in robotics in the UK has gone into voluntary liquidation. Colne Robotics of Twickenham was one of the first companies in the country to supply a small robot arm when in 1982 it launched Armdroid I, which proved popular especially in education.

It is not known how severe its financial problems were but it is understood that one of its major backers, Prutech, the high technology venture capital company set up by Prudential Assurance, was owed about £800,000.

Three factors have been blamed for the company's closure. There has been a general contraction in the industry which was made worse by the teachers' dispute. The directors made the final decision following the announcement of financial difficulties being experienced by Colne's US agent.

However, a further factor must be the failure to keep up with developments in the market. While other companies were bringing out new, cheaper and more reliable machines, Colne persisted with the Armdroid I while adding the Colvis vision system and a CNC lathe.

Attempts were made during the last year to upgrade the Armdroid but as mentioned in last month's article the specifications given for this new machine in the spring could not be met by the end of the year and a watered-down version was put on the market.

At the time of going to press no decision had been taken on the stocks still held at Colne's premises.

The Petsters have arrived. Nolan Bushnell's furry follow-ups to his first as$ault on the personal robot market with the ill-fated Androbot family have been available in selected outlets since before Christmas. At first they were available in relatively small numbers in two London stores, Selfridges and The Toy Factory.

The reaction was overwhelming with Selfridges re-ordering five times. They have now been launched throughout the country.

There are three in the range. The basic Petster, looking like a furry cat, costs about £50 and responds to handclaps and also has a roam mode. Petster deluxe, about £80 has 64 command modes, infra-red direction sensors, can speak and 'answer' questions. AG Bear (£30) responds with grunts to sounds, such as handclaps. PE

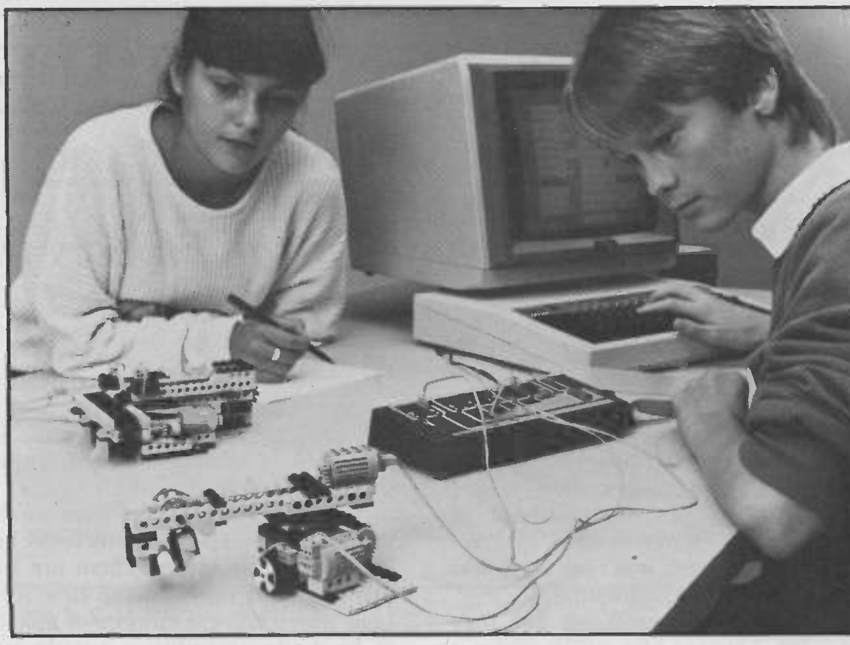


Photo 2. *Computer controlled Lego-Technic*

THE PE HOBBY BUS

PART ONE BY RICHARD BARRON

A universal and flexible interface and peripheral bus for all home micros—with multi user and multi tasking capabilities

LAST month in the 'Setting The Standards' article, a brief outline of the PE Hobby Bus was given. This month, the PE Hobby Bus constructional series starts with a complete circuit description of the mother board and backplane as shown in Fig. 1.1.

COMPUTER CONNECTIONS

Any popular home micro including the Spectrum, BBC, Amstrad and Commodore, etc. may be connected to the PE Hobby Bus to give complete control over an enormous range of peripherals and interface devices. Also, of particular interest to those who do not possess a personal computer, a couple of single board computer (SBC) projects will be published.

For those with a home computer, the Hobby Bus may simultaneously support both the host micro and an SBC. Indeed, it can support two SBCs and a host. This allows great flexibility and gives the system multi-tasking capabilities.

OPERATING PRINCIPLES

The bus consists of a control circuit section and a series of slot connectors. Seven connectors are shared between the SBCs and the host, whilst four are partially reserved for the use of SBCs, memory and expansion cards. There are seven slot select lines which are used to enable various input/output devices.

Interface and peripheral control cards may be plugged into any of the seven slots and depending on the user requirements may be controlled by the SBCs, host micro or both.

PRIORITY

As in any multi-tasking or shared bus system, a priority arrangement must exist. Also, steps should be taken to ensure that the bus is not being used by two separate elements, obviously a situation which, at the very least, would cause the system to crash.

In the PE system, a system busy (SBSY) line is provided which can be sampled by any card or device. If it is high (logic 1) then the bus may not be used. It is busy. If it is low, a device may take control of the bus by causing the system control line to go low. A hardware element in the control section automatically sets the SBSY line high. In some cases, however, it may not be possible for the host micro to sample the SBSY line. For this reason, the $\overline{\text{SCONT}}$ line going low automatically inhibits the host micro from taking control of the bus.

In other words, the priority for the bus users, works on a first-come-first-served basis, except, to avoid damage to the home micro, any SBC or bus device may take control away from the host by causing the $\overline{\text{SCONT}}$ line to go low.

CIRCUIT OPERATION

The host micro is connected to the PE Hobby Bus (PEHB) via a 40-way ribbon cable terminated at the bus end by a d.i.l. IDC connector and at the micro end by any suitable connector. Depending on the requirements of the host, various control lines, the data bus and part of the address bus may be decoded for system control.

Obviously, spare locations within the host's memory or I/O map may differ from machine to machine and user requirements. Therefore, a flexible decoding arrangement has been provided by IC1 and IC2, two 74LS85 4-bit comparator i.c.s connected to form an 8-bit comparator.

Any required 8-bit code may be set up via S3 to S10 connected to the 'B' side of the comparator. If an equivalent code is detected at the 'A' side, then the A=B output of the comparator will go high, indicating that the host micro is addressing the bus. It may be that less than eight decode lines from the home micro are required. This being the case, the unused lines are connected directly to ground on the 'A' side and the corresponding switches on the 'B' side are closed.

Providing that the $\overline{\text{SCONT}}$ line is high, indicating that an SBC is not using the bus, IC6a will produce a logic 0 at its output when the A=B line goes high. This does several things. It enables some of the 3-state buffers in IC2, IC4 and IC5, causes the SBSY line and the OE3 line of IC8 to go high (via IC6b).

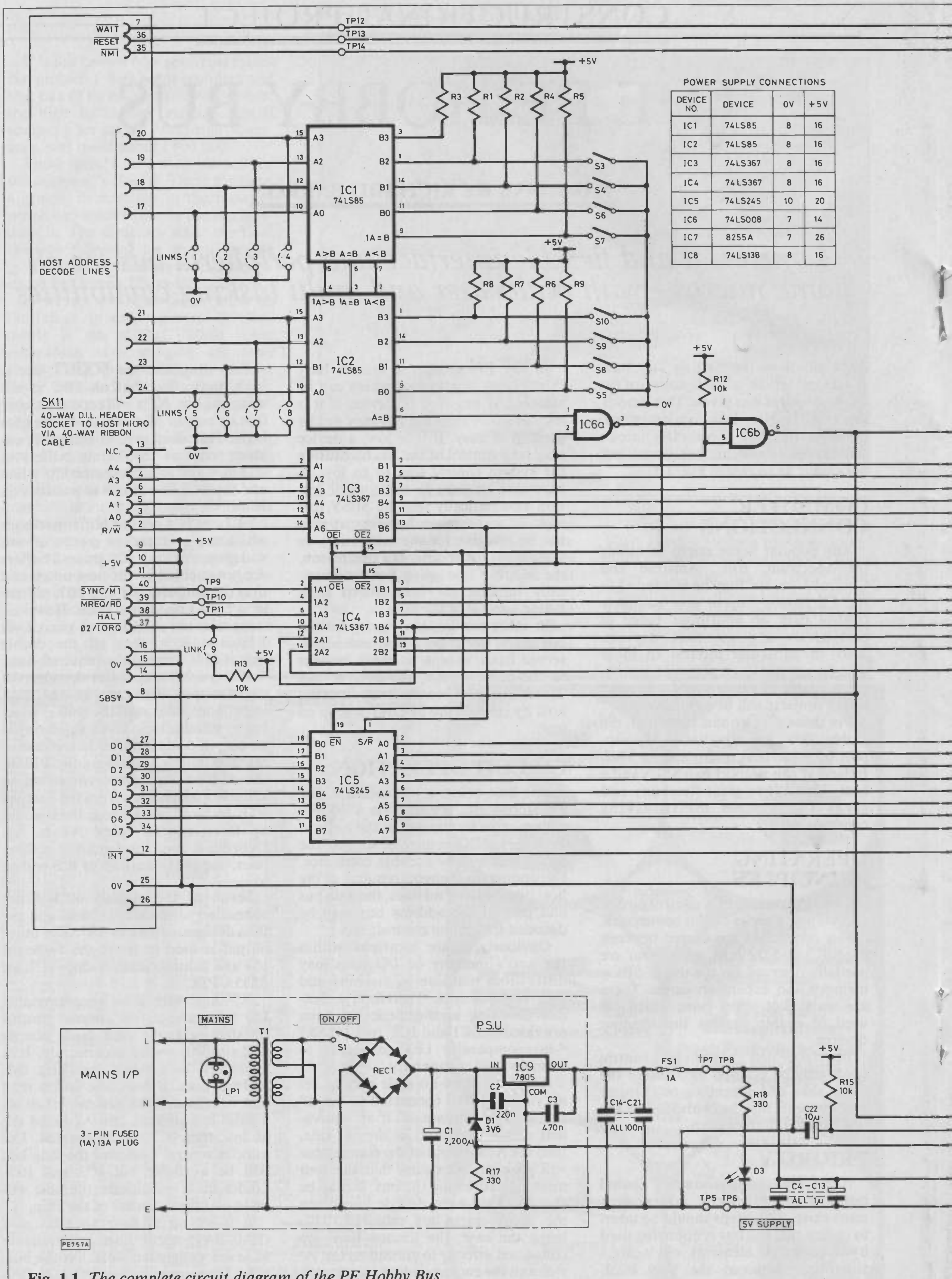
IC3 and IC4 are hex buffer packages which are arranged in groups of two and groups of four. IC4 group-2 buffers are not enabled by the host micro and thus the outputs, 2B1 and 2B2, remain in a high impedance state. However, these lines are connected to ground via R10 and R11, thus all the enable inputs of IC8 are at the required state.

IC8 is a 3-line to 8-line decoder. All eight output lines are in the high impedance state until the chip is selected by suitable logic levels appearing at its output enable inputs. In the case of the host micro addressing the PEHB, the address inputs are connected to suitable address lines from the host via IC3. In most cases, these lines would be three address lines, A2 to A4. Depending upon the condition of these lines, one of the outputs of IC8 will go low.

Seven of the outputs of IC8 are connected to the system slots and are thus designated SS1 to SS7. The other output is used to select the on-board I/O and communication chip, IC7, an 8255A PIA.

IC7 has three 8-bit programmable I/O ports and a few internal control registers arranged in a fairly simple and straightforward architecture. It is controlled by a select line ($\overline{\text{EN}}$), two address lines, a reset line and a read and write line. If the host micro sets up a valid bus address, and A2 to A4 are all low, then IC7 will be enabled. The various control lines and the data bus will be available via IC3 and IC5. Under these conditions, the host will be in complete control of the chip.

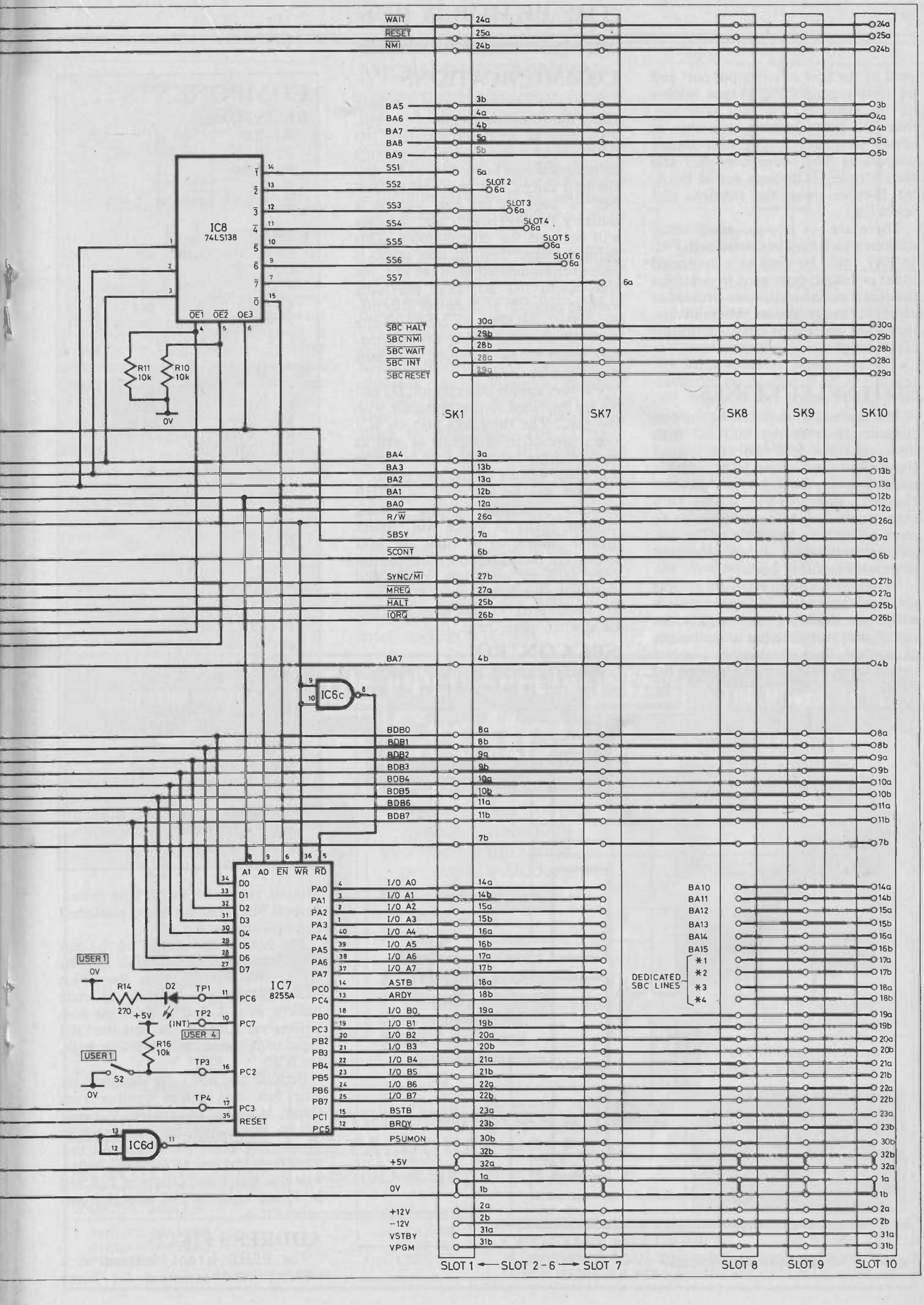
It is set up to have an 8-bit port (PA0–PA7) whose lines are available at seven designated slots. On the bus, these lines are known as I/O A0 to I/O A7. With this set-up, the port may be



POWER SUPPLY CONNECTIONS

DEVICE NO.	DEVICE	0V	+5V
IC1	74LS85	8	16
IC2	74LS85	8	16
IC3	74LS367	8	16
IC4	74LS367	8	16
IC5	74LS245	10	20
IC6	74LS008	7	14
IC7	8255A	7	26
IC8	74LS138	8	16

Fig. 1.1. *The complete circuit diagram of the PE Hobby Bus*



WAIT
RESET
NMI
BA5
BA6
BA7
BA8
BA9
SS1
SS2
SS3
SS4
SS5
SS6
SS7
IC8
74LS138
OE1 OE2 OE3
R11
10k
R10
10k
0V
SLOT 2
SLOT 3
SLOT 4
SLOT 5
SLOT 6
SBC HALT
SBC NMI
SBC WAIT
SBC INT
SBC RESET
SK1
SK7
SK8
SK9
SK10
BA4
BA3
BA2
BA1
BA0
R/W
SBSY
SCONT
SYNC/MI
MREQ
HALT
IORQ
BA7
IC6c
BDB0
BDB1
BDB2
BDB3
BDB4
BDB5
BDB6
BDB7
A1 A0 EN WR RD
D0
D1
D2
D3
D4
D5
D6
D7
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
PC0
PC4
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
PC1
PC5
PC6
PC7
PC2
PC3
RESET
IC7
8255A
USER 1
0V
R14
270
D2
TP1
TP2
(INT)
+5V
USER 4
R16
10k
TP3
S2
TP4
IC6d
I/O A0
I/O A1
I/O A2
I/O A3
I/O A4
I/O A5
I/O A6
I/O A7
ASTB
ARDY
I/O B0
I/O B1
I/O B2
I/O B3
I/O B4
I/O B5
I/O B6
I/O B7
BSTB
BRDY
PSUMON
+5V
0V
+12V
−12V
VSTBY
VPGM
BA10
BA11
BA12
BA13
BA14
BA15
*1
*2
*3
*4
DEDICATED SBC LINES
SLOT 1 ← SLOT 2 - 6 → SLOT 7
SLOT 8
SLOT 9
SLOT 10

used by the host as an output port and by simply connecting D-type latches at, for example, four slot positions, four I/O ports become available as shown in Fig. 1.2. The host simply outputs an 8-bit value from IC7 and then 'strobes' it through one of the 8-bit D-types using the required slot select line.

There are, of course, many other options which may be considered. PA0 to PA7 could be used as a dedicated input or output port used to control a particular peripheral device situated at any of the assigned slots. Alternatively, they may be used as control lines for other devices.

SLOT SELECT LINES

The slot select lines can be used in conjunction with the buffered data lines, and the R/$\overline{W}$ line to control simple input and output ports, without needing to rely on IC7. Using an octal D-type as shown in Fig. 1.3, an 8-bit output port may be constructed using one i.c. Similarly, as shown in Fig. 1.4, an octal transparent latch may be used to provide an input port.

As well as simple ports, there are lots for microprocessor add-on devices which are available, and require the use of, only, the data bus and a couple of control lines (including a select input), all of which are available on the PEHB.

COMMUNICATIONS

A second 8-bit I/O port is available along the complete length of the bus. This may be used for standard I/O functions or it can be used to provide communications between the SBC and the host micro. If a 'minimal system' SBC is used on the bus, then it is unlikely that keyboards and displays will be used for programming. This being the case, then the host micro is able to communicate with the SBC via I/O B0 to I/O B7, thus providing various program and control information. Also, the SBC can communicate with the host, and should any information need to be displayed, the host micro can be used.

For very simple user control, D2 and S2 are provided to communicate with the SBC. The third I/O port on IC7 takes care of these signals as well as various other functions such as strobe and ready signals for the user ports.

There will be a variety of PEHB projects published in the coming months, many of which will require greater control to or from the host micro. For these projects, other control lines such as interrupts, resets and wait/halt signals are available. Some are unbuffered, so care must be exercised when using them.

SBC CONTROL

All of the circuit elements described so far can be controlled by an SBC without the need for a host micro. Several SBC boards will be published and available soon.

The SBC takes control of the bus after first sampling the SBSY line, by taking the $\overline{SCONT}$ line, low. This enables the two separate tri-state buffers, in IC4, and disables the host buffers via IC6a. It also sets the OE3 input of IC8 and the SBSY line, high, via IC6b.

Because the SBCs are designed for other functions such as 'number crunching', as well as I/O control, IC8 may not be, necessarily, selected. In order to select IC8, the IORQ and A7 line must be taken low by the SBC, otherwise the active low inputs of IC8 will be forced high via 2B1 and 2B2 outputs of IC4.

ADDRESS FIELD

The PEHB is not designed as a memory card extension for home

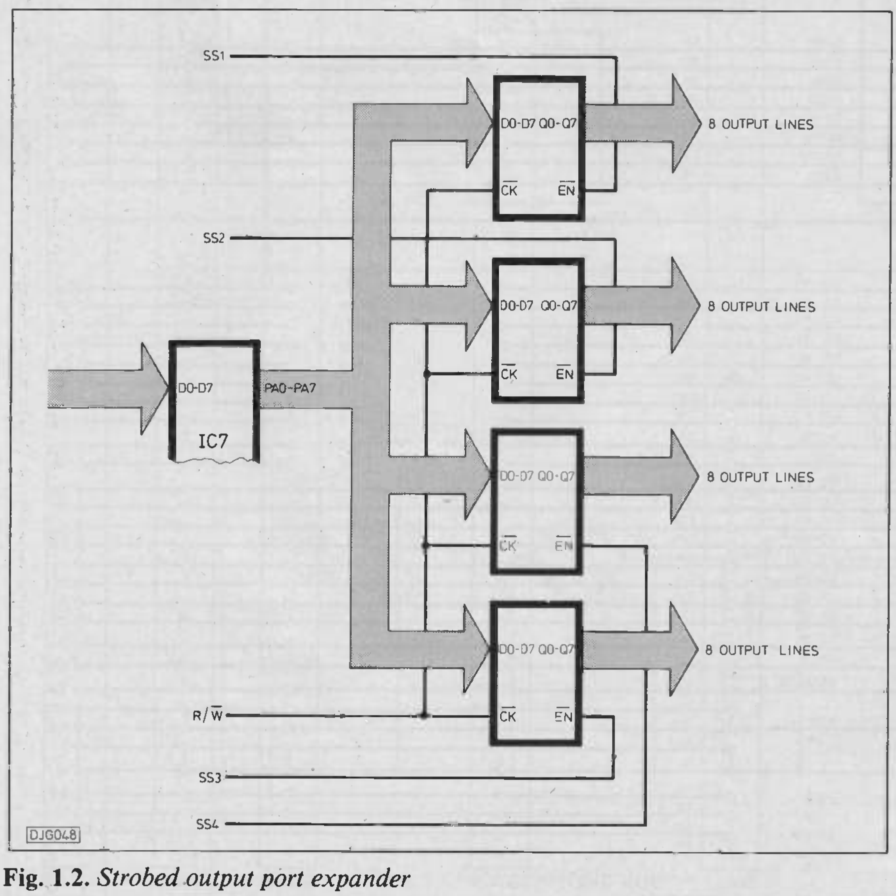


Fig. 1.2. *Strobed output port expander*

COMPONENTS . . .

RESISTORS

R1–R8	10k s.i.l.
R9–R13, R15,R16	10k ¼W (7 off)
R14	270 ¼W
R17,R18	330 ¼W (2 off)

CAPACITORS

C1	2,200µ elect
C2	220n polyester
C3	470n polyester
C4–C13	1µ tant bead (10 off)
C14–C21	100n polyester (8 off)
C22	10µ tant

SEMICONDUCTORS

D1	4V7 Zener 200mW
D2,D3	0·2" l.e.d. (2 off)
REC1	1A bridge rectifier
IC1,IC2	74LS85 (2 off)
IC3,IC4	74LS367 (2 off)
IC5	74LS245
IC6	74LS00
IC7	8255A PIA
IC8	74LS138
IC9	7805 voltage regulator

SOCKETS

16-pin d.i.l. socket	(5 off)
14-pin d.i.l. socket	(2 off)
20-pin d.i.l. socket	
40-pin d.i.l. socket	(2 off)
DIN 41612 sockets (as required)	

MISCELLANEOUS

T1 6V–0V–6V–0V secondary
FS1 1A and holder
LP1 mains neon
P.c.b. pins; p.c.b., rubber mounting feet (6 off); mains cable; wire; solder; S1, s.p.s.t.; S2, push to make; S3–S10, octal d.i.l. switch; small box for p.s.u.

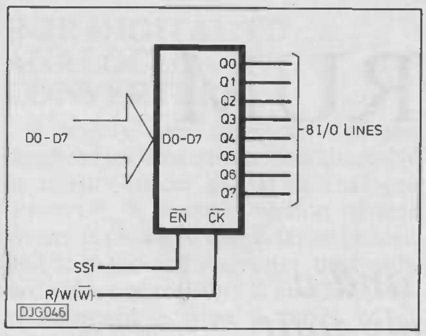


Fig. 1.3. *Simple output port*

micros, but it is obviously important that a full memory address field is available for such things as EPROM programming and program storage. For this reason, a complete address bus is available at slot 8 to slot 10.

Any SBC may have access to this bus, thus a full 64K of memory may be addressed. Should the host micro wish to use any of the system memory, it must do this via the SBC. There are also an additional four decoded lines reserved for SBC and memory use only. As with the host, various control lines are available along the complete length of the bus for SBC operations. Obviously, any line shared between SBCs and the host micro must be buffered by the SBC and only enabled when the host is not in control.

MICRO DIFFERENCES

As previously explained in the 'Setting The Standards' article, most microprocessors work on very much the same principle. There are only minor differences in the operation of most home micros, these being mainly due to the different type of CPU employed. Most home micros use either a Z80 or 6502 processor.

The 6502 microprocessor controls I/O from within its standard 64K address map and most home micros which use this processor have part of the address map reserved for I/O use. I/O operations are treated in much the same way as memory read or memory write instructions. The Z80 is quite different. As well as a standard memory map, it also has an input output map which is implemented using its IORQ line. The I/O map resides in the address field controlled by the least significant address lines.

On computers such as the Spectrum and the Amstrad, therefore, connections would be made to the PEHB using the IORQ line and a few address lines. Also to conform to the PEHB standard, only the $\overline{W}$ line will be used to generate a R/$\overline{W}$ line via IC6c. The 6502 only has a single R/$\overline{W}$ line so there are no such problems with machines such as the BBC.

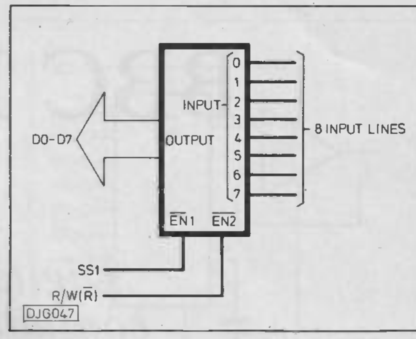


Fig. 1.4. *Simple input port*

Little need be said about the power supply as it is very simple. It supplies 5V regulated up to about 750mA via a 1A fuse. Another power supply will certainly be needed if other voltages are required for programming functions or analogue devices. Bus lines are reserved for these purposes.

If battery back-up is needed, a power supply monitor line PSUMON is available via IC6d. Under normal conditions, REC 1 supplies about 7·5V unregulated to D1. 3·6V is dropped across D1 supplying a high level to the input of IC6d. Should the supply fail, the input to IC6d will go low and the output high thus indicating failure.

NEXT MONTH: Details of the PEHB construction, p.c.b., home micro connection details and simple programs.

REGULAR FEATURE

BBC MICRO FORUM

BY RAY STUART

Digital to analogue converter and a computer controlled power supply unit

In the world outside computers most quantities cannot be measured directly in digital terms of 0 and +5 volts, some form of analogue to digital conversion is required. Temperature and pressure, for example, are measured on an infinitely variable analogue scale. To interact and control most real world systems computers have to convert digital signals to analogue signals and vice versa. The BBC microcomputer has a built-in analogue to digital converter, called the analogue port, but cannot provide an analogue output. This month's Microforum rectifies this by showing how a digital to analogue interface can be added, and gives an example of how this can be utilized to provide a computer controlled 25 volt–2 amp power supply.

DIGITAL TO ANALOGUE CONVERSION

A digital to analogue converter is a device that transforms a digital representation of a value, in say binary notation, to a voltage or current linearly proportional to the magnitude of that value. For example, if a value is digitally represented by an eight-bit binary number, it can have any one of 2^8 or 256 discrete values. Thus an eight-bit analogue to digital converter could not produce an infinitely variable voltage but rather a representation consisting of 256 steps. However, for most applications this resolution is adequate. If one required better resolution then one would have to resort to using a larger number of bits, say 10 or 12. As the BBC microcomputer is an eight-bit machine, this article will consider an eight-bit digital to analogue converter.

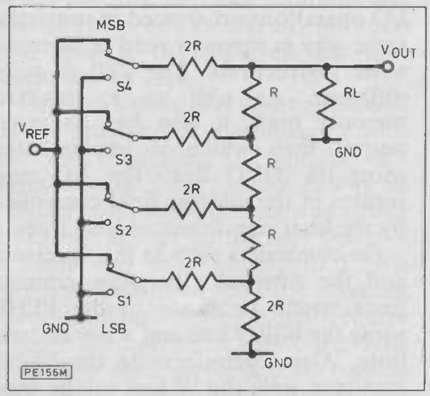


Fig. 2. *Resistor ladder converter*

There are two methods commonly used to translate digital to analogue signals: the weighted resistor and the R-2R methods.

WEIGHTED RESISTOR DIGITAL TO ANALOGUE CONVERTER

The circuit diagram of a typical four-bit weighted resistor digital to analogue converter is shown in Fig. 1. This can be considered as a summing amplifier with resistors switched into circuit as required, usually by solid state switches, to provide the input current. It can be seen that the smallest value resistor corresponds to the most significant bit and that successive lower significant resistors are twice the previous value. Thus the total current flowing through these resistors gives an analogue representation of the binary state of the switches. After being summed the current is converted to a voltage by the following operational amplifier. The feedback resistor R_f sets the gain and hence the output voltage.

At first sight this method appears to provide a simple solution. However, this type of converter suffers from several drawbacks. The accuracy of the system is determined by the accuracies of the resistors, the on resistance of the solid state switches and the characteristics of the operational amplifier. This may not be a problem in the circuit shown, but consider the case of a ten-bit digital to analogue converter. The value of the resistor associated with the least significant bit will be 2^9 or 512 times greater than that for the most significant bit. The result of this is that the current flowing through the least significant resistor could be lower than that which can be detected by the operational amplifier. This could be rectified by reducing the value of all the resistors, but the current requirements of the most significant bit would then be unacceptable for most applications.

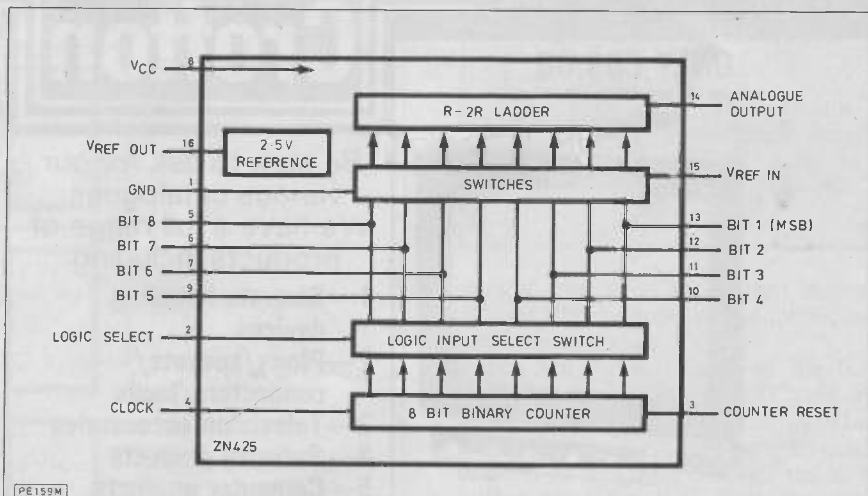


Fig. 3. *ZN425 block diagram*

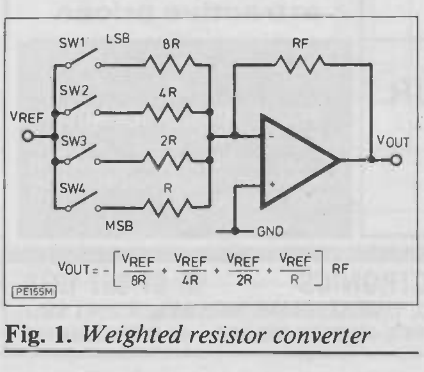


Fig. 1. *Weighted resistor converter*

R-2R DIGITAL TO ANALOGUE CONVERTER

A widely used alternative to the weighted resistor converter is the R-2R or resistor-ladder digital to analogue converter. A four-bit version of this system is shown in Fig. 2. It can be seen that this type of converter uses only two values of resistors R and 2R. This arrangement acts as a series of pi networks such that only half the current flowing into a node leaves it. Thus the current is halved each time it passes through a node, and therefore the switches represent a binary scale.

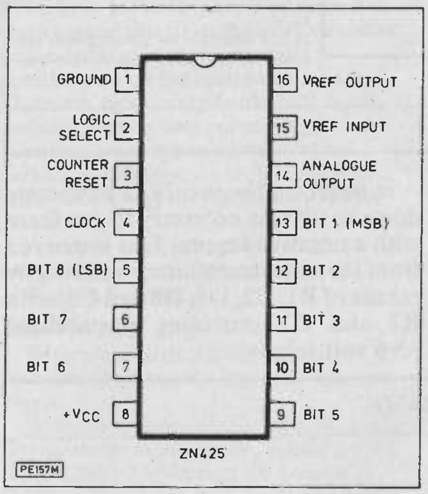


Fig. 4. *ZN425 pin connections*

This type of converter, although using more components than an equivalent weighted resistor converter, is easier and cheaper to produce. As there are only two values used (one if two R value resistors are used to produce 2R), value and temperature matching is easier to maintain during production thereby producing a better quality device. However, this system does have a relatively high output impedance thereby limiting the output current available. It is therefore common practice to buffer its output before it is used.

BBC MICROCOMPUTER DIGITAL TO ANALOGUE CONVERTER

In order to interface a digital to analogue converter to the BBC microcomputer one must first consider the interfaces available. The BBC's user port is ideal for this purpose as it provides an easily used eight-bit latched output. There are a number of eight-bit analogue to digital converters on the market suitable for our applications; but only one, the Ferranti ZN425, will be considered here. This provides an implementation of the R-2R converter discussed above.

The block diagram of this device (Fig. 3) shows that it contains all the elements required plus an additional eight-bit binary counter. The switches can be activated by digital inputs or by the counter, depending on the state of the logic select input, allowing the chip to be used in a variety of ways. For example, if the counter is selected it can be used as a ramp generator if a clock is applied to the counter's input. For the application described here, the counter will not be used. The pin connections of the ZN425 are shown in Fig. 4.

Connecting the ZN425 to the user port is straightforward as shown in Fig. 5. As the ZN425 is designed to operate on a supply voltage of 4·5 volts to 5·5 volts and consumes about 30 milliamps. It can be powered directly from the user port. The eight outputs from the port are connected directly to the ZN425's eight digital inputs and the counter is disabled by connecting the logic select input to ground. The R-2R resistor ladder can be connected to an external reference voltage if required via pin 15. However, in this case the ZN425's internal 2·5 volt reference (pin 16), is used and is therefore connected to pin 15. It is necessary to decouple this voltage with a 220n capacitor for optimum performance. The ZN425 generates a voltage output with a high output impedance. Therefore, to prevent following circuitry loading, and thus reducing the system's accuracy, the output is buffered by a 3140 operational amplifier wired as a voltage follower. In this configuration the maximum output voltage of 2·55 volts occurs when all the user port's outputs are at logic 1, and 0 volts when they are all at logic 0.

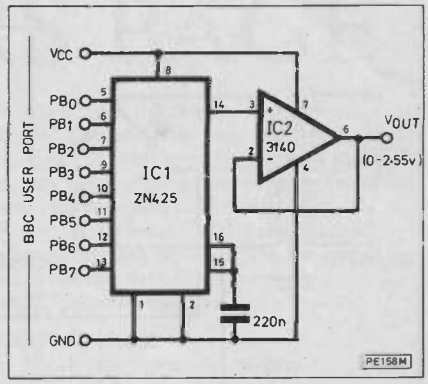


Fig. 5. *BBC D to A interface*

SOFTWARE

The software required to drive the analogue to digital converter is shown in Table 1. Before using the digital to analogue converter, the user port has to be configured to provide eight outputs. This is achieved by PROC_initialise_port which writes &FF into address &FE62 the port's data direction register (DDR). The user port

Table 1. *D to A program*

```
 10 REM
 20 REM
 30 REM
 40 REM
 50 REM
 60 REM
 70 REM
 80
 90 PROC_initialise_port
100 REPEAT
110   REPEAT
120     CLS:INPUTTAB(8,5)"OUTPUT VOLTAGE = "VOLTS
130     UNTIL VOLTS>-0.001 AND VOLTS<2.56
140   PROC_analogue_out
150   PRINTTAB(5,10)"Press < SPACE > to continue"
160   A$=GET$
170   UNTIL FALSE
180
190 DEF PROC_initialise_port
200 DDR=&FE62:DRB=&FE60:?DDR=&FF:?DRB=&00
210 ENDPROC
220
230 DEF PROC_analogue_out
240 OUT%=(VOLTS*1000) DIV 10
250 ?DRB=OUT%
260 ENDPROC
```

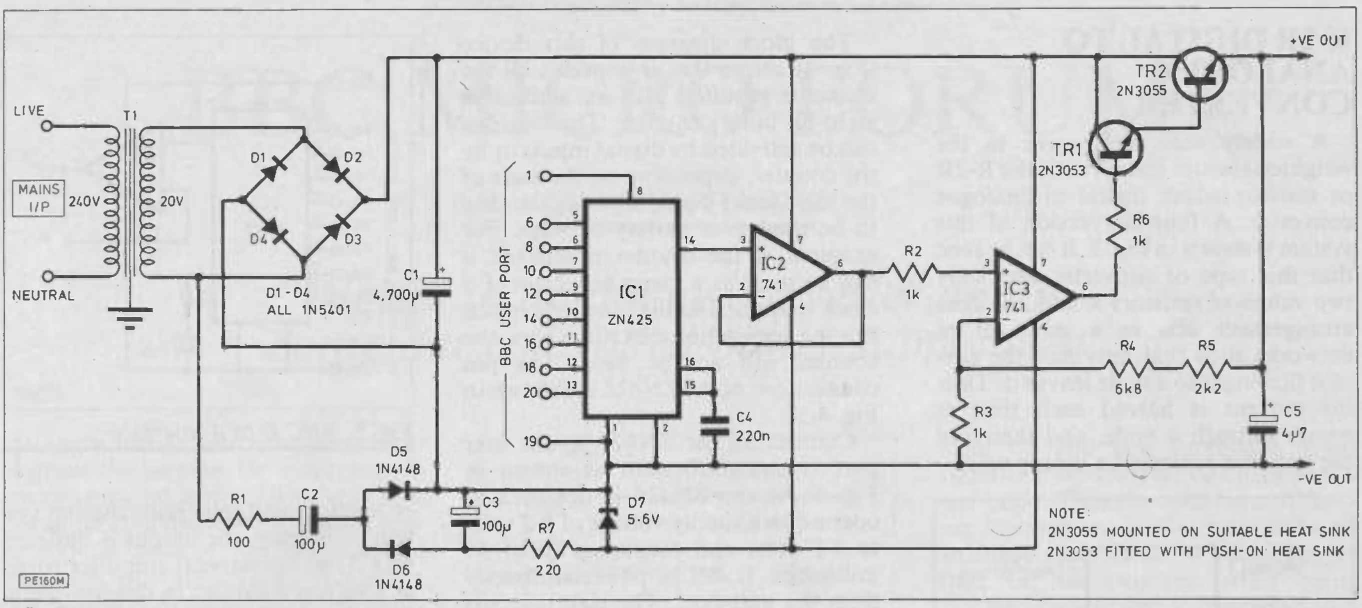


Fig. 6. *Complete circuit diagram of the BBC controlled PSU*

outputs are then set to zero by writing &00 into the data register buffer (DRB) located at memory location &FE60.

The user is asked to enter the output voltage required, denoted by the variable "VOLTS", if this is within the ZN425's range (0 to 2·55 volts) PROC_analogue_out is called. This procedure converts the voltage to an integer value in the range &00 to &FF and writes it into the appropriate data register.

As &00 corresponds to 0 volts and &FF to 2·55 volts it is evident that the least significant bit of the data word represents a change in the digital to analogue converter's output of 10 millivolts. Thus the output voltage can be set to within 10 millivolts of the required value which represents a resolution of 0·39% of full scale.

COMPUTER CONTROLLED POWER SUPPLY

Once an analogue output is available it can then be used for a variety of applications, an example of which is a computer controlled power supply. This could be used in automatic test equipment (ATE) or for controlling the speed of a small electric motor. The circuit presented in Fig. 6 is capable of supplying up to 25·5 volts at up to 2 amps.

The ZN425 produces a maximum voltage of 2·55 volts as described above, and is powered by the BBC's user port. This output is buffered by a 741, operational amplifier IC2 before being presented to the non-inverting input of IC3, a second 741.

This second 741 is used to compare the set point voltage from the digital to analogue converter with the power supply output voltage, i.e. it is an error amplifier. As the output voltage is ten times the setpoint voltage it is divided by ten, by R3, R4 and R5, before being fed to IC3's inverting input, pin 2. As the lower resistor in this divider chain is 1K, the upper part has to be 9K in order to produce the correct ratio. The nearest preferred values to this are 8K2 and 10K. Neither of these are close enough to the required value, therefore two resistors, a 6K8 ohm and a 2K2 ohm, are used to produce 9K.

The output of IC3, pin 6, is used to drive a darlington pair, TR1 and TR2, and thus produce the required output voltage. Obviously the BBC microcomputer cannot supply the power required by the operational amplifiers or the darlington pair which must be derived from the 240V mains. Transformer T1 produces a 20 volt output which is rectified by four 1N5401 diodes and smoothed by a capacitor C1.

In order for the two 741's to operate down to 0V it is necessary to run them with a negative supply. This is derived from the same transformer winding by means of R1, C2, D5, D6 and C3, with R7 and D7 providing a stabilised −5·6 volt supply.

Table 2. *PSU program (lines 10 to 80 for REMs)*

```
 90 PROC_initialise_port
100 REPEAT
110   REPEAT
120     CLS:INPUTTAB(8,5)"OUTPUT VOLTAGE = "VOLTS
130     UNTIL VOLTS>-0.001 AND VOLTS<25.6
140   PROC_analogue_out
150   PRINTTAB(5,10)"Press < SPACE > to continue"
160   A$=GET$
170   UNTIL FALSE
180
190 DEF PROC_initialise_port
200 DDR=&FE62:DRB=&FE60:?DDR=&FF:?DRB=&00
210 ENDPROC
220
230 DEF PROC_analogue_out
240 OUT%=(VOLTS*1000) DIV 100
250 ?DRB=OUT%
260 ENDPROC
```

The software required to drive this power supply is shown in Table 2. It is similiar to that previously described, the major changes being due to the increased maximum output voltage.

OTHER APPLICATIONS

A digital to analogue converter such as that described can be used for a range of applications other than a power supply. For example it could be used to calibrate a voltmeter, as a setpoint for say an analogue temperature controller or to generate various waveforms not easily achieved using conventional analogue techniques. **PE**

READERS' LETTERS PAGE

Dear Sir

On opening my copy of the March issue of *PE* this morning, I started to ponder over the recent demise in the computing hobbyist magazine field, amongst other things. I started reading *PE* as a result of the PE CHAMP and look where that went.

I am no good at filling in forms and I don't need your £2 voucher as my newsagent delivers what I want, so I'll just mention that my main interest in your periodical, now, is the kind of news that Barry Fox brings. I find the news and comment regarding DBS and cable TV fascinating.

We have got to get people interested in reality again; this morning there was news on the radio of more nightmare mindlessness on the motorways, in fog. This time, close to my home, in S. Yorks. It can only happen because people, in vast numbers, are living in a sort of 'cloud-cuckoo land', oblivious to the limitations of the technology they take too much for granted.

You have accepted a responsibility which you may not have noticed.

J. W. Hill, S. Yorks.

Dear Mr. Hill,

It sounds to us as if it was just one of those days for you. We hope, you have got over it.

Seriously, you are absolutely right about several things in your letter. People are, indeed, taking technology for granted. However, this is not necessarily a bad thing. That's the beauty of modern developments—transparent complexity. On the other hand, technology in the hands of the uninformed and uneducated can be extremely dangerous.

This brings us to another point, you made—our responsibility. We are aware of our responsibility to inform and educate. PE *will be publishing plenty of informative articles on modern developments and technology advances and will take extreme care to point out their limitations.*

Finally, if you liked 'The Champ', then we're sure that you'll like the PE Hobby BUS. It's a flexible and, potentially, extremely useful micro development system for the hobbyist designed to work with any home micro (or without one).

Editorial

Dear Editor

I am responding to your request for ideas in the editorial of the March issue of *PE*.

I am retired now, but am an electrical engineer by profession. My hobbies in retirement are: electronics (not including much in the way of computers), experimental mechanics and workshop practice. I have a well-equipped home workshop with lathes and welding gear, etc, as well as electronic test gear such as oscilloscopes and meters.

I do not think that I'm alone in this combination of interests but there seems to be no magazine that caters for it. Your magazine has many excellent projects for the home and car but never for the mechanical workshop.

An example of the sort of thing I have in mind is:

Digital readout of milling tables or lathes.
Strain-gauges for measuring forces or weights
Mechanical acoustic projects

You are devoting a good deal of attention to robotics which represents the marriage of electronics and mechanics—so some projects in the direction that I have suggested would, surely, not be out of place.

R. P. Gabriel, Chobham.

Dear Mr. Gabriel,

PE *has, and always will, place its emphasis on electronic constructional projects. There is no doubt that computers have been the most significant development in the field of electronics (and probably the world). This cannot be ignored, so PE will be publishing many micro related articles as well as the traditional projects for the home, workshop and car. We stress, though, that our projects will be hardware based and not include miles and miles of computer software.*

On the subject of mechanics, we would be happy to publish a project (or several) on machine control and monitoring systems, providing it is interesting, and of the usual, high, PE standard.

Editorial

Dear Mr. Grosvenor

I was interested to see your 'FSK Cleaner' circuit in February's *PE*, and would like to use it to square up serial data received over the phone.

Unfortunately, the tape input to my Oric operates at 2400 baud (or the very much slower 300), whereas you say the circuit will operate up to 1200 baud only.

I would be most grateful if you could suggest any way of modifying the circuit so as to operate at the higher speed.

D. R. Yearsley, Surrey.

Dear Mr. Yearsley,

We cannot, normally, suggest modifications to projects and ideas published in PE, however, after reading this, we're sure that Mr. Grosvenor or someone will come up with the answer. We will, of course, publish the best solution in a forthcoming issue.

Editorial

Dear PE

I am a subscriber to *Practical Electronics* and have noticed that in recent months, you have made reference to 'The British Amateur Electronics Association'.

I would very much like to join this association but do not know their address. I would be very grateful if you could forward a contact address.

Aidan Mitchell, Belfast.

Dear Aiden—*and other interested parties,*

All readers interested in the 'BAEC' should contact:
Cyril Bogod, 'Dickens', 26 Forrest Rd., S. Glam., CF6 2DP.

Editorial

Dear 'Back Issues'

I am interested in the article describing the Compukit UK101, a 6502 based single board computer. If this article is not available, please let me know of any similar articles dealing with the same subject.

Vishnu Raj, Malaysia.

Dear Vishnu,

Firstly, we are unable to supply back issues or deal with enquiries regarding aricles over five years old. However, we can supply photocopies of articles for £1 each inc. p&p.

Secondly, you will be pleased to know that PE *will be publishing several SBC based projects in the coming months, including one based around the 6502.*

Editorial/Services

STE-BUS POWER SUPPLY

PART 2 BY FARIBA SANIEENEJAD

Final constructional details of the STEbus and the PSU module

LAST month, the IEE 1000 series started with a brief look at the STEbus and constructional details of the PSU module p.c.b. This month, we will take a closer look at Eurocards, backplanes and the final constructional details of the PSU.

BUS STANDARDS

There are many bus standards now in use, many of which employ standard Eurocards and are designed to be housed in a standard size rack system. The most popular rack assembly used for both industrial and commercial products is the 19-inch model which takes on various shapes and sizes and is usually available in kit-form.

A basic sub-rack assembly, as it is commonly known, consists of two end-plates, mounting attachments, and four angle brackets and location strips. Add-ons such as top and bottom plates, card guides, module guides, backplanes and busbars are available as required. The Eurocard system is available in two heights; and two depths.

Eurocard heights are normally specified in terms of 'U' values, where single height (3U) is designed for 100mm cards and double height (6U) for 233·4mm cards. Widths are specified in units of 'E', where E = 0·2 inches. A 19-inch system has internal dimensions of around 84E. Standard depths are 160mm or 220mm. The STEbus specifications are for standard 3U, 160mm deep Eurocards.

The IEEE 1000 backplane can be fitted into the rear mounting bars of the sub-rack system and card guides located at appropriate points along the rack. Indirect edge connector sockets on the backplane then mate with the card plugs when they are slid into position. Alternatively, modules such as the PSU may be used, which are connected via special module plugs. Other miscellaneous items such as, horizontal mounting kits, hinged front panels, and card fronts are also available which provide for an extremely versatile and flexible system.

PSU CONSTRUCTION

Following on from last month, the overall wiring diagram for the STEbus PSU is shown in Fig. 2.1. As can be seen, in order to fit all the components into a 3U, 20E module, the component position is critical. It can be seen from Fig. 2.1 that the battery holder, battery, C3 and clip and T1 are all mounted on a screening kit side panel.

Before connecting any wires, the screening panel should be positioned about 6 inches from the p.c.b. with the module socket lying in between. This allows pleny of room for final assembly.

The wiring from the p.c.b. should be gathered together and fastened into two tidy looms. One loom should be arranged to make the module plug wiring easy, and the other should be directed towards the assembled screening panel, remembering that there will also be some wires to be connected to the module plug.

Once the looms are correctly positioned, wires should be distributed to the various plug connections and the panel-mounted components. All wiring and solder connections should be insulated. Finally, the l.e.d.s should be connected via about 5 inches of wire from the p.c.b.

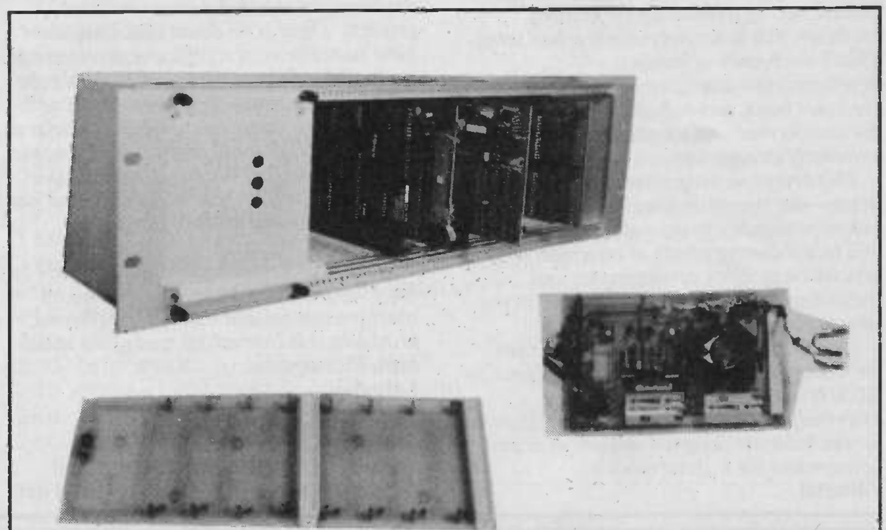


Photo 2.1. *Rack system complete with cards, PSU and backplane*

The connections to the p.c.b. should be made via suitable wire soldered to p.c.b. pins and insulated using plastic or rubber sleeves. The low voltage output from the transformer may be wired directly to the correct p.c.b. pins. All other connections are made using suitably rated wire. In normal use, most of the wires should carry less than 200mA, however, the 5V and 0V lines should be capable of carrying up to 2A continuous current.

MODULE ASSEMBLY

After all the wiring has been thoroughly checked, the completed p.c.b. and panel is ready for final module assembly. The Eurocard module front panel should be drilled with three holes to accept the l.e.d. mounting kits and the four card guides screwed into position.

Providing all is correct, so far, the completed wiring assembly, p.c.b. and

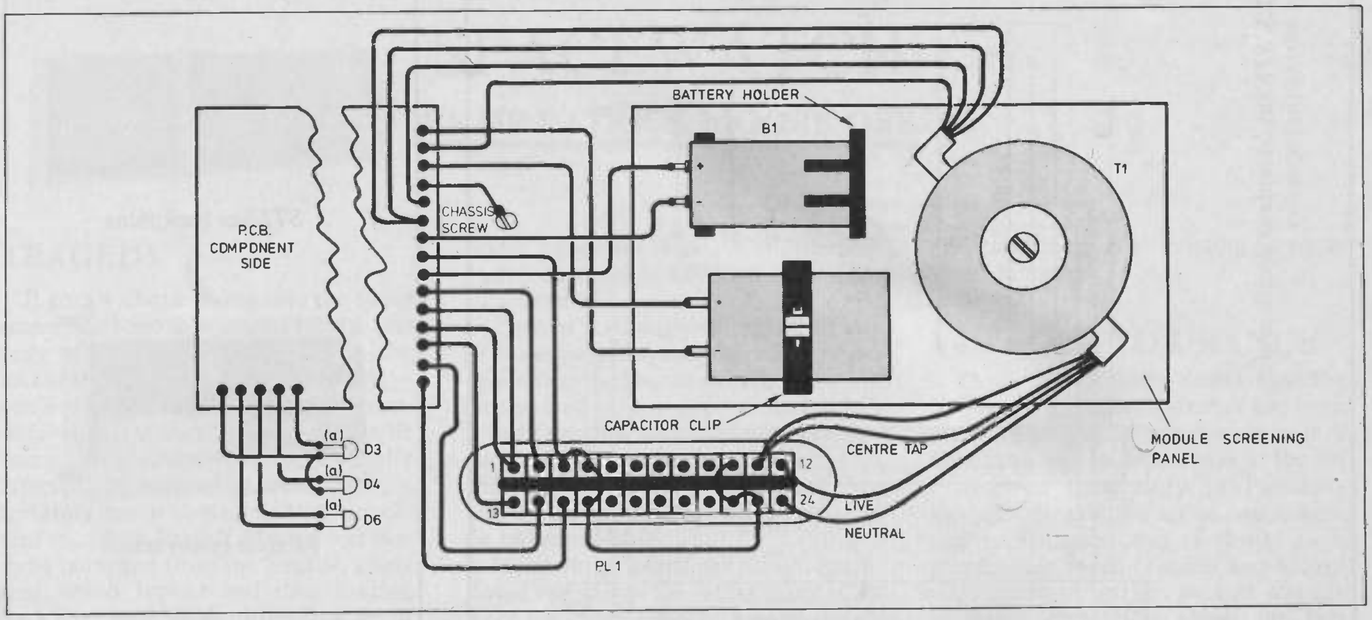


Fig. 2.1. *Overall wiring diagram of the PSU*

plug may be folded over as shown in Fig. 2.2 and slid into the module. Once everything is correctly aligned, the other screening panels and top and bottom platel may be positioned and the rear panel securely fastened. On most module units, the top panel can be slid open, giving access to the circuits, etc. inside, which in this case is useful as the pots may need adjustment and the battery may have to be fitted.

BACKPLANE

The p.c.b. design and component overlay for the STEbus backplane is shown in Fig. 2.3. It is a very simple design being only a single-sided board. Many industrial standard boards are extremely complex as they are designed to carry signals operating at 5MHz to 6MHz. This design is far cheaper to produce but limits system operations to around 2MHz.

The power supply rails are decoupled by a few capacitors situated in close proximity to the sockets. A resistor, R1, is connected across the 5V rail which carries a standing current of around 100mA. This was included as it was found that on the prototype, with very little load on the 5V rail, regulation was not very satisfactory.

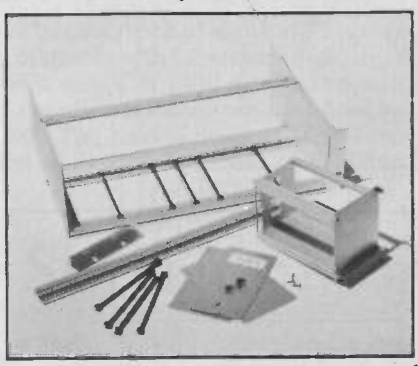


Photo 2.2. *System constructional details*

Mounting of the components onto the backplane should pose few problems and once completed, it may be fixed to the sub-rack system. It should be carefully aligned with the card guides, as fitted, and tightly fastened to the rear location strips.

The final task is simply to wire the backplane to the power supply module socket as shown in Fig. 2.3. *Extreme care must be taken to ensure that the mains wiring is well insulated and it must be noted that in normal use, the connections inside the socket are LIVE. Under no circumstances should the unit be switched on at the mains when the power supply module is not in position.* With the power supply in position, no live connections are exposed and the unit should be safe to use. For extra safety and to improve appearance the completed rack assembly may be mounted inside suitable equipment housing.

With the backplane in position and the PSU connected, the system is ready for use. Up to 9 cards may be inserted in addition to one further module. NOTE that when the PSU is switched on, it gets hot. This should be expected, as anything up to 37W may be dissipated within the module. With this in mind, check that the 17W resistor, (R3) stands well clear of the board.

COMPONENTS

RESISTOR

R101 50Ω 1W

CAPACITORS

C101–C116 100n (16 off)
C117–C124 1μ (8 off)

MISCELLANEOUS

P.c.b., PE 110, wire, solder, etc.
DIN 41612 a+c sockets (as required)

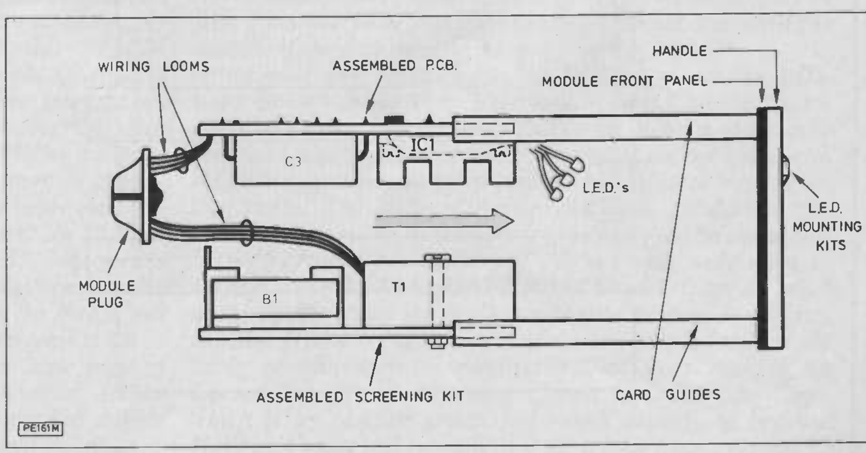


Fig. 2.2. *PSU mechanical details*

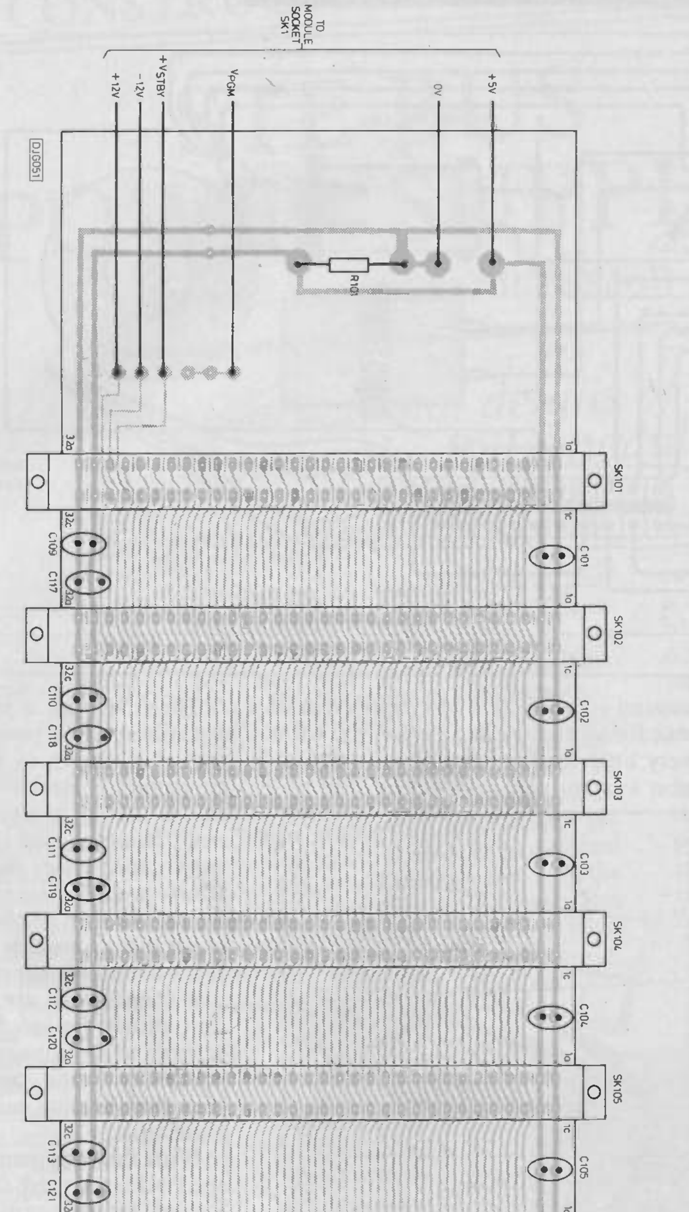
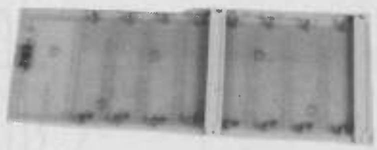


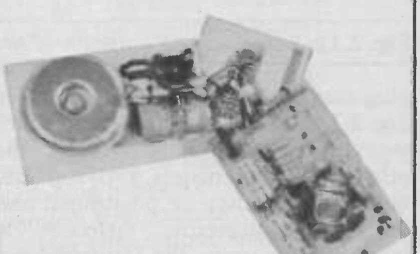
Fig. 2.3. STEbus backplane details and socket wiring (not to scale)

STEbus

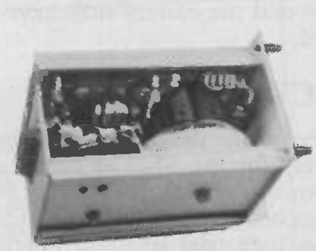


STEbus backplane

Module construction



P.c.b. details



Plug mounting details

STE-BUS PROJECTS

Over the coming months, PE will be publishing some exciting projects for use on the STEbus including SBCs, memory cards, mini-printers, I/O modules and terminals. As well as those, it is expected that readers will find their own applications for the system as the possibilities are enormous.

The STEbus has the facility to support a number of processors, and micro devices. It is designed to have a priority chain which can be configured as required. Thus to make the fullest use of the bus, in addition to the address and data lines, a number of request and acknowledge lines are included. More will be explained about these lines in the forthcoming months.

NEXT MONTH: This series continues with the first PE SBC constructional project.

SPACEWATCH

BY DR PATRICK MOORE OBE

TRAGEDY

It goes without saying that the space scene has been dominated by the tragedy of the *Challenger* Shuttle. The loss of the seven astronauts is in everyone's minds; everything else is secondary—but it is also true that the whole space programme has been badly affected. In particular, it will almost certainly mean delays to two important missions. Project Ulysses was due to be launched from the Shuttle, going first round Jupiter and then soaring back over both poles of the Sun, sending back information from these far-from-the-ecliptic regions which are relatively unknown. There was also the Galileo probe to Jupiter, which would have made its first encounter in December—not with Jupiter, but with the asteroid Amphitrite; after reaching Jupiter, Galileo would have dispatched an "entry" probe into the clouds of the Giant Planet and also used an orbiter to monitor not only Jupiter itself, but also its satellites. Finally, the Hubble Space Telescope is also a Shuttle project. It can now hardly hope to be kept to schedule.

There is no thought of cancelling any of these projects, and there can be no doubt that the Shuttle programmes will be resumed as soon as possible; but it is a sad fact that scientific payloads are liable to be put behind the queue of military and commercial projects. We can only hope that the delays will not be too protracted.

Meanwhile, plans for large Earth-based telescopes are being made. Cal-Tech has given a contract worth nearly 11,000,000 dollars to the Optical Systems of Lexington, Mass., to make the 42 hexagonal mirrors for the new 400-inch reflector to be set up on the summit of Mauna Kea, in Hawaii, at almost 14,000 feet. In fact 36 mirrors will be used, each of which is 72 inches in diameter with a thickness of 3 inches and a weight of 1400 lb. Construction of the mirrors should be completed by 1988. The Keck Telescope will be the first of its kind; it should be far more effective than any existing ground-based telescope.

VOYAGER TO URANUS

There can be little doubt that the Voyager 2 mission to Uranus has been one of the outstanding achievements of the Space Age to date. I was at the Jet Propulsion Laboratory in Pasadena throughout, and the air of excitement and anticipation was, I think, even greater than for the Jupiter and Saturn encounters. After all, we had already known a great deal about the two nearer giants, while our ignorance of Uranus had been fairly complete!

Initially it seemed that the encounter might be something of an anti-climax. Little could be seen on the planet as Voyager drew in, and neither was there any sign of a magnetosphere—remembering that the spacecraft was approaching Uranus "pole-on", because of the planet's extraordinary 98-degree axial tilt. Then, well before closest

continued on page 52

The Sky This Month

Of the bright planets, Venus continues to be visible in the evening, low in the west after sunset; its magnitude is −3·3, still vastly superior to any other star or planet. Mars, Jupiter and Saturn are all in the morning sky, though they are not yet well placed, and Jupiter is not likely to be seen properly until nearly the end of the month.

This is the best time for seeing Halley's Comet—if you happen to live in the southern hemisphere! During April, the comet passes through Corona Australis, Scorpius, Ara, Norma, Lupus and Centaurus; at its closest to the Earth, near the end of the first week, it will be just under 40,000,000 miles from us. Of course this is much further away than at the last return, that of 1910, but the comet should show a reasonably bright coma and a tail. Before dawn in mid-April it will be almost overhead from countries such as South Africa and Australia. Later in April the Moon will interfere; but on April 24 there will be a total lunar eclipse lasting for over an hour, and this may well be the last chance to see Halley's Comet with the naked eye until it comes back once more in 2061.

It is not necessary to go south of the equator to see the comet, though of course the further south the better. On 10 April the declination is −47, and on 20 April it is −32. This means that on the 10th it will theoretically rise from anywhere on the Earth's surface south of latitude 43°N, and on the 20th it will rise from anywhere south of 58°N. Unfortunately this is not so good as it may sound, because there will be little hope of seeing the comet unless it is well above the horizon. All the same, latitudes such as The Canary Islands will suffice —bearing in mind the need to escape from light pollution.

By the end of April the comet will have reached Hydra, and will again be above the British horizon. The position on 30 April will be RA 10h 58m, dec. −19°13′. However, the magnitude will have fallen below naked-eye visibility, and is dropping quickly as the comet moves away from the Sun and the Earth.

There is one important meteor shower this month. The Lyrids are active between about the 19th and 25th, with maximum on the 22nd. However, the zenuthal hourly rate is no more than 15, and the brilliant moonlight near maximum will hide all but the brighter meteors. A few members of the Eta Aquarid shower (associated with Halley's Comet) may be seen from the 24th, but the maximum is not due until the middle of the first week in May.

We have now virtually lost the brilliant winter constellations; Orion has vanished in the west, though Capella, Castor and Pollux can still be seen. The Great Bear is practically overhead, and high in the south there lies Leo, the Lion, with the first-magnitude Regulus and the line of stars making up the Sickle. The brilliant orange Arcturus, in Boötes (the Herdsman) is rising in the east; it is actually the brightest star in the northern hemisphere of the sky—the only stars to surpass it (Sirius, Canopus and Alpha Centauri) are all south of the equator, and the two latter cannot be seen at all from Britain. Hydra occupies much of the low south; look for the fairly prominent little quadrilateral of stars making up Corvus (the Crow). Adjoining Corvus is Crater (the Cup), which is an obscure group, but worth identifying because Halley's Comet will remain in it for a long time as it fades.

TTL LOGIC CHECKER

BY PETER COLLINS

A 16-channel programmable in-circuit testing device for all 14 and 16-pin TTL chips

LOGIC circuits are often relatively easy to check, since there are only two acceptable signal levels at every point in the circuit. These are logic 1 ('high', or about +4 volts), and logic 0 ('low', or little more than zero volts). Outputs must switch cleanly and rapidly from one state to the other, and must not take up an intermediate level under quiescent conditions. Many faults in logic circuits can therefore be located by simply checking that i.c. pins which should be at static levels are actually at a fixed state, and the right one, and that outputs which should be pulsing are providing a proper output signal.

The normal method of checking these points is to use either an oscilloscope or a logic probe, with the latter having the obvious attraction of far lower cost. A slight problem with either method is that it can be a little awkward going round dozens or even hundreds of test points on the circuit board testing each one in turn. Quickly making a reliable connection to minute integrated circuit pins can be rather awkward, and rapidly becomes tedious when it has to be repeated numerous times. I.c. test clips are available, and these certainly help by, in effect, physically raising the test points and spreading them out slightly to make them more accessible.

Things can be taken a step further though, and the test clip can be wired direct to a multichannel logic tester. For really useful results this would require what would amount to a proper logic probe circuit (including pulse indication) for each channel, and this would be rather complex and expensive with some sixteen channels to deal with. The large number of TTL chips and l.e.d. indicators required could also lead to the unit having a massive current consumption. A more simple form of indicator circuit could be used for each channel, and in most cases would give perfectly usable results, but results could sometimes be ambiguous or misleading.

The design finally adopted in this checker is a compromise between these two extremes, and the unit is basically a logic probe type circuit fed from an i.c. test clip via a 16-way selector circuit. In order to use the unit the i.c. test clip is fitted into place, and then the selector circuit is switched to check each pin in turn. In use this is nearly as fast as having separate state indicators for each pin, but it requires only a very simple and inexpensive circuit.

CHECKER OPERATION

The block diagram of Fig. 1 shows the system used in this design, which is not quite as simple as one might expect. There is a slight problem in that ordinary 16-way switches seem to be unavailable, and a circuit consisting of just a logic probe plus a 16-way single pole switch is not a practical proposition. Sixteen-way switches can be obtained, but only in the form of hexadecimal or 'hex' switches. These are small printed circuit mounting types with a built-in control knob and a dial (usually calibrated 0 to 15). There are five tags, which are 'common' plus four binary encoded outputs. If you are familiar with computers and binary then probably no further explanation is required, but for those who are not a little amplification is in order.

With the binary numbering system only two single digit numbers are used, 0 and 1. This is convenient for use with electronic circuits as 0 and 1 can be represented by different voltage levels. With the decimal numbering system the digits in a number (working from right to left) represent the number of units, tens, hundreds, thousands, etc. In a binary number the situation is similar, but the digits represent (again working from right to left) the units, twos, fours, eights, sixteens, and so on. Thus a binary number such as 1100 for example, is the equivalent of 12 in decimal (no units, no twos, one four, and one eight, equals 12).

A hex switch provides the appropriate four bit binary code for the number indicated on its dial, but four external load resistors are required. Although some people seem to have the impression that hex switches contain some electronics, they are in fact just ordinary mechanical switches, and are effectively a four pole 16-way switch wired up as shown in Fig. 2. Here each switch provides a closed circuit when it must provide a logic 1 output, and an open circuit when it must give a logic 0

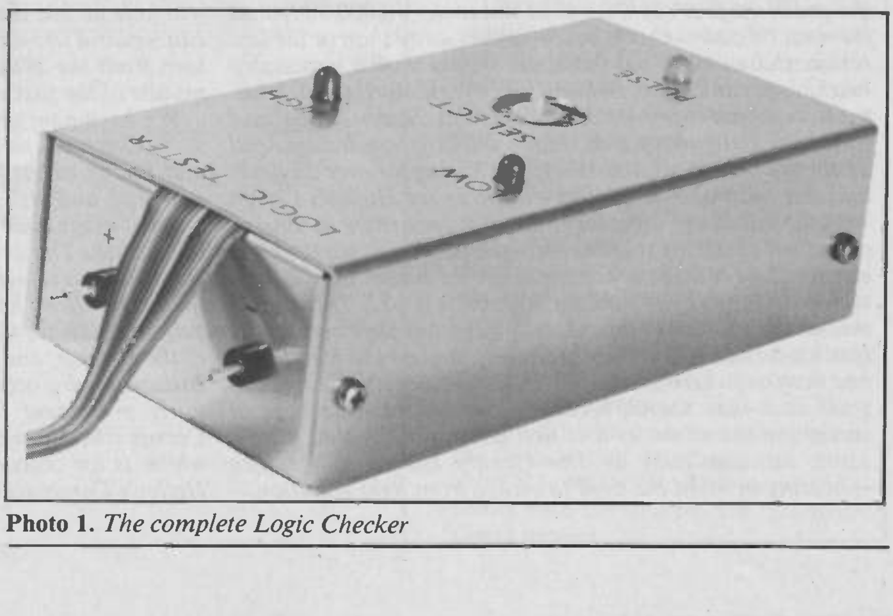


Photo 1. *The complete Logic Checker*

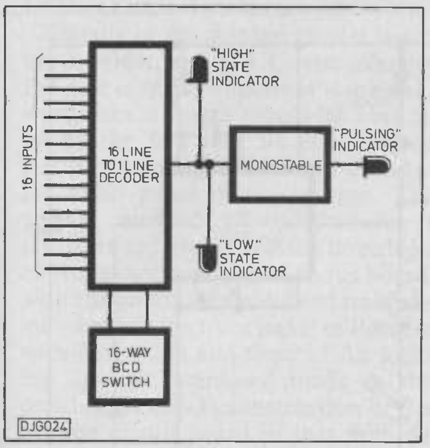


Fig. 1. *Block diagram*

output. In order to obtain the correct logic output levels it is therefore necessary to connect the 'common' terminal to the +5V supply line, and the '0' to '3' outputs are wired to earth via load resistors. There is actually an alternative type of switch where a logic 1 is represented by an open circuit, and a logic 0 is represented by a closed circuit. With these the 'common' terminal is wired to earth while the four outputs are connected to the +5V supply rail via load resistors. The two types are obviously not directly interchangeable, and only the former type of switch will operate in this unit.

On the face of it a hex switch is of little use in this application, but when utilised with a 16 to 1 decoder device it provides what is effectively a 16-way single pole switch, and although it can only handle logic signals, this is obviously all we require in this application. A 16 to 1 decoder, as its name suggests, has 16 logic inputs and a single output. There are four 'select' inputs, and the binary number fed to these determines which one of the inputs is coupled through to the output. With the sixteen inputs coupled to the i.c. test clip, the hex switch can be used to connect each pin of the test device, in turn, through to the output of the decoder. Here two l.e.d. indicators show whether each pin is in the high state or the low one. The decoder provides buffering so that the l.e.d.s do not load the test point.

CONDITIONS

Sometimes both l.e.d.s will light up, but at less than full brightness. This can indicate a fault with the input at an illegal voltage level, but it can also be caused by a pulsing input resulting in the two l.e.d.s being rapidly switched on and off. The switching rate is too high to be perceived by the human eye properly, and this gives the appearance of both l.e.d.s being turned on continuously, but at less than full brightness. Another problem is that very brief pulses may light up the appropriate l.e.d. for such a short period of time that it will not flash on noticeably, giving the impression that the expected pulses are absent.

To enable these possible sources of confusion to be resolved some additional circuitry has been included. This consists of a monostable multivibrator, which is simply a circuit that acts as a pulse stretcher. The monostable drives an l.e.d. indicator which it switches on for about half a second when an input pulse is detected. The l.e.d. might flash once when the position of the selector switch is changed, due to a change in the output state of the decoder during the switch-over, but if a series of input pulses are present it will repeatedly switch on and off at a fairly fast rate, or it might even appear to be switched on continuously. This depends on the frequency of the pulse train. Table 1, shown below, summarises the results produced by various types of input signal.

Table 1. *Possible indicator conditions*

TYPE OF INPUT	HIGH LED	LOW LED	PULSING LED
HIGH	ON	OFF	OFF
LOW	OFF	ON	OFF
FAST PULSING	PARTIALLY ON	PARTIALLY ON	ON OR FLASHING
SLOW PULSING	FLASHING	FLASHING	FLASHING
ILLEGAL	PARTIALLY ON	PARTIALLY ON	OFF
FLOATING	ON	OFF	OFF

CIRCUIT OPERATION

Fig. 3 shows the full circuit diagram of the checker. IC1 is the 16 to 1 decoder, and this is a 74150 TTL type. The unit is therefore compatible with the various TTL logic families, but with any logic tester fan-out has to be taken into account, and you should always bear in mind that whichever pin of the test device is being checked, it is subjected to an additional TTL load. The unit will often work properly with non-TTL devices, but when used in this way it is obviously advisable to view results with some caution. Pin 9 of IC1 is an inhibit input, but it is of no value here and is simply tied to earth. S1 is the hex switch and R1 to R4 are its load resistors. D1 and D2 are the 'high' and 'low' indicator l.e.d.s respectively, and these have R5 and R6 as their current limiting resistors. Although you might expect D1 to be the 'low' l.e.d. and D2 to be the 'high' indicator, this is not the case as there is an inversion through IC1. TTL inputs float high, and consequently D1 will switch on under stand-by conditions.

The monostable is built around another TTL device, IC2 which is a 74121 device. The output of IC1 is fed direct to its trigger input, and the Q

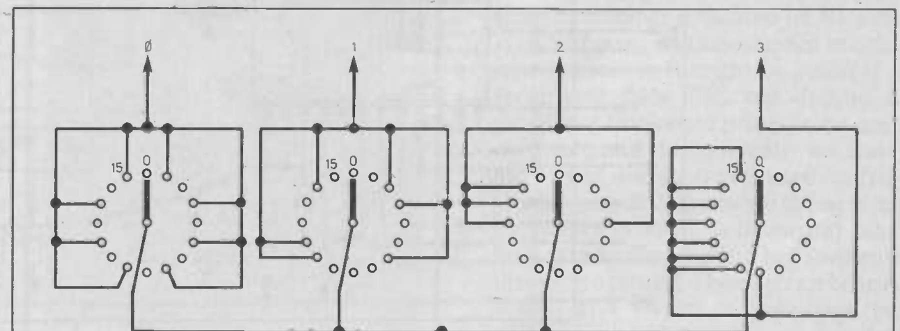


Fig. 2. *Switch details*

COMPONENTS . . .

RESISTORS

R1–R4	1k (4 off)
R5,R6,R8	390 (3 off)
R7	22k

All ¼ watt 5% carbon

CAPACITORS

C1	6μ8 6V tantalum bead
C2	100n ceramic

SEMICONDUCTORS

IC1	74150
IC2	74121
D1–D3	TIL209 or similar l.e.d.s (3 off)

MISCELLANEOUS

SK1,SK3	1mm sockets (2 off)
SK2	16-pin d.i.l. i.c. test clip
S1	horizontal hex switch (Cirkit 53-01163)

Case about 133 × 70 × 38mm; printed circuit board, PE108; 16-way ribbon cable; wire, solder, etc.

output drives l.e.d. indicator D3 via current limiting resistor R8. C1 and R7 are the discrete timing components.

No built-in power supply is included, but in most cases the unit can be powered from the 5 volt supply of the circuit being checked. The current consumption is not particularly low at typically a little over 100 milliamps, but most logic circuits can supply this, at least in the short term, without any danger of overloading the power supply. Unfortunately, low power (LS) versions of the 74121 and 74150 do not seem to be available, and there is no opportunity to reduce current consumption by using these. Of course, the unit could be powered from a built-in stabilised 5 volt mains power supply unit if desired, or battery operation from three HP2 size cells connected in series is another option.

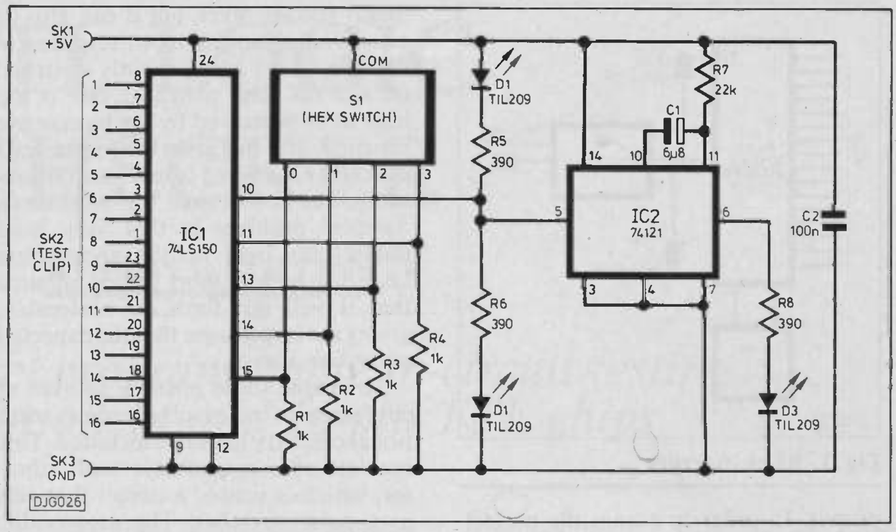


Fig. 3. *Complete circuit diagram*

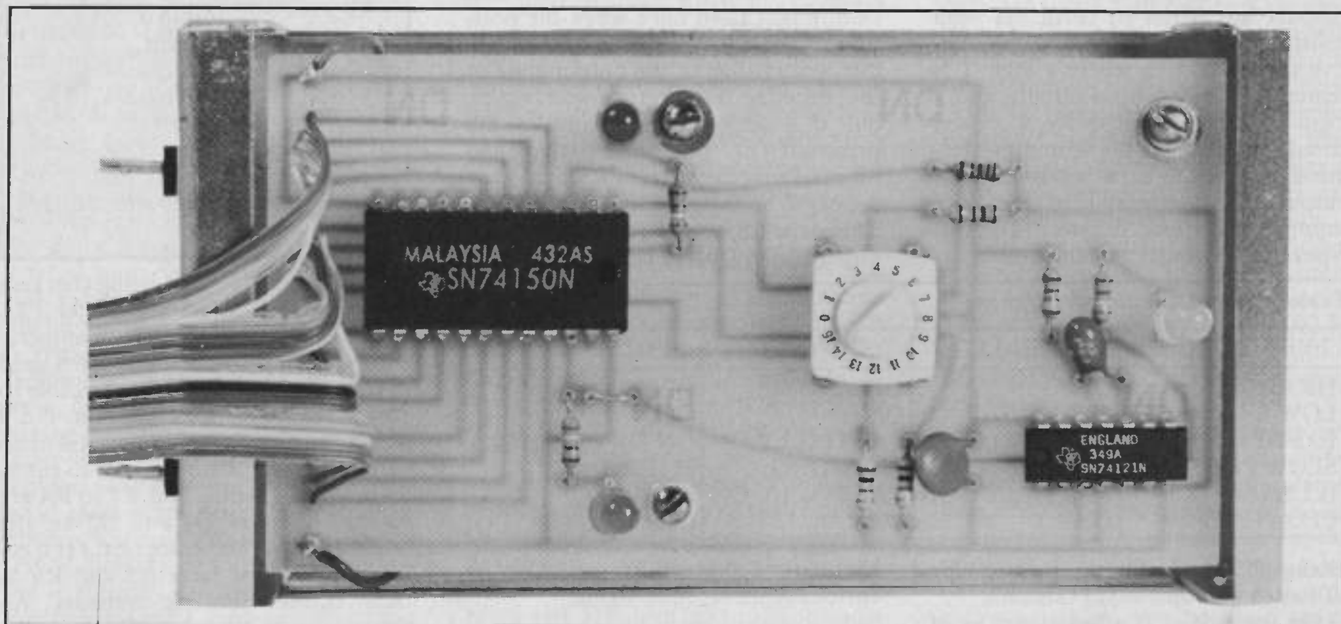


Photo 2. *P.c.b. details of the Logic Checker*

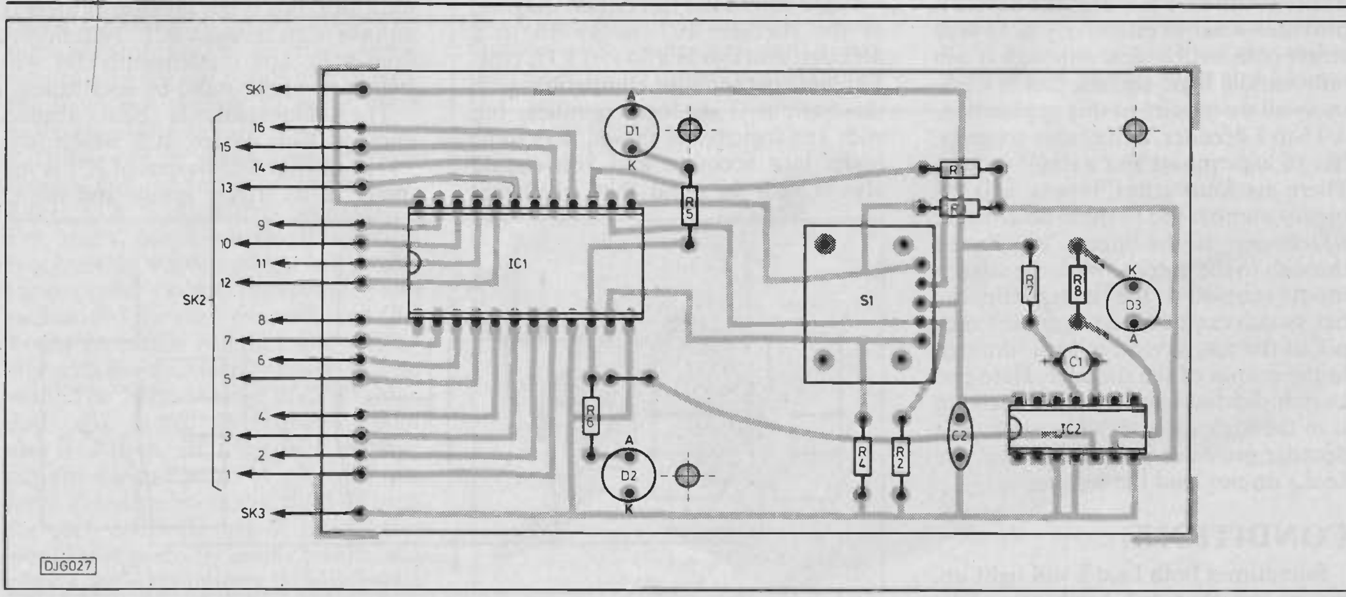


Fig. 4. *P.c.b. and component position details*

CONSTRUCTION

Details of the printed circuit board are provided in Fig. 4. Construction of the unit is made somewhat more awkward than it might otherwise need to be by the fact that S1 is a printed circuit mounting component and not the usual panel mounting type. The general method of construction is therefore to have S1 and the three light emitting diodes mounted on the board, with the board then mounted immediately behind the front panel of the case with the switch and three l.e.d.s looking through 'windows' made in the panel. This affects construction of the printed circuit board in that both S1 and the three l.e.d.s must stand proud of all the other components on the board, as otherwise it will not be possible to fit the complete board into place properly. For this reason it is best not to fit IC1 or IC2 in holders, and fortunately neither device is a static sensitive type. However, take due care not to overheat either of these components when soldering them into place.

COMPONENTS CHOSEN

A tantalum bead component is specified for C1 merely because this type of capacitor is generally physically smaller than an equivalent radial electrolytic. A miniature radial electrolytic could probably be used here though, and it could be mounted horizontally if necessary. Similarly, C2 must be a miniature type or it must be folded flat against the board. Note that if you use a type of hex switch other than the specified component, it is unlikely that it will fit properly onto the printed circuit board without some minor modifications being made first, and a wholesale redesign might be needed. Do not overlook the link wire next to R6 (this is the only one incidentally). Pins are fitted at the points where connections to SK1 and SK3 will eventually be made.

RIBBON CABLE

The board is connected to SK2 (the i.c. test clip) by way of a 16-way ribbon cable about 0·5 metres long. Do not be tempted to use a cable much longer than this as we are dealing with high speed logic signals here, and the capacitance in long cables would almost certainly cause a malfunction. Be careful to avoid crossed wires when connecting the cable ('rainbow' ribbon cable helps in this respect). I.c. test clips are not polarised, which would probably be impractical anyway, but they do not even have some form of marking to indicate a suggested orientation. To avoid confusion when using the unit it is advisable to clearly mark

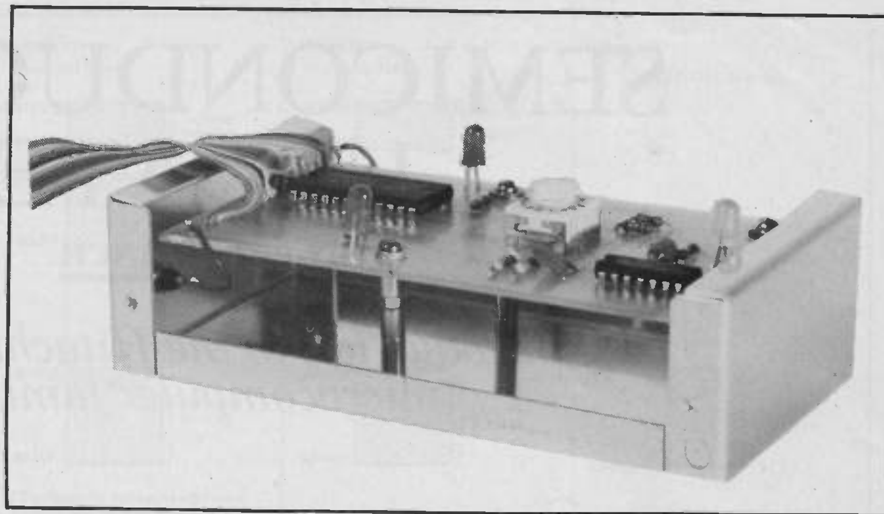


Photo 3. *Internal constructional details*

pin 1 of the clip, so that there is relatively little risk of the clip being fitted to test devices the wrong way around.

The prototype is housed in an aluminium box which measures about 133 by 70 by 38 millimetres. Other cases of about the same size should be equally suitable though. Holes for D1 to D3 and S1 are drilled in the front panel, and a fairly high degree of accuracy is needed here if everything is to match up properly. The board is mounted on the rear panel of the case, but use long mounting bolts plus sufficient spacers to raise the board high enough to bring S1 and the diodes into place in their front panel cutouts. SK1 and SK3 are mounted at one end of the case and wired to the board using ordinary hook-up wire. It might be necessary to make an exit hole for the ribbon cable at one end of the case, but it will probably be possible to take the cable out through the small gap between the two sections of the case.

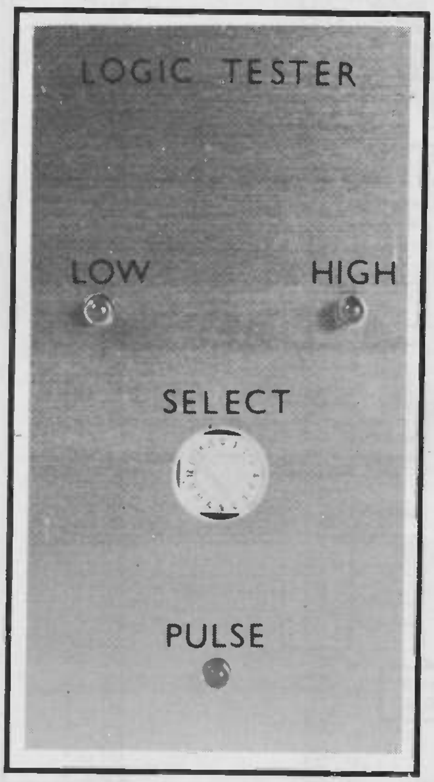


Photo 4. *Front panel details*

TESTING AND USE

A pair of test leads fitted with 1mm plugs and crocodile clips are used to connect the tester to the 0V and +5V supply rails of the circuit under test. If you choose to supply the unit from a different power source, bear in mind that the 0V rail of the tester must still be connected to the 0V rail of the circuit being checked. As a quick test of the unit, select a pin of the test clip using S1, and then connect this pin to the 0V supply rail. This should cause the 'high' l.e.d. to switch off and the 'low' l.e.d. to turn on. The ' pulsing' l.e.d. will probably flash on as well. If all is well the test clip can then be coupled to a 16-pin d.i.l. device so that the unit can be checked more thoroughly. Note that this checker is only suitable for testing 5V logic circuits, and it is unusable with either analogue circuits or logic types which use anything other than a single +5 volt supply.

When using the unit keep in mind that the number indicated on S1's dial is in fact one less than the pin number being checked. It might be possible to recalibrate S1's dial, but due to its small size this could prove to be quite diffficult, and it is not really necessary anyway as one soon gets used to using the existing dial. Probably the best test procedure to adopt is to start at pin 1 and gradually work in sequence through to pin 16. The unit can be used with 8 and 14-pin d.i.l. devices, but with some inputs left unused it is then essential to excercise more care to avoid confusion over which pin S1 is set to select. PE

SEMICONDUCTOR UPDATE

BY PETER FINCH

An introduction to the Hitachi HD63701 microcomputer family

THE microprocessor is now an established and integral part of not only personal computers, but also many electronic products from test equipment to musical instruments. The microprocessor is a universal 'black box' capable of being defined using software to perform functions which would otherwise require considerable numbers of components. This capability of microprocessors is often overlooked, particularly by the hobbyist.

With this in mind I have for some time been looking for a cheap, versatile, and easy to use single chip microcomputer capable of performing this kind of function. There are many such devices on the market but one set of products which particularly appealed is a family of low cost single chip microcomputers developed by Hitachi. These versatile devices are ideal for use by the hobbyist since they have been specially designed for prototyping and low volume production. Each chip incorporates not only the microprocessor—an upgraded version of the very well known 6800—but also EPROM, RAM, and I/O. In this article I shall be looking at two members of this family the HD63701V and the larger HD63701X.

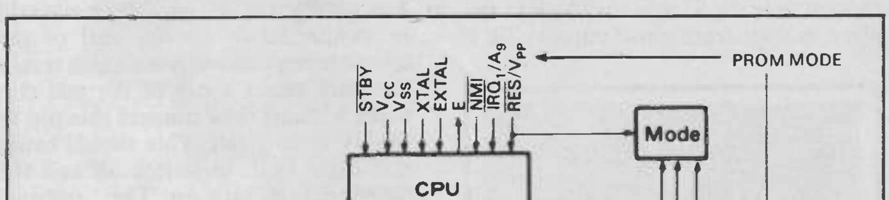


Fig. 1. *Block diagram of HD63701V*

THE MICROCOMPUTER CHIPS

The HD63701V and HD63701X are both high performance 8-bit CMOS microcomputers, with 4Kbytes of EPROM, 192 bytes of RAM, serial communications interface, parallel I/O ports and a multifunction timer. The features of these two chips are shown in Table 1. Both chips are available in two versions, an erasable (EPROM) version in a ceramic package and a non-erasable (PROM) version in a plastic package. The erasable EPROM versions are more expensive but are ideal for developing a project which can then be transfered to the cheap plastic cased version when the project has been finished and the software fully debugged.

The 63701 family is very versatile and can be operated in a variety of modes which are latched during reset. These different modes define whether the chip is operating as a single chip microcomputer or whether it is accessing external memory. If external memory or memory mapped I/O is not being accessed then the address and data lines are redefined in the single chip mode to act as I/O ports. Various combinations of address and data line availability are given in different modes thereby allowing the designer to tailor the chip to his own requirements. The various different mode configurations are shown in Figs. 3 and 5.

SYSTEM EXPANSION

In the expanded mode certain I/O lines are converted to true address, data and control lines, this allows easy interfacing with external memory and peripherals. Some modes use multiplexed data and address lines so as to leave more free I/O lines, this requires the use of a demultiplexer which is strobed by the address strobe line. The 63701 family can use any static or dynamic RAM, EPROM or ROM. The control lines available on all the 63701 family include a R/W line, which allows easy interfacing to any 6800 or 6502 family device; the 63701X has in addition RD and WR lines thereby also allowing it to interface to members of the 8080 or Z-80 families. The 63701X also has an MR input line which allows it to access low speed memory devices by stretching the system clock high period.

Each microcomputer chip contains 4Kbytes of PROM memory residing at the top end of memory addressing space. This EPROM can be programmed in the same manner as a conventional EPROM such as a 2732, and in the erasable version can be erased by exposing the window to strong light. This 4Kbytes of available EPROM memory is sufficient to store most programs utilising these microcomputer chips. In addition to the EPROM memory there are also 192 bytes of RAM memory for storing variables. This may not seem like a lot of RAM but is ample for many applications. A very useful feature of the RAM is that its contents can be maintained on a low power standby voltage. The CPU checks the validity of the RAM contents on returning from standby by automatically checking a single bit in one of the RAM registers.

I/O CAPABILITIES

The 63701 family has a powerful set of digital input and output functions. The number of available lines depends on which mode the chip is operating in, in single chip mode the 63701V has 29 parallel I/O lines and the 63701X has 53 lines. All the I/O lines are programmable using their associated data direction register and all lines in the output mode are capable of driving one TTL load and 90pF.

An important attribute of the 63701 family is its ability to send and receive serial communications messages with the minimum of software involvement. The on chip serial communications interface is capable of handling communications in full duplex asynchronous mode. Data transfer modes are programmable on the 63701X with a choice of either 8 or 9 data bits, 1 start bit and 1 or 2 stop bits. The serial communications hardware features separate transmitter and receiver shift registers and a programmable baud rate which is either derived from the system clock or an external clock. Interrupts are programmable and can occur either when the receiver is full or the transmitter is empty, overrun errors being detected. A further programmable feature of the serial communications interface is that it can be programmed to ignore all input messages. It will continue to do this until it

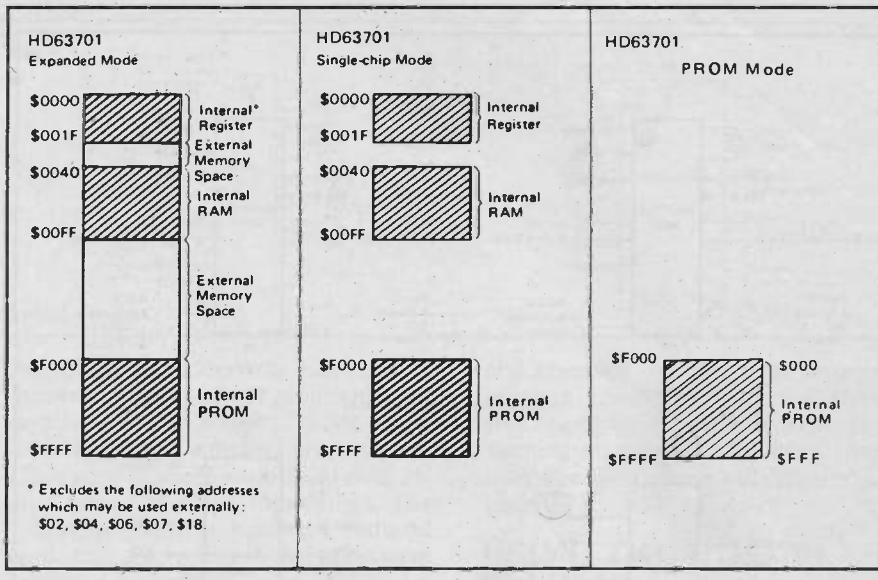
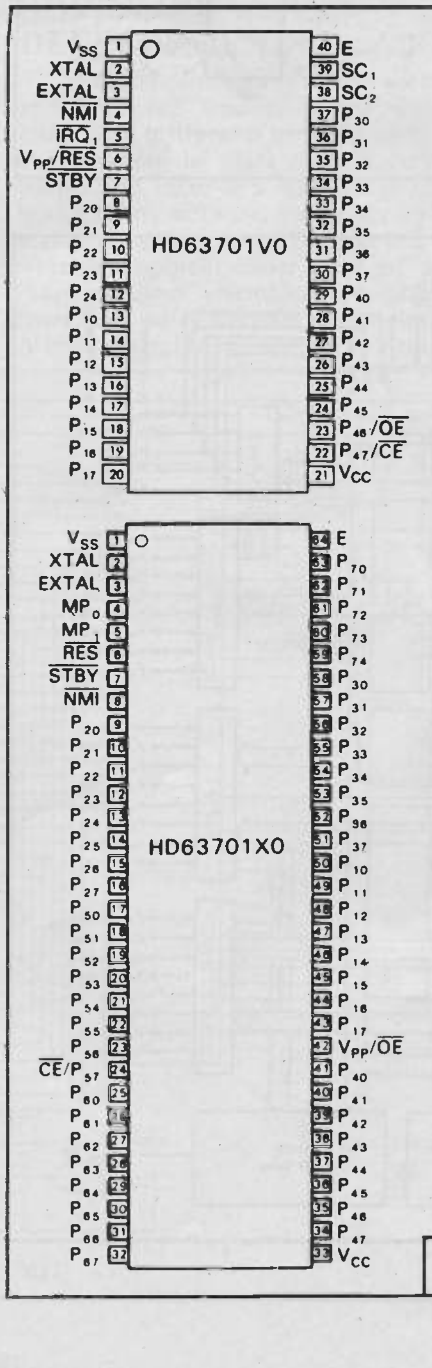


Fig. 2. *Memory maps for HD63701 family*



■ **FEATURES OF HD63701X**
- 4k Bytes of EPROM (compatible with 2732A type)
- 192 Bytes of RAM
- 53 Parallel I/O Pins
  24 I/O Common Pins (Port 2, 3, 6)
  21 Output Pins (Port 1, 4, 7)
  8 Input Pins (Port 5)
- Driving Darlington Transistor
- 16-bit Programmable Timer
  Input Capture Register × 1
  Free Running Counter × 1
  Output Compare Register × 2
- 8-bit Reloadable Timer
  External Event Count
  Spare Wave Occurrence
- Serial Communication Interface
  Asynchronous Mode/Clock Synchronous Mode
  3 Transfer Formats (Asynchronous Mode)
  6 Clock Sources
- Memory Ready for Low Speed Memory Access
- Halt
- Error-Detection (Address Error, Op-code Error)
- Interrupts—3 External, 7 Internal
- Operation Mode
  MCU Mode: Mode 1—Expanded (Internal ROM Inhibited); Mode 2—Expanded (Internal ROM Valid); Mode 3—Single-chip Mode
  EPROM Mode
- Up to 65k Bytes of Address Space
- Low Power Dissipation Mode
  Sleep
  Standby
- Minimum Instruction Execution Time—0·5μs (f=2·0MHz)

Table 1. *Pin outs and features on HD63701 family*

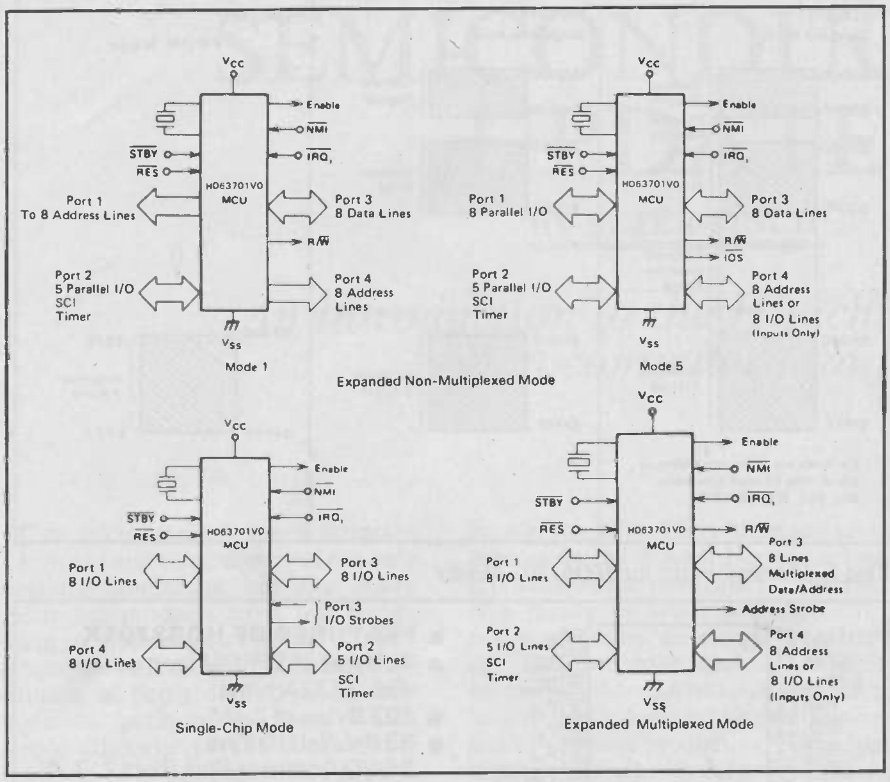


Fig. 3. *Operational modes for HD63701V*

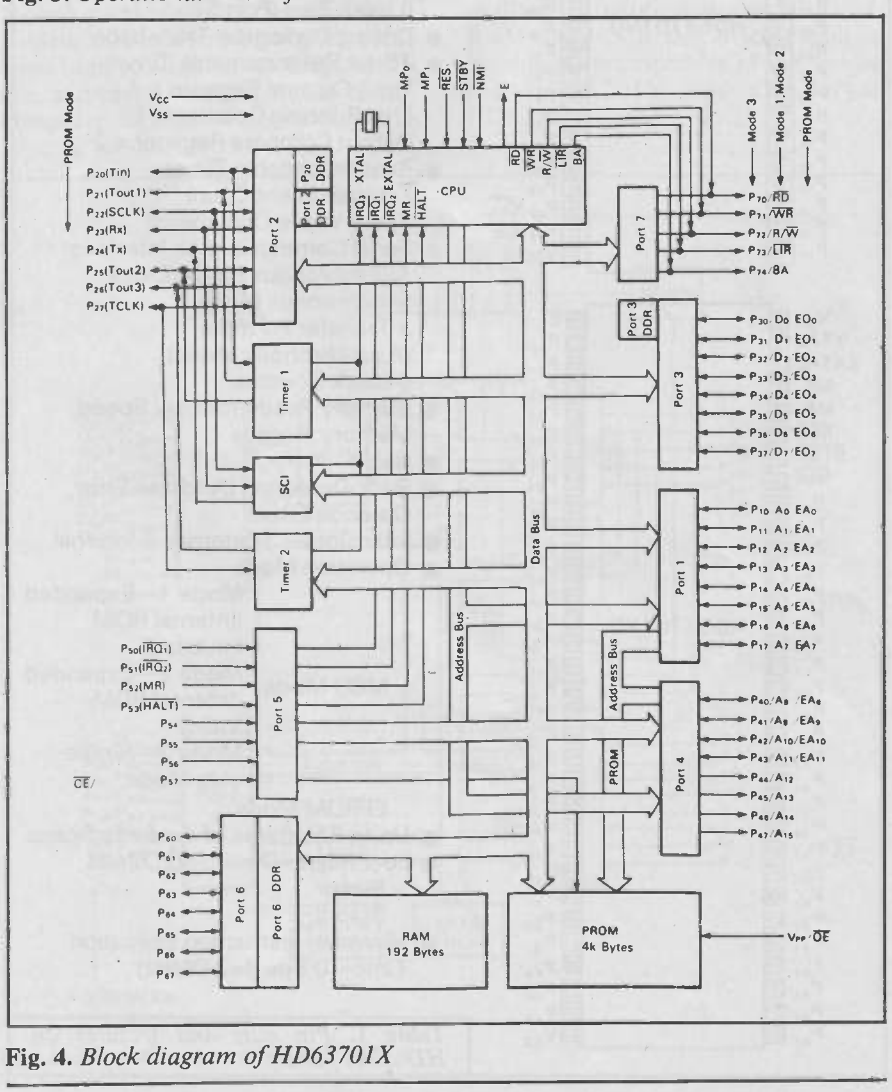


Fig. 4. *Block diagram of HD63701X*

receives a complete frame of consecutive '1's, a following ID code byte can then be examined by software and the following message either input or ignored.

TIMERS

The timers incorporated on the 63701 family chips are very sophisticated and can be put to a wide range of applications. The timer consists of a 16-bit programmable free running counter which generates the time base plus associated registers and control logic which enable the generation and measurement of variable frequency signals without the necessity of software control. The free running counter (FRC) is driven and incremented by the system clock. The FRC contents can be read by the processor at any time and will generate an interrupt whenever there is a counter overflow. An output compare register is used to continually compare the contents of the FRC with the value stored in the output compare register. When a match occurs then an output pin is set to a prescribed level and an interrupt generated. In this way the processor can generate a pulse width modulated output with any frequency and mark-space ratio within the 0·5μs resolution of the timer.

When used as a counter an input capture register is used to hold the value of the FRC when either a positive or negative transition occurs on an input pin. An interrupt is also generated to indicate to the processor that an input has occurred. The counter input feature allows pulses to be measured with an accuracy of up to 0·5μs.

In addition to the 16-bit counter, the 63701X also has an 8-bit reloadable up counter driven from the system clock or from an external clock source. If this counter is driven by an external clock it can be used to count events, if the system clock is used then it can be used to generate a square wave of variable frequency.

INTERRUPTS

The 63701 family supports 3 external interrupts. The NMI interrupt will always cause the processor to halt its current operation and transfer program control to code starting at a location stored in the NMI interrupt vector. The IRQ1 interrupt is identical to NMI except that an input on the NMI line has a higher priority, IRQ1 can unlike NMI be disabled by a software command. On the 63701X the third interrupt is IRQ2 which is a lower priority version of IRQ1. On the 63701V the third interrupt is generated by a strobe pulse on input port 3.

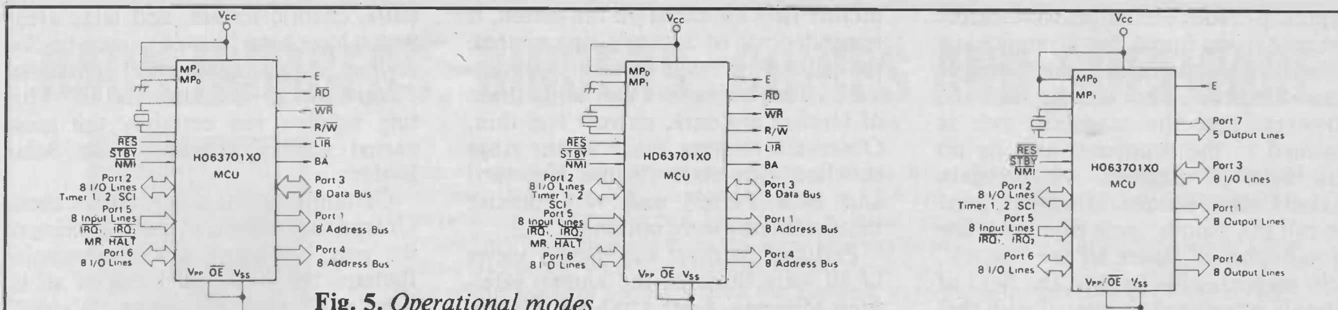


Fig. 5. *Operational modes*

POWER SUPPLY

The chips require 5V ±10% when operated at the full standard 1MHz clock rate. However, if the system clock speed is dropped to 500kHz then the chip will operate at 3V with all devices except the on chip EPROM. Power consumption is very low due to the fact that these are CMOS fabricated chips, again lower frequency operation (min 100kHz) brings lower power consumption (5mA).

A very useful feature of the 63701 family in applications where power supply is critical is the device's ability to be put into a low power 'sleep' mode under software control. In this mode the CPU clock is stopped but the registers and RAM are maintained and the peripherals remain active to count or communicate. The 'sleep' state is released by either an interrupt or a reset. In the 'sleep' mode power consumption is reduced to one-fifth of normal. A lower power requirement is available in the 'standby' mode where only the RAM contents are retained. This state requires a supply of over 2V and power of a few microamps. The 'standby' mode is hardware induced and can be released by a system reset.

SOFTWARE DEVELOPMENT

The 63701 family runs an extended and improved version of the well established instruction set of the 6800. Programming in 6800 code is very simple and there is a wide range of books, utility software, and public domain software available. To make software development easier there are a range of cross assemblers available from third party software companies. A cross assembler allows one to write and assemble machine code programs using a computer with a different processor, an example is a program running on the BBC 'B' from Crossware Products which will create object code for the 63701 family.

USING THE HD63701 FAMILY

The hardware required to implement a minimal 63701 system is very simple and an example is shown in Fig. 6 of a minimal system incorporating a HD63701V, an extra 8Kbytes of CMOS RAM and the drivers required to give RS232 serial communications. By using the EPROM version of the 63701 family, development is made much easier. There will be a programmer for the 63701 in a future issue. In future issues of PE I shall also be giving a number of applications projects using these chips. PE

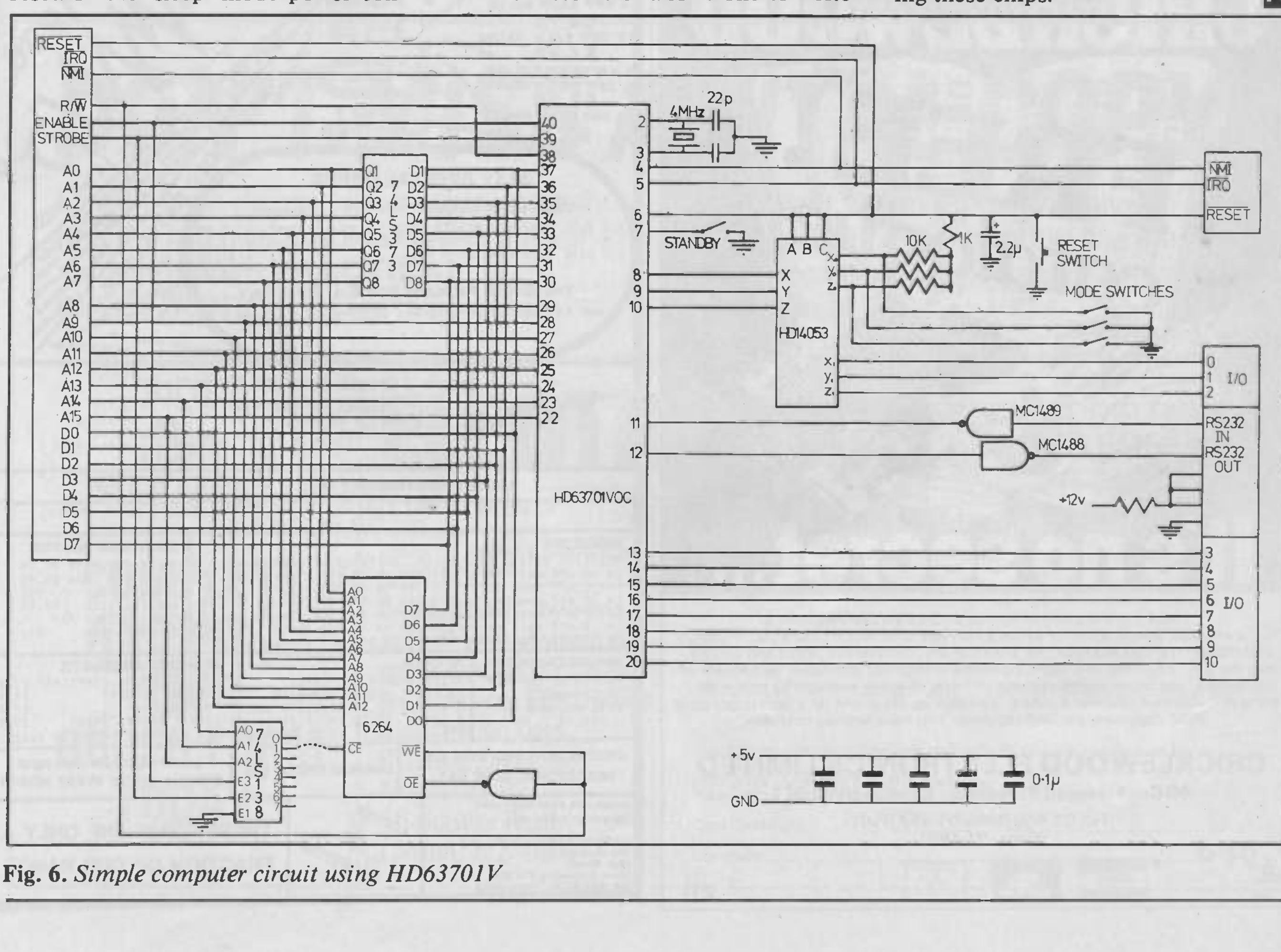


Fig. 6. *Simple computer circuit using HD63701V*

continued from page 43

approach, radio emissions were detected, and it was found that Uranus has a definite magnetic field, rather stronger than Saturn's. The strange fact is, however, that the magnetic axis is inclined to the rotational axis by no less than 55 degrees, which again makes Uranus unique. Moreover, what we call the "south" pole (the pole now in sunlight) is closer to the "north" pole magnetically. In fact, the field of Uranus is reversed compared with that of the Earth.

SURFACE MARKINGS

Surface markings are elusive; a few clouds were seen, and the rotation period is now defined fairly accurately as being 16·8 hours, but a great deal of work remains to be done. The amount of helium in the atmosphere was found to be 10 per cent, much less than the preciously-quoted figure of 40 per cent—which admittedly had seemed unreasonably high. There may be some internal heat source, though it is thought to be much less than those of the other giants.

Ten new satellites were discovered, and one of them (1985UI) was even imaged as Voyager passed by. A new ring was also found, and it was also learned that there is a layer of "dust" pervading the ring system. When this picture first appeared on the screen, it reminded me of Saturn's ring system, though there is really no valid comparison; Saturn's rings are icy, while those of Uranus are dark, narrow and thin. Observations were made as the rings occulted two stars (Sigma Sagittarii and Beta Persei) and very precise measurements were obtained.

Perhaps the most spectacular views of all were those of the known satellites: Miranda, Ariel, Umbriel, Titania and Oberon. All are smaller than our Moon; Titania and Oberon are around 1000 miles in diameter, Ariel 800, Umbriel 750 and Miranda only 300. It had been tacitly assumed that they would be rather similar to the icy satellites of Saturn, but in fact they are very different, and are also different from each other. Titania and Oberon are cratered and icy; some of Oberon's craters have dark internal deposits, and it looks very much as if there has been considerable tectonic activity in the past. Ariel has craters, and also grooves superficially not unlike those on Jupiter's major satellite, Ganymede. Umbriel is dark, and has larger craters, with no sign of past activity tectonically. Miranda is the most puzzling of all. "We're still trying to invent words to describe it," was the comment made to me by Dr. Eugene Shoemaker. There are craters, faults, cliffs, chaotic terrain, and large areas which have been likened to race-tracks. In fact, to quote another geologist: "You name it—Miranda has it." This tiny satellite has certainly the most varied surface known in the Solar System.

Certainly we know much more about Uranus than we did at the beginning of the year, but many problems remain. Perhaps the most intriguing of all is: Why is Uranus "tipped on its side?" The usual answer is that it was struck by a massive object; there are obvious objections to this, and certainly any such impact would have destroyed the satellite system, in which case the present satellites would have been formed later. But as yet nobody has been able to think of a better explanation.

Voyager 2 is still working perfectly —better, indeed, than it did during the Jupiter and Saturn encounters. It is surely a measure of NASA's triumph that all this has been achieved with a probe which was built ten years ago. There is every hope that it will continue to operate as it makes its rendezvous with Neptune in 1989. At all events, it is a good timekeeper. After a journey which began from Earth in 1977, it reached its closest point to Uranus 1 minute early! PE

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BBC latest OS, BASIC, DFS, 100k single disk drive, disks, cassette and speech synth, joystick, books, £420. Mr. J. B. Bebb, 685 Llangyfelach Road, Treboeth, Swansea, SA5 9EL.

Wanted: Practical Electronics Sept., Oct., Nov., Dec. 1980. J. Jordan, 36 Hillcrest Road, Gashes Green, Stroud, Glos. GL5 4NW. Tel: 04536 3914.

Tektronix scopes 545A, £125. 545B, £150. Both excellent inc. spares manuals. Both sweep delay and intensifier delay. K. E. Franklin, 50 Abington Street, Burnham-on-Sea, Somerset. Tel: 0278 784205.

Help! Electronically illiterate person seeks help from someone who could design time delay switching for solenoids. J. E. F. Swan, 164 The High Street, Lewes, East Sussex BN71.

Dragon computer for spares. £35 complete. 74LS783 £9. E809E £3, 2764 £2, 4164 £1.25, BE337 £4/100. Nick Spiers, 114 Greenway, Tunbridge Wells, Kent. Tel: 0892 44070.

Aquarius computer new unused £40 o.n.o. DX 200 communications receiver as new £100 o.n.o. New 3532s £2.50. J. Howells, 118 Heritage Park, St. Mellons, Cardiff. Tel: 0222 797956.

PE BAZAAR MAY '86

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PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE BP53
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.
Written not for the family bookshelf but for the electronics enthusiast's workshop bench. Its aim is to bridge the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled.
0 900162 70 8 — *256 pages* — *1979* — £2.95

ESSENTIAL THEORY FOR THE ELECTRONICS HOBBYIST 228
G. T. Rubaroe, T.Eng.(C.E.I.), Assoc.I.E.R.E.
The object of this book is to supply the hobbyist with a background knowledge tailored to meet his or her specific requirements and the author has brought together the relevant material and presented it in a readable manner with minimum recourse to mathematics.
Many formulae having a practical bearing are presented in this book and purpose-designed examples are employed to illustrate their applications.
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HOW TO DESIGN ELECTRONIC PROJECTS BP127
R. A. Penfold
There is a lot of information available on various circuit building blocks in catalogues, books, magazines, etc., but there is little information that helps the amateur user to integrate building blocks into practical projects. The aim of this book is to help the reader to put together projects from standard circuit blocks with a minimum of trial and error, but without resorting to any advanced mathematics.
0 85934 102 X — *128 pages* — *1983* — £2.25

PRACTICAL ELECTRONIC BUILDING BLOCKS – BOOK 1 BP117
PRACTICAL ELECTRONIC BUILDING BLOCKS – BOOK 2 BP118
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BOOK 1 contains: Oscillators – sinewave, triangular, squarewave, sawtooth, and pulse waveform generators operating at audio frequencies, including simple voltage-controlled types, L-C and crystal RF oscillators. Timers – simple monostable circuits using ICs, the 555 and 7555 devices, etc. Also precision long timers using the ZN1034E. Miscellaneous – noise generators, rectifiers, comparators and triggers, etc.
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E. A. Parr, B.Sc., C.Eng., M.I.E.E.
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0 900162 96 1 — *96 pages* — *1980* — £2.50

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R. A. Penfold
Provides the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as fuzz box, waa-waa pedal, sustain unit, reverberation and phaser units, tremelo generator, etc.
The text is divided into four chapters as follows: Chapter 1, Guitar Effects Units; Chapter 2, General Effects Units; Chapter 3, Sound Generator Projects; Chapter 4, Accessories.
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R. A. Penfold
Intended to complement the first book (BP74) by carrying on where it left off and providing a range of slightly more advanced and complex projects. Included are popular effects units such as flanger, phaser, mini-chorus and ring-modulator units. Some useful percussion synthesisers are also described and together these provide a comprehensive range of effects including drum, cymbal and gong-type sounds.
0 85934 148 8 — *128 pages* — *1986* — £2.95

A PRACTICAL INTRODUCTION TO MICROPROCESSORS BP123
R. A. Penfold
Provides an introduction which includes a very simple microprocessor circuit which can actually be constructed so that the reader can experiment and gain practical experience.
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MICRO INTERFACING CIRCUITS – Book 2 BP131
R. A. Penfold
Both books include practical circuits together with details of the circuit operation and useful background information. Any special constructional points are covered but PCB layouts and other detailed constructional information are not included.
BOOK 1 is mainly concerned with getting signals in and out of the computer.
BOOK 2 deals primarily with circuits for practical applications.
Book 1: 0 85934 105 4 — *112 pages* — *1984* — £2.25
Book 2: 0 85934 106 2 — *112 pages* — *1984* — £2.25

AN INTRODUCTION TO COMPUTER PERIPHERALS BP170
J. W. Penfold
Covers such items as monitors, printers, disc drives, cassette recorders, modems, etc., explaining what they are, how to use them and the various types and standards. Helps you to make sure that the peripherals you buy will work with your computer and with each other.
0 85934 144 5 — *80 pages* — *1985* — £2.50

EASY ADD-ON PROJECTS FOR SPECTRUM, ZX81 & ACE BP124
O. Bishop
Describes how to build a number of electronic projects which you can use with your Spectrum, ZX81 or Jupiter Ace microcomputer. The projects include a Pulse Detector, Picture Digitiser, Five-key Pad, Model Controller, Bleeper, Lamp Flasher, Light Pen, Magnetic Catch, Lap Sensor, Photo-flash, Games Control and six more projects that make up a Weather Station. All are fairly simple and inexpensive to construct.
0 85934 099 6 — *192 pages* — *1983* — £2.75

EASY ADD-ON PROJECTS FOR THE AMSTRAD CPC 464, 664, 6128 AND MSX COMPUTERS BP171
O. Bishop
The projects of books BP124 and BP134 adapted for use with the Amstrad CPC 464, 664, 6128 and the MSX range of machines. Again the Address Decoder is constructed as a separate item that can be used with any of the projects.
0 85934 145 3 — *196 pages* — *1986* — £2.95

EASY ADD-ON PROJECTS FOR COMMODORE 64, VIC-20, BBC MICRO AND ACORN ELECTRON BP134
O. Bishop
Similar in style to BP124 except, of course, many of the projects have been modified, where necessary, to operate with the different machines.
0 85934 109 7 — *208 pages* — *1985* — £2.95

A Z-80 WORKSHOP MANUAL BP112
E. A. Parr, B.Sc., C.Eng., M.I.E.E.
This book is intended for people who wish to progress beyond the stage of BASIC programming to topics such as machine code and assembly language programming, or need hardware details of a Z-80 based computer.
0 85934 087 2 — *192 pages* — *1983* — £2.75

AN INTRODUCTION TO COMPUTER COMMUNICATIONS BP177
R. A. Penfold
Provides details of the various types of modem and their suitability for specific applications, plus details of connecting various computers to modems, and modems to the telephone system. Also information on common networking systems and RTTY.
0 85934 151 8 — *96 pages* — *1986* — £2.95

PRACTICAL COMPUTER EXPERIMENTS BP78
E. A. Parr, B.Sc., C.Eng., M.I.E.E.
This book aims to fill in the background to the microprocessor by constructing typical computer circuits in discreet logic
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COMMENT . . .

Is The Microcomputer Entrepreneur Extinct?

IT IS barely two years since the microcomputer entrepreneur was a folk hero of the new, technology led, economic revival. They were epitomised by people like Sir Clive Sinclair, Stephen Jobs of Apple, Bill Gates of Microsoft or Chris Currey and Herman Hauser of Acorn. The conservative pillars of the financial community were then falling over themselves to back these often brash young entrepreneurs. Political leaders wished to be associated with them, and they were the darlings of the press.

Just twelve months later the industry had nose dived, many had lost their wealth even faster than they had made it. Their companies either bankrupt or absorbed by large corporations. This collapse has given rise, with just a few exceptions, to an industry now dominated by large multinationals. The entrepreneurs who gave birth to the microcomputer industry seem to be extinct.

The reasons for the disappearance of the technically innovative microcomputer entrepreneur probably lies in the origins of most of them, and it certainly lies in their success. A quick analysis of these entrepreneurs yields a few very interesting observations. Most of them belong in the same age group and were at university in the late sixties (though interestingly many dropped out without gaining a degree). They nearly all had one thing in common, they were hooked on technology. Their businesses were rarely founded with the primary aim of making money. They were instead founded as a means of funding a passion and to provide the products no one else could provide.

The faith in technology expressed by these individuals and the desire to create affordable computer power and apply it to the generation of a better life for people in general fired their innovation. In the mid 70s, in small rooms, on shoestring budgets, working late into the night these early microcomputer entrepreneurs created innovative products. Products which were the basis of the current microcomputer industry.

These early products were conceived to satisfy the needs of the inventor and his friends. The number of people involved in the industry was small, most people knew each other, not just nationally but internationally. Since nearly everyone had a science background and an academic leaning information was exchanged freely even between competitors. This free exchange of information had the effect of rapidly accelerating advances within the fledgling industry.

As the industry developed the commercial applications became obvious and many of the small companies started to grow often at alarming rates. Many fell by the wayside, victims of over-rapid expansion and lack of commercial experience. Of those who survived the first five years of expansion many had changed from a turnover of a few thousand pounds to tens of millions.

Despite their frequent lack of commercial experience these innovative entrepreneurs were able to succeed simply because the large established companies did not see the opportunities, and when they did it took them a long time to act. One senior manager from a major computer company declared in 1976 that no one could produce a desk top computer running Basic for less than £10,000, within a year the Apple and PET proved it could be done for £500.

It is certainly no coincidence that the move by IBM into the market and its subsequent domination of the market was followed very rapidly by the decline and collapse of many of the early entrepreneurial companies. Some survived for a while relying on the craze for computer games, but that was an inevitably short lived market.

What is interesting about the microcomputer market is the speed with which it was born, developed and matured. Other products have gone through the same sequence, cars, radio, TV, for them this maturing from the innovative entrepreneur to the mass market conglomerate has taken twenty or thirty years, for the microcomputer barely seven years.

It is probably no more use trying to generate further entrepreneurial activity in this market than it would be to encourage a new wave of motor car manufacturing entrepreneurs. Technologically innovative entrepreneurs are to be found wherever there is a new technology which lies unexploited due to the inertia of large companies and initial small size of any potential market.

This country needs more technologically innovative entrepreneurs, they can be created if much of the excellent research work carried out by Government bodies, universities and large company R&D departments is freed from the constraints on disseminating that information imposed by such organisations. Positive measures should be taken to hand new technology to the innovative entrepreneurs who are the only ones capable of extracting the maximum commercial potential from that technology in its early stages. There is now plenty of investment money, what is now needed is quality technological ideas which will make best use of that money, and financial experts with the ability to recognise such ideas. Perhaps even more important than all these measures is the necessity to put popular enthusiasm back into technology. This is required to raise a new generation with the faith in the ability of technology to be applied to solving some of the world's problems and thereby create a better and richer life for all the peoples of our planet. This faith in the power of applied science and technology coupled with a renewed popular enthusiasm will create the right climate for the new technological entrepreneurs. The responsibility for creating this popular enthusiasm lies with the media and to a lesser extent politicians. Don't knock technology, support it.

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TEMPESTUOUS STORM EFFECTS
MAKING MORE USE OF DRY CELLS

NEWS LATEST . . .

This page features a collection of last minute news and press releases received immediately prior to the magazine going to press. Many of the items mentioned on this page will be discussed in greater detail next month.

Chip makers are seeing a major upturn in the market. For the first time in 17 months the world semiconductor industry has in January and February seen its order book exceed in value the value of parts shipped. This move out of the slump which has affected semiconductor manufacturers last year is very welcome and industry analysts are predicting a slow but steady improvement in sales over the next twelve months.

A new standard has been announced jointly by Philips and Sony for optical data disks or CD-ROMs. This is a sector which is growing rapidly with CD-ROM players being produced for a wide range of personal computers. Information suppliers are also starting to produce information in CD-ROM form. These new standard augment standards already set up by these two companies for audio compact disks. The standards are designed to ensure that CD-ROM disks produced for personal computers will have the same level of easy interchangeability between different manufacturers products as audio compact disks.

A new high speed fibre optic computer chip has been developed by IBM. It is designed to allow high speed communication between the computer and peripheral devices. Using this chip the computer will be connected to a peripheral by fibre optic cables and can transfer data at up to 400 million bits per second. This chip will enable communication networks to be established within an area with light weight fibre optic cables. Such fibre optic cable networks have the advantage of being free from electro magnetic interference or static electricity both of which cause transmission errors. They are also 'bug' free and offer high security means of communication.

The worlds largest printed circuit boards with dimensions up to 15ft by 5ft are being made in the US by Buckbee Mears a division of the Birmingham company Steatite. These boards are being used in the manufacture of microwave radar aerials.

A big surge in Japanese basic research is currently taking place and it is expected that by 1988 an extra 76 research laboratories will have been built at a total estimated cost of over £1.5 billion. These laboratories will be investigating many areas of basic research including VLSI, fifth generation computers and expert system software, and computer aided design. The work carried out by these new laboratories will undoubtedly help maintain the strength of Japanese technology based manufacturing.

The Institute of Electrical Engineers has announced a project to help overcome 'technofear' in British school children. It is called 'Project Uncle' and is designed to make engineering skills and contacts available to teachers by providing professional engineers who will work in the classroom with teachers to bring their experience of industry to the pupils.